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Manual for the Oversight of Fatigue Management Approaches

Second Edition, 2016

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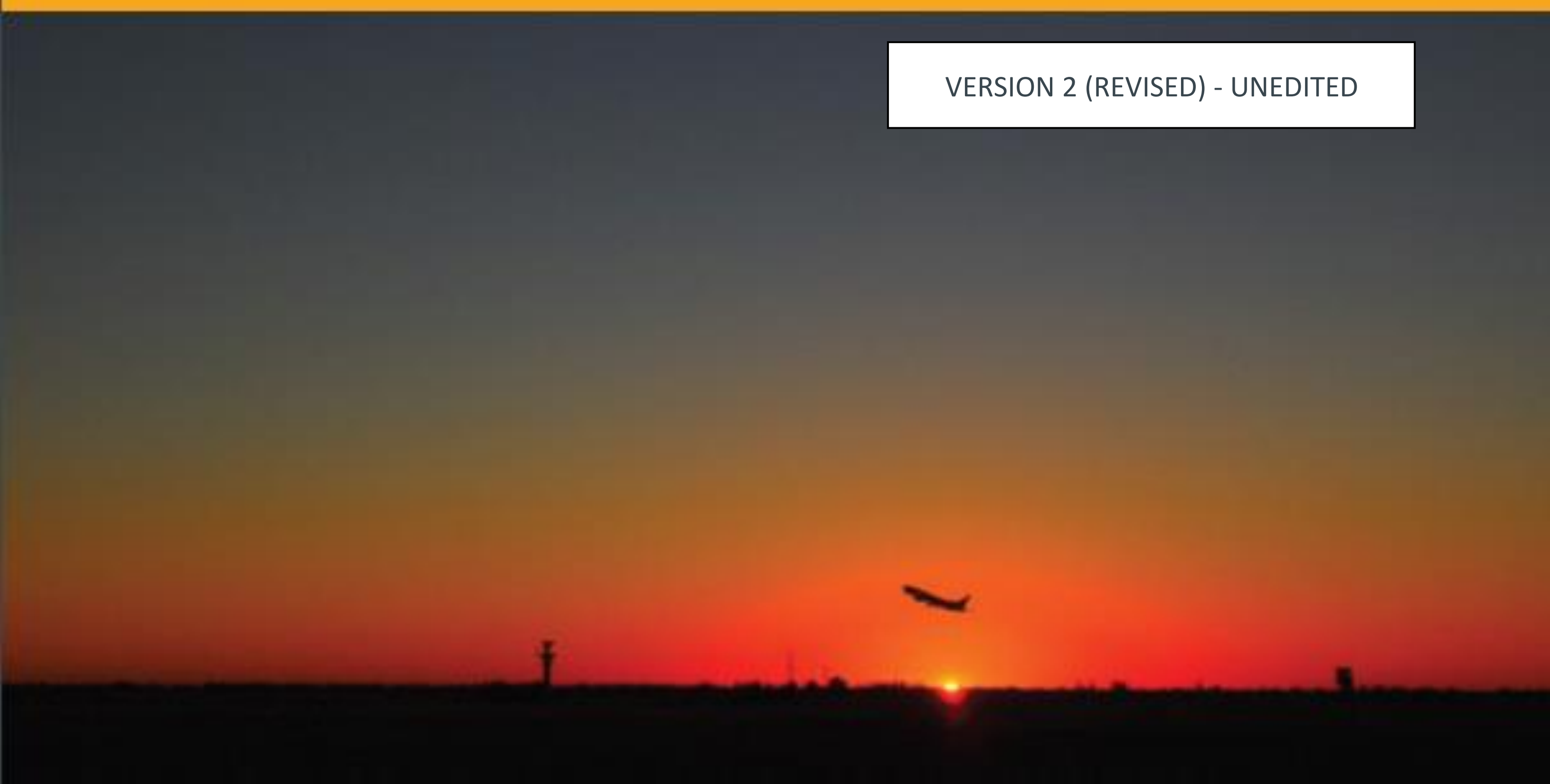

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INTERNATIONAL CIVIL AVIATION ORGANIZATION

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(Title in First Edition, Fatigue Risk Management Systems — Manual for Regulators)

AMENDMENTS

Amendments are announced in the supplements to the *Products and Services Catalogue;* the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
No.	Date	Entered by

CORRIGENDA		
No.	Date	Entered by

PUBLICATION HISTORY

The **first edition** of this manual (Doc 9966), titled *Fatigue Risk Management Systems Manual for Regulators* was published in **2011**. It was developed to support FRMS-related amendments (Amendment 37) to Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport — Aeroplanes*. The first edition focused specifically on the oversight of FRMS in airline operations and was published in association with the *IATA/ICAO/IFALPA FRMS Implementation Guide.*

The **second edition**, published in **2016**, represented a substantial expansion of topics to include:

- updated guidance related to implementation of fatigue management approaches based on experience gained in airline operations;
- information previously contained in Annex 6, Part I, Attachment A - *Guidance Material for Development of Prescriptive Fatigue Management Regulations*;
- information to support Amendment 50 to Annex 11 — *Air Traffic Services* regarding the implementation of prescriptive duty limitation regulations for air traffic controllers and the implementation of fatigue risk management systems (FRMS); and
- information to support existing fatigue management Standards in Annex 6 — *Operation of Aircraft*, Part II — *International General Aviation — Aeroplanes*.

To reflect the expansion of topics, the second edition was renamed *The Manual for the Oversight of Fatigue Management Approaches*. The following implementation manuals were published in support:

- *IATA/ICAO/IFALPA Fatigue Management Guide for Airline Operators*, 2nd Edition (2015). The second edition of this document also includes updated information and expanded topics which is reflected in a title change from the original *FRMS Implementation Guide;*
- *IBAC/ICAO/FSF Fatigue Management Guide for General for General Aviation Operator*s *of Large and Turbojet Aeroplanes*, 1st Edition (2016); and
- *CANSO/ICAO/IFATCA Fatigue Management Guide for Air Traffic Service Providers,* 1st Edition (2016).

The second edition was updated in **2019** in **Version 2 (Revised)**. Revisions largely related to the inclusion of helicopter operations information to support Amendment 22 to Annex 6 — *Operation of Aircraft,* Part III — *International Operations — Helicopters* which included harmonizing Part III fatigue management Standards and Recommended Practices (SARPs) with those in Part I. An implementation manual, the *xxx/ICAO/xxxx Fatigue Management Guide for Commercial Helicopter Operators*, First Edition is planned for publication in 2019.

In Version 2 (Revised), some amendments were also made to further clarify differences between the prescriptive approach and FRMS in Chapter 1 (revised and new text); Chapter 4 (new diagram outlining a prescriptive FM approach); and Chapter 5 (updated diagrams and associated text amendments to describe a fully functioning FRMS and the role of the Fatigue Safety Action Group (FSAG)).

USE OF THIS MANUAL

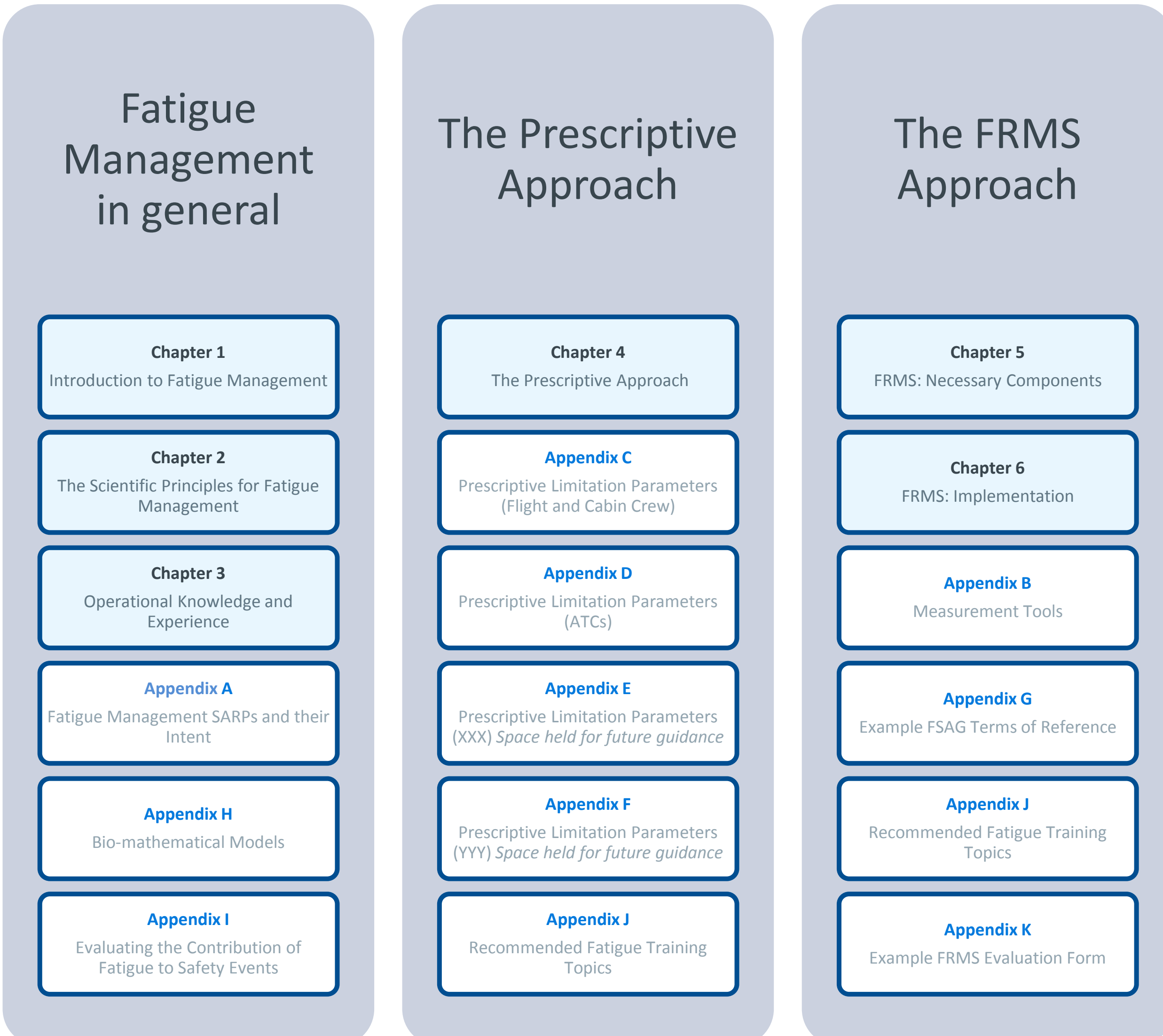
The *Manual for the Oversight of Fatigue Management Approaches* (Doc 9966) is one in a suite of manuals related to fatigue management. Developed for States, it presents an overview on the oversight of fatigue management approaches in general.

The suite of manuals also includes fatigue management implementation manuals, each specific to a different professional group, to assist aviation service providers subject to fatigue management Standards and Recommended Practices (SARPs) to effectively manage their fatigue risks. The *Manual for the Oversight of Fatigue Management Approaches* has been designed to be read in association with one or more of the relevant implementation manuals, depending on the professional group being regulated and monitored.

The content of all of these manuals is based on the work of the ICAO Fatigue Risk Management Systems (FRMS) Task Force. They follow a similar structure to facilitate their use.

The suite of fatigue management manuals, and the Annexes to which they pertain, is as follows:

The following diagram provides an overview of the *Manual for the Oversight of Fatigue Management Approaches* (Doc. 9966) and is presented to assist readers in navigating its contents[1]. The diagram separates the content of this document into three general areas:



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1 Corresponding diagrams are provided in each of the implementation guides to facilitate cross-referencing.

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GLOSSARY

**denotes an ICAO definition*

Actigraph. A wristwatch-like device containing an accelerometer to detect movement. Activity counts are recorded per unit time, for example every minute. The patterns of movement can be analysed using purpose-built software to estimate when the wearer of the actiwatch was asleep, and to provide some indication of how restless a sleep period was (i.e., sleep quality). Actigraphs are designed to record continuously for several weeks so they are valuable tools for monitoring sleep patterns, for example before, during, and after a period of work.

Actigraphy. Use of actiwatches to monitor sleep patterns. For actigraphy to be a reliable measure of sleep, the computer algorithm that estimates sleep from activity counts must have been validated against polysomnography, which is the gold-standard technology for measuring sleep duration and quality. The main weakness of actigraphy is that an actigraph cannot differentiate between sleep and still wakefulness (since it measures movement).

Afternoon nap window. A time of increased sleepiness in the middle of the afternoon. The precise timing varies, but for most people it is usually around 15:00-17:00. This is a good time to try to nap. On the other hand, it is also a time when it is more difficult to stay awake, so unintentional micro-sleeps are more likely, especially if recent sleep has been restricted.

Augmented flight crew**.** A flight crew that comprises more than the minimum number required to operate the aeroplane so that each crew member can leave his or her assigned post to obtain in-flight rest and be replaced by another appropriately qualified crew member.

Bio-mathematical Model. A computer programme 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. Bio-mathematical models are an optional tool (not a requirement) for predictive fatigue hazard identification within an FRMS. All bio-mathematical models have limitations that need to be understood for their appropriate use.

Circadian body clock. A neural pacemaker in the brain that is sensitive to the day/night cycle (via a special light input pathway from the eyes) and determines our preference for sleeping at night. Shift work is problematic because it requires a shift in the sleep/wake pattern that is resisted by the circadian body clock, which remains ‘locked on’ to the day/night cycle. Jet lag is problematic because it involves a sudden shift in the day/night cycle to which the circadian body clock will eventually adapt, given enough time in the new time zone.

****Civil aviation safety inspector (CASI).*** A designated official working on behalf of a State’s Civil Aviation Authority who is competent, qualified and authorized to execute specific inspection tasks, and who may undertake duties pertaining to the development, administration, and/or enforcement of national regulations and standards.

Countermeasures. Personal mitigation strategies that individuals can use to reduce their own fatigue risk. Sometimes divided into strategic countermeasures (for use at home, for example good sleep habits, napping before night duty), and operational countermeasures, for example strategic use of caffeine.

***Crew member*.** A person assigned by an Operator to duty on an aircraft during a flight duty period.

Cumulative sleep debt. Sleep loss accumulated when sleep is insufficient for multiple nights (or 24-hr days) in a row. As cumulative sleep debt builds up, performance impairment and objective sleepiness increase progressively, and people tend to become less reliable at assessing their own level of impairment.

****Duty*.** *This term is used with the same intent in different Annexes although specific definitions vary according to the context of the Annex in which they appear:*

***- Duty (Annex 6, Parts I and III)*.** Any task that flight or cabin crew members are required by the operator to perform, including flight duty, administrative work, training, positioning and standby when it is likely to induce fatigue.

- Duty (Annex 11). Any task that an air traffic controller is required by an air traffic services provider to perform. These tasks include those performed during time-in-position, administrative work and training.

****Duty period*.** *This term is used with the same intent in different Annexes although specific definitions vary according to the context of the Annex in which they appear:*

- Duty period (Annex 6, Parts I and III). A period which starts when a flight- or cabin-crew member is required by an operator to report for or to commence a duty and ends when that person is free from all duties.

- Duty period (Annex 11). A period which starts when an air traffic controller is required by an air traffic services provider to report for or to commence a duty and ends when that person is free from all duties.

Evening wake maintenance zone. A period of several hours in the circadian body clock cycle, just before usual bedtime, when it is very difficult to fall asleep. Consequently, going to bed extra early usually results in taking a longer time to fall asleep, rather than getting extra sleep. Can cause restricted sleep and increased fatigue risk with early duty start times.

****Fatigue.*** 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 perform safety related operational duties.

Fatigue Safety Action Group (FSAG). A group comprised of representatives of all stakeholder groups (management, scheduling, operational personnel) together with any additional specialist experts (i.e. scientists, data analysts, and medical professionals), that is responsible for coordinating all fatigue management activities in the organization.

