Aviation Fatigue

MANAGEMENT

GUIDEBOOK VERSION 2

This guidebook has been designed to provide guidance on fatigue management within the Defence aviation context. More broadly, this guidebook is intended to familiarise Defence aviation personnel with contemporary concepts of fatigue management and to provide practical guidance for implementation in day-to-day operations. While parts of the guidebook focus on considerations specific to select Defence aviation occupations, the themes and concepts remain applicable to all operating contexts.

Version 2.0 — August 2024

Date	Version	Description
April 2021	1.0	First release
August 2024	2.0	Minor amendments, Enclosure 1 update

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DEFINITIONS

Acclimatised time	The local time at the location where personnel are acclimatised (CASA)
Adaptation period	A continuous off-duty period (ODP) for an individual to become acclimatised to a particular location/time zone. (CASA)
Augmented crew operation	An aircraft operation in which one or more crew, additional to the minimum required number of crew, are engaged in a flight to allow one or more crew to be relieved of duty during flight time. (ICAO, CASA)
Bio-mathematical Model	A computer program designed to predict aspects of a schedule that might generate an increased fatigue risk for the average person, based on scientific understanding of the factors contributing to fatigue. All bio-mathematical models have limitations that need to be understood for their appropriate use. (ICAO)
Call-out	Being required by an operator to commence a duty period during a standby. (CASA)
Consecutive	A continuous, unbroken period of time for the duration of the hours or days mentioned. (CASA)
Crew/Aircrew	Includes Pilot(s) and other personnel on-board the aircraft and/or the UAV control station with responsibilities to ensure the safe conduct of the flight. (DASR)
Cumulative duty	The progressive sum of duty periods. (CASA)
Cumulative flight time	The progressive total of flight time accrued by aircrew when acting as a crew member on board any aircraft. Note: This includes time spent resting during augmented crew operations but does not include time spent positioning. (CASA)
Duty	Any task that a person is required to carry out associated with their employment. (ICAO, CASA)
Duty period	A period of time between when a member commences duties associated with their employment until they are finally relieved of all such duties and commence a rest period. This includes any 'non-aviation related' duties such as administration. (ICAO, CASA)

Fatigue	A physiological state of reduced alertness or capability to perform mental or physical tasks, which may impair the ability of an individual to safely conduct their duties and is caused by one or more of the following: • the individual's lack of sleep • the individual's extended wakefulness • the individual's circadian phase at any relevant time • the individual's workload of mental activities, and/or physical activities at any relevant time. Note: An individual's level of fatigue and state of alertness can also be influenced by their health, diet, fitness and overall wellbeing. (CASA)
Fatigue Management Program (FMP)	A generic term used in this document to describe the specific processes, practices, tools and techniques used to manage the hazard of fatigue; building upon and complementing an organisation's existing safety-management processes.
Local night	Referring to a sleep period aligned with the circadian rhythm (that is, a sleep period of 2200–0600 in the home time zone). (CASA)
Window of Circadian Low (WOCL)	Time in the circadian body clock cycle when subjective fatigue and sleepiness are greatest and people are least able to do mental or physical work. The WOCL occurs around the time of the daily low point in core body temperature — usually around 0200–0600 when a person is fully adapted to the local time zone. However, there is individual variability in the exact timing of the WOCL. (ICAO, CASA)

USE OF THIS GUIDEBOOK

The Defence *Aviation Fatigue Management* Guidebook has been designed to provide guidance on meeting an accountable person's obligations in relation to fatigue management within the Defence aviation context. More broadly, this guidebook is intended to familiarise Defence aviation personnel with contemporary concepts of fatigue management and to provide practical guidance for implementation in day-to-day operations. While parts of the guidebook focus on considerations specific to select Defence aviation occupations, the themes and concepts remain applicable to all operating contexts. For Defence organisations, it serves to complement Defence WHS requirements and should be used in conjunction with the *Defence Safety Manual* — Fatigue Management Policy and Guidance.

The following diagram provides an overview of the *Aviation Fatigue Management* Guidebook to assist readers in navigating its contents. Chapters 1 to 3 provide general information on fatigue management, including an overview of key scientific principles and the role of operational knowledge and experience in developing an aviation Fatigue Management Program (FMP). Chapters 4 to 7 detail the essential components of the FMP, including how it can be most effectively implemented. Chapter 8 provides a useful checklist to assist in the development and implementation of the FMP.

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CHAPTER 1 **INTRODUCTION TO FATIGUE MANAGEMENT**

1.1 Overview

In the Defence aviation context, fatigue is considered a significant workplace hazard. It impairs essential aspects of human performance resulting in increased susceptibility to error and greater risk of injury and accident. Fatigue is widely acknowledged as inevitable within the Defence aviation context due to the: (1) unique operational demands; (2) wide variability in how fatigue is experienced among individuals, and; (3) recognition that the conditions that produce fatigue originate not only in the workplace but also in an individual's personal life.

In general, across both the military and civil aviation industry, fatigue has historically been controlled using a single layer of defence (that is prescriptive flight and duty time limitations). Prescriptive limitations are broadly designed to manage the risk of fatigue due to sleep loss, time awake, time on duty and the time-of-day effects. The assumption is that compliance with the limits is evidence that an employee is rested and fit for duty. However, this may not always be the case. When used in isolation, prescriptive rule sets:

- Fail to adequately manage fatigue as they cannot take into account the complex interaction of factors that are linked to hours of work and rest periods.
- Promote a set-and-forget mentality within an organisation.
- Are susceptible to misuse should an organisation continually schedule duty periods to their maximum limits without consideration of the context.

Instead, commanders and managers are to establish and maintain a Fatigue Management Program (FMP) to ensure a more holistic and multi-layered approach for addressing the safety implications of fatigue.

Effective fatigue management in Defence aviation operations, large and small, is best addressed through a multi-layered approach.

This approach can be described as a risk-based approach as it allows fatigue to be actively managed in a way that is scalable and commensurate with the risk and complexity of the organisation's operations.

Defence aviation does have unique risks, especially when considering the types of aircraft and aspects of the operating environments cumulatively: complex machines, harsh operating environments, long duty periods that cover a 24-hour cycle and high-intensity workloads. These factors, which are often in flux, mean that Defence aviation is inherently different to civil aviation. For this reason, there is no one-size-fits-all approach to fatigue management across Defence aviation. Rather, commanders and managers are to establish and actively maintain an FMP to meet their unique requirements.

In broad terms, the FMP brings together the specific processes, tools and techniques that will be used to manage fatigue. Because the FMP has a safety function, it builds upon and complements an organisation's existing safety-management processes. This ensures fatigue is managed in a way similar to other hazards and that responsibility for managing fatigue risk is a shared responsibility of command/management, and the individuals covered under the FMP.

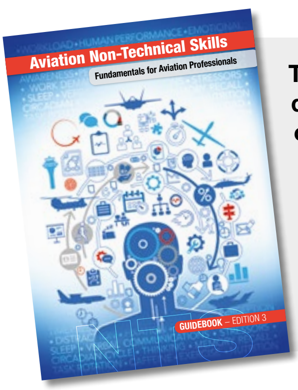
Within the FMP, no single component should be considered more important than another. Duty time limitations and informed scheduling essentially set the informed lines in the sand inside which organisations must actively manage their fatigue-related risks using Aviation Safety Management System (ASMS) processes. Such limitations and rules are to be based on scientific principles in combination with operator knowledge and experience (see Chapter 2 and Chapter 3).

In addition to providing the mechanisms to identify, assess and mitigate fatigue-related hazards and risks, integration of fatigue management within the ASMS serves to monitor, improve and promote the effectiveness of fatigue-management efforts over time (see Chapter 4, Chapter 5, Chapter 6 and Chapter 7).

It is not enough to only apply duty time limitations as a sole means of managing fatigue, as they are unable to accommodate unique factor(s) encountered in the Defence aviation context.

Commanders and managers are required to establish and maintain a Fatigue Management Program that is commensurate with the risk and complexity of their operations.

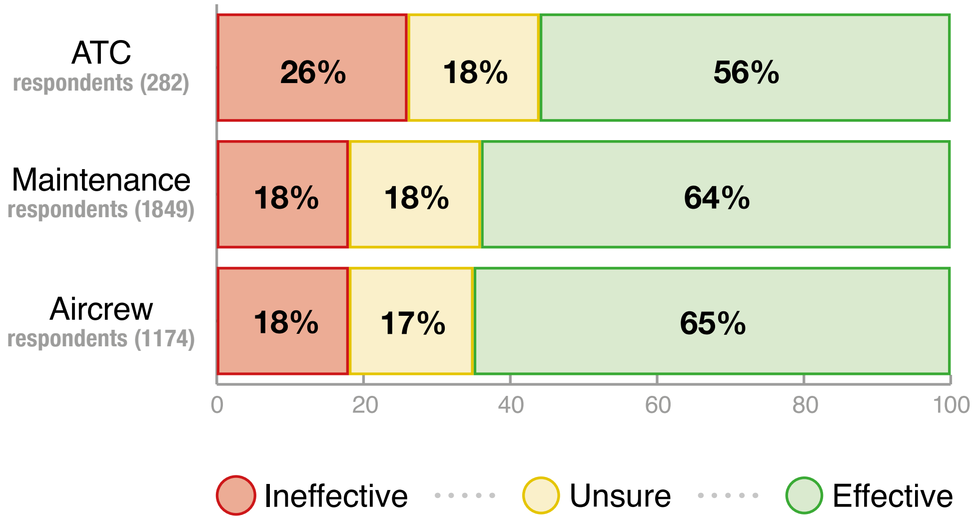
The individual components of the FMP are designed to complement each other to ensure the best possible outcomes for fatigue risk management and safety.



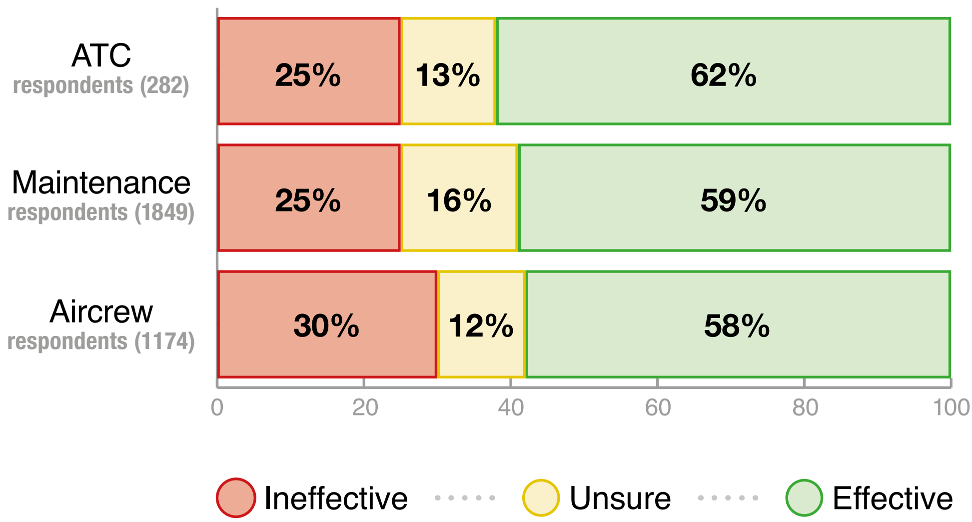
The *Aviation Non-Technical Skills* (NTS) Guidebook was developed by DFSB to introduce individuals to human-factors considerations such as human performance, error and violation, safety culture, and specific NTS such as situation awareness, decision-making, communication, leading and working in teams and managing stress and fatigue. The NTS Guidebook complements the DFSB NTS Foundation and Continuation courses and represents a key resource for Defence aviation organisations delivering safety training programs.

The 2024 DFSB *Snapshot* Survey included measures on fatigue. These measures were not just limited to personal experiences of fatigue, but also looked at the management of fatigue-related hazards. The proportion of ATC respondents identifying fatigue management as ineffective was highest (26 per cent). In comparison, aircrew respondents (30 per cent) reported greater perceptions of ineffective schedule management.

Fatigue management



Scheduling management



CHAPTER 2 THE SCIENTIFIC PRINCIPLES OF FATIGUE MANAGEMENT

ICAO defines fatigue as: a physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, and/or workload (mental and/or physical activity) that can impair a person's alertness and ability to adequately perform safety-related operational duties.

ICAO DEFINITION

It is important to establish the scientific basis for fatigue management. There is a large body of Australian and international research relating to fatigue and fatigue management in the workplace as well as substantial civil aviation regulatory guidance. While there remains ongoing debate on some topics, there is general agreement in the literature on a number of core principles.

In general terms, fatigue is a state of feeling tired, weary or sleepy that results from an imbalance between: (1) the physical and mental exertion of all waking activities (not only duty demands); and (2) recovery from that exertion, which (except for recovery from muscle fatigue) requires sleep. Following this line of thinking, to reduce fatigue in operations, strategies are required to manage the demands of waking activities and to improve sleep.

Both the International Civil Aviation Organization (ICAO) and Australian Civil Aviation Safety Authority (CASA) draw attention to four basic scientific principles that should underpin fatigue management. These basic principles relate to: (1) the need for sleep (2) sleep loss and recovery (3) circadian effects on sleep and performance and (4) the influence of workload. These principles must be addressed by an FMP, they are described further in the following sections.

2.1 Scientific Principle 1: The need for sleep

The 'need for sleep principle' can be summarised as follows:

- Everybody feels better after a good night's sleep. It is very often the first question we ask each other in the morning.
- Sleep has multiple functions. It has vital roles in memory and learning, in maintaining alertness, performance, mood and in overall health and wellbeing.
- Sleep cannot be sacrificed without cognitive, behavioural, emotional and/or physiological consequences.
- The longer an individual remains awake, the worse their alertness and performance becomes.
- The amount of sleep required by a person varies, with seven to eight hours of daily sleep considered the average by sleep experts.
- Sleep that is fragmented by multiple awakenings, or arousals into lighter stages of sleep, is less restorative than continuous sleep.
- The sleep environment (temperature, noise, light-level, and so on) can affect sleep quality.
- Sleep at work, such as in-flight rest facilities and split duty rest facilities, is often not as good quality as sleep under normal conditions at home. Sleep obtained when on call/standby is also often of poorer quality.
- The effects of restricting sleep accumulate. People will become progressively less alert and functional with each subsequent day of sleep restriction.
- Sleep disorders can reduce the amount and quality of sleep a person can obtain, even when they spend enough time trying to sleep.
- Controlled napping can temporarily relieve the symptoms of sleep loss. It is a valuable mitigation strategy, for example; prior to a night-duty period.

Consequences of fatigue

Though individuals vary in their experiences of fatigue, no one is immune from becoming impaired by fatigue. The adverse effects of fatigue on human performance include (but are not limited to):

- reduced alertness and vigilance
- inattentiveness
- inability to fully concentrate
- degraded situation awareness
- reduced communication
- sub-optimal decision-making
- carelessness or complacency
- delayed response time.

These impairments hold clear consequences for the standards of work performance as well as the risk to aviation safety and have been identified as a contributing factor in accidents and incidents in aviation and other industries.

Defence aviation survey data consistently shows that individuals who are fatigued also have lower scores on job satisfaction, morale, and enthusiasm for work.

Reducing the amount or the quality of sleep, even for a single night, decreases the ability to function and increases sleepiness the next day.

2.2 Scientific Principle 2: Sleep loss and recovery

The 'sleep loss and recovery principle' can be summarised as follows:

- Losing as little as two hours of sleep in one night reduces alertness the next day and degrades performance on many types of tasks.
- The effects of restricted sleep accumulate and the rate of accumulation is related to the rate of sleep loss (less sleep per day = more rapid accumulation of fatigue).
- Total sleep loss (one or two nights without any sleep) and cumulative sleep loss (reduced sleep on consecutive nights) are equally detrimental to performance and alertness.
- Sleep pressure eventually becomes uncontrollable, which results in unintentional sleep (micro-sleeps or unintended naps).
- Individuals vary widely in their ability to tolerate sleep loss.
- Lost hours of sleep do not need to be recovered hour-for-hour.
- Recovery of a normal sleep pattern after an accumulated sleep debt takes at least two nights of unrestricted sleep.
- Recovery of waking alertness and performance after accumulating a sleep debt may take longer than two nights of unrestricted sleep.
- Unrestricted sleep means being free to fall asleep when tired and wake-up spontaneously, with sleep occurring at the appropriate time in the cycle of the circadian body clock.
- Disruptions to normal sleep routines are common with night-shift employees or with aircrew who fly over long distances and transit time zones.

The circadian body clock affects the timing and quality of sleep and produces daily highs and lows in performance on various tasks.

- When individuals get less sleep than they need, they build up what is called a sleep debt. Each additional day without enough sleep increases the debt and when it becomes large enough, their performance declines.

2.3 Scientific Principle 3: Circadian effects on sleep and performance

The 'circadian effects principle' can be summarised as follows:

- The perfect schedule for the human body is daytime duties with unrestricted sleep at night. Anything else is a compromise.
- The circadian clock exerts a strong influence over sleep, creating windows when sleep is promoted and windows when sleep is opposed.
- There are two times of peak sleepiness in 24 hours: (1) a peak in the early afternoon (the afternoon nap window) that occurs around 1400–1800 for most people, and; (2) a peak in the early hours of the morning (the window of circadian low) that occurs around 0200–0600 for most people.
- The precise timing of the two peaks in sleepiness is different in people who are morning types (whose circadian rhythms and preferred sleep times are earlier than average) and evening types (whose circadian rhythms and preferred sleep times are later than average).
- Sleep at times of the day other than when there is greatest propensity to sleep is less efficient – it is often shorter because of disturbances and interruptions and is less restorative.
- The circadian body clock is not able to adapt immediately to a change in the work/schedules that occur with shift work and night work.
- Night duty forces an individual to go to sleep later than normal in their circadian body clock cycle. This means that they have a limited amount of time to sleep before the circadian body clock wakes them up.
- The circadian body clock does not adapt fully to altered schedules such as rotating shifts or night work. Some adaptation may occur on slow rotating schedules. There is no clear difference between forwards versus backwards rotating shift schedules.