****Fatigue Risk Management System (FRMS).*** A data-driven means of continuously monitoring and managing fatigue-related safety risks, based upon scientific principles and knowledge as well as operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness.

****Flight duty period.*** A period which commences when a flight or cabin crew member is required to report for duty that includes a flight or a series of flights and which finishes when the aircraft finally comes to rest and the engines are shut down at the end of the last flight on which he is a crew member.

****Flight time — aeroplanes.*** The total time from the moment an aeroplane first moves for the purpose of taking off until the moment it finally comes to rest at the end of the flight.

****Flight time — helicopters.*** The total time from the moment a helicopter's rotor blades start turning until the moment the helicopter finally comes to rest at the end of the flight, and the rotor blades are stopped.

****Hazard.*** A condition or an object with the potential to cause or contribute to an aircraft incident or accident.

Internal alarm clock. A time in the circadian body clock cycle when there is a very strong drive for waking and it is difficult to fall asleep or stay asleep. Occurs about 6 hours after the **Window of Circadian Low** in the late morning to early afternoon and can cause restricted sleep and increased fatigue risk after night duty.

Jet lag. Desynchronization between the circadian body clock and the day/night cycle caused by transmeridian flight (experienced as a sudden shift in the day/night cycle). Also results in internal desynchronization between rhythms in different body functions. Resolves when sufficient time is spent in the new time zone for the circadian body clock to become fully adapted to local time.

Micro-sleep. A short period of time (seconds) when the brain disengages from the environment (it stops processing visual information and sounds) and slips uncontrollably into light non-REM sleep. Micro-sleeps are a sign of extreme physiological sleepiness.

Mitigations. Interventions designed to reduce a specific identified fatigue risk.

Non-rapid eye movement sleep (Non-REM sleep). A type of sleep associated with gradual slowing of electrical activity in the brain (seen as brain waves measured by electrodes stuck to the scalp, known as EEG). As the brain waves slow down in non-REM sleep, they also increase in amplitude, with the activity of large groups of brain cells (neurons) becoming synchronized. Non-REM sleep is usually divided into 3 stages, based on the characteristics of the brainwaves. Stages N1 and N2 represent lighter sleep. Stage N3 represents deeper sleep and is also known as ***slow-wave sleep***.

Non-REM/REM Cycle. Regular alternation of non-REM sleep and REM sleep across a sleep period, in a cycle lasting approximately 90 minutes.

On-call. A defined period of time, during which an individual is required by the service provider to be available to receive an assignment for a specific duty. Synonymous with ***standby.***

****Operational personnel.*** Personnel involved in aviation activities who are in a position to report safety information. (For the purposes of this manual, the relevant operational personnel are those for whom ICAO Fatigue Management Standards and Recommended Practices apply.)

Pairing. A scheduling expression describing the time from when a flight crew member initially reports for duty until he/she returns home from the sequence of flights and is released from duty (see ***Trip***).

Rapid eye movement sleep (REM sleep). A type of sleep during which electrical activity of the brain resembles that during waking. However, from time to time the eyes move around under the closed eyelids – the ‘rapid eye movements’ – and this is often accompanied by muscle twitches and irregular heart rate and breathing. People awakened from REM sleep can typically recall vivid dreaming. At the same time, the body cannot move in response to signals from the brain, so dreams cannot be ‘acted out’. The state of paralysis during REM sleep is sometimes known as the ‘REM block’.

Recovery sleep. Sleep required for recovery from the effects of acute sleep loss (in one 24-hour period) or cumulative sleep debt (over multiple consecutive 24-hour periods).

****Rest period.*** A continuous and defined period of time, subsequent to and/or prior to duty, during which flight or cabin crew members are free of all duties.

Roster (noun). A list of planned shifts or work periods within a defined period of time. Synonymous with ***Schedule;***
(verb). To assign individuals to a schedule or pattern of work. Synonymous with ***Schedule.***

****Safety.*** The state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level.

****Safety management system (SMS).*** A systematic approach to managing safety, including the necessary organizational structures, accountability, responsibilities, policies and procedures.

****Safety oversight.*** A function performed by a State to fulfil its responsibility for the effective implementation of safety-related Standards and Recommended Practices (SARPs), guidance material and associated procedures, as well as national regulations, including SMS where required.

****Safety performance.*** A State or a service provider's safety achievement as defined by its safety performance targets and safety performance indicators.

****Safety performance indicator.*** A data-based parameter used for monitoring and assessing safety performance.

****Safety performance target.*** The planned or intended objective for safety performance indicator(s) over a given period.

****Safety risk.*** The predicted probability and severity of the consequences or outcomes of a hazard.

Schedule (noun). A list of planned shifts or work periods within a defined period of time. Synonymous with ***Roster***.
(verb). *To* assign individuals to a roster or pattern of work. Synonymous with ***Roster***.

Shift work. Any work pattern that requires an individual to be awake at a time in the circadian body clock cycle that they would normally be asleep.

Sleep. A reversible state in which conscious control of the brain is absent and processing of sensory information from the environment is minimal. The brain goes "off-line" to sort and store the day's experiences and replenish essential systems depleted by waking activities.

Sleep debt. See ***Cumulative sleep debt.***

Sleep disorders. A range of problems that make it impossible to obtain restorative sleep, even when enough time is spent trying to sleep. Examples include obstructive sleep apnea, the insomnias, narcolepsy, and periodic limb movements during sleep.

Sleep homeostatic process. The body's need for ***slow-wave sleep*** (non-REM stage N3), that builds up across waking and discharges exponentially across sleep.

Sleep inertia. Transient disorientation, grogginess and performance impairment that can occur after wakening. The length and intensity of sleep inertia is greatest when the individual has not had enough sleep, is woken from **slow-wave sleep** (non-REM stages 3 and 4) or woken during the window of circadian low (WOCL).

Sleep need. The amount of sleep that is required on a regular basis to maintain optimal levels of waking alertness and performance. Sleep need is very difficult to measure in practice because of individual differences. In addition, because many people live with chronic sleep restriction, when they have the opportunity for unrestricted sleep, their sleep may initially be longer than their theoretical 'sleep need' due to recovery sleep.

Sleep quality. Capacity of sleep to restore waking function. Good quality sleep has minimal disruption to the non-REM/REM cycle. Frequent fragmentation of the non-REM/REM cycle by waking up, or by brief arousals that move the brain to a lighter stage of sleep without actually waking up, decreases the restorative value of sleep.

Sleep restriction. Obtaining less sleep than needed. The effects of sleep restriction accumulate, with performance impairment and objective sleepiness increasing progressively. The need for sleep will eventually build to the point where people fall asleep uncontrollably (see ***Micro-sleep***).

Slow-wave sleep. The deepest stage of non-REM sleep (stage N3), characterized by high amplitude slow brainwaves.

Standby**.** A defined period of time, during which an individual is required by the service provider to be available to receive an assignment for a specific duty. Synonymous with ***on call.***

****State safety programme (SSP).*** An integrated set of regulations and activities aimed at improving safety.

Transient fatigue. Impairment accumulated across a single duty period, from which complete recovery is possible during the next rest period.

Trip. A scheduling expression describing the time from when a flight crew member initially reports for duty until he/she returns home from the sequence of flights and is released from duty. A trip may include multiple flights and many days of travel (see ***Pairing***).

Unforeseen operational circumstance**.** Unexpected conditions that could not reasonably have been predicted and accommodated, such as bad weather or equipment malfunction, which may result in necessary on-the-day operational adjustments.

Unrestricted sleep. Sleep which is not restricted by any demands. Sleep can begin when an individual feels sleepy, and does not have to be delayed for any reason. In addition, the individual can wake up spontaneously and does not have to set the alarm.

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.

ACRONYMS

ATC	Air Traffic Controller
ATS provider	Air Traffic Service provider
CASI	Civil Aviation Safety Inspector
FRMS	Fatigue Risk Management System
FSAG	Fatigue Safety Action Group
SMS	Safety Management System
SPIs	Safety Performance Indicators
SSP	State Safety Programme
WOCL	Window of circadian low

CHAPTER 1. INTRODUCTION TO FATIGUE MANAGEMENT

The aviation industry provides one of the safest modes of transportation in the world. Nevertheless, a safety-critical industry must actively manage hazards with the potential to impact safety. Fatigue is now acknowledged as a hazard that degrades various types of human performance, and can contribute to aviation accidents or incidents. Fatigue is inevitable in a 24/7 industry because the human brain and body function optimally with unrestricted sleep at night. Therefore, as fatigue cannot be eliminated, it must be managed.

1.1. FATIGUE MANAGEMENT APPROACHES SUPPORTED BY ICAO SARPS

Fatigue management refers to the methods by which service providers and operational personnel address the safety implications of fatigue. In general, ICAO Standards and Recommended Practices (SARPs) in various Annexes support two distinct methods for managing fatigue:

1. a prescriptive approach that requires the service provider to comply with duty time limits defined by the State, while identifying and managing fatigue hazards through the SMS processes; and
2. a performance-based approach that allows service providers an option to develop and implement a fatigue risk management system (FRMS) that is approved by the State.

These approaches share two important basic features. First, they are based on scientific principles and knowledge and operational experience that should take into account:

- the need for adequate sleep (not just resting while awake) to restore and maintain all aspects of waking function (including alertness, physical and mental performance, and mood);
- the circadian rhythms that drive changes in the ability to perform mental and physical work, and in sleep propensity (the ability to fall asleep and stay asleep), across the 24h day;
- interactions between fatigue and workload in their effects on physical and mental performance; and
- the operational context and the safety risk that a fatigue-impaired individual represents in that context.

Second, because fatigue is affected by all waking activities (not only work demands), fatigue management has to be a shared responsibility between the State, service providers and individuals:

- the State is responsible for providing a regulatory framework that enables fatigue management and ensuring that the service provider is managing fatigue-related risks to achieve an acceptable level of safety performance. The State is required to establish prescriptive limitation regulations for specified safety-critical personnel. However, the establishment of FRMS regulations is optional, depending on the experience level and resources of the State, and necessary only where the intention is to allow service providers to move outside of prescriptive fatigue management regulations (Section 1.1.1 refers).
- service providers are responsible for providing fatigue-management education, implementing work schedules that enable individuals to perform their duties safely, and having processes for monitoring and managing fatigue hazards (Section 3.3 refers); and

- individuals are responsible for arriving fit for duty, including making appropriate use of non-work periods to obtain sleep, and for reporting fatigue hazards (Section 3.3 refers).

1.1.1. STATE RESPONSIBILITIES FOR FATIGUE MANAGEMENT APPROACHES

For the purposes of fatigue management, the State is responsible for providing:

- a regulatory framework that enables adequate fatigue management. (For specified safety-critical personnel, States are required to establish prescriptive fatigue management regulations and also have the option of establishing FRMS regulations.);
- technical guidance, tools, procedures and information associated with its requirements for fatigue management; and
- effective oversight that ensures service providers are managing their fatigue-related risks to achieve an acceptable level of safety performance.

The means by which States meet these responsibilities differ according to the fatigue management approach used. These are discussed below.

PRESCRIPTIVE FATIGUE MANAGEMENT

In a prescriptive approach to fatigue management, the State is responsible for establishing prescriptive flight and/or duty limitations based on scientific knowledge and operational experience. This approach requires the State to prescribe maximums for work periods, minimums for non-work periods and other elements as relevant to the risks associated with a specific type of work (e.g. limiting consecutive night duties, increasing controls with increasing numbers of time zone crossings).

The prescribed limits are essentially ‘informed boundaries’ identified by the State that aim to address the general fatigue risk for particular groups of aviation professionals. To address different risks, personnel in different industry sectors are likely to need unique limitations (e.g. flight and duty limitations for airline pilots will differ from those for helicopter pilots and from the duty limitations of air traffic controllers).

Through their oversight practices, the State ensures that the service provider is managing their fatigue risk to an acceptable level within the constraints of the prescriptive limitations and requirements using SMS processes applied to their operational context. This means that operational personnel should be sufficiently alert to perform at an adequate level in normal and abnormal situations.

Prescriptive fatigue management regulations provide the baseline, in terms of safety equivalence, from which an FRMS is assessed. Therefore, before providing FRMS regulations, the State needs to be confident that it has robust, scientifically-based prescriptive limitation regulations appropriate to the context in which they are to be used and that their inspectors provide adequate oversight of these regulations.

Chapter 4 provides information on the establishment of prescriptive limitation regulations and the oversight of a service provider who implements a prescriptive fatigue management approach.

FRMS

States have the option of whether they will establish FRMS regulations. However, if a State intends to allow service providers to move outside of prescriptive limitations through the implementation of an FRMS, they must commit to establishing FRMS regulations and the associated oversight methodology. An FRMS is not the same as an SMS, and it requires a separate approval process.

Implementing FRMS is more onerous than the prescriptive approach for both the State and the service provider due to the increased effort and resources needed to focus specifically on fatigue risk. A State should only consider establishing FRMS regulations when it has the confidence it can provide the necessary oversight of a service provider's FRMS from a scientific and performance-based perspective. While FRMS can offer considerable safety and efficiency benefits, these may be reversed if the State does not have the resources to develop the supporting regulatory processes and provide the necessary oversight.

Even when a State has the resources, it may be that the industry group being served does not need FRMS regulations and can operate comfortably within prescriptive limits. Despite this, it is possible that many service providers will want to implement an FRMS, given that this offers the possibility of increased flexibility outside of prescribed limits. Importantly, an FRMS should not be considered a 'right' of all service providers. It is more a privilege for those who have demonstrated that they can use mature SMS processes to manage fatigue, can capture and analyze fatigue data, and who are prepared to do even more. Section 6.1 discusses the considerations when States are making the decision to offer FRMS regulations.

Where a State chooses to establish FRMS regulations, it will be required to have an FRMS approval process in order to assess the suitability and effectiveness of each FRMS in the operations to which they apply. This process ensures that the associated level of safety is at least equivalent to, if not better, than that achieved through compliance with the prescribed limits. The FRMS approval process and continued oversight is described in detail in Section 6.2.

1.1.2 COMPARING PRESCRIPTIVE AND FRMS APPROACHES

Prescriptive limitation regulations identify maximum work periods and minimum non-work periods for specific groups of aviation professionals. Within these limits the service provider must manage their fatigue-related risks as part of their existing safety management processes. With a prescriptive approach, fatigue is one of the possible hazards that the SMS should consider, but data-driven evidence related to fatigue is not specifically and actively collected unless a fatigue issue has been identified.

When complying with prescribed limits, the service provider is obligated to manage their risks, including those related to fatigue, using their SMS.

The FRMS approach represents an opportunity for service providers to use advances in scientific knowledge to use resources more efficiently and increase operational flexibility, whilst maintaining or even improving safety. An FRMS is a specialized system that uses principles and processes, similar to those of an SMS, to specifically manage fatigue risks. FRMS seeks to achieve a realistic balance between safety, productivity, and costs. However, an FRMS is a separate system from an SMS, focused specifically on fatigue risk. To move outside of prescriptive limitations, an FRMS has to be implemented, and the onus shifts to the service provider to prove to the State that what they propose to do and how they continue to operate under an FRMS is safe. Therefore, implementation of an FRMS requires explicit approval and has requirements over and above those associated with a prescriptive approach:

An FRMS allows a service provider to go beyond prescribed limits. With an FRMS, the service provider must do more to manage fatigue than would reasonably be expected using an SMS.

- The service provider must identify and assess potential fatigue risks prior to conducting operations outside of the prescriptive flight and duty time limits and validate the effectiveness of their mitigations to the satisfaction of the State.
- An FRMS approach requires additional resources to be allocated to fatigue management, enhanced processes specifically established to address identified operational fatigue risks, and more comprehensive fatigue management training than that required for working within the prescriptive flight and duty time limitations only. Full documentation is required.
- The fatigue monitoring data required for operational FRMS activities are more comprehensive than what is required for managing fatigue in operations that operate within the prescriptive limits and are managed under an operator's SMS.

Where a service provider already has sufficiently mature SMS processes in place, it should not be necessary for them to develop entirely new processes to implement FRMS. Rather, the service provider can build upon the organization's existing SMS processes to address the added requirements of an FRMS.

Chapter 5 provides detailed information on how an FRMS functions.

The cost and complexity of an FRMS may not be justified for operations that can operate comfortably inside prescribed limits and where fatigue-related risk is low. Where their State has developed FRMS regulations and oversight capabilities, service providers have the opportunity to manage none, some, or all of their operations under an FRMS. Where FRMS regulations are not established, service providers must comply with the State's prescriptive limitation regulations.

Table 1-1 compares key characteristics of the two fatigue-management approaches.

Table 1-1. A comparison of key characteristics of prescriptive and FRMS fatigue-management approaches

		PRESCRIPTIVE APPROACH	FRMS APPROACH
AIM	The State	• The State ensures that the service provider is managing their fatigue risks to a level acceptable to the State.	• The State ensures that the service provider is managing their fatigue risks to a level equivalent to, or better than, a prescriptive approach.
AIM	Service provider	• Service provider manages fatigue risks within constraints of prescribed limits using existing SMS processes.	• Service provider identifies their limits, manages their fatigue risks within agreed safety objectives and targets, and monitors them through their FRMS processes. These are continually assessed and may be altered as a result of FRMS experience.
POLICY & DOCUMENTATION	The State	• Regulator sets the regulations for prescriptive limits and service provider obligations. The prescriptive limits are intended to be outer limits, not targets.	• The State establishes FRMS regulations and develops processes for approval and oversight of FRMS.
POLICY & DOCUMENTATION	Service provider	• Service provider's SMS policy includes fatigue as a hazard to be managed. • Service provider documents duty time limits and non-duty time minimums in their operations manual. • Service provider maintains records of planned and actual working times.	• Service provider has specific FRMS policy signed by the accountable executive. • Service povider's policy defines maximum work periods and minimum non-work periods for each operation covered by the FRMS. These limits may be altered by agreement with the Regulator as a result of FRMS experience. • Service provider develops full FRMS documentation including description of processes, outputs and training records. • Service provider develops specific fatigue report procedures and documentation. • Service provider documents decisions and actions made in response to fatigue hazards detected by the FRMS. • Service provider maintains records of planned and actual working times.
FATIGUE RISK MANAGEMENT PROCESSES	The State	• The State identifies generic fatigue hazards within an operational context. • The State makes risk assessment based on generic information (scientific principles, literature reviews, best practices). • The State identifies prescriptive limits.	• The State reviews and approves the service provider's maximum work periods and minimum non-work periods for each part of their operations covered by the FRMS. • The State reviews and approves the service provider's processes for fatigue hazard identification, risk assessment and mitigation.
FATIGUE RISK MANAGEMENT PROCESSES	Service provider	• Service provider identifies fatigue hazards mainly through reactive processes, including data collected through existing safety reporting mechanisms. • Service provider considers scientific principles when developing work schedules (rosters) that are compliant with prescriptive limitation regulations. • Service provider assesses and mitigates their fatigue-related risks using existing SMS processes.	• Service provider identifies maximum work periods and minimum non-work periods for each part of their operations covered by the FRMS. • Service provider develops and implements reactive, proactive and predictive processes for identifying fatigue. • Service provider develops and implements fatigue risk assessment methodologies and adds specific fatigue mitigation strategies.

		PRESCRIPTIVE APPROACH	FRMS APPROACH
SAFETY ASSURANCE	The State	• The State reviews compliance with prescriptive limits. • The State reviews service provider's scheduling practices to evaluate whether they are based on scientific principles. • SMS Safety Performance Indicators are agreed by the State and service provider.	• The State reviews and agrees to service provider-identified Safety Performance Indicators. • The State may require adjustment of service provider-identified maximum duty limits and non-duty minimums.
	Service provider	• SMS Safety Performance Indicators are agreed by regulator and service provider. • Service provider considers changes to its operating environment and any impacts these changes may have on fatigue risks.	• Service provider identifies FRMS Safety Performance Indicators. • Service provider considers changes to its operating environment and any impacts these changes may have on fatigue risks.
TRAINING AND COMMUNICATION	The State	• The State provides guidance for safety education and promotional material that includes fatigue.	• The State provides guidance for FRMS training and promotional material. • The State assesses the service provider's fatigue training programme. • The State develops an FRMS approval and oversight training programme for inspectors. • The State assesses the effectiveness of their FRMS training programme.
	Service provider	• Service provider assesses fatigue management training needs using SMS processes. • Service provider safety training includes fatigue management specific to the operational context. • Service provider keeps safety training records. • Service provider considers fatigue when reporting on safety performance. • Service provider includes general fatigue information in internal safety communications.	• Service provider training includes fatigue management specific to how the FRMS works and roles of the various stakeholders. • Service provider assesses the effectiveness of their FRMS training programme. • Service provider keeps safety training records. • Service provider identifies a feedback process to communicate fatigue issues identified through data collection. • Service provider includes fatigue topics in internal safety communications.

1.2. ICAO FATIGUE-MANAGEMENT SARPS

ICAO fatigue management Standards and Recommended Practices (SARPs) that support these approaches to fatigue management are provided in the following Annexes:

- Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport – Aeroplanes* pertains to flight and cabin crew;
- Annex 6 — *Operation of Aircraft*, Part II — *International General Aviation – Aeroplanes*, Section 2 applies to all international General Aviation (GA) operations and Section 3 pertains to all operator personnel involved in the operation and maintenance of large and turbojet aeroplanes in GA operations;
- Annex 6 — *Operation of Aircraft,* Part III — *International Operations – Helicopters*, Section II pertains to flight and cabin crew of international commercial air transport helicopters; and
- Annex 11 — *Air Traffic Services* pertains to air traffic controllers.

It should be noted that, in the case of Annex 6, ICAO SARPs pertain only to international air transport and are developed to reflect the types of international operations covered in its different Parts. While it is recognized that many States also choose to establish regulations for domestic operations based on ICAO SARPs and guidance, ICAO provisions have not been developed with domestic operations in mind.

Further, consistent with the intent of the fatigue management SARPs to manage fatigue-related risks in operations, some States extend the applicability of their associated regulations to include personnel other than those identified in ICAO SARPs.

Where ICAO SARPs are used as a basis for developing regulations for types of operations and personnel outside those addressed in a particular Annex, States are reminded that their fatigue management regulations may need to be adjusted to reflect the particular risk profiles of different types of operations.

An overview of the fatigue management SARPs are provided below. Appendix A presents the actual fatigue management SARPs, along with a detailed description to ensure clarity of their intent, according to the Annex in which they appear.

1.2.1. ANNEX 6, PART I

In Annex 6, Part I, SARPs related to fatigue management are found in:

- Chapter 4, Section 4.10;
- Appendix 2, Section 2.1.2; and
- Appendix 7

Section 4.10 of Annex 6, Part I presents the fatigue management SARPs for flight and cabin crew on international commercial airline operations. The first Standard (4.10.1) presents the fatigue management regulations to be established by States. It identifies regulations prescribing flight and duty limits as mandatory and FRMS regulations as optional. Standard 4.10.2 identifies the obligations and options the operator has for managing its fatigue-related safety risks, depending on whether the State offers FRMS regulations.

Standard 4.10.3 specifically addresses variations to prescriptive limits while Standards 4.10.4 to 4.10.7 (the latter is actually a recommendation) identify additional requirements associated with FRMS regulations. Standard 4.10.6 outlines the components of an FRMS and directs the reader to Appendix 7 of Annex 6, Part I, which details the minimum requirements within each of these FRMS components. The last Standard in the fatigue management section (4.10.8) requires records of flight and duty times to be maintained and relates to both prescriptive limitation regulations and FRMS regulations.

These SARPs can be summarized in a diagram as follows in Figure 1-1.

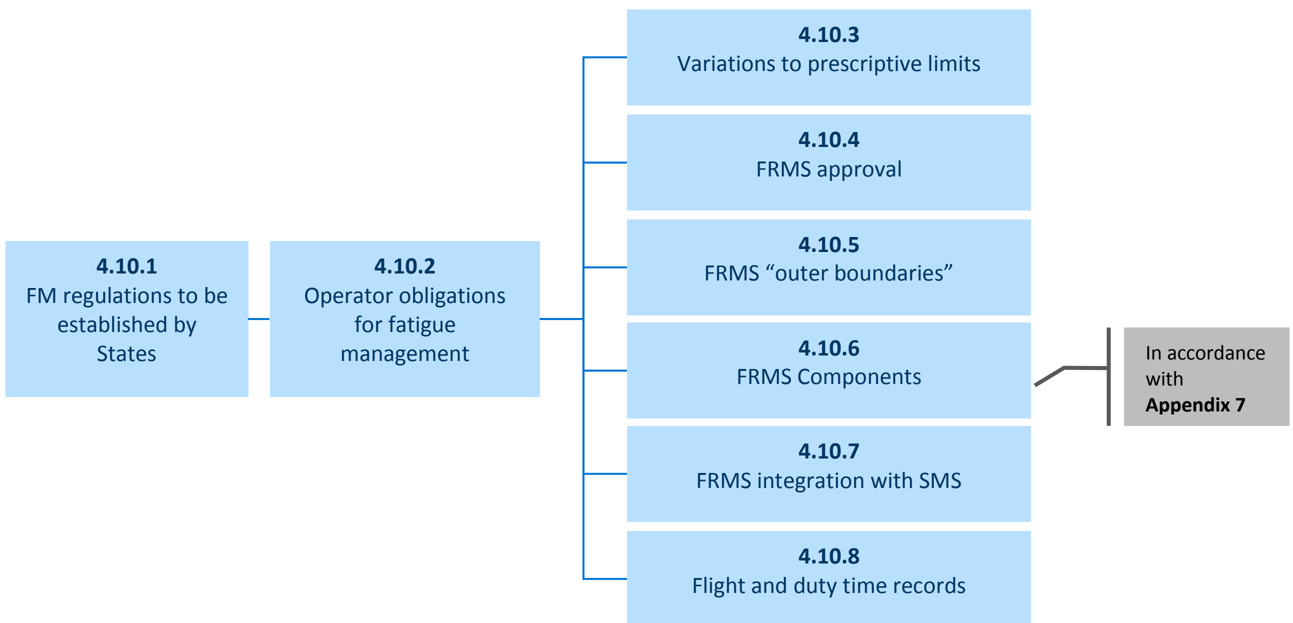

Figure 1-1. Structure of Annex 6, Part I, 4.10 Fatigue Management SARPs

Appendix 2, Section 2.1.2 identifies the fatigue management-related content that must be included in an Operations Manual. This includes the operator's rules pertaining to flight time, flight duty period, duty period limitations and rest requirements for flight and cabin crew members as well as FRMS policy and documentation.

Details of the Annex 6, Part I fatigue management SARPs and their intent are discussed in Appendix A. of this manual under Section A 1.

1.2.2. ANNEX 6, PART II

The two fatigue management SARPs in Annex 6, Part II are presented in different sections:

- section 2 is primarily focused on the pilot-in-command in any international general aviation operation. Paragraph 2.2.5.2 of this section (Duties of pilot-in-command) presents a Standard which outlines the responsibilities of the pilot-in-command with regards to managing fatigue risks; and
- section 3 focuses on the operators of large and turbojet aeroplanes conducting international general aviation operations. Paragraph 3.4.2.8 of this section (Fatigue management programme) outlines the fatigue management responsibilities of such operators.

Although the underlying philosophy remains the same, Annex 6, Part II fatigue management SARPs vary from those in other Annexes where the State must provide prescriptive flight and duty time regulations. Instead, GA operators are expected to establish their own flight and duty time limitations and use their SMS processes to develop a fatigue management programme to manage their fatigue risk.

Details of the Annex 6, Part II fatigue management SARPs and their intent are discussed in Appendix A. of this manual under Section A 2.

1.2.3. ANNEX 6, PART III

SARPs pertaining to international **commercial air transport** helicopter operations and to international **general aviation** helicopter operations differ and are presented in separate sections of Annex 6, Part III.

Section II of Annex 6, Part III addresses international **commercial air transport helicopter** operations[2]. In Annex 6, Part III (Section II), SARPs related to fatigue management are found in:

- Chapter 2, Section 2.8 - Fatigue Management;
- Appendix 6; and
- Attachment G

Section 2.8 presents the fatigue management SARPs for flight and cabin crew on international commercial air transport helicopter operations. In this section, the first Standard (2.8.1) presents the fatigue management regulations to be established by States. It identifies regulations prescribing duty limits as mandatory and the establishment of FRMS regulations as optional. If established, FRMS regulations must be in accordance with Appendix 6 of Annex 6, Part III.

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[2] ICAO defines commercial air transport operations as those "involving the transport of passengers, cargo or mail for remuneration or hire". For commercial helicopter operations that do not conform to this strict definition, States do not need to comply with the fatigue management SARPs in Annex 6, Part III (Section II). However, it is recognized that some States may choose to extend the applicability of their fatigue management regulations to include these types of commercial helicopter operations.

Further, the fatigue management SARPs in Annex 6, Part III (Section II) refer specifically to flight and cabin crew. Some States choose to establish fatigue management regulations that include helicopter technical crew, such as search and rescue hoist operators and specialist technical crew members on HEMS operations.

Standard 2.8.2 identifies the obligations and options the CAT helicopter operator has for the management of its fatigue-related safety risks, depending on whether their State offers FRMS regulations. Standard 2.8.3 requires records of flight and duty times to be maintained and relates to both prescriptive limitation regulations and FRMS regulations. Standards 2.8.4 and 2.8.5 list additional requirements associated with prescriptive regulations and FRMS regulations, respectively.

This can be summarized in a diagram as follows in Figure 1-2.

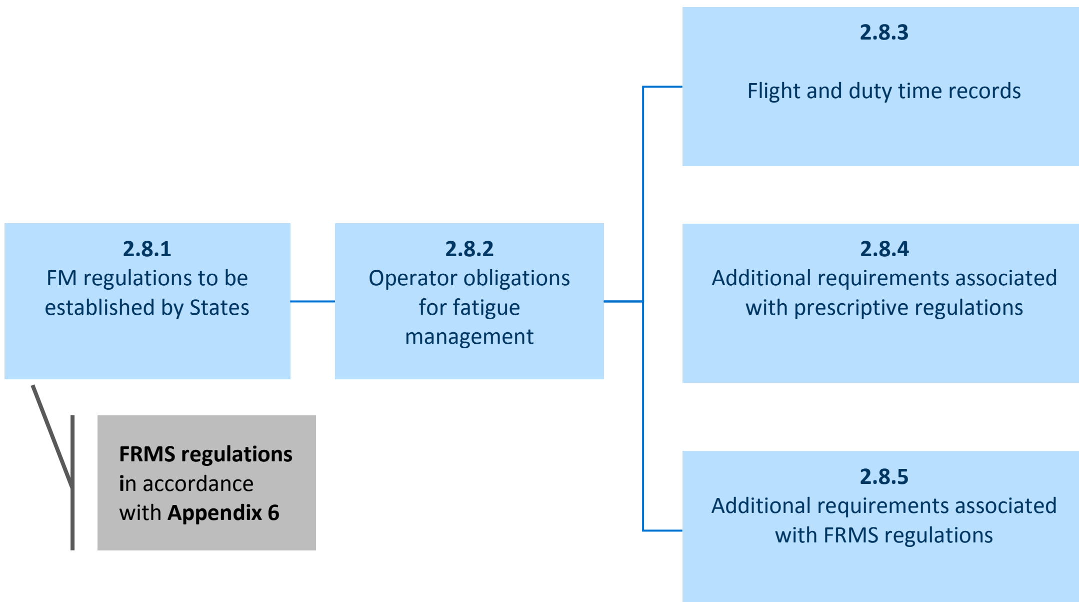

Figure 1-2. Structure of Annex 6, Part III (Section II), 2.8 Fatigue Management SARPs

Annex 6, Part III (Section II) fatigue management SARPs and their intent are discussed in Appendix A. of this manual under Section A3.