- Whenever a duty period overlaps an individual's usual sleep time, it can be expected to restrict sleep. Examples include early duty start times, late duty end times and night work.
- The circadian body clock is not able to adapt immediately to changes in time zones.

2.4 Scientific Principle 4: The influence of workload

The 'influence of workload principle' can be summarised as follows:

- The relationship between workload and fatigue is significant but has not been well researched.
- There is general agreement that both high and low workload can contribute to fatigue.
- Fatigue generally accumulates faster in high-intensity tasks than in low-intensity tasks.
- The factors contributing to workload and the consequences of workload need to be considered for each operational situation.

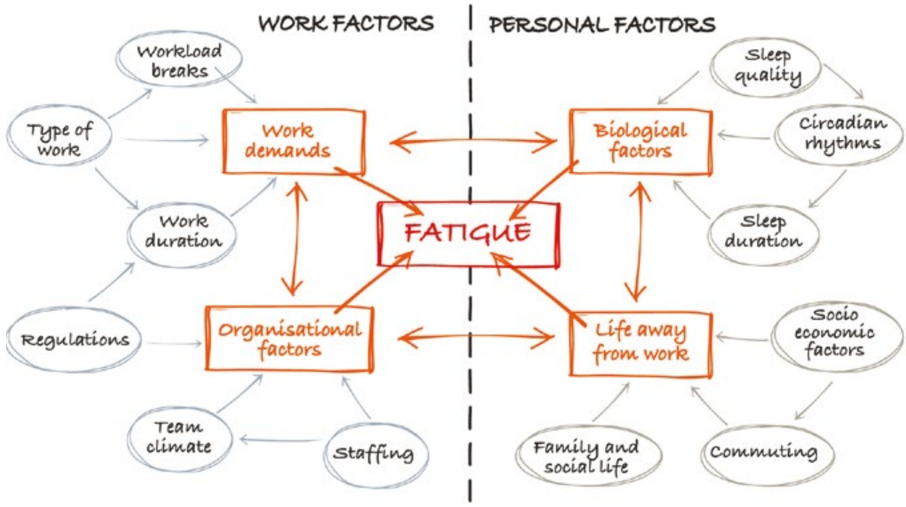
Workload can contribute to an individual's level of fatigue. Analysis of the 2020 DFSB *Snapshot* Survey data showed that aircrew who reported uncomfortably high workloads were four times more likely than those with comfortable workloads to have fatigue scores that fell into the "high risk" category. Maintainers were three times more likely. Conversely, low workload may unmask physiological sleepiness while high workload may exceed the capacity of a fatigued individual.

- Three aspects of workload should be considered: (1) the nature and amount of work to be done (including time on task, task difficulty and complexity, and work intensity) (2) time constraints (including whether timing is driven by task demands, external factors, or by the individual) and (3) factors relating to the performance capacity of an individual (for example experience, skill level, effort, sleep history, and circadian phase).

CHAPTER 3 **OPERATIONAL KNOWLEDGE AND EXPERIENCE**

Effective fatigue management not only requires consideration of scientific principles, but also needs to be based on operational knowledge and experience, acquired through conducting specific operations over time and managing fatigue-related risks in those operations. These two sources of expertise are complementary. This means that knowledge of the operational and organisational context must be considered alongside the science when determining and implementing an appropriate Fatigue Management Program (FMP).

The ADF Aviation Workforce Fatigue Management Study conducted by the RAAF Institute of Aviation Medicine in 2013 identified some of the key factors that influence fatigue in Defence aviation. The study included the conduct of focus groups to identify risk factors among ADF aircrew and maintenance personnel. The key findings from the focus groups of ADF aircrew and maintenance personnel are detailed to the right.



Workplace and personal factors that contribute to fatigue (adapted from Hobbs, Avers and Hiles, 2011)

Aircrew identified the following sources of fatigue-related risk:

- imbalance between workload and crewing/experience levels
- accumulation of a sleep debt from consecutive days of night flying
- irregular duty/rest schedules
- transition from night to day duty periods
- difficulty sustaining an appropriate work/life balance
- impact and extent of non-flying-related duties
- operational tempo
- post-duty driver fatigue.

Maintenance personnel identified the following sources of fatigue-related risk:

- operational tempo
- sustaining continuous maintenance operations
- absence of appropriate peaks and troughs in tempo
- shift work
- resuming maintenance activities immediately following major activities and exercises (that is no period of reconstitution).

By having a clear understanding of causes of fatigue inherent in their operations, commanders and managers are able to identify flight and duty limits and construct schedules that address their unique operational context as part of their FMP.

Causes of fatigue for Defence aviation personnel

Given cause of fatigue	% reporting this cause
Poor or disrupted sleep	48
Shift work (particularly night shift)	38
Work demands	31
Work-related stress	30
Family demands	25
Demanding mental work	23
Personal choices	19
Stress related to private life	18
Changing time zones or jet lag	18
Extended periods of constant work	15
Periods of boredom/ monotony at work	13
Environmental conditions	10
Physical hard work or prolonged exertion	8
Lack of adequate food or water	2

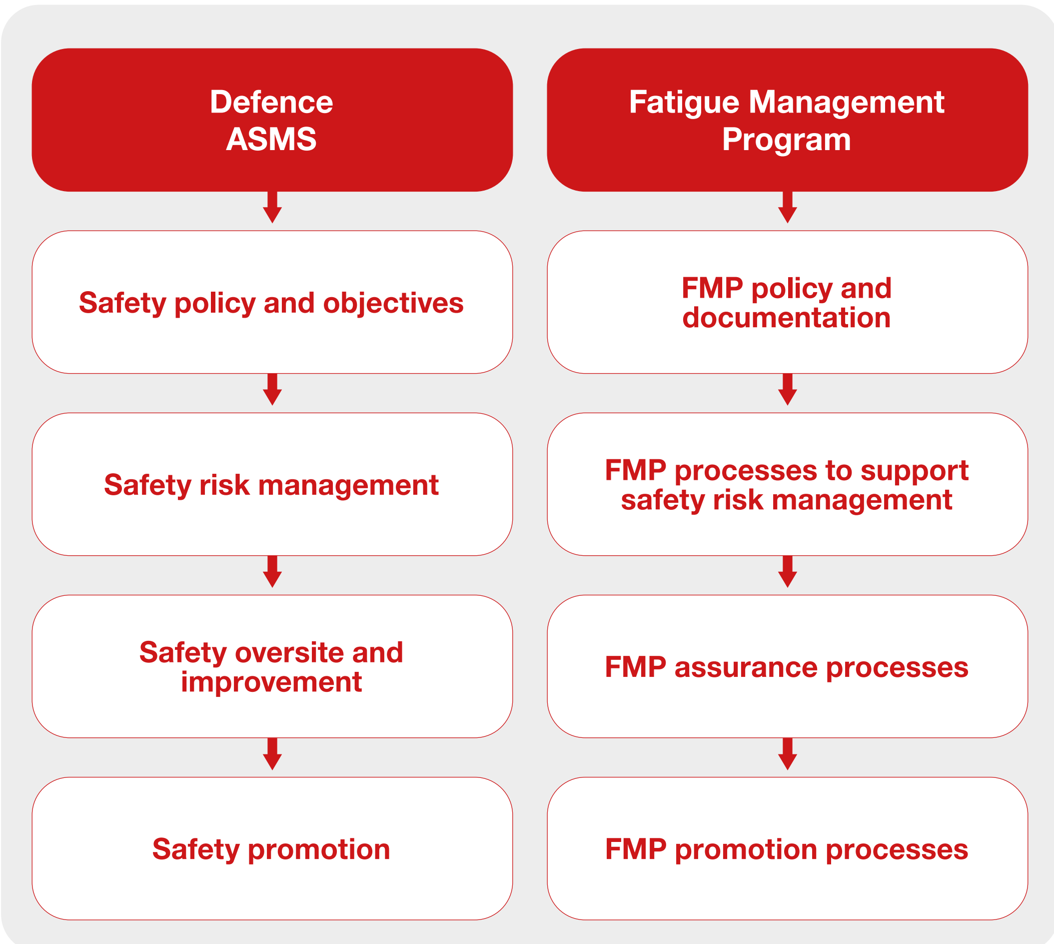
Defence Aviation Fatigue Survey, 2011 > 1600 respondents

3.1 The Fatigue Management Program

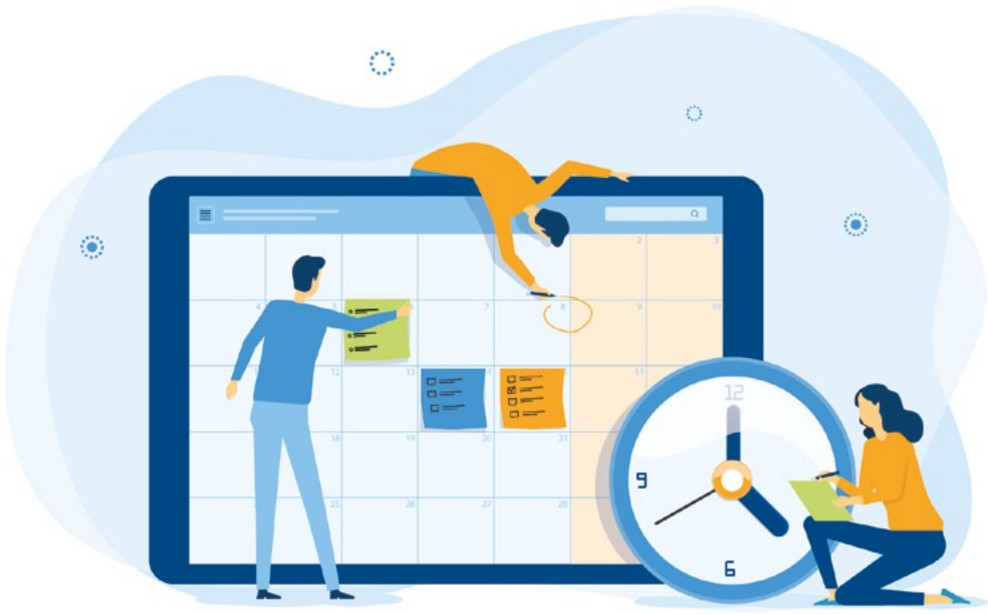
The following chapters focus on the development and implementation of an FMP. As the FMP has a safety function, it is essential that it builds on and complements an organisation's existing safety-management processes. To support this outcome, an FMP is best viewed as an integrated extension of an organisation's ASMS. This ensures fatigue is managed in a way similar to other hazards. The purpose of the FMP is to bring together the specific processes, tools and techniques that will be used to manage fatigue. The following chapters describe the components of an FMP and how they might be coupled with the ASMS.

The FMP brings together the specific processes, tools and techniques that will be used to manage fatigue. Because the FMP has a safety function, it builds upon and complements an organisation's existing ASMS processes.

Relationship between the FMP and Defence ASMS



CHAPTER 4 **FMP POLICY AND DOCUMENTATION**



4.1 Key components of FMP policy and documentation

FMP policy specifies the organisation's commitment and approach to the management of their fatigue hazards and risks. It is unique to the organisation that develops it and reflects its particular context and operational needs. The key components of an effective FMP policy are that it:

- States the organisation's commitment to managing the risk of workplace fatigue and the objective of the FMP.
  Sample text: All levels of command/ management are committed to managing the risk of workplace fatigue. The objective of this FMP is to manage the fatigue-related hazards and risks encountered by personnel involved in the operation, maintenance and control of aircraft, and to ensure that such personnel are performing at an adequate level of alertness.
- Identifies and documents the organisational position responsible for managing the safety processes associated with the FMP.
- Reflects that the management of fatigue is a shared responsibility of command/ management, and the individuals covered under the FMP (discussed further below).
- As appropriate, specifies flight and duty time limitations for aircrew and duty time rules for other personnel involved in the operation, maintenance and control of aircraft – including procedures for extending beyond the identified limits (discussed further below).
- Documents the FMP processes associated with Safety risk management (Chapter 5), FMP safety assurance (Chapter 6) and FMP promotion processes (Chapter 7).

4.2 Shared responsibility between the organisation and individuals

Primary responsibility for fatigue management rests with the organisation (that is commanders and managers) who control the activities of operational personnel and the distribution of resources in the organisation.

Above all, commanders and managers must not assign a duty if they reasonably believe that an employee involved in the operation, maintenance or control of an aircraft is unfit to perform the duty because of fatigue. Other organisational responsibilities with respect to the management of fatigue generally include:

- providing adequate resourcing for fatigue management
- developing policies, procedures and practices that manage fatigue-related risks, including mechanisms for monitoring and continuous improvement
- ensuring the FMP contains appropriate linkages with the organisation's ASMS
- providing training for all organisational stakeholders on how the organisation's fatigue-management approach works and how individuals can better manage their own fatigue.

Fatigue management is just as much an individual responsibility as a command/management function. Shared responsibility under fatigue management requires that personnel should not commence any tasks if they are likely to be unfit to perform the task due to fatigue. Other individual responsibilities with respect to the management of fatigue are likely to include:

- making optimum use of non-work periods to get adequate sleep
- arriving at work in a fit and rested state so that there is a reasonable expectation of being adequately alert throughout the duty period
- communicating fatigue-related safety and performance concerns with work peers and supervisors
- reporting all fatigue-related safety events and issues
- identifying and managing fatigue-related hazards when encountered during a duty period
- complying with their fatigue-management responsibilities set out by their organisation.

4.3 Duty time limitations and scheduling practices

There is wide acknowledgement that fatigue is a significant hazard for individuals and groups that work outside the standard 40-hour working week. DFSB *Snapshot* data can be used to support these claims. As shown in the figure on page 19, fatigue scores climb steeply as the working week extends beyond the 40-hour mark.

There is also considerable evidence to suggest that working more than 50 hours per week is associated with a general decline in health and higher rates of safety events. The likelihood of such risks being realised can vary depending on how the hours are organised, the nature of work and the characteristics of individual personnel. Evidence also suggests that individuals who work such long hours tend to reduce their hours of sleep rather than cut back on competing social and domestic demands.

There exists substantial civil aviation guidance on duty and flight time limitations, rest requirements and scheduling practices. Examples include:

- International Civil Aviation Organization (ICAO) — Fatigue Management Guide for Airline Operators (2016)
- ICAO — Fatigue Management Guide for General Aviation Operators of Large and Turbojet Aeroplanes (2016)
- ICAO — Fatigue Management Guide for Helicopter Operators (2020)
- Fatigue Management Guide for Air Traffic Service Providers (2016)
- Civil Aviation Advisory Publication — Fatigue Management for Flight Crew Members (2020)
- Flight Safety Foundation — Duty/Rest Guidelines for Business Aviation (2014).

A FMP includes the identification of limits and adoption of scheduling practices based on scientific principles and operational experience as a means of mitigating fatigue. In general, this means:

- providing adequate sleep opportunities prior to duty periods, taking into account the likelihood that an individual will attain adequate sleep
- limiting the duration of work periods and identifying minima for non-work periods to allow for adequate recovery
- limiting consecutive and total work periods over defined periods of time in order to prevent cumulative fatigue
- considering the impact of commencing duties at different times of the day

- considering the number and direction of time-zone changes experienced (where relevant)
- considering the impact of undertaking duties within a window of the circadian low (WOCL)
- considering whether the duty is being undertaken by a single operational person or a team
- considering the impact of workload during the work period.

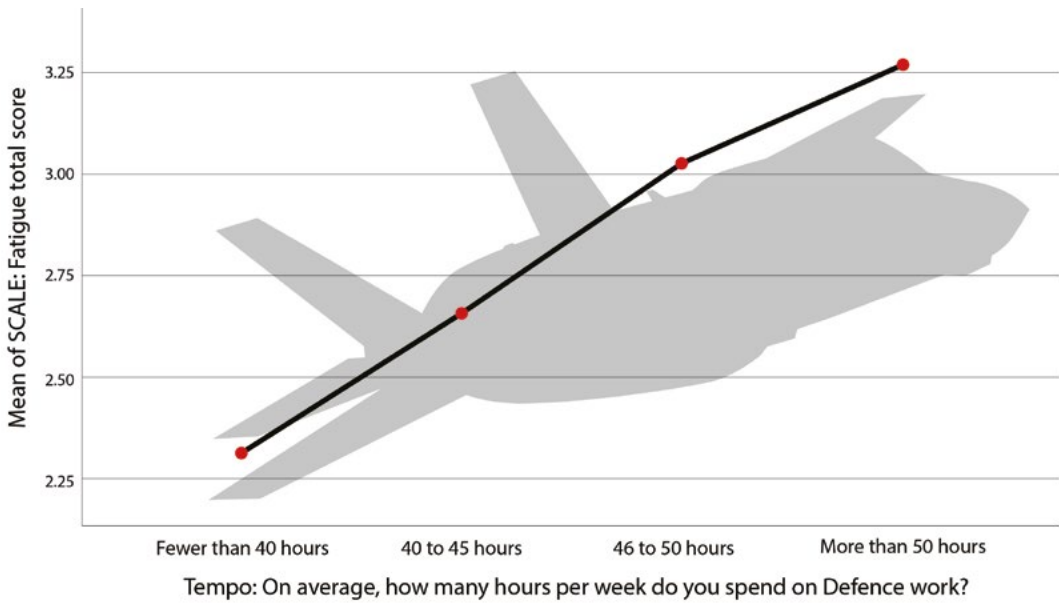
This chapter addresses the above considerations under the following headings:

- Duty periods
- Rest periods (minimum rest requirements)
- Flight times and fight duty periods (where applicable)
- Augmented crew operations
- In-flight/on duty rest facilities
- Informed scheduling practices
- Transitions
- Long haul/transmeridian operations
- Simulator-related fatigue
- Cumulative fatigue
- Extensions due to unforeseen operational circumstances
- Scheduling and rostering principles
- Transitions
- Disruptive schedules.