Section III of Annex 6, Part III addresses international **general aviation** helicopter operations. For these operations, current fatigue management-related SARPs are limited to those pertaining to the pilot-in-command's responsibilities for fitness for duty and are not addressed in this document.

1.2.4. ANNEX 11

In Annex 11, SARPs related to fatigue management are found in:

- Chapter 2, Section 2.28;
- Appendix 6; and
- Appendix 7

Section 2.28 of Annex 11 relates to fatigue management of air traffic controllers. In this section, the first Standard (2.28.1) presents the fatigue management regulations to be established by States. It identifies regulations prescribing duty limits as mandatory and directs the reader to Appendix 6 of Annex 11, which then details what the prescriptive regulations must address. Also identified in 2.28.1 is the option of FRMS regulations which, if established, must be done so in accordance with Appendix 7 of Annex 11. Standard 2.28.2 identifies the obligations and options the air traffic services (ATS) provider has for the management of its fatigue-related safety risks, depending on whether their State offers FRMS regulations. Standards 2.28.3 and 2.28.4 list additional requirements associated with prescriptive regulations and FRMS regulations, respectively.

This can be summarized in a diagram as follows in Figure 1-3:

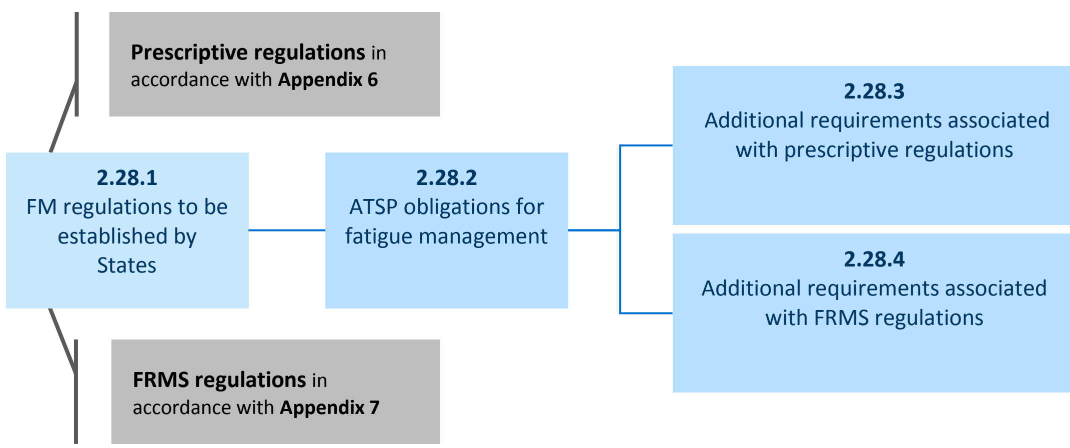

Figure 1-3. Structure of Annex 11, 2.28 Fatigue Management SARPs

Details of the Annex 11 fatigue anagement SARPs and their intent are discussed in Appendix A. of this manual under Section A3.

CHAPTER 2. THE SCIENTIFIC PRINCIPLES OF FATIGUE MANAGEMENT

The operational demands in aviation continue to change in response to changes in technology and commercial pressures, but human physiology remains unchanged. Both prescriptive fatigue management regulations and FRMS represent an opportunity to use advances in scientific understanding of human physiology to better address fatigue risks in aviation settings. This chapter describes the scientific principles that are fundamental to understanding how fatigue is generated, and how it can be managed.

Fatigue results in a reduced ability to carry out operational duties and can be considered an imbalance between:

- the physical and mental demands of all waking activities (not only duty demands); and
- recovery from those demands, which (except for recovery from muscle fatigue) requires sleep.

Fatigue. 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

Following this line of thinking, to reduce fatigue in operations, strategies are required to manage the demands of waking activities and to improve sleep. Two areas of science are central to this and are the focus of this chapter.

1. Sleep science — particularly the effects of not getting enough sleep (on one night or across multiple nights), and how to recover from sleep loss;
2. Circadian rhythms — daily cycles in physiology and behaviour that are driven by the circadian clock (a pacemaker in the brain). Aspects of physiology and behaviour that show circadian rhythms include:
   - subjective feelings of alertness and sleepiness;
   - ability to perform mental and physical work; and
   - ability to fall asleep and stay asleep (sleep propensity).

ICAO requires that regulations be established, based upon scientific principles for the purpose of managing fatigue. 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, and can be summarized as:

1. Periods of wake need to be limited. Getting enough sleep (both quantity and quality) on a regular basis is essential for restoring the brain and body.
2. Reducing the amount or the quality of sleep, even for a single night, decreases the ability to function and increases sleepiness the next day.
3. The circadian body clock affects the timing and quality of sleep and produces daily highs and lows in performance on various tasks.
4. Workload can contribute to an individual's level of fatigue. Low workload may unmask physiological sleepiness while high workload may exceed the capacity of a fatigued individual.

These principles are described further in the following sections.

2.1. SCIENTIFIC PRINCIPLE 1: THE NEED FOR SLEEP

Have you ever wondered what happens from the time you fall asleep at night to when you wake up in the morning? If you have slept well, you will wake up feeling physically and mentally refreshed. Your experiences of the previous day will have been sorted, stored, and linked to your existing memories so that you wake up with a seamless sense of who you are. If you have not slept well, you know that the coming day will not be easy.

We are meant to spend about a third of our lives asleep. The optimal amount of sleep per night varies between individuals, but most healthy adults require between 7 and 9 hours. There is a widespread belief that sleep time can be traded off to increase the amount of time available for waking activities in a busy lifestyle. Sleep science makes it very clear that sleep cannot be sacrificed without consequences. Sleep has multiple functions – the list keeps growing - but it is clear that it has vital roles in memory and learning, in maintaining alertness, performance, and mood, and in overall health and well-being.

SCIENTIFIC PRINCIPLE 1

PERIODS OF WAKE NEED TO BE LIMITED. GETTING ENOUGH SLEEP (BOTH QUANTITY AND QUALITY) ON A REGULAR BASIS IS ESSENTIAL FOR RESTORING THE BRAIN AND BODY.

2.1.1. TYPES OF SLEEP

A complex series of processes is taking place in the brain during sleep. Various methods have been used to look at these processes, from reflecting on dreams to using advanced medical imaging techniques. Sleep scientists have traditionally looked at sleep by monitoring electrical patterns in brain wave activity, eye movements, and muscle tone.

These measures indicate that there are two very different types of sleep:

- non-rapid eye movement (Non-REM) sleep; and
- rapid eye movement (REM) sleep.

NON-RAPID EYE MOVEMENT SLEEP (NON-REM SLEEP)

During non-rapid eye movement sleep (non-REM), brainwave activity gradually slows compared to waking brainwave activity. The body is being restored through muscle growth and repair of tissue damage. Non-REM sleep is sometimes described as "a quiet brain and quiet body". Across a normal night of sleep, most adults normally spend about three quarters of their sleep time in non-REM sleep.

Sleep is a complex series of processes that has multiple functions.

Non-REM sleep is divided into three stages, based on the characteristics of the brainwaves. Stages N1 and N2 represent lighter sleep (it is not very difficult to wake someone up). It is usual to enter sleep through Stage N1 and then Stage N2.

Stage N3 sleep is also known as slow-wave sleep (SWS) or deep sleep. Basically, in slow-wave sleep the brain stops processing information from the outside world and huge numbers of brain cells (neurons) start firing in synchrony, generating big, slow electrical waves. More stimulation is needed to wake someone up from SWS than from Stages N1 and N2. During SWS, consolidation of certain types of memory is occurring, so SWS is necessary for learning.

The longer you are awake and the more physically active you are, the more slow-wave activity your brain will show in your next sleep period. Thus SWS fits the traditional idea that sleep somehow restores you from the demands of waking activities. This is often described as the 'sleep homeostatic process'.

RAPID EYE MOVEMENT SLEEP

During rapid eye movement sleep (REM sleep) brainwave activity looks similar to waking brainwave activity. However, in REM sleep, from time to time the eyes move around under the closed eyelids — the so-called "rapid eye movements" — and it is often accompanied by muscle twitches and irregular heart rate and breathing. Most adults normally spend about a quarter of their sleep time in REM sleep.

There are two different types of sleep: non-REM and REM (rapid eye movement) sleep.

During REM sleep, the brain is repairing itself and information is consolidated from the previous day and being sorted and related to stored memories. People awakened from REM sleep can typically recall vivid dreaming. During REM sleep, the body cannot move in response to signals from the brain so dreams cannot be acted out. (The signals effectively get blocked in the brain stem and cannot get through to the spinal cord.) People sometimes experience brief paralysis when they wake up out of a dream, when reversal of this "REM block" is slightly delayed. Because of these features, REM sleep is sometimes described as a "busy brain and paralyzed body." Figure 2-1 summarizes the proportion of night time sleep that a young adult typically spends in each of the types of sleep.

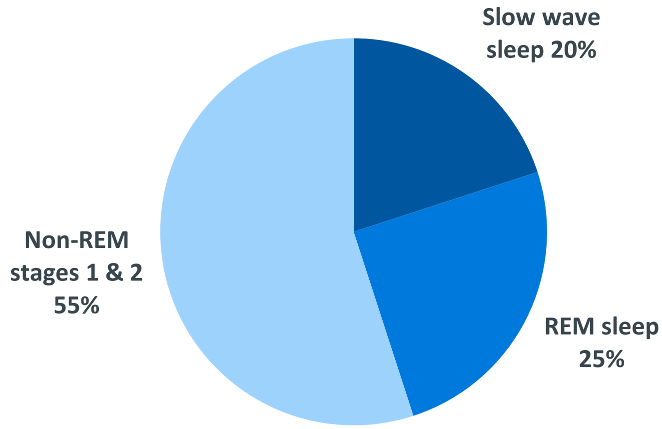

Figure 2-1. Proportion of the night spent in each type of sleep for a young adult

2.1.2. THE NON-REM/REM CYCLE

Across a normal night of sleep, non-REM sleep and REM sleep alternate in a cycle that lasts roughly 90 minutes (but is very variable in length, depending on a number of individual and environmental factors). Figure 2-2 is a diagram describing the non-REM/REM cycle across the night in a healthy young adult who goes to bed at 23:00 and awakens around 07:30. Real sleep is not as tidy as this — it includes more arousals (transitions to lighter sleep) and brief awakenings. Sleep stages are indicated on the vertical axis and time is represented across horizontal axis.

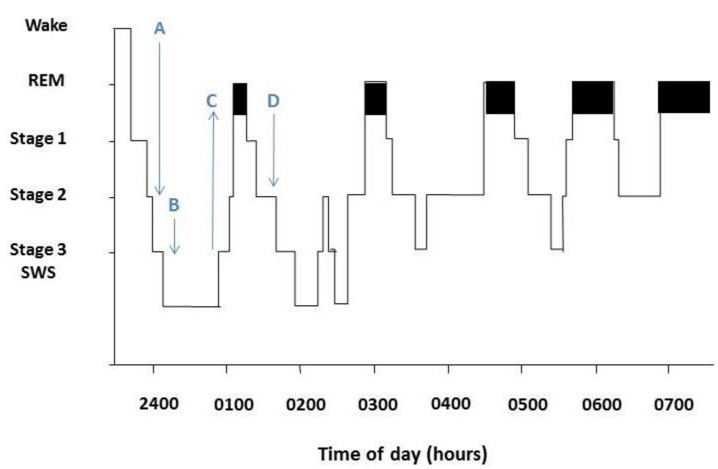

Figure 2-2. The Non-REM/REM cycle across the night for a healthy young adult[3]

[3] Figure provided by Prof. P.H. Gander, Sleep/Wake Research Centre, Massey University, New Zealand.

Sleep is entered through Stage N1 and then progresses through Stage N2 (see 'A' in Figure 2-2) and eventually into slow-wave sleep (see 'B' in Figure 2-2). About 80-90 minutes into sleep, there is a shift out of slow-wave sleep. This shift is often marked by body movements, as the sleeper transitions briefly through Stage N2 (see 'C' in Figure 2-2) and into the first REM period of the night (REM periods are indicated as shaded boxes in Figure 2-2). After a fairly short period of REM, the sleeper progresses back down again through lighter non-REM sleep (see 'D' in Figure 2-2) and into slow-wave sleep, and so the cycle repeats. In the morning, the sleeper in Figure 2-2 wakes up out of REM sleep and is likely to be able to remember dreaming.

In each non-REM/REM sleep cycle across a normal night of sleep:

- the amount of slow-wave sleep decreases (there may be none at all in later cycles); and
- in contrast, the amount of REM sleep increases.

Waking up from sleep is a process, not an on/off switch and various parts of the brain have to reactivate in sequence. People sometimes experience grogginess or disorientation when they first wake from sleep. This is known as sleep inertia. It can occur when waking from any stage of sleep but may be worse after longer periods of sleep, and is more severe when waking occurs during the night.

MITIGATION STRATEGIES FOR SLEEP INERTIA

The possible occurrence of sleep inertia is sometimes used as an argument against sleeping or napping when there is an expectation that an individual may be required to work at short notice. Although it would not be desirable to have an individual who is woken up for an emergency impaired by sleep inertia, the benefits of sleep must also be taken into account.

The risk of sleep inertia can be reduced by:

- having a protocol for returning to active duty that allows time for sleep inertia to dissipate. After any period of sleep longer than 20 minutes, at least 10-15 minutes should be allowed before recommencing safety-related duties or driving; and
- limiting the duration of a nap opportunity to no more than 20 minutes; however, such a short period of sleep will not provide sustained benefits for alertness.

Some emergency services operators have addressed the possible performance decrements associated with sleep inertia by introducing a protocol for returning to active duty that requires all key actions to be double checked. If the mission is non-urgent, then the crew need to wait 15 minutes before they return to safety-related tasks. See *Operational Implication 5: Napping as a Fatigue Mitigation* for more information on how napping can be used to mitigate fatigue.

2.1.3. FACTORS THAT AFFECT SLEEP QUALITY

The restorative value of sleep, or sleep quality, depends on going through uninterrupted non-REM/REM cycles, which suggests that both types of sleep are necessary and one is not more important than the other. The more the non-REM/REM cycle is fragmented by waking up, or by arousals that move the brain to a lighter stage of sleep without actually waking up, the less restorative value sleep has in terms of how you feel and function the next day.

For sleep to be fully restorative, it must contain unbroken cycles of non-REM and REM sleep.

OPERATIONAL IMPLICATION 2.
PROCEDURES FOR MINIMIZING SLEEP INTERRUPTIONS

Because uninterrupted non-REM/REM cycles are the key to good quality sleep, there should be procedures in place to minimize possible interruptions during both work and non-work periods. For example, individuals who are able to sleep when on duty (such as on standby at home or on standby at base) should be provided with protected blocks of time for sleep during which they are not contacted except in emergencies. These protected sleep opportunities need to be known to individuals and all other relevant personnel.

Service providers should also develop procedures to protect individuals' sleep at company-provided accommodation, e.g. on base or in layover accommodation. The operator should restrict access to where individuals are trying to sleep, and ensure that quiet periods are respected (e.g. no maintenance work or routine cleaning).

For further information on procedures to protect an individual's sleep when on call or standby, see *Operational Implication 4: Protocols for Standby, Reserve and On-Call Duties*.

For further information on procedures to protect an individual's sleep during work periods, see *Operational Implication 5: Napping as a Fatigue Mitigation*.

SLEEP QUALITY AND AGING

Across adulthood, the proportion of sleep time spent in slow-wave sleep declines, particularly among men[4]. Sleep generally becomes more fragmented after about age 50-60 years and an individual's ability to tolerate shiftwork may decline.

However, it is not yet clear whether these age-related changes in sleep reduce its effectiveness for restoring waking function. Laboratory studies that experimentally interrupt sleep are typically conducted with young adults. In aviation settings, experience (both in terms of skills and knowing how to manage sleep across different shift-work patterns or when flying different trips) could help reduce potential fatigue risk associated with age-related changes in sleep. From both practical and scientific perspectives, age is not considered to be a specific factor to be addressed in order to manage fatigue.

Sleep quality declines as a normal part of aging.

SLEEP DISORDERS

The quality of sleep can also be disrupted by a wide variety of sleep disorders, which make it impossible to obtain restorative sleep, even when people spend enough time in bed trying to sleep. Sleep disorders pose a particular risk for those personnel for whom operational requirements often restrict the time available for sleep. Fatigue management training should include basic information on sleep disorders and their treatment, where to seek help if needed, and any requirements relating to fitness for duty.

Sleep disorders can reduce the amount and quality of sleep a person can obtain, even when they spend enough time trying to sleep.

CAFFEINE, NICOTINE AND ALCOHOL

Caffeine found in coffee, tea, energy drinks, colas, chocolate and some over-the-counter medications, stimulates the brain, making it harder to fall asleep and disrupting the quality of sleep. Some people are more sensitive to the effects of caffeine than others, but even heavy coffee drinkers will have lighter and more disturbed sleep if they drink coffee close to bedtime (although they may not even notice this). Nicotine in cigarettes is also a stimulant and affects sleep in a similar way. Alcohol on the other hand makes us feel sleepy but it also disturbs sleep. While the body is processing alcohol (at the rate of about one standard drink per hour), the brain cannot obtain REM sleep. Pressure for REM sleep builds up, and sleep later in the night often contains more intense REM periods and is more disturbed as a consequence.

Caffeine, nicotine, and alcohol can disrupt sleep quality.

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[4] Redline, S., Kirchner, HL, Quan, S.F., Gottlieb, D.J., Kapur, V. and Newman, A. (2004), "The effects of age, sex, ethnicity and sleep-disordered breathing on sleep architecture", *Archives of Internal Medicine*, 164:406-418.

OPERATIONAL IMPLICATION 3.
USE OF CAFFEINE

Caffeine can be useful to temporarily reduce sleepiness on duty because it blocks a chemical in the brain (adenosine) that increases sleepiness. It can also be used in advance of a period that is likely to be associated with higher fatigue (e.g. the early hours of the morning). Caffeine takes approximately 30 minutes to have an effect and can last for up to 5 hours, but people differ widely in how sensitive they are to caffeine and how long the effects last. It is important to remember that caffeine does not remove the need for sleep and it should only be used as a short term strategy. For maximum benefit, caffeine should be used strategically and avoided when alertness is high, such as at the beginning of a duty period, and used at times when alertness is low (e.g. towards the end of a long duty period or when called into work at night time).

Caffeine can also be used to minimize sleep inertia. Research has shown that consuming caffeine prior to a brief period of sleep (20-30 minutes) reduces sleep inertia on awakening.

ENVIRONMENTAL FACTORS

The sleep environment can affect sleep quality.

Environmental factors, including light, noise, temperature and comfort, can disturb sleep. Bright light increases alertness (and can be a short-term countermeasure to temporarily relieve fatigue in the work environment). It is much easier to sleep in a dark room, and heavy curtains or a mask can be used to block out light. Noise, such as traffic noise, can be masked using white noise (e.g. tuning a bedside radio between stations), or reduced by using ear plugs. Falling asleep requires being able to lower core body temperature (by losing heat through the extremities), so it is easier if the room is cooler rather than hotter. For most people (18-20 °C/ 64-68 °F) is an ideal room temperature for sleep. A clean and comfortable sleep surface is also important. Individuals sleeping in a supine position is more restorative than sleeping in an inclined position.

QUALITY OF SLEEP AT WORK AND WHEN ON-CALL (STANDBY)

Studies of flight crew and air traffic controllers taking a planned sleep at work show that their sleep is lighter and more disturbed than expected[5,6]. Nevertheless, there is good evidence that naps improve subsequent alertness and reaction speed and are a valuable mitigation strategy in fatigue management (see *Operational Implication 5: Napping as a Fatigue Mitigation).*

5 Signal, T.L., Gander, P.H., van den Berg, M.J. and Graeber, R.C. (2012), "In-flight sleep of flight crew during a 7-hour rest break: implications for research and flight safety" *Sleep*, 36(1): 109-115.

6 Signal, T.L., Gander, P.H., Anderson, H. and Brash, S. (2009)', " Scheduled napping as a countermeasure to sleepiness in air traffic controllers", *Journal of Sleep Research*, 18:11-19.

Trying to sleep in different locations or under different circumstances can have consequences for the quality of sleep obtained. The factors most commonly identified by crew members as disturbing their in-flight sleep are random noise, thoughts, not feeling tired, turbulence, ambient aircraft noise, inadequate bedding, low humidity and going to the toilet.

A study of air traffic controllers taking a planned sleep in the workplace during a night shift showed that less than half of the available time for sleep was actually spent asleep, and that the sleep obtained was light NREM sleep (despite sleep occurring at an ideal time in the circadian body clock cycle – see *Scientific Principle 3*). Air traffic controllers also reported that they found it moderately difficult to fall asleep and that the quality of the nap sleep was relatively poor[7]. Even though sleep was lighter and more disturbed than expected, the nap was found to improve the alertness and reaction speed of air traffic controllers at the end of the night shift.

Sleep obtained at work is often not as good quality as sleep under normal conditions at home.

Sleep may also be disturbed if there is an expectation of being woken and called to work, as is the case when on standby or on call. A laboratory study compared the sleep of people who were told on one night that they may be woken and required to respond to a noise, to their sleep on another night when they received no instructions[8]. The findings showed that it took people longer to fall asleep and they spent longer awake during the night when they expected to be woken. In this study the noise never occurred so sleep was not disturbed by external factors.

Sleep obtained when on call may be poorer quality.

A limited number of field studies have looked at the effects on sleep quality of being on-call. For example, an older study of the sleep of ship engineers found that sleep during on-call nights (with an average of two alarms) was shorter and contained more light non-REM sleep, less slow-wave sleep and less REM sleep, and higher heart rate than sleep on nights when engineers were not on call.[9] Many of these effects were observable before any alarms had occurred on on-call nights. In addition, engineers rated their sleep quality as lower on on-call nights and their sleepiness as higher on the day following an on-call night. These findings support the idea that the anticipation of expecting a wake-up somehow interferes with sleep quality.

Further research is necessary to quantify the extent to which sleep quality might be diminished when on call, and also whether there might be benefits for sleep in some circumstances. For example, aviation professionals on standby may have more time to sleep because they do not have to commute and, if they have young families at home, sleeping at base in high quality rest facilities could result in better quality sleep.

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7 Signal, T.L., Gander, P.H., Anderson, H. and Brash, S. (2009), "Scheduled napping as a countermeasure to sleepiness in air traffic Controllers", *Journal of Sleep Research*, 18:11-19.

8 Wuyts, J., De Valck, E., Vandekerchove, M., Pattyn, N., Exadaktylos, V. Haex, B., Verbraecken, J. and Cluydts, R. (2012), "Effects of pre-sleep simulated on-call instructions on subsequent sleep", *Biological Psychology*, 91:383-388.

9 Torsvall L, Akerstedt T., "Disturbed sleep while being on-call: an EEG study of ships' engineers", *Sleep*, 11: 35-38, 1998

OPERATIONAL IMPLICATION 4.
PROTOCOLS FOR STANDBY, RESERVE AND ON-CALL DUTIES

Although standby, reserve and on-call duties lack the certainty associated with scheduled shifts, the same scientific principles still apply. It is important to establish protocols for assigning unscheduled duties that aim to:

- *Minimize interruptions during circadian times when sleep is more likely (*Circadian influences are further discussed in *Section 2.3: Circadian Effects on Sleep and Performance)*.

  During periods of being on standby, reserve or on-call, there will be times when an individual is more likely to be able to sleep. Therefore, interruptions (such as non-urgent phone calls from work) during those times should be minimized (see *Operational Implication 2. Procedures for Minimizing Interruptions to Sleep*).

- *Limit continuous hours of wakefulness before and during periods of standby, reserve and on-call.*

  Where possible, a notification period should be provided before the individual is required to report for duty. This would allow an individual to prepare by taking a nap at home and limit hours of wakefulness before starting duty. If minimal notification periods are not operationally feasible, or if it is necessary to extend duty period, napping during the duty period can mitigate the accumulation of fatigue across extended hours of wakefulness. Consideration should be given to appropriate napping facilities and the establishment of napping protocols (see *Operational Implication 5: Napping as a Fatigue Mitigation*).

- *Schedule these duties in a predictable manner*.

  Standby, reserve and on-call duties should be scheduled with as much advance notice as possible, and ideally in a predictable manner. This provides some level of consistency in the timing of duty periods and allows for individuals to plan and manage their sleep opportunities.

  If individuals are likely to be activated during their time on standby, reserve or on-call, the number of consecutive unscheduled duty days assigned should be limited, and recovery time following this may be necessary.

Further information on establishing regulations related to unscheduled duties is provided in 4.1.3, *Identifying Limits – Unscheduled duties*.

2.1.4. THE IMPACT OF CONTINUOUS TIME AWAKE

The longer an individual remains awake, the worse his/her alertness and performance become. This is due to an increasing homeostatic pressure for sleep associated with the longer period of wakefulness. Sleep is the only way to reverse the effects of extended wakefulness.

The US National Transportation Safety Board has examined the relationship between time since awakening (TSA) and errors in 37 fixed wing aircraft accidents (1978-1990) in which flight crew actions or inactions were causal or contributing factors[10]. The median time since awakening at the time of the accident was 12 hours for captains and 11 hours for first officers. Six crews were classified as low time since awakening (both the captain and the first officer were below the median) and six crews were classified as high time since awakening (both the captain and the first officer were above the median). For low time since awakening crews, the median time awake was 5.3 hours for captains and 5.2 hours for first officers. For high time since awakening crews the median time awake was 13.8 hours for captains and 13.4 hours for first officers. Overall, high time since awakening crews made about 40 per cent more errors than low time since awakening crews (12.2 versus 8.7 errors), primarily due to making more errors of omission (5.5 versus 2.0 errors). In terms of error types, high time since awakening crews made significantly more procedural errors and tactical decision errors than low time since awakening crews.

Napping is an effective strategy to reduce continuous time awake. In air traffic control[11], aircraft maintenance personnel[12] and flight crew[13], research has shown that a nap during a period of work can improve performance and/or alertness. In all these studies the nap at work had no measurable effect on the next sleep episode. Note that not all States permit napping in the work environment.

A short nap can improve alertness and performance and is a valuable mitigation strategy in fatigue management.

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[10] National Transportation Safety Board Safety Study 94/01.

[11] Signal, T.L., Gander, P.H., Anderson, H. and Brash, S. (2009), "Scheduled napping as a countermeasure to sleepiness in air traffic controllers", *Journal of Sleep Research*, 18:11-19.

[12] Purnell, M.T., A.-M. Feyer, and G.P. Herbison (2002), "The impact of a nap opportunity during the night shift on the performance and alertness of 12-h shift workers", *Journal of Sleep Research*, 11: p. 219-227.

[13] Rosekind, M.R., Graeber, R.C., Dinges, D.F., et al. (1994), "Crew factors in flight operations IX: Effects of planned cockpit rest on crew performance and alertness in long-haul operations", NASA Technical Memorandum 108839. Available at: http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19950006379.pdf

OPERATIONAL IMPLICATION 5.
NAPPING AS A FATIGUE MITIGATION

When a person has been awake for a long period of time or if they have not had enough sleep over one or more days, napping is an effective strategy for reducing fatigue. Napping is a short-term mitigation that can be used before and during duty to help maintain performance and alertness. However, napping should not be used as a means of extending a duty period because to completely recover from fatigue, one or more complete sleep periods are required.

Napping before work: When a duty period starts later in the day (e.g. in the evening or at night) a nap prior to commencing work will reduce the period of wakefulness and can benefit performance and alertness during the duty period. The time of day when we are most likely to be able to nap is during the afternoon nap window (3 – 5pm) or during the normal night time window for sleep.

Napping during a duty period: A nap during a duty period can help maintain performance during extended work periods or during duty periods at night. How such naps are managed will depend on the context in which they occur and where they can be taken (e.g. for airline pilots: in designated crew rest facilities or on the flight deck (controlled rest); for ATCs: in the ATC unit or in separate rest facilities; for GA pilots: on the aircraft or on the ground). The length of the time given to nap will depend largely on the time of day and the available time away from duties, which may be difficult to control. Ideally, the nap period should allow enough time for individuals to fall asleep (it may take people longer than usual to fall asleep in these circumstances) and enough time after waking before recommencing duties to ensure that any sleep inertia has dissipated (see Operational Implication 1: Mitigation Strategies for Sleep Inertia). It is also critical that individuals be educated to not reduce their sleep time in anticipation of a nap during a duty period. If they sleep less before work because they assume they will get a nap at work, the overall benefit of allowing napping may be negated.

When napping is possible during a duty period there should be a protocol in place that covers when napping is allowed to occur, where naps can be taken, who the aviation professional must notify when they start and finish their nap, and how they can be contacted in the event of an emergency. Although the benefits of napping are clear, sleep inertia is sometimes used as an argument against napping when on duty (see *Operational Implication 1: Mitigation Strategies for Sleep Inertia* for information on how sleep inertia can be mitigated).

Controlled rest on the flight deck: These types of naps are taken by pilots in response to unexpected fatigue experienced during flight operations. If these are allowed, they need to be supported by specific guidance material and policies to ensure operational integrity and continued safe operations when this fatigue mitigation measure is necessary (see the relevant Implementation Guide for further information on sector-specific policies for the use of “controlled rest”).

2.2. SCIENTIFIC PRINCIPLE 2: SLEEP LOSS AND RECOVERY

Even for people who have good quality sleep, the amount of sleep they obtain is very important for restoring their waking function.

SCIENTIFIC PRINCIPLE 2

REDUCING THE AMOUNT OR THE QUALITY OF SLEEP, EVEN FOR A SINGLE NIGHT, DECREASES THE ABILITY TO FUNCTION AND INCREASES SLEEPINESS THE NEXT DAY.

2.2.1. SLEEP RESTRICTION IN THE LABORATORY

Numerous laboratory studies have looked at the effects of 'trimming' sleep at night by an hour or two (known as *sleep restriction*). Losing as little as two hours of sleep on one night will reduce alertness the next day and degrade performance on many types of tasks. Importantly, in studies where sleep has been restricted on multiple nights in a row, the effects of sleep loss on performance add up.

EFFECTS OF SLEEP RESTRICTION ACCUMULATE AND ARE DOSE DEPENDENT

The effects of restricting sleep night after night accumulate and performance progressively declines each day. This is sometimes described as *accumulating a sleep debt*. This can occur in aviation operations when minimum off-duty periods are scheduled for several days in a row or when the start and/or end times of shifts overlap the normal opportunity for night time sleep for several days in a row.

Figure 2-3 below shows the average amount of sleep loss accumulated (compared to the amount of sleep obtained on days off) across each 24-hour period on a backward rapidly rotating air traffic control shift schedule worked by 28 air traffic controllers[14]. When working an afternoon-day-morning shift pattern, air traffic controllers get less sleep than they do on days off and a sleep debt accumulates. In the first 24-hour period that includes the night shift air traffic controllers sleep more than they usually do on days off and the sleep debt reduces slightly. This 24-hour period starts on midday before the night shift and includes any sleep obtained before commencing the night shift and ends at midday after the night shift.

[14] Signal, T.L. and Gander, P.H. (2007), "Rapid counterclockwise shift rotation in air traffic control: Effects on sleep and night work", *Aviation Space and Environmental Medicine*, 78: 878-85. Figures 2-3 provided courtesy of Prof. T. L. Signal.