Duty periods

A duty period is defined as that period of time between when a member commences duties associated with their employment until they are finally relieved of all such duties and commence a rest period. This includes any non-aviation-related duties.

A duty period of eight hours (not including meal breaks) is considered the benchmark for sustainable operations although a 12–14 hour maximum may be acceptable when a 10 hour minimum sleep/rest period can be guaranteed. Duty periods of greater than 12–14 hours involve an ever-increasing level of fatigue-related risk. Results from the 2018 DFSB *Snapshot* survey revealed that, compared with personnel working regular hours, aircrew and maintainers who frequently worked shifts longer than 12 hours were twice as likely to have fatigue scores that fell into the high-risk category.



Rest periods

Regular rest periods are required to mitigate acute fatigue. Individuals require an opportunity to obtain not less than eight consecutive hours of sleep (and nine hours in bed) in suitable accommodation; time to travel to and from that accommodation; and time for personal hygiene and meals.

A rest period is defined as that period of time where the member is relieved of all duties associated with the member's employment. Where possible, members are not to be on-call or on standby during the rest period. The rest obtained while a passenger on the aircraft is not equivalent to the rest obtained in a bedroom. Therefore, transit rest may not meet rest-period requirements.

Rest-period considerations include:

- **Minimum rest period.** Commanders and managers should define minimum rest periods. Shorter off-duty rest periods (less than 10 hours) should be used as an exception, but this exception should be minimised and after several days of shorter off-duty periods, sufficient rest will be required to counter cumulative fatigue. A 10-hour minimum rest period is only to be used to keep crews in a 24-hour duty cycle, not for scheduling convenience, shift transition or additional sortie generation.

A potential risk with setting maximum duty time limitations is that they become de facto standard working hours, rather than upper bounds on standard working hours.

- **Effectiveness of rest periods.** A rest period will only be effective if personnel can realistically sleep during that period. The opportunity to acquire the optimal period of sleep is influenced by a number of factors including circadian rhythm and rest facilities. For example, if a person's normal sleep period is 2200–0600, granting them a rest period of 10 hours during the day (in the same time zone) with no acclimatisation period may only result in 1–3 hours of sleep. In this case, although the minimum rest-period requirement may have been met, the level of risk in the following duty period will be significant.
- **Maximum number of consecutive days.** There is wide acceptance that extended rest periods are required to sustain performance and mitigate the cumulative build-up of fatigue over consecutive duty days. An extended rest period is of a length that allows a member to fully recover from the fatiguing effects of prior duty periods. Unless operationally necessary, the number of consecutive days should be restricted to six or less and the rest period should be at least 48 hours in length.

  Provision of both rest periods and days off from duty should be managed in combination to support operational requirements. For example, a member can arguably manage levels of fatigue for longer periods (that is weeks) if scheduling incorporates increased rest between duty periods.
- **Rest breaks.** A rest break is defined as a period of time free from operational duty for members to overcome the fatigue arising from work and to attend to personal needs. Where possible, a rest break should be provided at least every four hours and more often in high-workload circumstances. Rest breaks are necessary on night shifts. Rest breaks should be a minimum of 20 minutes and should be consistent with the need to balance any risks associated with the handover of a task to another member. Sufficient time outside of rest-break allocations should be allocated to operational staff so they can attend to non-operational requirements (for example administration). It is acknowledged that regular rest breaks are not compatible with many flying operations. Consideration should be given to task-workload management strategies to minimise fatigue arising from work in these circumstances.

Condition	Potential fatigue risk factor
Minimum rest that does not encompass the WOCL.	Minimum rest that does not encompass the WOCL may result in sleep of a shorter duration or poorer quality due to the circadian rhythm.
Minimum rest following high workload or elongated duty.	Minimum rest may be insufficient for recovery following a high workload or elongated duty.
During daylight hours or not encompassing a local night.	Rest periods occurring during daylight hours require sleep to be achieved at a time when the circadian rhythm in alertness, light and noise degrade sleep quality and reduce sleep duration.
Consecutive minimum rest periods.	Consecutive minimum rest periods can result in cumulative sleep loss and increase the risk of cumulative fatigue.
Single day off – preceded by a late duty period and/or followed by an early duty period.	The encroachment of the duty period(s) that bookend the day off reduce its effectiveness as a recovery period.

Compounding fatigue risk factors can be easily overlooked. For example, when approving operations over the WOCL, Immediate RM may only focus on the need of the task vs the risk of operations in the WOCL. What may be overlooked are compounding fatigue risk factors such as reduced sleep and/or time awake, whereby the level of risk is much higher than expected.

The timing of a rest period and subsequent duty period may result in a sleep debt (waking up early for duty) or extended wakefulness (starting duty late). Duty periods and task requirements should be adapted to account for reduced sleep or extended wakefulness caused by rest-duty periods that do not align with the circadian rhythm.

Flight times and flight duty periods

Across Defence aviation, individuals are required to carry out safety-critical operational duties throughout a duty period, including the conduct of aviation operations/tasks exceeding eight hours in duration. The ability to implement additional risk controls following the commencement of a duty period is comparatively limited. Both aircrew and air traffic controllers require enhanced emphasis on preventative fatigue-management risk controls as individuals/crews are generally unable to stop the task when confronted with fatigue-related risk during task execution.

The primary purpose of daily flight time and/or flight duty period limitations is to address short-term acute or transient fatigue that is brought about by time on task. When determining daily flight and/or flight duty time limitations, commanders and managers need to consider the unique needs of their operational environment including consideration of the aircraft type, crew composition, crew rest facilities, operating environment, crew workload and mission profiles. Specific considerations include:

- **Cumulative flight time.** More scientific evidence is available to support guidelines for acute limits than for determining specific cumulative limits. Limiting cumulative flight time over medium (that is weekly and monthly) and long (that is annual) time periods is a means of managing cumulative fatigue. Weekly and monthly flying hour limits vary from 20–55 hours and 45–120 hours respectively, depending on type of aircraft, number of crew and complexity of missions flown.
- **Standby operations.** Standby may be undertaken at home or at another place where suitable sleeping accommodation conditions exist. In order to maximise the effectiveness of any rest/sleep opportunities while on standby, instructions should emphasise reducing contact to a minimum and where possible, not including the member in operational planning and decision-making prior to the start of the duty period. It is recommended that crew members on standby be given a block-sleep period of protected time during each 24-hour period on standby and that the crew member is not contacted or assigned duty during this period. The block-sleep period should be assigned before the crew member begins standby duty and should occur at the same time during each 24-hour period.
- **Standard and extended operations.** Setting a single maximum limit may not adequately support sustainable scheduling and the management of fatigue-related risk factors in day-to-day operations. To provide operational flexibility, consideration should be given to setting limits for both standard and extended operations. This allows standard operations to be extended when accompanied by additional risk controls and compensatory off-duty periods. A flight duty period of 8–12 hours may be considered sustainable with no other fatigue-risk factors (such as reduced sleep and circadian dysrhythmia). When operational requirements require flight duty periods exceeding 12 hours, the decision to proceed with the task should be supported by appropriate risk management to consider whether: (1) all reasonable controls are in place, or if there are additional controls available that are not grossly disproportionate to the reduction in fatigue risk and (2) any residual risk to be retained is acceptable for the nature (and benefit) of the task.

Nominal (low fatigue risk) duty period that is rostered/duty time up to 12 hours outside of the WOCL.

Extended (heightened fatigue risk) duty period (that is roster/duty times over 12 hours and/or over the WOCL).

Exceptional (high fatigue risk) duty period (that is duty times over 14 hours and during the WOCL).

Civil Aviation Industry-developed guidelines

The table below contains duty and flight-time limitations, rest requirements and crew-scheduling guidance from the Flight Safety Foundation — *NBAA Duty/Rest Guidelines for Business Aviation* (2014) document, which is also referenced in the ICAO Fatigue Management Guide for General Aviation Operators of Large and Turbojet Aeroplanes (2016). They are industry-developed guidance on duty and flight time limitations, rest requirements and crew-scheduling guidance based on the scientific principles outlined in Section 2 and are not to be considered as a regulatory standard or suggested limits. Defence operators, particularly those of two-pilot fixed-wing aircraft, may serve as a starting point for developing or reviewing their Fatigue Management Program, adapting them as necessary to meet their specific operational context and conditions.

Recommended guidance for Non-Augmented Crews (24-hour period)

OPERATION **STANDARD**[1]	
Duty period (max hours)	**14**
Flight time (max hours)	**10**
Off-duty period (min hours)	**10** Weekly: Minimum of 36 continuous hours, including two consecutive nights, in 7-day period.

OPERATION **WINDOW OF CIRCADIAN LOW (WOCL)**[2]	
Duty period (max hours)	**12**
Flight time (max hours)	**10** Restricted landings (see Section 2.4.2).
Off-duty period (min hours)	**12** 48 continuous hours in 7-day period following multiple WOCL duty periods.

OPERATION **EXTENDED**[3]	
Duty period (max hours)	**14**
Flight time (max hours)	**12** Restricted landings and compensatory time off duty (see Section 2.4.2). Weekly: Maximum of 4 cumulative hours of extension.
Off-duty period (min hours)	**12**

OPERATION **WINDOW OF CIRCADIAN LOW**	
Duty period (max hours) Flight time (max hours)	No extensions recommended
Off-duty period (min hours)	48 continuous hours in a 7-day period following multiple WOCL duty periods.

OPERATION **MULTIPLE TIME ZONES**	
Off-duty period (min hours)	48 continuous hours off duty on return home following a duty period crossing multiple time zones.

Notes

1. Standard operations are defined as operations that do not encroach on the WOCL and are not extended operations.

2. Window of circadian low (WOCL) operations are defined as a flight in which landing occurs during the WOCL, the flight passes through both sides of the WOCL or the duty period starts at 0400 or earlier in the WOCL (see Section 2.1).

3. Extended operations are defined as any operation with a duty period longer thatn 14 hours or flight time longer than 10 hours. Extended operations can involve duty/rest cycles longer than 24 hours.

Source: Flight Safety Foundation and U.S. National Aeronautics and Space Administration.

Recommended guidance for Augmented Crews[1] (24-hour period)[2]

OPERATION **RECLINING SEAT AVAILABLE FOR REST**	
Duty period (max hours)	18
Flight time (max hours)	16
Off-duty period (min hours)	12

OPERATION **SUPINE BUNK AVAILABLE FOR REST[3]**	
Duty period (max hours)	20
Flight time (max hours)	18 Each flight crewmember to have maximum sleep opportunity with a minimum of 4 hours total.
Off-duty period (min hours)	12 Maximum of two consecutive duty periods with 18 hours off duty after two consecutive duty periods.

OPERATION **WINDOW OF CIRCADIAN LOW (WOCL)[4]**	
Duty period (max hours)	No extensions recommended.
Flight time (max hours)	
Off-duty period (min hours)	

OPERATION **MULTIPLE TIME ZONES**	
Off-duty period (min hours)	48 continuous hours off duty on return home following a duty period crossing multiple time zones.

Notes

1. Augumented crew is a flight crew that comprises more than the minimum number required to operate the aeroplane so that each crewmember can leave his or her assigned post to obtain in-flight rest and be replaced by another appropriately qualified crewmember.

2. Augmented operations can involve duty/rest cycles longer than 24 hours.

3. A 'supine bunk' is one that allows sleep in a horizontal position, equivalent to a Class 1 rest facility below.

4. Window of circadian low (WOCL) operations are defined as a flight in which landing occurs during the WOCL, the flight passes through both sides of the WOCL or the duty period starts at 0400 or earlier in the WOCL (see Section 2.1).

Source: Flight Safety Foundation and U.S. National Aeronautics and Space Administration.

The Flight Safety Foundation — *NBAA Duty/Rest Guidelines for Business Aviation* (2014) document also contains a useful example of how to develop weekly duty and flight time limits. It uses daily recommended maximum duty periods with minimum rest periods from on a per-week basis, then uses basic arithmetic to calculate the weekly limits. However, it does not consider organisational or operational conditions that may influence fatigue, or address the operator's assessment of the associated level of risk.

Augmented crew operations

An augmented crew includes additional members to the minimum number required by the flight manual to allow specified crew responsibilities to be conducted by more than one person over the duration of the flight. With appropriate procedures and resting facilities, augmentation allows crews to rotate rest times in order to manage their alertness and mitigate against the effects of fatigue.

Augmented crews can be used to increase the maximum duty period and/or flight time limits. Augmented flight duty periods vary up to 20 hours depending on adequacy of in-flight rest facilities and the use of full or partial crew augmentation. It is important that the use of augmented crews includes awareness and management of sleep inertia and individual variability in the restorative effect of rest breaks during a duty period. Additional crew will still become fatigued even when they are not in an operational role.

The decision to conduct extended operations and/or utilise augmented crew operations in order to achieve operational requirements should be a conscious decision by commanders and managers with appropriate risk management. Refer to the *Defence Aviation Safety Manual* for more information on risk-management processes.

In-flight/on duty rest facilities

Rest facilities need careful design and consideration in order to allow adequate rest. Rest facilities that enable a person to sleep in the horizontal or near horizontal position are considered optimal.

Rest should be taken in a facility that is remote from the working area. The period should allow for time to relax and get to sleep, a period of sleep, and time to recover from the effects of sleep inertia before recommencing duties.

While still beneficial, controlled naps on the flight deck or equivalent are not a complete substitute for post-duty sleep opportunities nor do they provide adequate facilities for fully restorative sleep. The Flight Safety Foundation publication *Controlled Rest on the Flight Deck: A Resource for Operators* is a useful resource for operators implementing related procedures.

Classes of rest facilities

The Civil Aviation Safety Authority defines three classes of rest facilities to assist in determining the relative restorative value for rest in each category, with Class 1 being the highest rating and Class 3 the lowest.

Class 1 means a bunk or other surface that:

- is fit for the purpose of aircrew obtaining sleep in a horizontal sleeping position
- is located separate from both the flight deck and passenger compartment in an area that:
  - is temperature-controlled
  - allows the crew member to control light
  - provides isolation from noise and disturbance.

Class 2 means a seat in an aircraft cabin that:

- is fit for the purpose of aircrew obtaining sleep in a horizontal or near-horizontal sleeping position
- is separated from passengers by at least a curtain that provides darkness and some noise mitigation
- is reasonably free from disturbance by passengers or crew members.

Class 3 means a seat in an aircraft cabin or flight deck that:

- is fit for the purpose of aircrew obtaining rest (but not adequate for sleep)
- reclines at least 40 degrees from the vertical plane
- provides leg and foot support in the reclined position.

Adaptation period to adapt to new location. Source: CAAP48-1(1)

Time zone change (measured in time zones)	Adaptation period to adapt to new location (hours)	
Note: See definition of time zone	WEST	EAST
2	24	30
3	36	45
4	48	60
5	48	60
6	48	60
7	72	90
8	72	90
9	72	90
10 or more	96	120

Time zone. A defined region of earth with a uniform local time that differs by on hour, or by part of one hour, from the uniform local time of an adjoining region of the earth.

Long haul/transmeridian operations

Once individuals have spent time in a location where the local time differs from their home base, their body clock will begin to align itself with the local time. The length of time required for an individual to align with the local time will be dependent on the number of time zones crossed, the direction of travel and the extent to which the body is exposed to natural cues such as daylight and local meal times. For aviation operations that cross multiple time zones, commanders and managers should take into account the following points:

- **East/west travel.** The fatigue resulting from eastward flight is greater than that associated with westward flight.
- **Adaptation period.** See table for general guidance on adaptation periods following eastward and westward travel.

There is ongoing debate within the scientific community about whether it is preferable for individuals to have an extended period off duty at an overseas location after long transmeridian flights, or to commence the return to home base after a shorter rest period, thereby reducing the impact of being in a location where the time zone is substantially different from that at home base.

Unless aviation personnel/aircrew return from transmeridian travel to their home base within 48 hours, the application of an extended rest period is recommended. Personnel may perform non-safety-critical duties during the adjustment period. Acclimatisation is a complex issue. Particular consideration should be given to the impact of acclimatisation for operations which require multiple movements between differing time zones.

Simulator-related fatigue

Operation of high-fidelity flight simulators are known to produce a variety of phenomena such as simulator induced sickness, postural disequilibrium and fatigue. This safety concern may also carry over to the airborne environment, if the after-effects are present when an individual operates an aircraft soon after a simulator session. Limitations to flight duty after simulator events must be included in local procedures.

Not flying on the same day or within a period of 12 hours of operating a simulator is considered a conservative approach to rest times between simulator operation and flying. Organisations seeking to conduct high-fidelity simulator and flying operations within a single duty period should consult with the Institute of Aviation Medicine.

Cumulative fatigue

Fatigue-management policy typically places the primary emphasis on the management of acute fatigue. However, guidance is also required to address the cumulative fatigue-related risk encountered within the aviation operating context.

One of the most important (but frequently overlooked) factors contributing to fatigue is an imbalance between workload and crewing levels, which can have a direct impact on levels of fatigue and undermine safety. Analysis of 2018 DFSB *Snapshot* Survey data showed that aircrew who reported crewing shortages were three times as likely to have fatigue scores in the high-risk category. Maintainers who reported crewing shortages were twice as likely to have fatigue scores in this category. Arguably, enduring periods of high tempo/workload can only be sustained through personal sacrifice and can affect the long-term sustainability of the workforce.

The management of cumulative fatigue depends on the willingness of commanders and managers to recognise the impact of cumulative fatigue, accept responsibility and show some determination to appropriately manage it. In addition, the management of cumulative fatigue is dependent upon the willingness of individuals to recognise signs and symptoms of stress and fatigue and to report them.

In situations where cumulative fatigue is attributable to the impact of stressors (for example excessive workload, workplace grievance and personal issues) the situation can often be alleviated by resolving the problem or altering the situation. If these strategies are not feasible, an individual must find another means of coping. To assist personnel who find themselves in this situation, the inclusion of stress-management techniques within unit education initiatives is advocated.

Scheduling and rostering principles

Scheduling and rostering are activities where situational demands must be balanced against conventions based on fatigue science. There is no optimal shift schedule or design. There is considerable disagreement in the scientific literature, based mainly on civilian sector research, about the timing and duration of shifts, speed and direction of shift rotation and flexibility of shift systems. Nevertheless, the list below provides some useful guidelines for developing shift schedules that are human-centred:

- Avoid schedules that are not compatible with the 24-hour circadian cycle, such as a shift that ends at 0300 hrs.
- Allow a major rest/sleep period within every 24 hours.
- Schedule the main rest period for the same time each 24-hour period.
- Attempt either to allow at least a week on each shift before a rotation, or limit night shifts to only one or two consecutive nights (the latter is especially important for individuals who appear night-shift intolerant). Longer rotation periods are best if optimum performance is the primary priority because the body clock is allowed to adapt to the new schedule. The rationale for a one or two-night rotation period is that the body clock has only just begun its adaptation and should readjust to the day shift relatively quickly and with few adverse side-effects. In addition, short night-shift rotations generally provide for a more balanced social life and contribute to perceptions of equity among the pool of shift workers.
- A span of successive night shifts should be limited to six for shifts of up to eight hours long, four for shifts of eight-to-ten hours long, and two for shifts of 10 hours or longer. Wherever possible these limits should not be extended.
- During periods of critical work demands, attempt to provide a 10-hour rest/non-work period each 24-hour period (this generally allows for a six to eight-hour period for sleeping, depending on commute times). An eight-hour rest period normally will only allow up to six hours of sleep which is below the recommended amount.

TRANSITION	IMPACT ON FATIGUE RISK
Early-late transition (Forward rotation)	Early starts result in truncated sleep opportunity. The early start can also result in an early waking time on the morning of the late finish because of acclimatisation to early starts.
Late-early transition (Backward rotation	Backward rotation requires individulas to advance their bedtime (go to bed earlier). Due to the circadian rhythm in alertness it is difficult to achieve sleep prior to normal bedtime resulting in shorter sleep duration.
More than 1 transition per duty block	Operating more than one transition in the duty block will lead to significant circadian disruption.

- Avoid daily or continuously rotating schedules (those who advocate rapidly rotating shifts tend to do so mainly for social considerations).
- When possible, do not commence morning shift before 0700 hours to avoid beginning work during the circadian trough and to maximise restorative sleep.
- A span of successive morning or day shifts that start before 0700 should be limited to four, immediately following which there should be a minimum of two successive rest days. Wherever possible these limits should not be extended.
- Shift length should be determined by the physical and mental characteristics of likely duties. Hours should be reduced for highly complex and demanding tasks (such as working on safety-critical systems or developing operational orders for complex and unanticipated events).
- When possible, program short nap periods into night shifts. There is a need for education about napping if this strategy is to be effective. Similarly, there may need to be a change in organisational culture if the practice of napping in the workplace is to be accepted.
- Set shift rosters ahead of time and avoid sudden changes to allow workers to plan leisure time.
- When possible, offer alternatives to members who may have difficulties adjusting to working hours.
- When possible, consult with members and design shift rosters that will enable workers to meet both work and personal commitments.

Transitions

A transition is two consecutive duties that have significantly different start and/or end times. Transitions can cause disruption to the circadian rhythm in alertness and impact on an individual's ability to achieve adequate sleep between duties.

Disruptive schedules/fatigue-roster triggers

The impact of consecutive night duties, early starts and duty transitions provides a strong argument for additional fatigue-management measures. For example, there is evidence to suggest duty periods that either begin or finish during the WOCL (between 0200 and 0600) have a higher potential of fatigue and increased requirements for recovery. Likewise, incorporating an intervening night's sleep between day/night and night/day duty transitions is recommended.

When assessing the potential for fatigue there are certain schedule/roster-related factors that can increase the likelihood of an individual becoming affected by fatigue. These are known as fatigue-roster triggers. Although a roster may contain fatigue-roster triggers, this does not necessarily correlate to an unacceptable fatigue risk. Rather, roster triggers serve to draw attention to specific fatigue risk factors so that they may be eliminated (if possible) or otherwise effectively managed. Examples of fatigue-roster triggers are listed on page 29.

Roster triggers

Roster triggers serve to draw attention to specific fatigue risk factors so that they may be eliminated (if possible) or otherwise effectively managed.

Individual duty periods

FEATURE	TRIGGER
Start time	Early starts — encroaching on the WOCL (window of circadian low 0200–0600)
End time	Late finishes or night duties
Duty length	10–12 hours
	12–15 hours
	15 hours + (with no access to rest facilities)
Workload	High workload — strenuous or complex tasks, simulator/training, etc.

Consecutive duty periods

ROSTER FEATURE	TRIGGER
Duty start times	Consecutive early starts (insufficient sleep is likely prior to early starts, particularly duties that commence in the WOCL).
Duty end times	Consecutive late finishes or night duties (late finishes and night duties impact on the individual's ability to sleep during the WOCL).
Durations	Consecutive extended length duties (consecutive extended duties are associated with an increased risk of cumulative fatigue).
Workload	Consecutive high-workload duties (high workload is associated with increased physical and cognitive demands and an increased risk of fatigue).

Trigger combinations

Trigger combinations refer to situations where more than one fatigue trigger is present. Combinations typically create an even greater risk of fatigue. That is, their effects are additive. Some examples follow.

TRIGGER	REASONING
Early start and a long duty	Sleep loss is likely prior to early starts due to the circadian rhythm resulting in shorter sleep duration. When combined with an elongated duty there is a risk of transient fatigue towards the end of the duty.
Elongated duty on last day	Elongated duties should be avoided on the last day of a series of duties as the risk of cumulative fatigue is greatest at the end of the duty block.
Night duty and high workload	Due to working in the WOCL it is more difficult to maintain high levels of alertness and performance. If there is the increased pressure of high workload during the WOCL the risk of errors is significantly increased.
Night duty not preceded by a late duty	Operating one or more prior late duties enables the individual to adjust their sleep cycle sufficiently for an extended period of wakefulness to be avoided. Without this adjustment a night duty can result in a period of wakefulness more than 17 hours which is associated with a performance impairment equivalent to a blood alcohol concentration of 0.05 per cent BAC.
Night duties in the same duty block as early starts	Night duties in the same block as early starts are likely to make sleep management difficult and cause significant disruption to the circadian rhythm in alertness.

This, or similar listings, could form part of a predetermined set of proactive triggers requiring the introduction of additional risk controls or further management attention. While not exhaustive, the tables cover some of the most obvious or likely roster factors that can result in fatigue impairment.

Other operational factors

There are many additional operational factors that are known to contribute to fatigue. These factors are specific to the operational environment and may include but are not limited to:

- night flying/use of night vision devices
- low flying/tactical flying/high workload
- time-critical operations
- cockpit temperature and pressurisation
- lack of automation
- high noise or vibration levels.

This guidebook can only draw attention to these influences. Commanders and managers should consider their circumstances using prior operator experience or discussions with other organisations and groups so that operationally specific fatigue hazards may be identified within their FMP.

Biomathematical fatigue models and scheduling

A primary application of biomathematical fatigue models is to assist with developing optimal flight or duty schedules. By predicting times at which performance should be optimal, identifying timeframes where sleep can be maximised, and determining the impact of proposed work and rest on overall fatigue and performance, models can be used to assist in the development of schedules that reduce fatigue-related risk.

When applying biomathematical fatigue models for scheduling purposes, it is important to recognise the limitations of their use, as discussed in Enclosure 1.

In particular, it is essential to avoid overly simplistic interpretations of fatigue scores without reference to organisational experience and the operational environment. For more information on biomathematical models refer to Enclosure 1.

4.4 Extensions due to unforeseen operational circumstances

When operationally necessary, extensions to documented flight and duty limits may be required. Such extensions should be consistent with the relative importance and complexity of the mission. Generally speaking, extensions should only be required due to unforeseen operational circumstances and not due to organisations continually scheduling duty periods to maximum limits and/or regularly relying on extensions to achieve their operational goals.

The member's continuous time awake, previous 72-hour activities and the complexity of the mission/task should be carefully evaluated before extensions to duty periods are approved using risk-management processes.

As aviation personnel are poor judges of their own performance impairment due to fatigue, the decision to extend duty periods should not lie with members themselves. When an extension is approved, the subsequent rest period should be (as a minimum) extended by a commensurate amount.

If planning and resourcing is working effectively, extensions should only occur in a limited percentage of any sample of similar duty periods or operational situations. If extensions to normal duty periods (or reductions to normal rest periods) are being used regularly, an organisation should consider re-evaluating its current policies and practices and re-assessing any associated risk management.

The use of Duty Limit Variation reports in Sentinel (see 5.1 — Fatigue reporting) allow an organisation to collect data on duty extensions and rest reductions supporting safety performance monitoring within an ASMS. Additionally, as it is prudent to conduct Deliberate or Immediate Risk Management during the approval process for extensions and reductions, the use of Duty Limit Variation reports allow risk decisions to be formally documented.

CHAPTER 5 FMP SAFETY RISK-MANAGEMENT PROCESSES

Risk-management processes, as an essential component of an ASMS, require the identification of hazards, assessment of the associated risks and implementation of mitigations where necessary.

The following sections describe how fatigue can be identified, assessed and mitigated as part of the organisation's ASMS risk-management processes.

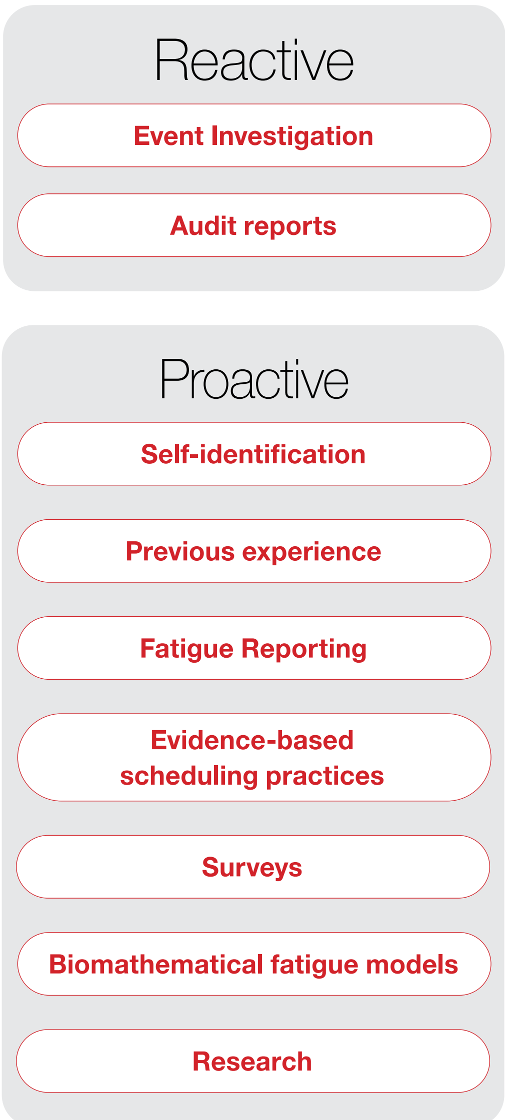
5.1 Hazard identification

Hazard identification is an ongoing activity and is based on identifying fatigue after it has occurred (reactive processes), as well as through proactive processes by measuring fatigue levels in current operations. Hazards can be identified from a range of sources including, but not limited to:

- self-identification of fatigue risks
- previous experience (of the organisation or others in the industry)

- fatigue reporting
- evidence-based scheduling practices
- biomathematical fatigue models
- investigation of aviation safety events
- fatigue surveys
- internal and external audit reports
- fatigue-related information resulting from published scientific research and external sources.

Some of these are discussed in more detail below.



Self-identification of fatigue risks

Individuals are not good judges of their own level of fatigue-affected performance. Research has demonstrated that without training, humans are quite poor at determining their actual level of fatigue. However, validated tools, such as the Samn-Perelli Scale, increase the reliability of self assessment.

The DFSB Fatigue Risk Awareness tool, which incorporates the Samn-Perelli Scale, is an example of a decision-making aid when determining fitness for duty. The tool is designed to enhance individual awareness and to promote supervisor engagement. In all instances, self-identification should prompt the development of appropriate risk management that takes into consideration the nature of scheduled tasks and available control measures.

When determining an individual's fitness for flight/duty, the following factors should be considered:

- **Level of alertness.** The individual's self-reported current level of alertness rated on a scale from fully alert to feeling unable to function effectively.
- **Prior sleep.** As a general rule, if starting from a well-rested state, less than 13 hours sleep in the last 48 hours and six hours in the last 24 hours should be considered significant.
- **Timing of the duty period.** Duty periods that either begin before 0700 or finish after 2200 have a higher potential of fatigue.
- **Complexity of the duty period.** The level of complexity associated with the duty period, including the mental and physical demands of the task(s), environmental conditions (for example extreme temperatures, lighting, weather conditions, noise, vibration and use of hazardous chemicals) and individual/team factors (for example experience/skill levels).

There are a number of alertness consideration applications that may be found at the iOS App Store or the Google Play Store that could be used as a starting point in the assessment of an individual's fatigue level. For example, Jeppesen CrewAlert assists individuals to collect data and analyse their predicted level of alertness or performance degradation for upcoming duty periods. If you choose to use an application of any sort be sure all of your members are using the same one for consistency.

Individuals should also be encouraged and supported to intervene should they observe a peer whose fatigue state may present a risk to safety. In general terms, changes in a person's appearance or behaviour that may be suggestive of fatigue include the individual saying they are tired/have not had enough sleep, yawning, slower response time, lapses in attention and low motivation. The support could include a suggestion to use one of the self-identification tools. If the advice is not followed and the risk is evident, further action may be necessary.

Simple go or no-go fatigue-based decisions relying on limited data are strongly discouraged unless erring on the side of caution. It is important to remember that although tools like the Samn-Perelli Scale are helpful in determining whether an individual is fit to work, they should not be the only thing that is considered.

The Samn-Perelli Scale

The Samn-Perelli Scale is designed to help individuals to describe their own fatigue levels. It is a self-assessment tool based on an individual's interpretation of how alert or tired they feel and as such, is subjective. While self-perception of fatigue levels may vary between individuals, a personal assessment is still considered more accurate than an assessment by an observer such as a colleague, supervisor, or a researcher.

Samn-Perelli Scores

1. Fully alert, wide awake
2. Very lively, responsive, but not at peak
3. Okay, somewhat fresh
4. A little tired, less than fresh
5. Moderately tired, let down
6. Extremely tired, very difficult to concentrate
7. Completely exhausted, not able to function.

Common errors to avoid

A common error when using any of the subjective scales is to focus on the numbers (that is, giving a mark out of 7) rather than taking the time to think about how they are feeling and selecting the word picture that corresponds to how it could best be described.

Previous experience

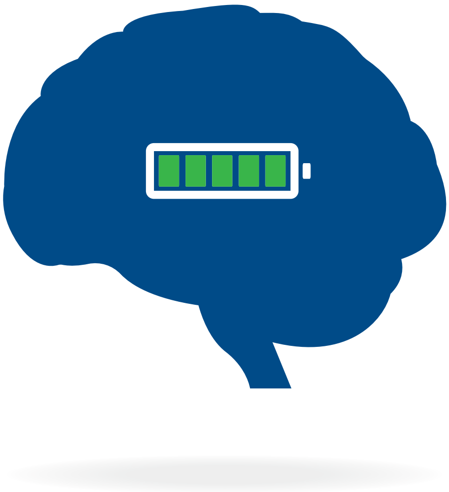
The collective experience of supervisors, schedulers and individual personnel is an important source of information for identifying fatigue hazards relating to scheduling. For example, personnel may recognise a particular trip as generating a high level of fatigue because of regular delays caused by heavy traffic; or air traffic controllers/maintenance staff may recognise a pattern of shifts as particularly fatiguing.

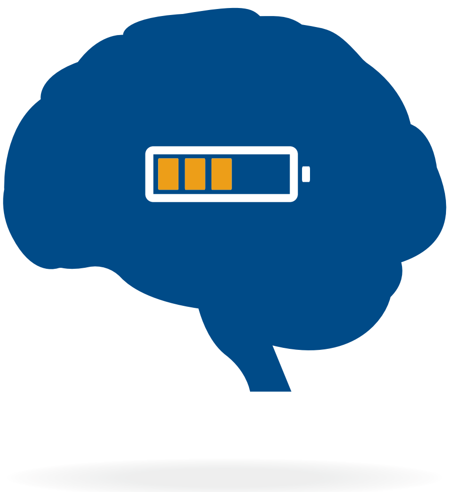
The value of this collective experience can be enhanced by having personnel educated about the dynamics of sleep loss and recovery and about the circadian biological clock. These biological factors help explain why particular scheduling practices affect fatigue (for example, practices such as early starts, long duty days, short layovers, daytime sleep opportunities, and time-zone crossings). However, when operational demands are changing, reliance on previous experience can have limitations.

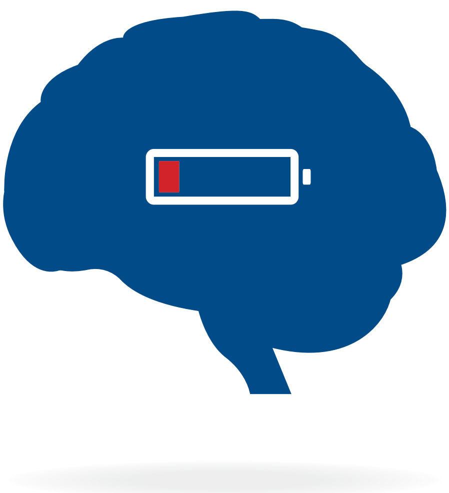
Fatigue reporting

Reports about high fatigue levels or fatigue-related performance issues provide vital information about fatigue hazards in the day-to-day running of an operation. As for any other safety hazard, a series of hazard reports citing fatigue on a particular route or associated with a particular part of a schedule may indicate that further action is needed to assess and mitigate that hazard.