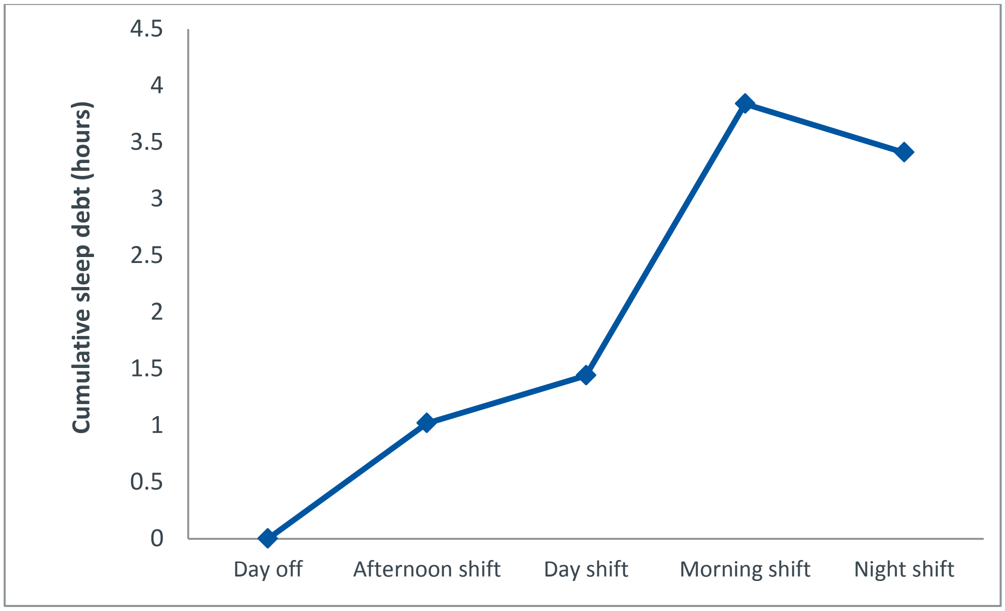

Figure 2-3. Cumulative sleep debt across a backward rapidly rotating air traffic control shift schedule[15]

The shorter the time allowed for sleep each night, the faster alertness and performance decline. For example, one laboratory study found that spending seven hours in bed for seven consecutive nights was not enough to prevent a progressive slowing down in reaction time[16]. The decline was more rapid for a group of participants who spent only five hours in bed each night, and even more rapid for a group who spent only three hours in bed each night. This is described as a *dose-dependent* effect of sleep restriction. Figure 2-4 summarizes the results of this study.

The effects of restricting sleep night after night accumulate. Less sleep per night = more rapid performance degradation.

[15] Figure provided courtesy of Prof. T. L. Signal.

[16] Balkin TJ, Thorne D, Sing H, Thomas M, Redmond D, Wesensten N, Williams J, Hall S, Belenky G., "Effects of sleep schedules on commercial motor vehicle driver performance", U.S. Department of Transportation, Federal Motor Carrier Safety Administration Report No. DOT-MC-00-133, May 2000.

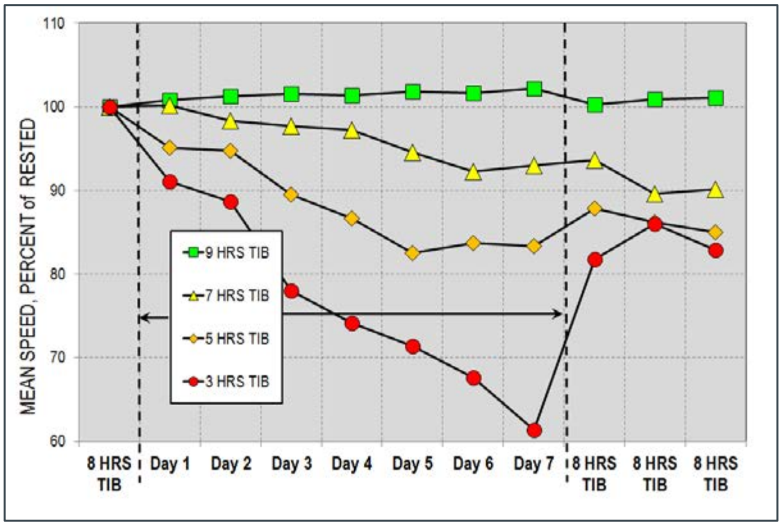

Figure 2-4. Impact of different nightly times in bed (TIB) on daytime performance[17]

SOME TYPES OF TASKS ARE MORE AFFECTED THAN OTHERS

Insufficient sleep impacts many facets of cognitive functioning, with the most consistent and largest effects found when measuring processing speed and attention. However, brain imaging studies suggest that the brain regions involved in more complex mental tasks (for example anticipating events, planning and determining relevant courses of action particularly under novel situations) are the most affected by sleep loss and have the greatest need for sleep to recover their normal function. Studies using more complex cognitive tasks do show changes in short-term memory, mental arithmetic, executive functions and language with sleep loss but the findings are less consistent and the change in performance smaller than in studies using attention and reaction-time tasks.

HOW YOU FUNCTION VERSUS HOW YOU FEEL

For the first few days of severe sleep restriction (for example, 3 hours in bed), people are aware that they are getting progressively sleepier. However, after several days they no longer notice any difference in themselves, even though their alertness and performance continues to decline. In other words, as sleep restriction continues, people become increasingly unreliable at assessing their own functional status. While both objective and subjective tests are useful in measuring fatigue and alertness levels, objective tests of fatigue are more reliable for measuring fatigue related performance impairment (see Appendix B).

People are not very accurate at judging their alertness and performance after sleep has been restricted for several days

[17] Figure 2-4 adapted from Figure 2-24, U.S. Department of Transportation Federal Motor Carrier Safety Administration Report No. DOT-MC-00-133, May 2000.

SLEEPINESS CAN BECOME UNCONTROLLABLE

Sleepiness eventually becomes overwhelming and results in uncontrollable micro-sleeps.

The pressure for sleep increases progressively across successive days of sleep restriction. Eventually, it becomes overwhelming and people begin falling asleep uncontrollably for brief periods, known as micro-sleeps. During a micro-sleep, the brain disengages from the environment (it stops processing visual information and sounds). In the laboratory, this can result in missing a stimulus in a performance test. Driving a motor vehicle, it can result in failing to take a corner. Similar events have been recorded on the flight deck during descent into major airports and in air traffic controllers at the end of a night shift[18].

SOME PEOPLE ARE MORE AFFECTED THAN OTHERS

Individuals vary widely in their ability to tolerate sleep loss.

At least in the laboratory, some people are more resilient to the effects of sleep restriction than others (inter-individual differences). Currently, there is a lot of research effort aimed at trying to understand why this is, but it is still too early for this to be applied in fatigue management (for example, by recommending different personal mitigation strategies for people who are more or less affected by sleep restriction).

LIMITATIONS OF LABORATORY SLEEP RESTRICTION STUDIES

Laboratory studies are currently the main source of information on the effects of sleep restriction, but they have some obvious limitations. Laboratory studies usually look at the effects of restricting sleep at night and participants sleep in a dark, quiet bedroom. More research is needed on the effects of restricting sleep during the day, and on the combination of restricted sleep and poor quality sleep. This limitation may mean that current understanding of the effects of sleep restriction is based on a “best-case scenario”.

When examining performance effects, laboratory studies have also focused on the performance of individuals, not people working together as a team. More research is needed to improve understanding of how the fatigue levels of individuals affect the performance of two or more people working together. For example, one simulation study with 67 experienced B747-400 crews found that sleep loss in the last 24 hours increased the total number of errors made by the crew (the captain was always the pilot flying)[19]. Paradoxically, greater sleep loss among first officers improved the rate of error detection, but greater sleep loss among captains led to a higher likelihood of failure to resolve errors that had been detected. Greater sleep loss was also associated with changes in decision-making, including for some crews, a tendency to choose lower risk options, which would help mitigate fatigue risk. Similar challenges would be expected in other aviation operations.

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[18] Signal, T.L., Gander, P.H., Anderson, H. and Brash, S. (2009), “Scheduled napping as a countermeasure to sleepiness in air traffic controllers”, *Journal of Sleep Research*, 18:11-19.

[19] Thomas, M.J.W., Petrilli, R.M., Lamond, N.A., et al. (2006), “Australian long haul fatigue study”, In: Enhancing Safety Worldwide: Proceedings of the 59th Annual International Air Safety Seminar. Alexandria, USA, Flight Safety Foundation.

2.2.2. RECOVERY FROM THE EFFECTS OF SLEEP RESTRICTION

Prolonged sleep restriction may have effects on the brain that can continue to affect alertness and performance days to weeks later[20]. Available laboratory studies do not yet give a clear answer to the question of how long it takes to fully recover from these effects. However, the following findings are reliable.

Recovery of a normal sleep pattern after an accumulated sleep debt takes at least two nights of unrestricted sleep.

- Lost sleep is not recovered hour-for-hour, although recovery sleep may be slightly longer than normal sleep at night.
- At least two consecutive nights of unrestricted sleep are required for the non-REM/REM sleep cycle to return to normal.
  - Typically, on the first night of recovery, more SWS will occur, but this can limit the time available for REM sleep.
  - On the second night of recovery, the brain catches up on REM sleep.
  - Recovery of a normal non-REM/REM cycle may take longer if recovery sleep is not at night, or if the individual is not adapted to the local time zone.
- If sleep restriction continues over multiple nights, then the recovery of waking alertness and performance will normally require more than two consecutive nights of unrestricted sleep.
  - Three 8-hour sleep opportunities at night are not enough to recover from 7 nights of sleep restricted to 7 hours per night.[21]
  - It has also been shown that extending sleep to 10-hours for one night is not enough to recover from the cumulative effects of 5 nights of sleep restricted to 4 hours per night.[22]

Recovery of waking alertness and performance after accumulating a sleep debt may take longer than two nights of unrestricted sleep.

During prolonged low-level sleep restriction, it may be that the brain somehow reconfigures the way it manages tasks, so that we adapt by settling at a stable but sub-optimal level of alertness and performance. However, the prolonged recovery times seen in laboratory sleep restriction studies suggest that return to optimal performance may be a slow process. Longer periods of time off, such as blocks of annual leave, may be important for full recovery.

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[20] Rupp, T.L., Wesensten, N.J, Bliese, P.D. et al. (2009), "Banking sleep: realization of benefits during subsequent sleep restriction and recovery", *Sleep*, Vol. 32, pp. 311-321.

[21] Belenky, G., Wesensten, N.J., Thorne, D.R., et al., "Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: a sleep dose-response study," *Journal of Sleep Research*, Vol. 12, pp. 1-12.

[22] Banks, S., Van Dongen, H.P.A., Maislin, G., et al (2010), « «Neurobehavioral dynamics following chronic sleep restriction: dose-response effects of one night for recovery" *Sleep*, Vol'. 33, pp 1013-26.

OPERATIONAL IMPLICATION 6. ALLOWING FOR SLEEP RECOVERY

Because the effects of sleep restriction are cumulative, schedules must be designed to allow periodic extended opportunities for recovery. Recovery opportunities need to occur more frequently when daily sleep restriction is greater, because of the more rapid accumulation of fatigue.

The usual recommendation for a recovery opportunity is a minimum of two consecutive nights of unrestricted sleep. This is not necessarily 48 hours off duty. A 48-hour break starting at midnight will not allow most people two consecutive nights of unrestricted sleep (most people go to sleep before midnight). Conversely, a 40-hour break starting at 20:00 will allow most people two consecutive nights of unrestricted sleep.

THE RECOVERY VALUE OF SPLIT SLEEP

Laboratory studies addressing recovery sleep typically allow participants a single sleep opportunity at night. However, split sleep (a short sleep period at night and another short sleep period during the day) is common in some types of aviation operations. For example, many airline operators schedule long-haul trips with augmented crews and on-board designated crew rest facilities. This allows multiple in-flight sleep opportunities across the duration of the flight. Different types of shift patterns may also result in split sleep. A common shift pattern in air traffic control is an early morning shift followed by a night shift with a short rest break of 8-9 hours in between. Sleep the night before the morning shift is often short and a nap is obtained between the morning and night shifts. For example, ATCs working a 2-2-1 pattern of shifts (two consecutive evening shifts to two consecutive early morning shifts to a night shift separated only by a short rest break of 8-9 hours in between) obtained just over 5 hours of sleep the night before the first morning shift and 2.5 hours of sleep between the morning and night shifts.[23]

Laboratory studies suggest that having a restricted sleep period at night plus a daytime nap has equivalent recovery value to an identical total amount of sleep taken in one consolidated block at night.[24] However, these are short-term studies that take place in dark, quiet laboratory environments with no distractions, and participants are fully adapted to the local time zone. These conditions do not always apply in 24/7 operations, so careful consideration is needed before applying the findings to aviation personnel.

An important advantage of split sleep is that it reduces the length of time that an individual is continuously awake (see *Section 2.1.4*).

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[23] See http://www.faa.gov/data_research/research/media/nasa_controller_fatigue_assessment_report.pdf

[24] Mollicone, D.J., Van Dongen, H., Rogers, N.L., et al. (2008), "Response surface mapping of neurobehavioral performance: Testing the feasibility of split sleep schedules for space operations", *Acta Astronautica*, Vol. 63, pp 833-40.

2.2.3. LONG-TERM SLEEP RESTRICTION AND HEALTH

Evidence from laboratory studies, and from epidemiological studies that track the sleep and health of large numbers of people across time, indicates that chronic short sleep may have negative effects on health in the long term. This research suggests that people who report averaging less than 7 hours of sleep per night are at greater risk of becoming obese and developing type-2 diabetes and cardiovascular disease. There is still debate about whether habitual short sleep actually contributes to these health problems, or is just associated with them. In addition, flight crew members as a group are healthy compared to the general population. What is clear is that good health depends not only on good diet and regular exercise, but also on getting enough sleep on a regular basis. Sleep cannot be sacrificed without consequence.

2.3. SCIENTIFIC PRINCIPLE 3: CIRCADIAN EFFECTS ON SLEEP AND PERFORMANCE

Sleeping at night is not just a social convention. It is programmed by the circadian clock - an ancient adaptation to life on our 24-hour rotating planet.

SCIENTIFIC PRINCIPLE 3

THE CIRCADIAN BODY CLOCK AFFECTS THE TIMING AND QUALITY OF SLEEP AND PRODUCES DAILY HIGHS AND LOWS IN PERFORMANCE ON VARIOUS TASKS.

Like other mammals, we have a circadian master clock located in a small cluster of cells (neurons) deep in the brain. The cells that make up the master clock are intrinsically rhythmic, generating electrical signals faster during the day than during the night. However, they have a tendency to produce an overall cycle that is a bit slow – for most people the "biological day" generated by the master clock is slightly longer than 24 hours.

This master clock, also known as the circadian body clock, receives information about light intensity through a direct connection to special cells in the retina of the eye (this special light input pathway is not involved in vision). This light sensitivity enables the circadian body clock to stay in step with the day/night cycle. However, it also creates problems for individuals who work at night and sleep during the day, out of step with the day/night cycle, or who have to travel across time zones and experience sudden shifts in the day/night cycle. The effects of light on the circadian body clock are considered in more detail later in this chapter.

The circadian body clock is a pacemaker in the brain that is sensitive to light through a specialized input pathway from the eyes (separate from vision).

Other parts of the brain and some other organs including the liver, kidneys and gut, contain peripheral circadian clocks that generate their own local circadian rhythms. (Indeed, every cell in the body contains the "clock genes" that are the basic molecular machinery for generating circadian rhythms.) The circadian body clock in the suprachiasmatic nucleus (SCN) is at the top of a hierarchy, keeping the rhythms in other parts of the brain and body in step with the day/night cycle and with each other.

The circadian body clock programmes humans for daytime wakefulness and night-time sleepiness.