It is essential that the culture of Defence aviation normalise and encourage fatigue reporting. Issues associated with fatigue are difficult to detect if people are unwilling or unable to report them. Consistent with maintaining an open, just, and fair aviation safety reporting culture, personnel need to be able to discuss fatigue-related issues in an open and communicative environment, without experiencing fear of penalty.







To encourage an ongoing commitment by members to reporting fatigue hazards, commanders and managers should:

- have clear processes for reporting fatigue hazards
- be clear that the organisation expects personnel to report fatigue hazards
- establish a process for what to do when a member considers that they are too fatigued to perform safety-critical tasks to an acceptable standard
- identify how the organisation will respond to reports of fatigue hazards, including acknowledging receipt of reports and providing feedback to individuals who report
- take appropriate actions in response to fatigue reports
- provide feedback on the analysis of reports and changes made in response to identified fatigue hazards.

Fatigue reporting in Sentinel

One of the main purposes of fatigue reports is the identification of fatigue risks in daily operations. They identify areas where fatigue was a risk to safe operations or was anticipated to pose a risk. As detailed in the *Defence Aviation Safety Manual* (DASM), fatigue issues are reported through Sentinel by using the Other Aviation Safety Reports – Fatigue Form.

A Fatigue report may be raised by an individual or on behalf of a group, where a potentially unsafe level of fatigue has been experienced. For all aircrew, air traffic controllers, air battle management, UAS pilots and operators, engineers, maintenance and movements personnel, fatigue-related hazards must be reported where:

- fatigue contributes to a duty period not being started or completed
- a member completes a duty period in which they believe their own fatigue or that of others reduced the safety margin or required unplanned mitigation
- a member identifies something in their operating environment that could significantly increase their fatigue or that of others.

The submission of a fatigue form does not replace the broader requirements associated with the reporting of aviation safety events and issues.

FATIGUE RISK AWARENESS TOOL

	MONITOR	ACTIVELY MANAGE	CAUTION!
At the START of duty, how many hours of sleep have you had in the past 24 hours? (Note: The figures used in this question can be tailored to account for individual sleep needs. It is important to understand how much sleep you need to feel well rested. The average sleep needed is 7–8 hours to consistently feel well rested; however, some people may require only 6 hours and some 10 hours.)	○ **>7 Hours**	○ **6–7 Hours**	○ **<6 Hours**
At the START of duty, how many hours of sleep have you had in the past 48 hours? (Note: The figures used in this question can be tailored to account for individual sleep needs. It is important to understand how much sleep you need to feel well rested. The average sleep needed is 7–8 hours to consistently feel well rested; however, some people may require only 6 hours and some 10 hours.)	○ **>14 Hours**	○ **12–14 Hours**	○ **<12 Hours**
How many hours will you have been awake at the end of planned duty? (Note: The timings in this question are based on the acclimatised circadian rhythm of an individual, their 'body-clock time'. Further consideration is required for transmeridian travel.)	○ **<16 Hours**	○ **16–18 Hours**	○ **>18 Hours**
When will you be performing safety-critical tasks during the duty period?	○ **0730–2200**	○ **0600–0730 or 2200–0200**	○ **0200–0600**
How ALERT are you feeling?	○ • Fully alert, wide awake • Very lively, responsive but not at peak • Okay, somewhat fresh	○ • A little tired, less than fresh • Moderately tired	○ • Extremely tired, very difficult to concentrate • Completely exhausted, unable to function effectively

A tool for individuals, for the identification of emerging fatigue-related risk to complement risk management

- Try to eliminate all fatigue risks.
- If the fatigue risk can't be eliminated, minimise that risk by applying all reasonable treatments/controls.
- Ensure all risk decisions are made at the appropriate level.

Fatigue management is a shared responsibility, individuals must:

- arrive for duty in a fit and rested state
- communicate fatigue-related safety and performance concerns
- identify and manage fatigue-related hazards during a duty period.

A single occurrence of an amber or red should initiate the corresponding amber or red actions below. Multiple occurrences of amber and/or red increase the potential fatigue risk level and due consideration should be given during the risk-management process. Apply the principles of **Rule of Three** to any identified ambers, that is, **three or more ambers** is a **red** and should be managed in-line with the **CAUTION** response.

CONTINUE TO MONITOR ALERTNESS	**MONITOR**	Continue to monitor your alertness and fatigue levels throughout duty. Consider asking a team member to monitor you for any observed decline in alertness. Implement lifestyle factors that will help you to manage your alertness on an ongoing basis e.g. nutrition, sleep, stress, et cetera.
ACTIVELY MANAGE FATIGUE & ALERTNESS	**ACTIVELY MANAGE**	Advise your supervisor of your heightened fatigue risk and ask team members to monitor you. Consider adjusting tasks. Increase team communication and task cross-checking. Consider taking a break or accessing controlled rest/napping. Consider strategic use of caffeine and food intake.
CONSIDER FITNESS FOR DUTY. GET HELP TO MANAGE FATIGUE LEVELS	**CAUTION!**	Pre-duty, inform your supervisor of your heightened fatigue risk. Discuss with them your fitness for duty and ability to safely operate. If mid-duty, inform your supervisor and team members of your heightened fatigue risk. Discuss with them your continued fitness for duty, ability to safely operate or how to safely manage your ongoing performance.

Available for download on DFSB website

Duty Limit Variation reporting in Sentinel

Tracking of duty limit variations is complementary to fatigue reporting. As detailed in the DASM, tracking must be implemented via a Duty Limit Variation report where there is an extension to a normal duty period or a reduction to a normal rest period. A Duty Limit Variation report must be submitted using the Other Aviation Safety Reports — Duty Limit Variation report. To enable consistent and useful data analysis, units must submit Duty Limit Variation reports as part of their normal approval processes for duty variation.

Review of Fatigue reports

Fatigue reports should be reviewed/analysed as a part of the organisation's Aviation Hazard Review Board (AHRB) processes. AHRBs serve to provide a focal point for the conduct and capture of hazard identification activities.

Investigation of fatigue-related events

Basic fatigue-related information can be collected in relation to safety events, with more in-depth analyses reserved for events where it is more likely that fatigue was an important factor and/or where the outcomes were more severe.

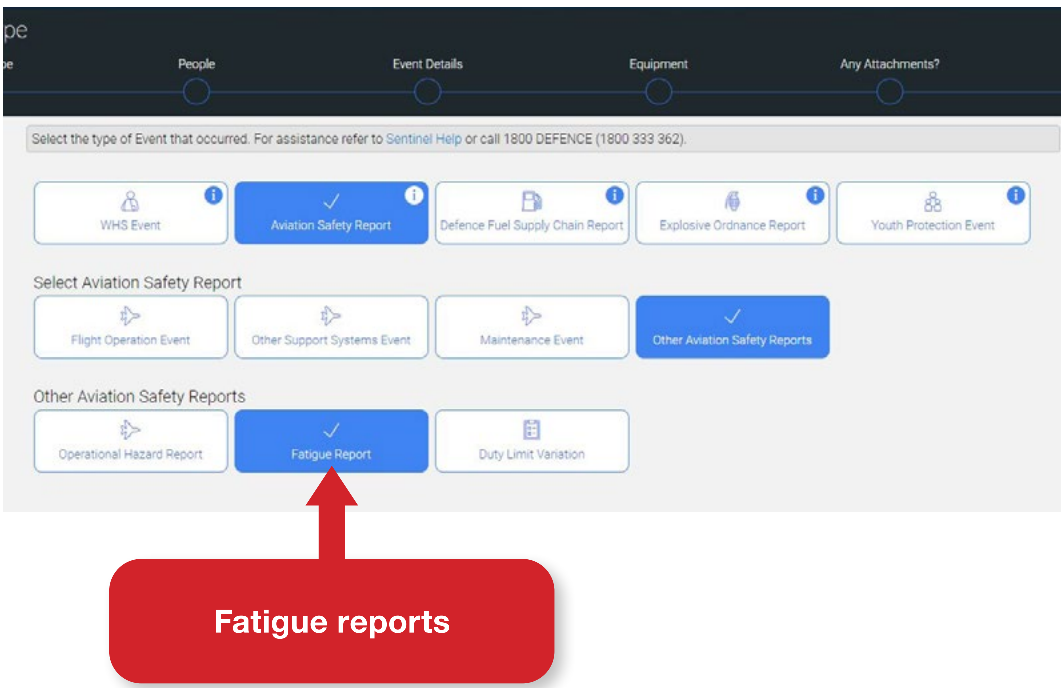
For the purposes of fatigue management, the aim is to identify how the effects of fatigue could have been mitigated, in order to reduce the likelihood of similar occurrences in the future. There is no simple test (such as a blood test) for fatigue-related impairment.

To determine whether an individual was likely to have been fatigued at the time of a safety event, four pieces of information are needed.

1. The time of day that the event took place. If it was in the WOCL (0200–0600), then fatigue may have been a factor.
2. Whether the individual's normal circadian rhythm was disrupted (for example, if in the last 72 hours they had been on duty at night, or had flown across time zones).
3. How many hours the individual had been awake at the time of the occurrence. (It may be more reliable to ask "what time did you wake up from your last sleep period before the event?"). If this is more than 16 hours, then sleepiness may have been a factor.
4. Whether the 72-hour sleep history suggests a sleep debt. As a rough guide, if the average adult requires seven to eight hours of sleep per 24 hours, then a crew member or controller who has had less than 21 hours sleep in the past 72 hours was probably experiencing the effects of a sleep debt. If information on sleep history is not available, duty history can provide information on sleep opportunities.

If answers to the four questions above suggest that the individual was fatigued at the time of the event, then more in-depth investigation is required – looking at whether the person or crew/team took particular actions or decisions that contributed to the event and whether those actions or decisions are consistent with the type of behaviour expected of a fatigued person or team.

A Fatigue Investigation Form is available as a tool to investigate whether fatigue had a role in the event and, if so, the impact it had. The form is available on the DFSB website.



Aviation safety surveys

Surveys provide an inexpensive source of significant safety information such as levels of workforce fatigue and opinions on fatigue-related topics across work groups. Survey questions may be developed to target specific areas of concern or to gather general information concerning fatigue within an aviation organisation.

The DFSB *Snapshot* Survey is administered annually to all Air Force and Defence aviation organisations and seeks to support commanders and managers in the management of safety and performance. The *Snapshot* Survey incorporates validated measures/items that examine levels of fatigue and related issues. *Snapshot* allows organisations to compare fatigue levels between work groups and across time. It utilises a variety of sophisticated statistical techniques to identify patterns of fatigue among survey respondents and to identify other challenges within operations that might be appropriate for further objective evaluation or immediate mitigation.

Fatigue surveys may also be administered on an ad hoc basis to focus on a particular operation or issue. For example, a series of fatigue reports about a particular pattern of duties might trigger the organisation to undertake a survey of all individuals undertaking that duty pattern, to see how widespread the problem is. An organisation might also undertake a survey to get feedback about the effects of a schedule change.

Biomathematical fatigue models and hazard identification

Biomathematical fatigue models incorporate aspects of fatigue science in order to provide predictions of acute fatigue risk levels, performance levels, and/or optimum sleep times/opportunities. Predictions of fatigue risk can highlight operational periods where elevated fatigue levels may coincide with critical tasks. Mitigation strategies for crew members may then be considered to assist with the management of these high-risk periods.

Biomathematical fatigue models can also contribute to fatigue risk assessments when extending working hours beyond prescriptive flying and/or duty time limitations, or to evaluate the risk of reducing crew rest periods.

A biomathematical fatigue model on its own, is not a system for managing fatigue and should not be used as a go/no-go decision-making tool. Biomathematical fatigue models have limitations that must be considered, including:

- predicting risk probabilities for a population average rather than fatigue levels of a specific individual
- not accounting for the impact of workload that may affect fatigue and performance levels
- using predicted rather than actual time asleep
- limited testing (validation) against military aviation-specific conditions.

For more information on biomathematical fatigue models, refer to Enclosure 1.

Monitoring individual sleep and alertness

The monitoring of an individual's sleep and/or fatigue levels is relatively resource intensive and time consuming compared to other hazard-identification methods.

However, it may be justified in particular circumstances such as in response to significant fatigue reports on a particular duty (to further identify the extent and severity of the hazard), in response to a safety incident, or as part of the operational validation of a new schedule.

As a general rule, the type of monitoring undertaken should be appropriate to the expected level of fatigue and safety risk.

Sleep monitoring

Sleep can be monitored in a variety of ways, all of which have advantages and disadvantages. The simplest and most cost-effective method of monitoring sleep is to have individuals complete a daily sleep diary before, during and after the operation or part of the roster being studied.

Individuals are typically asked to record when they sleep and to rate the quality of their sleep, as soon as possible after waking up. The information derived from sleep diaries can provide a basis for modifying schedules, providing training, or implementing other interventions.

Sleep diary

	Sleep Location	Start Date/ Time (Local)	Pre-sleep Fatigue	End Time (Local)	Post-sleep Fatigue	Sleep Quality	Remarks
eg	H A C O	28 2200	1 2 3 4 5 6 7	29 0600	1 2 3 4 5 6 7	1 2 3 4	
1	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
2	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
2	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
3	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
4	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
5	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
6	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
7	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
8	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
9	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
10	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
11	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
12	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
13	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	
14	H A C O		1 2 3 4 5 6 7		1 2 3 4 5 6 7	1 2 3 4	

Sleep Location

H = Home

A = Away (hotel etc.)

C = Crew Room

O = Other (note in Remarks)

Faitgue Level

1. Fully alert, wide awake.
2. Very lively, responsive, but not at peak.
3. Okay, somewhat fresh.
4. A little tired, less than fresh.
5. Moderately tired, let down.
6. Extremely tired, very difficult to concentrate.
7. Completely exhausted, unable to function effectively.

Sleep Quality

1. Excellent
2. Good
3. Fair
4. Poor

Work diary

	START (Local)	PRE-work Faitgue	Work Description (all duties, flight times, mission details, time zone, etc.)	POST-work Faitgue	FINISH (Local)	Fatigue/ Duties*
eg	28 0800	1 2 3 4 5 6 7	3hr brief, 2 x 1.5hr sorties, 2hr debrief, 1hr admin	1 2 3 4 5 6 7	1700	Y N
1		1 2 3 4 5 6 7		1 2 3 4 5 6 7		Y N
2		1 2 3 4 5 6 7		1 2 3 4 5 6 7		Y N
2		1 2 3 4 5 6 7		1 2 3 4 5 6 7		Y N
3		1 2 3 4 5 6 7		1 2 3 4 5 6 7		Y N
4		1 2 3 4 5 6 7		1 2 3 4 5 6 7		Y N
5		1 2 3 4 5 6 7		1 2 3 4 5 6 7		Y N
6		1 2 3 4 5 6 7		1 2 3 4 5 6 7		Y N

Available for download on DFSB website

A more objective measure of sleep/wake patterns can be obtained by continuously monitoring movement using a scientifically validated actigraphy. This is a wristwatch-like device that is worn continuously. Data on the amount of movement is recorded regularly (typically every minute) and is downloaded to a computer after several days/weeks for analysis. Usually only a sample of crew members on a given schedule would have their sleep monitored in this way. The use of actigraphy should be overseen by a trained person to process and analyse the data.

Alertness monitoring

Subjective alertness/sleepiness assessments are also valuable tools for proactively assessing the level of fatigue within aviation operations, or among a particular working population. They can help to identify specific aspects of work schedules or other factors that may contribute to fatigue. Repeated assessments may also provide a basis for assessing how effective workplace changes, policies, or other interventions have been in managing and mitigating fatigue.

Subjective alertness/sleepiness assessments typically ask individuals to rate their fatigue, sleepiness, or alertness levels at a given moment in real time. For example, individuals are asked to rate their alertness/sleepiness when commencing duty, at critical stages of the duty period (such as Top-of-Climb and Top-of-Descent for aircrew), and when completing duty.

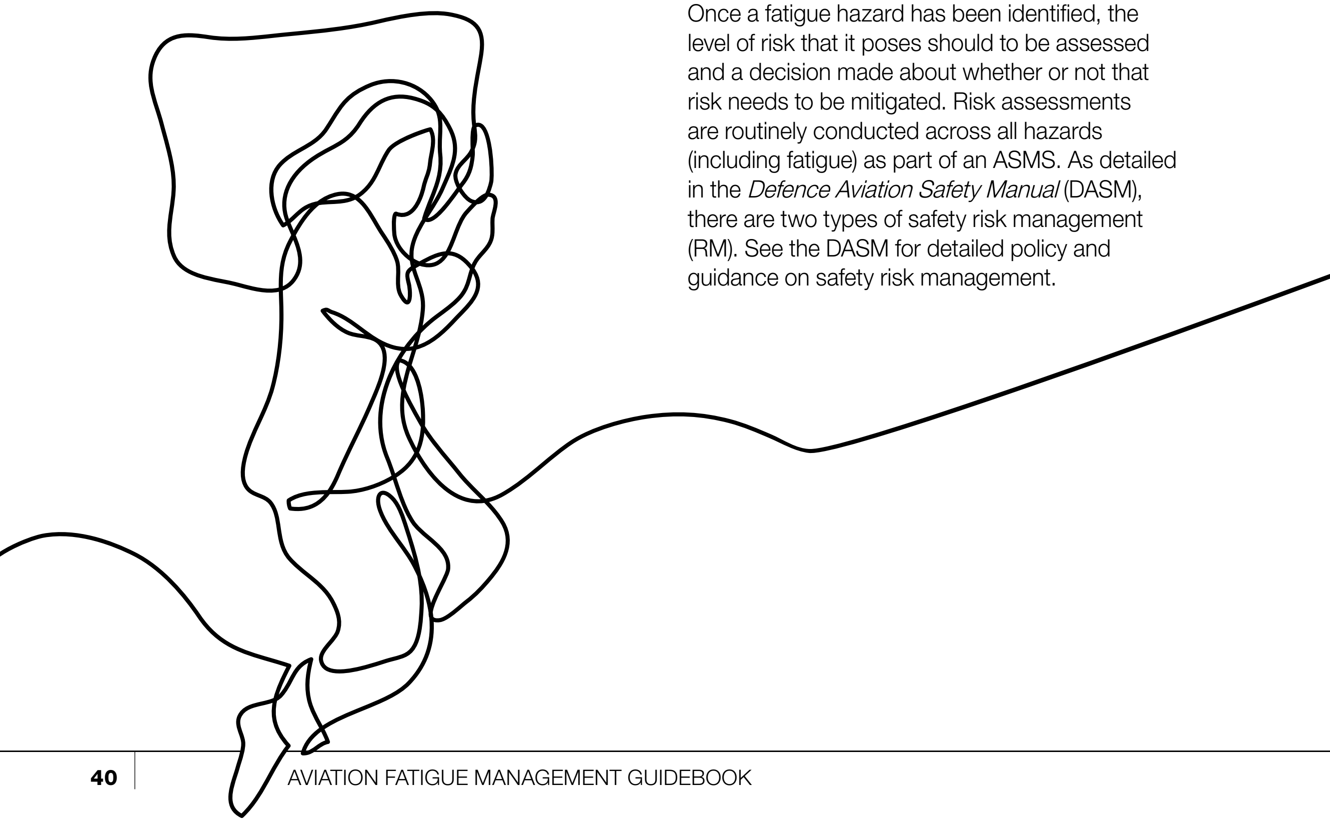
These assessments tend to be short for very quick assessments. They can be administered at multiple times during the day or across a duty cycle to assess how fatigue, alertness or sleepiness changes across the day or duty period. It is important that these surveys have been scientifically validated to ensure that the data being collected are reliable and measure the variables of interest at all times of day and at varying levels of sleep loss. Validated tools for assessing subjective alertness/ sleepiness include:

- The Karolinska Sleepiness Scale (Akerstedt & Gillberg, 1990)
- The Samn-Perelli Scale (Samn & Perelli, 1982)
- The Stanford Sleepiness Scale (Hoddes et. al, 1973)
- The Profile of Mood States (McNair et. al, 1971).

The Samn-Perelli Scale is used within the DFSB Fatigue Risk Awareness tool.

5.2 Safety risk assessment and mitigation

Once a fatigue hazard has been identified, the level of risk that it poses should to be assessed and a decision made about whether or not that risk needs to be mitigated. Risk assessments are routinely conducted across all hazards (including fatigue) as part of an ASMS. As detailed in the *Defence Aviation Safety Manual* (DASM), there are two types of safety risk management (RM). See the DASM for detailed policy and guidance on safety risk management.

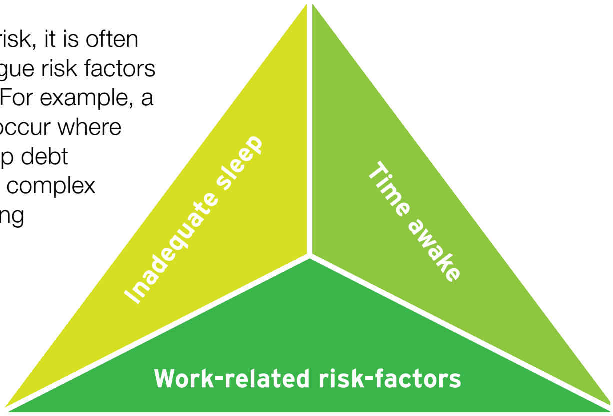


The fatigue risk triangle

For a fatigue hazard to be impactful as a risk, it is often the result of the interaction of multiple fatigue risk factors combined within the operational context. For example, a heightened fatigue risk would potentially occur where a person with an acute or cumulative sleep debt was conducting a cognitively demanding, complex or high-risk task at or near the end of a long duty period.

In line with this concept, critical fatigue risk factors can be defined by three categories and illustrated as a fatigue risk triangle:

- hours of wakefulness during work, duty or shift duration
- sleep obtained vs sleep needed (that is adequate vs inadequate sleep)
- work-related fatigue risk factors.



Fatigue risk triangle. Depicting the major risk-factor categories that aid in identifying the degree of individual and organisational fatigue risk.

While inadequate sleep and hours awake are self-explanatory, work-related fatigue risk factors can be viewed as additional environmental, work or organisational risk factors that contribute to either: (1) increase the likelihood or rate of fatigue occurring or (2) increase the severity of an adverse outcome stemming from any subsequent reduced performance. Examples could be:

- a laborious or repetitive task
- a task with low error tolerance or
- working during a circadian low point where alertness levels are considered to be lower.

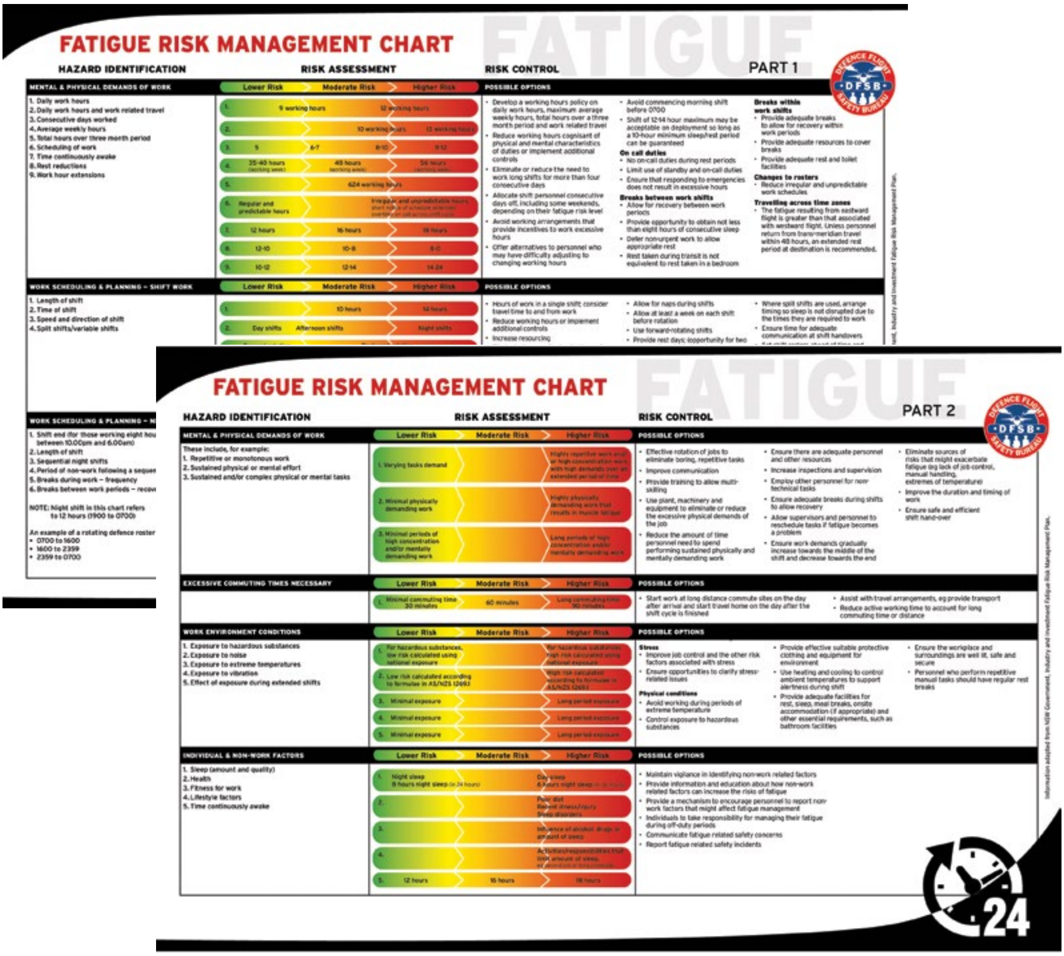
It is important to understand that it is not just the presence of individual fatigue risk factors that should be identified during risk-management and task-planning processes, but also the interaction between these risks factors and the subsequent potential to increase overall risk.

Situations in Defence aviation where deliberate risk management (in this case, for fatigue risk) is likely to be required include (but are not limited to):

- in response to identification of a new fatigue hazard or risk that is not covered by existing orders, instructions and procedures (OIP)
- where OIP do not provide sufficient information on the fatigue hazard and relevant controls
- whenever changes are made to the workplace, system or method of work and where these changes are likely to induce additional fatigue
- to support development of OIP that are required for a new task/activity that exceeds the scope of existing OIP and where fatigue risk is likely
- in response to workplace events that are fatigue related (even if they have not caused injury)
- where new information concerning a fatigue hazard or risk becomes available
- in the planning stages of a major activity/task
- prior to changes in an organisation which could directly or indirectly impact safety (and fatigue risk).

It is acknowledged that assessing the risks associated with the hazard of fatigue can be challenging because: (1) fatigue can diminish an individual's ability to perform almost all operational tasks and; (2) there are many factors that can contribute to an individual's level of impairment. Many of these factors may be unpredictable.

DFSB Fatigue Risk Management Chart



Available for download on DFSB website

The DFSB Fatigue Risk Management Chart is designed to aid commanders, supervisors and members in the identification, analysis and management of fatigue-related risks. Use of the fatigue management chart is recommended by DFSB to enable commanders and managers to identify the fatigue risk factors that are currently or potentially present in their work areas, and the degree to which they may affect performance. The chart also allows users to determine whether there are multiple risk factors that may interact to greatly increase overall risk.

Although this chart may not provide all of the solutions to the risks involved in the operational environment being experienced, it is a starting point for consideration of fatigue risk factors during an assessment.

Effective controls and mitigation strategies go beyond rest and duty times. For duties that are either very long, start very early in the morning, finish late at night or go through the night, controls and mitigations need to be considered in the context of successive days and duties.

Special attention needs to be given to the circadian influences on sleep and wake times regardless of rest and work times. Mitigation strategies that focus solely on an isolated duty may not address the effects of cumulative fatigue and become ineffective across a work roster.

Tactical fatigue management

Tactical fatigue management is a term used to describe the use of pragmatic fatigue-mitigation strategies before, during and after duty periods. In general terms, these interventions involve two approaches: (1) measures directed towards individuals (sleep hygiene, suitable sleeping quarters, hydration, and diet, managing impact of personal lives et cetera) and (2) measures directed towards tasks. Specific interventions advocated for use include:

Napping. Substantial opportunity exists to exploit the operational benefits of napping in order to sustain optimal performance and manage acute fatigue. Naps lasting 30 minutes or less have positive effects in prolonging alertness and reducing the chance of fatigue-related error. Time must also be allowed for the member to get to sleep (10–15 min) and to overcome the effects of sleep inertia (15–20 min). Commanders and managers must be cognisant of the napping facilities available when determining the effectiveness of naps as a countermeasure. It is important that the use of naps includes awareness and management of sleep.

Caffeine. The use of caffeine is considered appropriate as a fatigue countermeasure while on duty (including in-flight) — 100mg of caffeine can assist in maintaining cognitive performance. Personnel should make an effort to use caffeine only when it is truly necessary to reduce the impact of fatigue and adhere to guidance relating to its use (see fact sheet available on the DFSB website or the DFSB *NTS Guidebook*). Caution is warranted when consuming high quantities or drinks with high levels of caffeine as tolerance can develop with usage and withdrawal symptoms when ceasing. Caffeine intake should be limited in the afternoon unless using it for operational purposes as subsequent sleep quantity and quality may be affected. Facilitating controlled access to caffeinated products in the workplace (including as aircraft rations) is likely to promote the responsible use of caffeine and reduce the use of less desirable caffeinated products. Commanders, managers and individuals are advised to consult with a Defence health practitioner prior to using caffeine in this manner.

Sleep aids. The use of sleep-aid agents may be considered operationally beneficial when operational requirements disrupt normal sleep-rest cycles. Use of all prescription, non-prescription and complementary medicines must be in accordance with Defence policy. The decision to use sleep-inducing agents is a command responsibility, with a requirement that their use is conducted in accordance with prescribed protocols. The decision to employ sleep-aid agents should only be made after all other mitigation strategies have been exhausted.

Task-based approaches. Task-based approaches are based upon the probability that an error will occur during a task, not necessarily the severity of the consequences. Task-based approaches typically focus on when the task is performed, changing how it is performed and/or introducing additional administrative controls.

ASMS processes require that such risk mitigations are regularly reviewed and assessed to ensure their desired outcome continues. If the controls and mitigations perform to an acceptable standard, they become part of normal operations and are monitored by the ASMS safety-assurance processes.

However, if the controls and mitigations do not perform to an acceptable standard, it will be necessary to re-enter the risk-management processes at the appropriate step. This could involve gathering additional information and data; the re-evaluation of the fatigue hazard and associated risks; or identification, implementation and evaluation of new or revised controls and mitigations.

Deliberate RM may be prudent even when situations are covered by OIP because risk controls such as duty time limitations will never be able to contain the risk in all situations. Duty time limitations often overlook compounding risk factors where Immediate RM tools like Rule of Three may prompt Deliberate RM, for example:

reduced sleep + extended wakefulness + complex task = Deliberate RM.

CHAPTER 6 **FMP SAFETY-ASSURANCE PROCESSES**

Safety-assurance processes monitor the FMP's continued effectiveness. Ongoing evaluation by ASMS safety-assurance processes not only enables the management of risks to be adapted to meet changing operational needs, it also allows the ASMS to continuously improve the management of risks, including those related to fatigue. The sections below summarise the safety-assurance processes of an ASMS and how these can be used to monitor the FMP.

6.1 Safety-performance monitoring and measurement

Data for monitoring and measuring safety performance comes from a variety of sources. As detailed in Chapter 5, risk management involves identifying fatigue-related hazards through reactive and proactive processes. These processes involve the collection of data that can be used to generate fatigue safety performance indicators (SPIs). SPIs provide a metric to monitor the effectiveness of fatigue controls and mitigations.

For example, data on fatigue will be collected through the *Snapshot* Survey as well as the safety reporting system via investigations conducted into safety events, fatigue reports and duty variation forms inputted within Sentinel. From these data sources, a range of fatigue-related safety performance indicators can be developed such as:

- number and severity of fatigue reports submitted
- breakdown of fatigue reports by reason for submission
- number of duty-period extensions and rest reductions
- breakdown of duty variation reports by reason
- number of fatigue-related safety events
- proportion of *Snapshot* Survey respondents rating fatigue management/scheduling as ineffective
- overall *Snapshot* Survey fatigue and work rate safety indicator ratings that can be compared with Defence aviation benchmarks and results from previous years.

Using a variety of SPIs is expected to give a more reliable indication of fatigue levels and how well fatigue is being managed. It is also important to note that different SPIs may be appropriate in different types of operations.

If trends in SPIs indicate that current mitigations are not adequate and that a fatigue hazard remains, then a detailed risk assessment of the issue should be conducted in line with the organisation's processes and new mitigations proposed where necessary.

6.2 Aviation safety audits

The auditing process is an important means of assessing the effectiveness of the FMP. The table below outlines the kinds of information that can be useful for conducting an internal audit.

Sample questions have been provided that make it possible for individuals or groups who are not necessarily fatigue risk experts to perform the audit.

SAFETY POLICY AND OBJECTIVES
There is a documented FMP that includes a commitment towards the management of fatigue risk approved by the Accountable Person.
FMP documentation details responsibilities of the organisation and individuals for managing fatigue.
FMP documentation includes scheduling guidelines (and duty and rest period limitations) that meet both organisational requirements and fatigue risk management principles.
FMP documentation details procedures for extending beyond the identified limits.
FMP documentation contains linkages to the organisation's ASMS.
FMP documentation is appropriately referenced or reflected in existing organisational OIP.
FMP documentation is readily available to all personnel.
The FMP policy is reviewed periodically to ensure it reamins current.
A person has been nominated to manage the FMP.

SAFETY RISK MANAGEMENT

Fatigue risks are being identified and reported throughout the organisation.

Fatigue reporting has been integrated into the organisation's ASMS.

Safety investigations established contributing factors (including examining the potential contribution of fatigue).

FMP documentation details the fatigue hazard-identification tools (appropriate to the operational context) used by the organisation.

Fatigue hazard identification is based on a combination of reactive and proactive methods of data collection.

The organisation has proactively identified all the major fatigue risks and assessed them in relation to its current activities and operation context.

There is evidence that fatigue risks are being eliminated or managed SFARP as a part of the organisation's risk-management processes.

SAFETY ASSURANCE

Safety-performance indicators relevant to fatigue are being monitored and analysed.

Fatigue risk mitigations and controls are being verified/audited to confirm they are working and effective.

Audits are carried out that focus on the fatigue-mitigation performace of the organisation.

Fatigue-assurance activities feed back into the hazard-identification process.

Evidence that the organisation's Aviation Hazard Review Board or equivalent monitors the effectiveness of the FMP.

Evidence of lessons learnt are incorporated into the FMP policy and procedures.

All organisational and operational changes which could impact fatigue risk are subject to the change-management process.

SAFETY PROMOTION

All personnel are trained on their FMP roles and responsibilities.

Fatigue-related information is appropriately shared throughout the organisation.

Fatigue is integrated appropriately into Non-Technical Skills inital and recurrent training.

6.3 The management of change

Commanders and managers need to consider the fatigue-related consequences of organisational or operational changes. Changes, whether externally or internally driven, need to be appropriately risk assessed as they can:

- reduce the effectiveness of the controls and mitigations that have been implemented to manage existing fatigue hazards
- introduce new fatigue hazards into an operation, which need to be managed.