2.3.1. EXAMPLES OF CIRCADIAN RHYTHMS

It is not possible to directly measure the electrical activity of the circadian body clock in the SCN of human beings. However, many circadian rhythms in physiology and behaviour can be measured as a way of indirectly tracking the cycle of the circadian body clock. Figure 2-5 shows an example of some circadian rhythms of a 46-year old short-haul fixed-wing flight crew member monitored before, during, and after a 3-day pattern of flying on the east coast of the USA while remaining in the same time zone[25]. The black horizontal bars indicate when he was on duty.

- He kept a daily diary of his activities, including when he slept (the shaded vertical bars in Figure 2-5).
- His core body temperature was monitored continuously (shown in the upper panel in Figure 2-5).
- In his logbook, he also rated his fatigue every 2 hours while he was awake, on a scale from 0 = most alert to 100 = most drowsy (shown in the lower panel in Figure 2-5).

His core temperature fluctuated by about 1 degree Celsius across the 24-hour day. Notice that his temperature started to rise each morning *before* he woke up. In effect, his body was preparing ahead of time for the greater energy demands of being more physically active. (If body temperature only began to rise after he started to be more physically active, it would be a lot harder to get up in the morning).

This crew member did not feel at his best first thing in the morning. He tended to feel least fatigued about 2-4 hours after he woke up, after which his fatigue climbed steadily across the day. (He was not asked to wake up across the night to rate his fatigue).

Core body temperature is often used as a marker rhythm to track the cycle of the circadian body clock because it is relatively stable and easy to monitor. However, no measurable rhythm is a perfect marker of the circadian body clock cycle. For example, changes in the level of physical activity also cause changes in core temperature, which explains the small peaks and dips in temperature in Figure 2-5.

The circadian body clock affects every aspect of human functioning resulting in cycles of high performance and low performance.

[25] Gander, P.H., Graeber , R.C., Foushee, H.C., Lauber, J.K., Connell, L.J. (1994), “Crew factors in flight operations ii: psychophysiological responses to short-haul air transport operations”. NASA Technical Memorandum #108856. Moffett Field: NASA Ames Research Center.

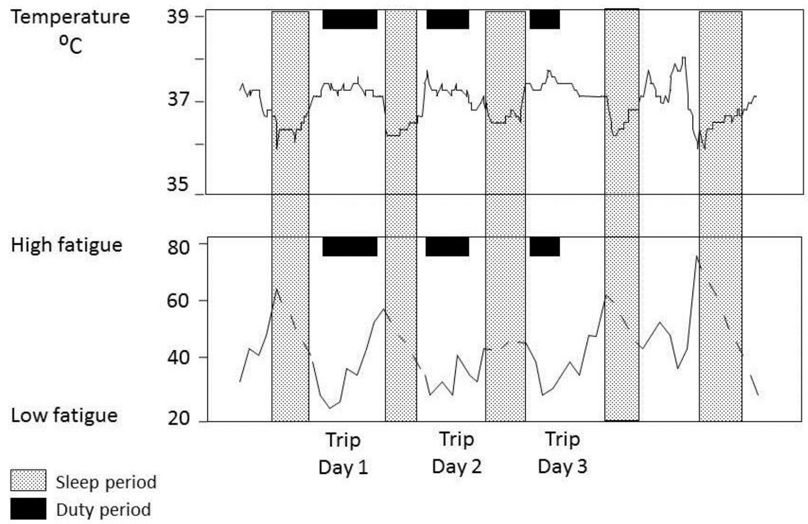

Figure 2-5. Circadian rhythms of a short-haul pilot

2.3.2. SLEEP REGULATION: THE CIRCADIAN BODY CLOCK AND THE SLEEP HOMEOSTATIC PROCESS

The circadian body clock is one of two key processes that regulate sleep timing and quality (the other is the sleep homeostatic process, which is described in more detail below). The circadian body clock has connections to sleep-promoting and wake-promoting centres in the brain, which it modulates to control the sleep/wake cycle. It also influences the timing and amount of REM sleep. Just after the minimum in core body temperature, the brain goes more quickly into REM sleep and stays in REM for longer than at any other time in the circadian body clock cycle. This is sometimes described as a circadian rhythm in 'REM sleep propensity'. Thus, during a normal night of sleep, the longest bouts of REM sleep occur in the last non-REM cycles towards morning (see Figure 2-2).

Figure 2-6 is a diagram that summarizes the relationships between sleep and the circadian body clock cycle (tracked here by the circadian rhythm in core body temperature). The figure is based on data collected from 18 night cargo pilots on their days off (i.e., when they were sleeping at night). The core body temperature was monitored continuously and they recorded their sleep and duty times in a daily diary. Their average core body temperature rhythm has been simplified (the continuous curve). The dot represents the average time of the temperature minimum, which is used as a reference point for describing the other rhythms. Although these data were collected during night cargo operations, they can be used as an illustrative example for any individual working at night.

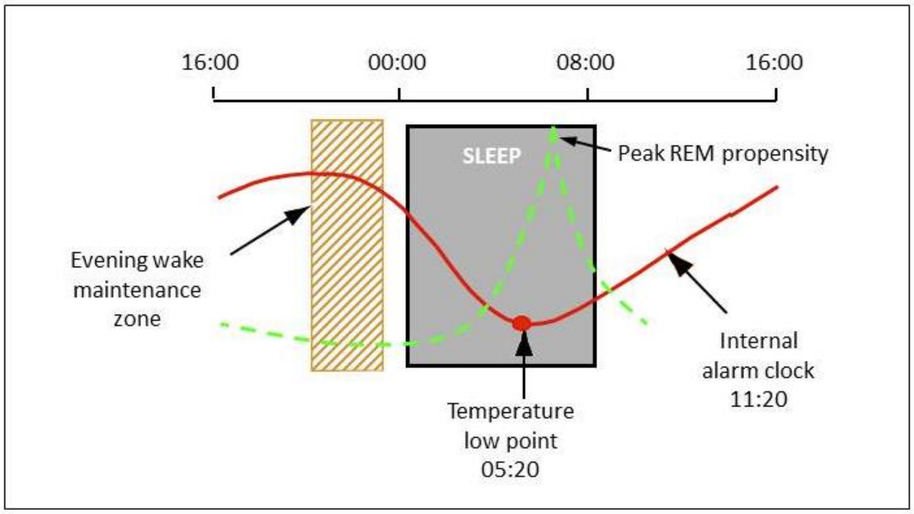

Figure 2-6. Relationship between normal sleep at night and the circadian body clock cycle[26]

Figure 2-6 highlights the following relationships:

The circadian clock exerts strong influence over sleep, creating windows when sleep is promoted and windows when sleep is opposed.

- Sleep normally begins about 5 hours before the minimum in core body temperature.
- Wakeup normally occurs about 3 hours after the minimum in core body temperature.
- REM sleep propensity peaks just after the minimum in core body temperature (the dashed curve).
- As core body temperature begins to rise, the circadian body clock sends an increasingly strong signal to the brain centres that promote wakefulness, sometimes called the 'circadian alerting signal'. About 3 hours after waking up, the homeostatic pressure for sleep is low (see below) and the circadian alerting signal is strong enough to make it very hard to fall asleep or stay asleep. This is sometimes referred to as the *internal alarm clock*.
- The circadian alerting signal is strongest just before usual bedtime. This makes it very difficult to fall asleep a few hours earlier than usual, and this part of the circadian body clock cycle is known as the *evening wake maintenance zone*.

[26] Figure provided by Prof. P. H. Gander, adapted from Gander P.H. et al (1998) Gregory, K.B., Connell, L.J., Graeber, R.C., Miller, D.L., and Rosekind, M.A., "Flight crew fatigue IV: overnight cargo operations", *Aviation, Space, and Environmental Medicine 69:* B26-B36.

The time around the daily minimum in core body temperature is the part of the circadian body clock cycle when people generally feel most sleepy and are least able to perform mental and physical tasks. This is sometimes described as the *Window of Circadian Low (WOCL)*.

The Window of Circadian Low (WOCL), which occurs around the time of the daily minimum in core body temperature, corresponds to the time of day when people feel most sleepy and are least able to perform.

The second key process regulating sleep timing and quality is the sleep homeostatic process. This can be summarized as: your brain's need for sleep builds up while you are awake and the only way to discharge this pressure is to sleep. The homeostatic process can be tracked by the amount of slow-wave sleep.

- Across time awake, the pressure for slow-wave sleep builds up. The longer you are awake, the more slow-wave sleep you will have in the first few non-REM/REM cycles when you next sleep.
- Across sleep, the amount of slow-wave decreases in each subsequent non-REM/REM cycle. In other words, the pressure for slow-wave sleep is discharged across the sleep period.

Discharging the homeostatic pressure for sleep seems to take priority - slow-wave sleep is always greatest in the first non-REM/REM cycles, regardless of when that sleep occurs in the circadian body clock cycle.

The circadian body clock and the sleep homeostatic process interact to produce two times of peak sleepiness in 24 hours.

1. Sleepiness is greatest when people are awake during the *WOCL*, which occurs around 03:00 to 05:00 for most people on a normal routine with sleep at night.
2. Sleepiness increases again in the early afternoon - sometimes called the *afternoon nap window* (around 3-5 pm for most people). Restricted or disturbed sleep at night makes it harder to stay awake during the next afternoon nap window.

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). Across the teenage years, most people become more evening-type. Across adulthood, most people become more morning-type. This progressive change towards becoming more morning-type has been documented in flight crew members across the age range 20-60 years.

The combined effects of the sleep homoeostatic pressure and the circadian body clock can be thought of as defining "windows" when sleep is promoted (the early morning and afternoon times of peak sleepiness) and 'windows' when sleep is opposed (the time of the internal alarm clock in the late morning, and the evening wake maintenance zone).

2.3.3. HOW LIGHT SYNCHRONIZES THE CIRCADIAN BODY CLOCK

The cells (neurons) in the circadian body clock spontaneously generate electrical signals faster during the day than at night (usually described as "firing" faster during the day than at night). Light exposure effectively increases the firing rate of the clock cells. Depending on when in the body clock cycle light is received, there are three possible outcomes:

1. light in the morning shortens the body clock cycle in that cycle (known as a phase advance);
2. light in the middle of the day does not change the body clock cycle length (no phase change); or
3. light in the evening lengthens the body clock cycle in that cycle (known as a phase delay).

Figure 2-7 shows graphically how these different responses are possible. The solid line in each panel represents the circadian rhythm in firing rate on the circadian body clock cells.

- In the left-hand panel, light speeds up the rising part of the body clock cycle, leading to a phase advance.
- In the middle panel, light causes no phase change.
- In the right-hand panel, light slows down the falling part of the body clock cycle, leading to a phase delay.

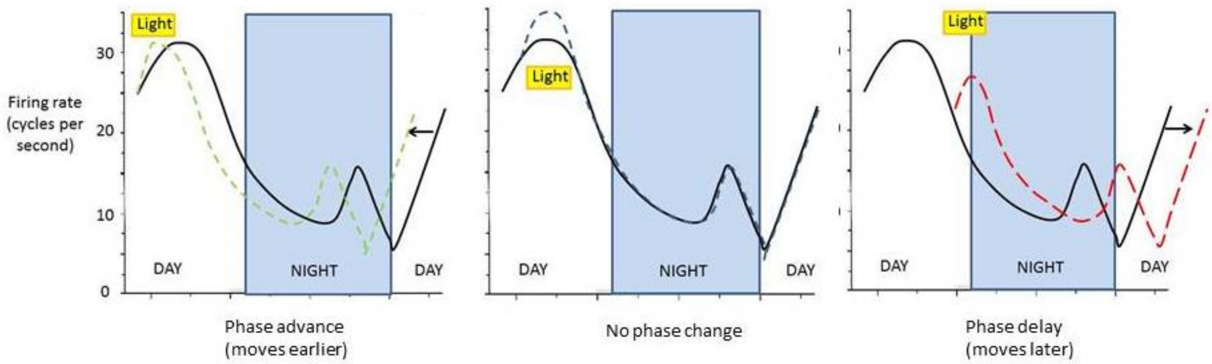

Figure 2-7. Effects of light on the circadian body clock[27]

Bright light causes bigger shifts in the circadian body clock cycle than dim light, and the clock is particularly sensitive to blue light.

In summary, for an individual fully adapted to the local time zone and sleeping regularly at night:

- light exposure after the circadian temperature low point in the morning will result in a phase advance of the body clock cycle;
- light exposure in the middle of the day will have minimal effect on the body clock cycle; and
- light exposure in the evening before the circadian temperature low point will result in phase delay of the body clock cycle.

Light in the morning shortens the circadian body clock cycle and light in the evening lengthens the body clock cycle.

In theory, this means that just the right amount of light exposure at the same time every morning would speed up a slightly slow circadian body clock cycle just enough to synchronize it to exactly 24 hours (most of us have an innate body clock cycle slightly longer than 24 hours). In practice, staying in step with the day/night cycle is more complex than this. In modern industrialized societies, people have very haphazard exposures to light, particularly bright outdoor light. In addition, the circadian body clock is sensitive to other time cues from the environment, for example it can also be moved backwards or forwards in its cycle by bouts of physical activity.

[27] Figure provided by Prof. P. H. Gander, adapted from Meijer J.H., Schaap J., Watanabe K., Albus H. (1997), "Multiunit activity recordings in the suprachiasmatic nuclei: *in vivo* versus *in vitro* models", *Brain Res*. 753:322-327.

The ability of the circadian clock to “lock on” to the 24-hour day/night cycle is a key feature of its usefulness for most species, enabling them to be diurnal or nocturnal as needed to enhance their survival. However, it can create challenges for individuals involved in 24/7 operations because it causes the circadian body clock to resist adaptation to any pattern other than sleep at night.

In extreme latitudes, where there are long periods of darkness in winter, the biological clock receives less light information to help keep in step with the 24-hour cycle. A small number of studies have looked at the effects on sleep and fatigue in the extreme latitudes and show that in the winter months people go to bed and get up later, have more difficulty falling asleep and may sleep for slightly longer (although other studies find no difference in sleep duration) compared to in summer. Although sleep may be slightly longer, fatigue levels are greater in the winter months at these extreme latitudes.

2.3.4. SHIFT WORK

From the perspective of human physiology, shift work can be defined as any duty pattern that requires a crew member to be awake during the time in the circadian body clock cycle when they would normally be asleep if they were free to choose their own schedule. This means that all work outside of “typical” office hours (e.g. early start times, late finishes, night work or extended duty hours, can be considered shift work).

The further sleep is displaced from the optimum part of the circadian body clock cycle, the more difficult it becomes for individuals to get adequate sleep (i.e., the more likely they are to experience sleep restriction). For example, individuals working at night are typically on duty through most of the optimum time for sleep in the circadian body clock cycle. This happens because the circadian body clock is “locked on” to the day/night cycle, and does not flip its orientation to promote sleep during the day when an individual is awake and working at night.

Figure 2-8 is a diagram that summarizes what happened to the circadian biological clock and sleep when the night cargo crew members in Figure 2-6 (see above) were flying at night and trying to sleep in the morning. Again, their average core body temperature rhythm has been simplified (the continuous curve).