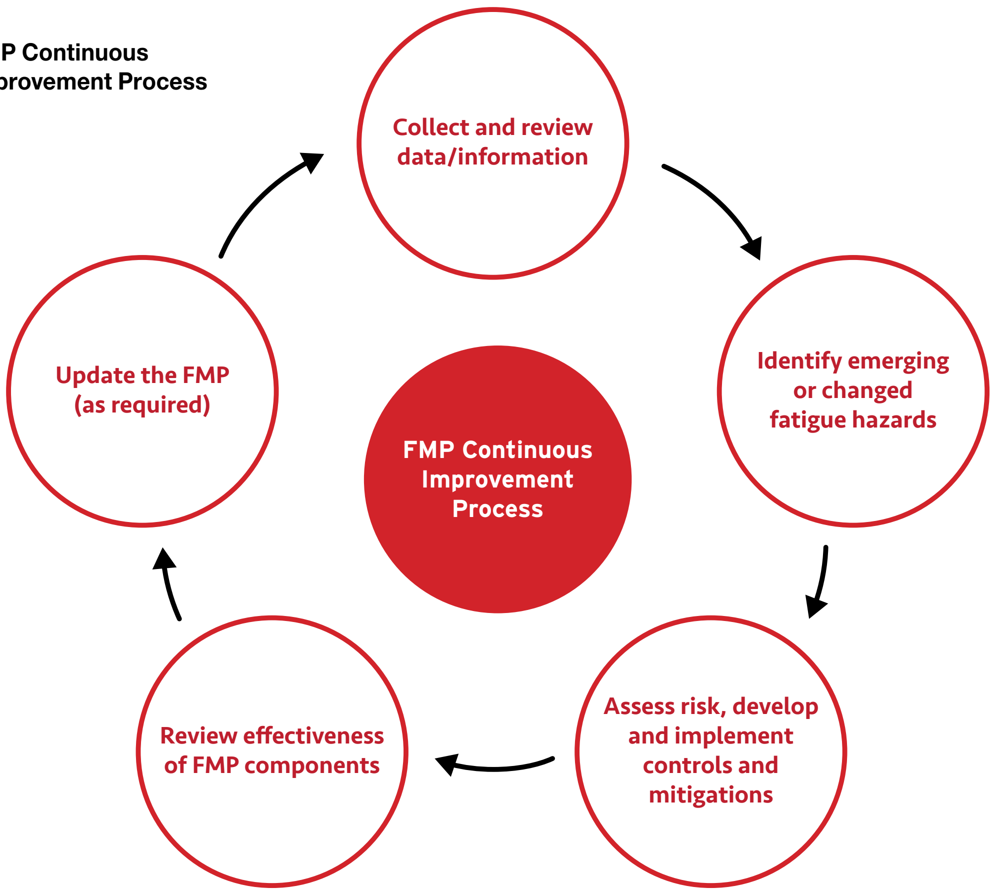
Because the FMP safety-assurance processes assess the overall performance of an FMP, they provide a means for recognising emerging fatigue risks and managing planned changes.

6.4 Continuous improvement

The continuous improvement process is fundamental to the success of the FMP. The components of the FMP will evolve over time as additional information is collected and operational knowledge/experience continues to mature. Organisations need to monitor and evaluate the effectiveness of their fatigue-management controls, such as policies and practices. Where controls are found to be inadequate or ineffective, the organisation should address deficiencies as part of their continuous improvement.

As the safety-assurance processes provide a means to monitor the overall performance of an FMP, they not only offer the means to ensure that adequate fatigue management is maintained but also the means for continued improvement of the FMP. It is important that the FMP is periodically reviewed, with the review schedule documented, to drive continuous improvement.

FMP Continuous Improvement Process



CHAPTER 7 **FMP SAFETY-PROMOTION PROCESSES**

7.1 Safety training

As part of the ASMS, organisations have a safety training program to ensure that involved personnel are competent to perform their ASMS duties and a communications plan that encourages their participation. Training of involved personnel should result in an understanding of their unit's FMP and their individual responsibilities regarding the management of fatigue riskss. Related training standards for initial and continuation training should be specified in the FMP and/or ASMS documentation.

The effective management of fatigue-related risk is dependent on all personnel possessing a basic understanding of fatigue and fatigue-management concepts. For example, an understanding of the signs and behaviours that are associated with fatigue will assist personnel in identifying fatigue both within themselves and others.

All personnel should also be trained and have an understanding of their unit's Fatigue Management Program.

In addition to these requirements, there is a need to tailor fatigue-management training to meet the needs of commanders and managers. Such initiatives should reinforce their roles and obligations within an ASMS and target the specific knowledge, skills and attitudes required to support the informed management of fatigue.

For efficiency, fatigue training is integrated within the ASMS training framework. Specifically, fatigue and fatigue-management concepts are addressed within the Defence Aviation Non-Technical-Skills Training Framework. Likewise, modules on the development and implementation of the FMP are a component of DFSB Aviation Safety Officer training courses.

7.2 Safety communication

The ASMS requires that organisations develop and maintain a formal means for safety communication that:

- ensures personnel are aware of the ASMS commensurate with their positions
- conveys safety-critical information
- explains why particular safety actions are taken
- explains why safety procedures are introduced or changed.

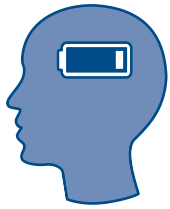
A training program that includes appropriate fatigue-management elements will address a number of these requirements but there needs to be on-going communication to explain FMP policies, procedures and responsibilities. There also needs to be ongoing communication about the performance of the FMP to keep fatigue ‘on the radar’ and encourage the continuing commitment of all involved personnel.

To acquire information necessary to manage fatigue adequately, personnel need to know not only what to report, but feel confident that information they provide will be received in a positive manner and is valued by commanders and managers. It is particularly important that personnel are advised of all changes made in response to information they provide.

Fatigue training

There are three main subject areas that form the substance of a suitable fatigue training program (fatigue, sleep and countermeasures). The following is a basic list of topics that would comprise these subject areas:

Fatigue



- types of fatigue
- contributors to fatigue
- consequences of fatigue on safety
- fatigue in accidents
- high-risk situations.

Sleep

- sleep physiology
- circadian body clock
- the sleep process
- amount of sleep required
- sleep debt recovery
- quality of sleep
- sleep disorders and individual differences
- shift work
- jet lag.

Countermeasures

- managing sleep habits
- tailoring the sleep environment
- napping
- exercise
- nutrition and hydration
- caffeine
- avoidance of alcohol before bed
- use of sleep aids
- keeping a sleep log.

CHAPTER 8 **FMP CHECKLIST**

A list of Fatigue Management Program-recommended elements with limited guidance details is contained in a consolidated checklist. This checklist is intended to provide a holistic program overview to aid in design and development of an organisation's FMP.

FMP POLICY AND DOCUMENTATION	FMP elements expanded information
Fatigue management policy — FMP policy specifies the organisation's commitment and approach to the management of their fatigue hazards and risks.	1. Policy details overall objective of the FMP as organisational commitment to managing the risk of workplace fatigue. 2. FMP policy details linkages between the organisation's ASMS and safety processes in the FMP.
Responsibilities — FMP documentation details responsibilities of the organisation and individuals for managing fatigue.	1. Organisational position responsible for managing the safety processes associated with the FMP are documented. 2. The management of fatigue is a shared responsibility of command/ management and the individuals covered under the FMP. 3. Organisational (commanders and managers) responsibilities with respect to the management of fatigue such as: a. providing adequate resourcing for fatigue management b. developing policies, procedures and practices that manage fatigue-related risks, including mechanisms for monitoring and continuous improvement. 4. Individual responsibilities with respect to the management of fatigue such as: a. making optimum use of non-work periods to get adequate sleep b. arriving at work in a fit and rested state so that there is a reasonable expectation of being adequately alert throughout the duty period c. communicating fatigue-related safety and performance concerns with work peers and supervisors.
Duty time limitations and scheduling practices — FMP documentation details flight/duty time limitations and information on scheduling practices to be used in planning of tasking.	1. Policy includes scheduling practices based on scientific principles and operational experience as a means of mitigating fatigue such as: a. roster lengths b. rest periods (minimum rest requirements) c. flight duty periods (where applicable) d. extensions due to unforeseen operational circumstances. 2. In addition, if relevant to operations: a. augmented crew operations b. long haul/transmeridian operations.
FMP documentation — all components of the FMP are documented.	1. FMP procedures and processes to support safety risk management, FMP safety assurance and FMP promotion are documented (see below for more detail).

FMP SAFETY RISK-MANAGEMENT PROCESSES	FMP elements expanded information
Hazard identification — reactive and proactive activities to identify the presence or potential for fatigue.	1. Fatigue hazard identification based on a combination of reactive and proactive methods of data collection such as. a. self-identification of fatigue risks b. previous experience (of the organisation or others in the industry) c. fatigue reporting d. evidence-based scheduling practices e. bio-mathematical models f. investigation of aviation safety events g. fatigue surveys h. internal and external audit reports i. fatigue-related information resulting from published scientific research and external sources.
Safety risk management and mitigation — processes for the assessment and decisions on fatigue risk and whether/how fatigue risk/s need to be mitigated.	1. FMP fatigue risk-assessment processes aligned with DASM guidance. 2. FMP contains information on 'decision gates' that guide the level and type of assessment required depending on tasking context and fatigue hazards that have been identified. 3. FMP incorporates the DFSB Fatigue Management Chart to support safety risk-management processes.

FMP SAFETY-ASSURANCE PROCESSES	FMP elements expanded information
Safety performance monitoring and measurement — data and methods for monitoring and measuring of Fatigue Management Program performance.	1. A range of fatigue-related safety performance indicators are developed such as: a. number and severity of Fatigue reports submitted b. breakdown of Fatigue reports by reason for submission c. number of duty period extensions and rest reductions d. breakdown of Duty Limit Variation reports by reason e. number of fatigue-related safety events f. proportion of *Snapshot* Survey respondents rating fatigue management/ scheduling as ineffective g. overall *Snapshot* Survey fatigue ratings.
Aviation safety audits — Fatigue Management Program component/s of the ASMS audit schedule and any specific compliance standards.	2. Fatigue focus areas within Safety Audit may include: a. compliance with requirements for submission of Duty Limit Variation reports and Fatigue reports b. examination for potential fatigue contributing factors during investigations c. compliance with rostering guidelines d. duty period extension-management practices e. compliance with mandatory and specialised fatigue training requirements.

FMP SAFETY-ASSURANCE PROCESSES (cont)	FMP elements expanded information
The management of change — structured process to reduce any fatigue-related performance impact or unanticipated fatigue-related outcomes from changes to organisational policy and processes.	1. Commanders and managers consider the fatigue-related consequences of organisational or operational changes. 2. FMP safety-assurance processes provide a means for recognising and managing emerging fatigue risks from any planned changes.
Continuous improvement — use of performance data and validated outside learning to improve efficacy of fatigue risk controls.	1. The components of the FMP will evolve over time as additional information is collected and operational knowledge/experience continues to mature. 2. FMP safety-assurance processes provide a means to inform potential changes that may address deficiencies and improve performance.

FMP SAFETY-PROMOTION PROCESSES	FMP elements expanded information
Fatigue training and education — training to ensure a functional understanding of fatigue and fatigue-management concepts for all required personnel.	1. Organisations maintain a training program to ensure that involved personnel are competent to perform their FMP responsibilities. 2. Fatigue-related training standards for initial and continuation training is specified in the FMP and/or ASMS documentation.
Communication and consultation — updates on emerging fatigue risks and useful information on individual management of fatigue.	1. Ongoing communication to explain FMP policies, procedures and responsibilities, and about the performance of the FMP to keep fatigue 'on the radar' and encourage the continuing commitment of all involved personnel.

RESOURCES LIST

Defence Aviation Safety Manual

DFSB *Aviation Non-Technical Skills* Guidebook

DFSB Fatigue Risk Awareness Tool

DFSB Fatigue Risk Management Chart

Aviation Safety Reporting (ASR) in Sentinel – Duty Limit Variation report

ASR in Sentinel – Fatigue report

DFSB Salus Safety Intelligence System – Fatigue report

DFSB *Snapshot* Survey

REFERENCE MATERIALS

(The following reference documents were utilised to inform the content within this guidance.)

Defence WHS Manual, Volume 2, Part 2, Chapter 10 – Fatigue Management

Defence WHS Manual, Volume 3, Part 2, Chapter 10:

FM:01 – Types, Causes and Symptoms of Fatigue

FM:02 – Guidance – Sleep Management

FM:03 – Guidance – Fatigue Proofing and Napping

FM:04 – Guidance – Circadian Rhythms and Combating Jet and Shift Lag Fatigue

FM:05 – Guidance – Designing Shift or Duty Rosters

FM:06 – Guidance – Tools to Determine Levels of Fatigue

Air and Space Interoperability Council. Advisory Publication ACS (ASMG) 6000 (2011) – *Fatigue Countermeasures in Sustained and Continuous Operations*

Defence Flight Safety Bureau, Aviation Non-technical Skills Guidebook (2nd Ed) (2020) – Chapter 9, Managing Fatigue, pages 126-163

AVMED-CR-2013-002 – *ADF Aviation Workforce Fatigue Management*

Health Directive 311 – *Use of Medications by Aircrew and Aircraft Controllers*

Health Directive 271 – *Use of Dietary Supplements and Complementary Medicines by Australian Defence Force Personnel*

International Civil Aviation Organization (ICAO) – *Fatigue Management Guide for Airline Operators* (2016)

ICAO – *Fatigue Management Guide for General Aviation Operators of Large and Turbojet Aeroplanes* (2016)

ICAO – *Fatigue Management Guide for Helicopter Operators* (2020)

Fatigue Management Guide for Air Traffic Service Providers (2016)

Flight Safety Foundation – *Duty/Rest Guidelines for Business Aviation* (2014)

Mining NSW Fatigue Management Plan – *A practical guide to developing and implementing a fatigue management plan*

Civil Aviation Advisory Publication (CAAP) 48-1(1) v3.2 – *Fatigue Management for Flight Crew Members*

Fatigue Management Strategies for Aviation Workers: A Training & Development Workbook

Biomathematical Fatigue Models Guidance Document – March 2014

Civil Aviation Authority (CAA) CAP 371 – *The Avoidance of Fatigue in Aircrew*

Murphy, P.J. (2002). *Fatigue Management on Operations: A Commander's Guide,* Doctrine Wing, Land Development Centre, Puckapunyal: Department of Defence (Army)

Fogarty, G & Murphy, P. J. (2012). *Preventing and Managing Shiftwork Fatigue. A Workbook for Shift Workers in Defence.* Joint Health Command

Navy – Australian Book of Reference (ABR) 6303 – *Navy Safety Systems Manual*, Section 4, Chapter 27, 4.10.3 – Fatigue

Air Force (Air Crew) – Defence Instruction (Air Force) Operations (OPS) 6-6 – *Crew Duty Limits*

Air Force – Standing Instruction Air Command SI(AC) OPS 01-13 – *Work Routines and Deployment Scheduling*, SI(AC) OPS 06-01 – *Air Command Crew Duty Limits*

Safe Work Australia – *Guide for Managing the Risk of Fatigue at Work*

Caldwell, John A. et al. (2009) 'Fatigue Countermeasures in Aviation', *Aviation, Space, and Environmental Medicine*, 80: 29-59.

House of Representatives, Standing Committee on Communication, Transport and the Arts (2000). *Beyond the Midnight Oil. An Inquiry into Managing Fatigue in Transport.* Canberra, Australia

Reason, J.T. (1997), *Managing the Risks of Organisational Accidents*, Aldershot, UK: Ashgate

Gander P.H., Mangie J., van den Berg M.J., Smith A.A.T., Mulrine H.M., Signal T.L, 'Crew Fatigue Safety Performance Indicators for Fatigue Risk Management Systems', *Aviation, Space, and Environmental Medicine*, Vol. 85, No. 2, February 2014

Bosley G.C., Miller R. M., Watson J., *Evaluation of aviation maintenance working environments, fatigue and maintenance errors/accidents*, Prepared for the Federal Aviation Administration (FAA) Office of Aviation Medicine under Contract Number DTFA01-99-C-00088

LeClair M.A., Maj, *Fatigue Management for Aerospace Expeditionary Forces Deployment and Sustained Operations*, USAF

ENCLOSURE 1 **BIOMATHEMATICAL FATIGUE MODELS**

This enclosure provides additional guidance on the use of biomathematical fatigue models (BFMs), specifically SAFTE-FAST, as a tool to support fatigue risk management within Defence aviation. This guidance includes a general overview of BFMs before providing a detailed overview of the web-based SAFTE-FAST program and some key considerations to optimise its use.

It is important to remember that while BFMs, such as SAFTE-FAST, are powerful tools in fatigue hazard identification, they are only one piece of the puzzle when it comes to fatigue risk management. Effective fatigue management in Defence aviation operations, large and small, is best addressed through a multi-layered approach within an Aviation Safety Management System (ASMS).

What are biomathematical fatigue models (BFMs)?

BFMs are a tool designed to help predict personnel fatigue levels based on a scientific understanding of the factors that contribute to fatigue. BFMs use sets of equations that quantitatively predict a fatigue risk metric based on factors such as time awake, sleep history and time of day. While BFMs can be incredibly useful, they are an optional tool for fatigue hazard identification and should never form the sole means upon which operational decisions about fatigue risk management are made.

Potential usage for BFMs

BFMs are used in various ways to support predictive, proactive and reactive fatigue hazard identification. The output of BFMs provide metrics that are used to identify potential fatigue risks and levels of performance during duties. The information provided by BFMs can support the development and optimisation of schedules, enhance safety through effective risk management and intervention, and enhance personnel performance by predicting effectiveness throughout a duty.

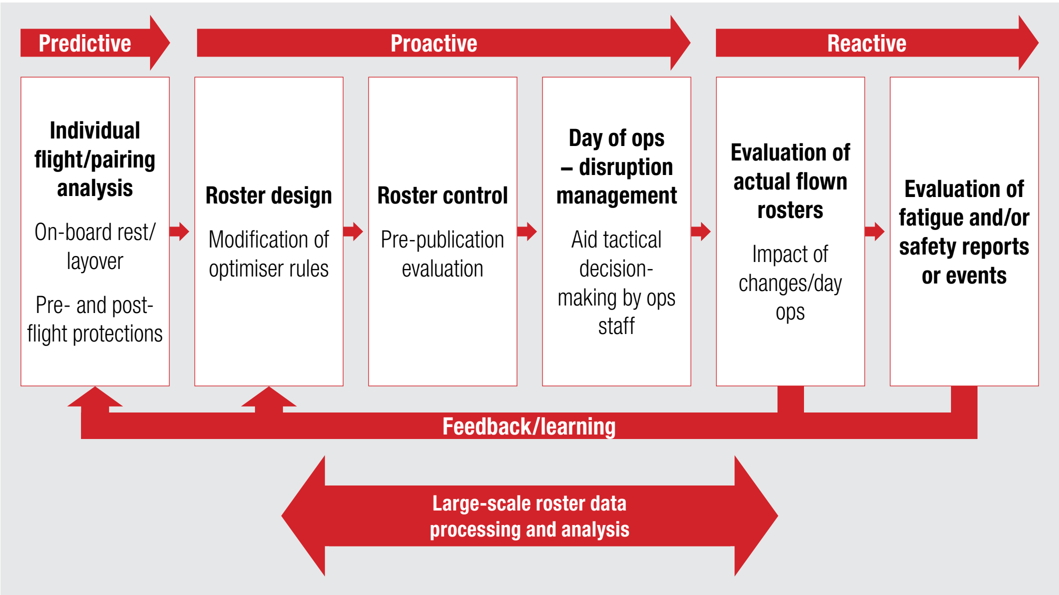


Figure 1: Potential usage of Biomathematical Model[1]

1 IATA — *Uses and Limitations of Biomathematical Fatigue Models — White Paper*

Limitations of BFMs

Although BFMs are a valuable tool for analysing the risk of fatigue, they have important limitations that need acknowledgement.

a. A model used on its own is not an effective system for managing fatigue.

b. A model should not be used by individuals, operators or regulators as a sole go/no-go decision-making tool.

c. The output of a model does not necessarily predict safety risk or subjective measures for individual fatigue or sleepiness.

d. Model outputs represent the population average and may not be accurate for specific individuals.

e. Model sleep predictions may not reflect actual sleep, which is fundamental to the validity of its output.

f. Models are limited in their ability to account for operational contexts, mental and physical demands of work, work environment conditions (for example, extreme hot and cold) and other non-sleep-related factors that may affect fatigue and alertness (for example, caffeine intake).

Given these limitations, modelling is a decision aid that should be combined with operational experience and other fatigue hazard-identification tools, like fatigue reports and pre-duty checks, to form guidance regarding performance-based fatigue management.

What is SAFTE-FAST?

SAFTE-FAST is the recommended BFM by the Defence Flight Safety Bureau (DFSB) for use within the Defence aviation context. Derived from research conducted by the US Army on sleep deprivation and performance at the Walter Reed Army Institute of Research, SAFTE-FAST enables users to build schedules of work and evaluate the predicted fatigue risks associated.

DFSB maintains a limited number of licences to allow access to the web-hosted version of the SAFTE-FAST program. Additional information regarding the access of SAFTE-FAST is available on the DFSB website.

Using SAFTE-FAST to analyse the risk of fatigue

As with most BFMs, SAFTE-FAST is used primarily in three ways to analyse the potential risk of fatigue within a schedule: predictively, reactively and proactively. The principal difference between these analyses is the information that is required to be input to the program and the measurement of sleep.

Predictive analysis

When performing predictive analysis SAFTE-FAST uses planned work schedules to estimate potential fatigue risks and performance. Information that is required for this type of analysis includes the time and duration of planned duties within a schedule. SAFTE-FAST then uses its auto-sleep algorithm to plot the best-recommended sleep times and durations between duties to support fatigue management. The outputs from this will help in identifying where potential fatigue risks lie within a planned schedule and what adjustments might need to be made to support fatigue management.

Reactive analysis

Compared with predictive analysis, reactive analysis uses actual work and sleep periods to estimate the potential fatigue risks a schedule posed on individuals. This information can only be captured after the fact through interviews, sleep/duty diaries or activity measures (for example, ACTigraph watches). The output from this help evaluate the fatigue risks posed within flown rosters or the potential contribution of fatigue to safety events.

Proactive analysis

Proactive analysis is applied within SAFTE-FAST by using a combination of both planned work periods and actual work/sleep periods to identify potential fatigue risks. This is often used when a schedule shifts significantly due to day of operation changes (such as delays) and the remaining planned schedule needs to be re-evaluated based on the actual schedule experienced thus far. This re-evaluation supports fatigue management for individuals throughout the remainder of the planned schedule.

Key aspects for building schedules in SAFTE-FAST

It is recommended that new users undertake the training provided by SAFTE-FAST and familiarise themselves with the program user guide when first using the program. While these resources are highly useful and the program itself is relatively intuitive, there are some key aspects that users should have awareness of when building schedules in SAFTE-FAST.

Different types of schedules

SAFTE-FAST has two options available for building schedules within the program: event schedules and shift schedules. Which option is most useful will depend on the operational context that is being scheduled.

Event schedules: An event schedule consists of one or more duty days and allows you to create multiple crewing duties in a day at different times and locations. It also allows you to define the tasks in between safety critical periods (such as briefing and debriefing) and outside of duty. This option is used to build schedules evaluating missions and flights.

Shift schedules: A shift schedule consists of a pattern of shifts over an extended period. A pattern includes a number of shifts over a defined number of days and a shift contains a shift type along with a start and end time. By default, one crewing event is created per shift and typically the shift occurs in one location.

However, you can create a pattern that has multiple shifts on the same day. This method is used to build schedules evaluating shift rosters undertaken by crews, maintenance and air traffic controllers. The shift schedules can be particularly useful when creating a longer schedule (for example, weeks or months) to determine the long-term effects on individuals' fatigue risk.

Tags

Tags allow you to include custom labels at the Event level within a schedule. Tags can be automatically or manually created and applied to different event types within schedules such as duties, work, markers and sleep. This enables easier analysis of common events such as certain aircraft, mission profiles, locations, roles, et cetera, within a larger schedule. Tags are also used within the reporting tool of SAFTE-FAST to analyse fatigue risk metrics across multiple schedules.

Auto-sleep

Auto-sleep functionality is the preferred method of annotating sleep in a schedule when performing predictive analysis. However, it is recommended that once these periods are plotted that the option be switched off to allow for sleep period timings, lengths and qualities to be manually adjusted based on operational experience to more closely reflect 'reality'. This will also enable the implementation of naps within the model as a potential fatigue treatment/control.

Sleep quality

The quality of sleep specified within SAFTE-FAST schedules plays an important role in how the program calculates how restorative

Sleep quality	Description
Excellent	This environment setting assumes no interruptions in sleep from disturbances from the environment, such as sleep at home or a quiet and comfortable hotel.
Good	The environment that on average results in two interruptions per hour that each cost 5 min of sleep time, which is 50 min of restorative sleep per hour or 83% of Excellent. For aviation, this is the level assumed for a Class 1 rest facility.
Fair	The environment that results in four interruptions per hour which is 40 min of restorative sleep per hour or 67% of Excellent. For aviation, this is the level assumed for a Class 2 rest facility.
Poor	The environment that results in six interruptions per hour which is 30 min of restorative sleep per hour or 50% of Excellent. For aviation, this is the level assumed for a Class 3 rest facility.

Note: For the definitions of rest class facilities, refer back to page 25 of this guidebook.

sleep is for individuals. As such, the quality should be adjusted accordingly based on the environment in which sleep occurred. Sleep quality cannot be adjusted for auto-sleep within SAFTE-FAST. General guidance regarding sleep quality is provided below.

Schedule parameters

When building schedules within SAFTE-FAST, users can define parameters such as work preparation, commuting, briefing/debriefing and unwinding. Parameters support the development of schedules more aligned with reality.

This is particularly important when performing predictive analysis as the auto-sleep functionality plots sleep based on the available time within a schedule. For instance, auto-sleep may place sleep periods immediately before or after duty if parameters are not specified to account for the out of duty time an individual spends commuting, having meals, preparing for work, checking in/out of accommodation, and personal time.

Not including these parameters can result in inaccurate estimations of sleep and subsequent predictions of fatigue risk.

As such, it is important to develop standardised scheduling parameters to use within SAFTE-FAST. Standardised parameters ensure consistency across schedules and alignment with policy requirements (for example, minimum 30-minute commute).

SAFTE-FAST fatigue risk metrics

While SAFTE-FAST provides a number of risk metrics regarding fatigue, the two key metrics that should be analysed when evaluating a schedule is effectiveness and sleep reservoir.

Effectiveness

Effectiveness is the primary fatigue-risk-metric output in the SAFTE-FAST program. The metric is the predicted speed of performance on a psychomotor vigilance test (PVT), scaled as a percentage of a fully rested person's normal best performance. Effectiveness levels are considered highly sensitive to fatigue and correlate with many other variables that known to effect performance such as continuous wakefulness, reaction time and blood alcohol level.

Effectiveness (% of baseline)	Continuous hours of wakefulness	Reaction time (% increase from baseline)	Blood alcohol level equivalent
80%	18	+25%	
77%	18.5	+30%	0.05%
75%	19	+33%	
70%	21	+43%	0.08%
65%	40	+54%	

The general guidance for SAFTE-FAST effectiveness scores is outlined below. It is important to remember that effectiveness scores represent the potential fatigue risk within a schedule and are **not to be used solely** to make go/no-go decisions.

Effectiveness score	Fatigue risk management recommendations	
Green (above 90%)	Proceed	The work schedule is unlikely to contribute to fatigue.
Yellow (90-77%)	Monitor	The work schedule may contribute to low levels of fatigue. Tactical fatigue-management strategies should be utilised to minimise fatigue arising from the schedule.
Amber (77-65%)	Caution	The work schedule is likely to contribute to heightened levels of fatigue. Caution is advised for personnel conducting duty or tasks in safety critical areas. Consider adjusting duty and rest periods to increase the schedule's effectiveness score above 77 per cent. If the schedule cannot be amended, minimise risk by applying available and authorised treatments/controls.
Red (below 65%)	Re-evaluate	The work schedule is highly likely to contribute to heightened levels of fatigue. Duty or conduct of tasks in safety-critical areas should not be conducted if predicted fatigue risk falls in this zone. Re-evaluate duty and rest periods to increase the schedule's effectiveness score. If duty must be conducted, the decision to proceed should be supported using local deliberate risk-management processes.

While effectiveness is the primary indicator of fatigue risk in SAFTE-FAST it is important to identify its root cause, particularly when performing predictive and proactive analysis. Effectiveness is driven by other metrics within SAFTE-FAST such as the sleep in the prior 24 hours, extended wakefulness, sleep debt, and circadian effects.

Analysing these metrics will give you a better understanding of what is driving lower effectiveness scores and the subsequent remedies to improve the schedule (for example, additional rest, later start times, augmented crews, task swapping, et cetera).

Sleep reservoir

The sleep reservoir is the percentage of an individual's full sleep capacity and correlates with other variables such as sleep debt and hours awake. The sleep reservoir is restored by gaining adequate sleep each day. However, it is important to remember that not all sleep is equal.

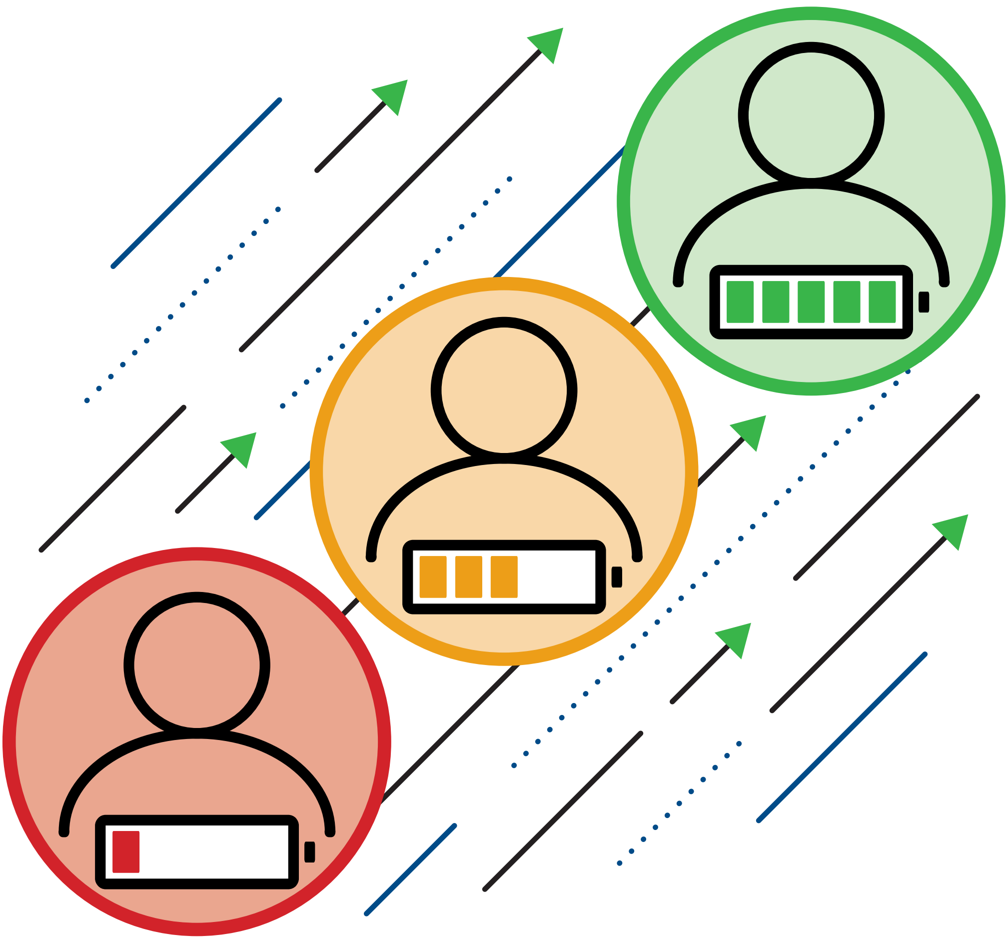
Reservoir value	Equivalent sleep debt	Threshold
80%	6.4 hours	19 hours awake
75%	8.0 hours **(equivalent of missing a full night of sleep)**	24 hours awake
72%	9.0 hours	

[2] Circadian effects refers to the impact an individual's internal body-clock can have on alertness and fatigue. This is particularly relevant for transmeridian schedules as an individual's ability to acquire adequate sleep may be compromised due to being out of sync with their internal clock (for example, sleeping when they would normally be awake).

The quality of sleep can be effected by factors such as the location, the time of day and circadian effects. Poor or degraded quality of these factors also effects how restorative that sleep is. For example, a regular eight hours of sleep at night in one's own home may restore the reservoir back to full capacity but eight hours of sleep away from home in a different time zone during the day will be less effective in restoring the reservoir.

Importantly, getting back to full capacity after lower quality sleep requires additional sleep to make up for the lack of restoration. Because of this, lower quality sleep can sometimes have a cumulative effect on the sleep reservoir and is a common challenge with transmeridian schedules. As such, schedules should be analysed by looking at the reservoir scores at the beginning of duties to ensure sufficient time for sleep is being allocated.

An additional consideration for sleep-reservoir scores is that while they often coincide and drive-effectiveness scores, the two can also be independent of one another. Disparity between the sleep reservoir and effectiveness is commonly due to the impacts of circadian effects. These circadian effects can result in instances where a schedule might indicate an acceptable effectiveness score despite there being a lower sleep reservoir. This commonly occurs due to duty being planned during a period of peak alertness in one's circadian effect. It is important to identify when this occurs, as these peaks of effectiveness are short lived and will begin to decline rapidly due to the underlying reservoir as time goes on.



Key considerations when using SAFTE-FAST

While SAFTE-FAST is a powerful tool for analysing fatigue risk there are some key considerations that need to be taken into account when using the program.

SAFTE-FAST modelling assumptions

Modelling within SAFTE-FAST has some important assumptions that need to be recognised when building and evaluating schedules.

a. It is assumed that crewing events/shifts will be conducted as planned until changed otherwise.

b. It is assumed that personnel will commute to the point of reporting with sufficient allowance of time to obtain adequate sleep prior to duty.

c. The model assumes a pattern of sleep typical of the average person with a need for eight hours of sleep per day.

d. The model assumes that planned work sleep opportunities will be used for sleep. In the case of aviation, the landing pilot will get the best opportunity for sleep.

e. The model assumes that the environmental conditions for sleep will be appropriate for the quality of rest facility defined in the schedule.

f. The model assumes that personnel will be fully rested at the beginning of the schedule and acclimatised to the location at the start of the schedule. As such, transmeridian work duties should be consolidated within one schedule and not be separated based on location or breaks between work duties.

g. The model does not account for individuals within a crew neither does it account for the physicality of work, work environment (for example, extremes of hot and cold, vibration, repetitiveness) or health and fitness of individuals in its prediction of fatigue risk.

Anticipating prior fatigue

When developing a schedule, it is important to consider an individual's fatigue prior to starting duty. This prior fatigue may be due to personal life factors (for example, stressors experience in preparing to be away from home) or from the previous work schedule they completed. Not accounting for this prior fatigue when developing a schedule may lead to an **underestimation of potential fatigue risks**, particularly at the beginning of a schedule.

When creating a new schedule, SAFTE-FAST assumes that an individual has received three days of good rest prior to the schedule start date. One way to account for prior fatigue is by creating a prior seven-day schedule template that can be imported when developing a new schedule. This template should provide a generic work schedule for the week prior to duty. However, templates can also be adjusted to mimic specific individuals' schedules when needed.

Additionally, it is also important to consider introducing other fatigue hazard-identification tools to form a comprehensive approach to fatigue risk management. Relevant tools include the Fatigue Risk Awareness Tool (FRAT) to support awareness of individual fatigue prior to duty.

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DEFENCE FLIGHT SAFETY BUREAU

DFSB