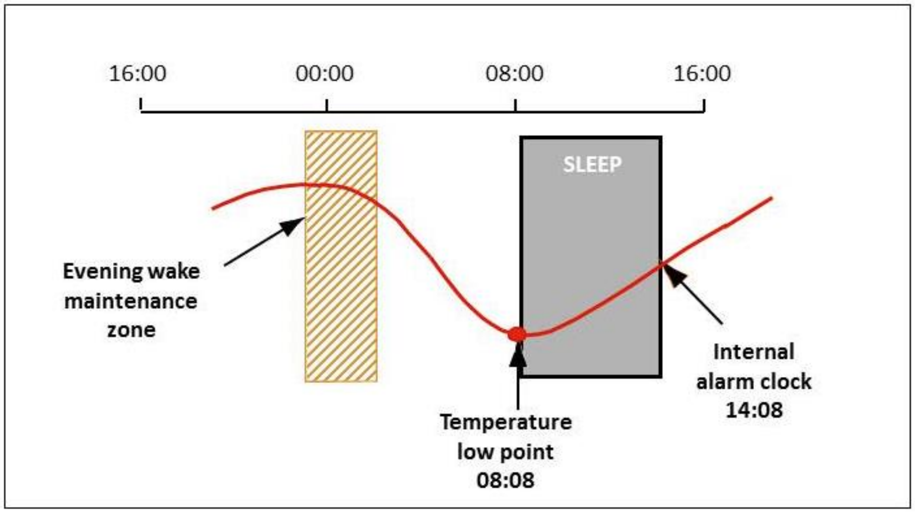

Figure 2-8. Relationships between sleep after night duty and the circadian body clock cycle[28]

On off duty days, when these crew members were sleeping at night, the average time of the temperature minimum was 05:20 (Figure 2-6). When they were flying at night (Figure 2-8) this moved to 08:08 (i.e. the average temperature minimum delayed by 2 hours 48 minutes). The circadian body clock did not adapt fully to night duty, which would have required a shift of about 12 hours. As a result, crew members had to sleep in a different part of the circadian body clock cycle after night duty.

- After night duty (Figure 2-8), they fell asleep close to the circadian temperature minimum. In contrast when they slept at night (Figure 2-6), they fell asleep about 5 hours before the temperature minimum.
- After night duty (Figure 2-8), crew members woke up about 6 hours after the circadian temperature minimum, within 5 minutes of the predicted time of the *internal alarm clock*. In contrast when they slept at night (Figure 2-6), they woke up about 3 hours after the temperature minimum.
- Crew members were not asked what woke them up from sleep episodes after night duty, but they rated themselves as not feeling well-rested after these restricted morning sleep episodes.

Early morning shifts also have consequences for sleep, as night time sleep is truncated. Going to sleep earlier in anticipation of an early start the next day does not work for most people as the evening wake maintenance zone (see Figure 2-8 above) prevents sleep onset. There have been several studies showing that, compared to afternoon or day shifts, air traffic controllers obtain the least sleep prior to morning shifts.

In addition to obtaining less and poorer quality sleep, there are other consequences to working shifts. A changed pattern of work and sleep (if it remains consistent over several days) provides cues to the circadian body clock to realign. The cues from the pattern of work and sleep are in conflict with light information the circadian body clock is receiving. Different rhythms in the body get out of step with each other resulting in circadian disruption. As a consequence, an individual may experience fatigue, poorer mood and changes in performance.

[28] Figure provided by Prof. P.H. Gander.

SPEED AND DIRECTION OF SHIFT ROTATION

Shift patterns can be classified according to the speed (fast or slow) and direction (forward or backward) of rotation. When the timing of duty periods change rapidly from one day to the next (also known as a rapidly rotating schedule) then the circadian biological clock cannot adapt to the pattern of work and rest. The advantage of this is that on days off an individual's circadian biological clock is still aligned with the normal day/night cycle and symptoms of circadian disruption are minimized. The downside of rapidly rotating schedules is that at certain times, such as on the night shift, an individual will be working when their circadian drive for sleepiness is high and their performance is at its poorest. A slowly rotating schedule (e.g. a week of early morning shifts) is more likely to result in some circadian adaptation but then on days off an individual will be slightly out of alignment with the normal day/night cycle and some re-adaptation needs to occur.

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.

Shift schedules can also rotate forwards (each successive shift or set of shifts occurring later than the one before, e.g. morning, day, afternoon, night shift) or backwards (each successive shift or series of shifts starting earlier than the one before, e.g. afternoon, day, morning, night shift). From what we know about the circadian body clock it would be expected that forward rotating shifts were preferable, as the circadian clock normally runs slightly slow making it easier for individuals to go to bed later and get up slightly later. However, there is not a great deal of information that supports this. In fact a carefully conducted laboratory-based study that compared rapidly forwards and backwards rotating air traffic control schedules found no difference in the amount of sleep obtained or the performance of individuals across either of these schedules[29]. What the study did find is that the least amount of sleep is obtained before an early morning shift and ratings of fatigue are highest and performance poorest at the end of a night shift, regardless of the direction of shift rotation.

[29] Cruz, C., Boquet, A., Detwiler, C., and Nesthus, T.E. *A Laboratory Comparison of Clockwise and Counter-Clockwise Rapidly Rotating Shift Schedules, Part II: Performance*. 2002, Office of Aerospace Medicine, Federal Aviation Administration: Washington, DC. and Cruz, C., Detwiler, C., Nesthus, T.E. and Boquet, A. *A Laboratory Comparison of Clockwise and Counter- Clockwise Rapidly Rotating Shift Schedules, Part I: Sleep*. 2002, Office of Aerospace Medicine, Federal Aviation Administration: Washington, DC.

OPERATIONAL IMPLICATION 7.
SCHEDULING

The perfect schedule for the human body is daytime duties with unrestricted sleep at night. Anything else is a compromise. There are, however, general scheduling principles based on fatigue science that should be taken into account when designing a duty schedule:

- 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 more a duty period overlaps an individual’s usual sleep time, the less sleep the individual is likely to obtain. Working right through the usual night-time sleep period is the worst-case scenario.
- When individuals work at night and must remain awake through the night, they work through the time in the circadian body clock cycle when self-rated fatigue and mood are worst, and additional effort is required to maintain alertness and performance. Napping before and during a night duty period is a useful strategy (discussed above in *Operational Implication 5: Napping as a Fatigue Mitigation*).
- When indivduals are awake during night duty, their subsequent sleep period is later than normal in their circadian body clock cycle. This means that they have a limited time to sleep before the circadian alerting signal wakes them up. This can cause restricted sleep following a night shift. To provide the longest sleep opportunity possible, night shifts should be scheduled to end as early as possible and individuals need to get to sleep as soon as possible after coming off duty.
- Early report times have been identified as a cause of restricted sleep in aviation operations. One reason for this is the evening wake maintenance zone that occurs in the few hours before usual bedtime. This makes it very difficult to fall asleep earlier than usual, ahead of an early duty report time.
- Across consecutive duty periods that result in restricted sleep, individuals will accumulate a sleep debt and fatigue-related impairment will increase.
- To recover from a sleep debt, individuals need a minimum of two full nights of sleep in a row. The frequency of rest periods should be related to the rate of accumulation of sleep debt.

2.3.5. JET LAG

Flying across time zones exposes the circadian body clock to sudden shifts in the day/night cycle. Because of its sensitivity to light and (to a lesser extent) social time cues, the circadian body clock will eventually adapt to a new time zone. During the period of adaptation, common symptoms include wanting to eat and sleep at times that are out of step with the local routine, problems with digestion, degraded performance on mental and physical tasks, and mood changes.

Studies with participants flown as passengers have identified the following factors that affect the rate of adaptation to a new time zone:

- Adaptation generally takes longer when more time zones are crossed.
- Adaptation is usually faster after westward travel (phase delay) than after eastward travel (phase advance) across the same number of time zones. The fact that the innate cycle of the circadian body clock is slightly longer than 24 hours (for most people) probably contributes to this. It is easier to lengthen the cycle to adapt to a westward shift.
- After eastward flights across 6 or more time zones, the circadian body clock may adapt by shifting in the opposite direction, for example shifting 18 time zones west rather than 6 time zones east. When this happens some rhythms shift eastward and others westward (known as resynchronization by partition) and adaptation can be particularly slow.
- Rhythms in different functions can adapt at different rates, depending on how strongly they are influenced by the circadian body clock. Thus, during adaptation, rhythms in different body functions can be out of step with each other, as well as out of step with the day/night cycle.
- Adaptation is faster when the circadian body clock is more exposed to local time cues, including outdoor light, and exercising and eating on local time.
- Beginning a trip with a sleep debt seems to increase the duration and severity of jet lag symptoms.

Flight crew members that operate transmeridian flights rarely have enough time in a destination to adapt fully to local time, with 1-2 day layovers being typical. However, different patterns of transmeridian flights can have different effects. For example, there appears to be very little circadian adaptation across flights leaving and returning to a crew member's domicile time zone, with a 1-2 day layover in the destination city. On the other hand, longer sequences of back-to-back transmeridian flights can lead to the circadian body clock adopting a non-24-hour period that may be close to its intrinsic period.[30] This presumably happens when repeated time zone crossings are combined with a non-24-hour sleep/wake pattern, so that there are no longer any 24-hour day/night cues to synchronize the circadian body clock.

The circadian body clock is not able to adapt immediately to changes in time zones.

[30] Gander, P.H., Gregory, K.B., Miller, D.L., Rosekind, M.R., Connell, L.J., and Graeber, R.C. (1998), "Flight crew fatigue V: long-haul air transport operations", *Aviation, Space, and Environmental Medicine,* 69:B37-B48.

The fact that long-haul crew members seldom stay long enough in any destination time zone to become adapted to local time has effects on their layover sleep. Often, crew members split their sleep, having one sleep period on local night and another corresponding to local night in their home time zone, which overlaps the preferred part of the circadian body clock cycle for sleep (at least for the first 24-48 hours in a new time zone). Another factor affecting layover sleep, particularly for unaugmented crews who do not have the opportunity for in-flight sleep, is that long-haul duty days are often associated with extended periods of wakefulness. For example, one study that monitored crew members on unaugmented long-haul trips found that the average duty day involved staying awake for 20.6 hours (the average duty period lasted 9.8 hours)[20].

There is some evidence that when crew members stay longer in the destination region, for example doing several days of local flying with minimal time zone changes before flying the long-haul trip home, their circadian body clocks begin to adapt to the destination time zone.[31] This may improve layover sleep. On the other hand, when they arrive back in their home time zone, they may need additional days to readapt to local time.

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31 Gander, P., van den Berg, M., Mulrine, H., et al. (2013), "Circadian adaptation of airline pilots during extended duration operations between the USA and Asia", *Chronobiol Int,* 30: 963-972.

2.4. SCIENTIFIC PRINCIPLE 4: THE INFLUENCE OF WORKLOAD

The ICAO definition of fatigue describes workload as “mental or physical activity” and recognizes workload as a potential cause of fatigue. Workload is, however, a complex concept and there is no universal definition or agreed way of measuring it. However, three aspects of workload are commonly identified:

1. the nature and amount of work to be done (including physical and mental demands; and task complexity and intensity);
2. time constraints (including the duration of the tasks; and 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).

SCIENTIFIC PRINCIPLE 4

WORKLOAD CAN CONTRIBUTE TO AN INDIVIDUAL’S LEVEL OF FATIGUE. LOW WORKLOAD MAY UNMASK PHYSIOLOGICAL SLEEPINESS WHILE HIGH WORKLOAD MAY EXCEED THE CAPACITY OF A FATIGUED INDIVIDUAL.

The factors contributing to workload and the consequences of workload need to be considered for each operational situation.

For each type of operation being regulated the factors contributing to workload and the consequences of workload need to be considered. They are likely to be quite different in one operational situation compared to the next. For example, the nature of the workload will be very different in air traffic control compared to flight crew, but also different in an *en route* centre compared to a control tower or in short-haul compared to long-haul flight operations.

Across most types of operations there is fairly wide acceptance of the concept that intermediate levels of workload may contribute least to performance impairment. Low workload situations may lack stimulation, leading to monotony and boredom which could unmask underlying physiological sleepiness and thus degrade performance. Instead of leading to boredom, low workload can also result in an individual making a greater effort to remain engaged which in turn increases their workload. At the other end of the spectrum, high workload situations may exceed the capacity of a fatigued individual, again resulting in poorer performance. High workload may also have consequences for sleep, due to the time required to “wind down” after demanding work.

High and low workload can contribute to fatigue.

Research in fixed-wing operations has shown that pilot workload increases with the number of sectors in a flight duty period[32, 33, 34]. For this reason, in their prescriptive flight and duty limits, many States (including EASA and the US Federal Aviation Administration) identify maximum flight duty periods that decrease as more flight segments are flown.

Limited research has been undertaken in rotary wing operations to explore the relationship between workload and fatigue, and this research is necessary because of the different factors which influence workload in rotary wing operations, e.g.:

- helicopter operations do not necessarily have a low workload cruise period and the entire flight can be cognitively demanding;
- the use of night vision goggles (NVG), common to different types of helicopter operations, has been associated with high levels of workload; and
- the role helicopter crew can be physically demanding, because aircraft are not pressurized or air conditioned, and crew can experience thermal stress on the ground and in the air.

A study of helicopter operations in the North Sea found that workload was related to different factors depending on the phase of flight[35]. In the pre-flight, taxi, climb and cruise phases of flight workload was related to the quality of the aircraft systems. During descent and approach the weather was the primary factor influencing workload and during landing the quality of the landing site and quality of the air traffic control service were related to workload ratings.

High workload may disturb sleep due to the time required to "wind down" after demanding work.

Few studies have attempted to investigate the influence of workload on fatigue or the potential interaction between workload and other causes of fatigue such as time-on-task, time awake, sleep loss and time of day. A study of fatigue ratings made by air traffic controllers found some evidence for self-rated workload and time-on-task having interactive effects on fatigue.[36] When self-rated workload was low, fatigue ratings remained relatively stable for continuous work periods up to 4 hours.

[32] Powell D, Spencer MB, Holland D, et al. Pilot fatigue in short haul operations: effects of number of sectors, duty length, and time of day. Aviation, Space, and Environmental Medicine 78:698-701, 2007.

[33] Powell D, Spencer MB, Holland D, et al. Fatigue in two-pilot operations: implications for flight and duty time regulations. Aviation, Space, and Environmental Medicine 79:1047-1050, 2008.

[34] Air crew fatigue: a review of research undertaken on behalf of the UK Civil Aviation Authority. CAA Paper 2005/4.

[35] Gander PH, Barnes RM, Gregory KB, Graeber RC, Rosekind MR. Flight Crew Fatigue III. North Sea Helicopter Air Transport Operations. Aviation Space Environ Med 1998; 69(9, Suppl.):B16-25.

[36] Spencer, M.B., Rogers, A.S., Stone, B.M. (1997), "A review of the current scheme for the regulation of air traffic controllers hours (SCRATCOH)", Farnborough, England: Defense Evaluation and Research Agency.

However when workload was high, there was a rapid increase in fatigue after 2 hours of continuous work. These effects of workload became more evident after controllers had been awake for at least 12 hours. The time-of-day variation in fatigue ratings was also influenced by workload, being more marked at low and high levels of workload than at intermediate levels. Operationally, breaks during a duty period are an important way of reducing the decline in performance with increasing time-on-task.

The relationship between workload and fatigue has not been well researched.

OPERATIONAL IMPLICATION 8.
PROVIDING BREAKS DURING A DUTY PERIOD

Operationally, breaks during a duty period are an important way of reducing the decline in performance with increasing time on task due to the effects of high workload. Such breaks differ from rest periods between duty periods which are designed to allow for sleep and other recovery, as well as preparation for future work.

The length of time working before a break occurs, and the duration of the break are dependent on the type of task being performed. For example, performance on tasks requiring sustained attention, such as monitoring for an infrequent event, has been shown to improve with frequent short breaks. As with any continuous operation, where a task performed by one person is handed over to another person, it is critical to consider the risk of the handover itself. In some cases, less frequent handovers (perhaps with higher levels of supervision) may be associated with a lower overall risk exposure.

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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, which is acquired through conducting specific operations over time and managing fatigue-related risks in those operations. These two sources of expertise are complementary.

While science generally aims to develop principles that can be broadly applied, non-scientific knowledge acquired through operational experience offers contextual insights that are essential for the development and implementation of robust fatigue management regulations.

Prior operational experience alone is not sufficient for fatigue management in either prescriptive or FRMS approaches. There needs to be evidence of consideration of scientific principles, risk assessment, and risk mitigation. Many of the findings of the scientific studies that underpin the principles in Chapter 2 must be extrapolated for use in specific aviation industry sectors and within different types of operations. This means that knowledge of the operational and organizational context, as well as understanding of the constraints and motivations of the workforce must be considered alongside the science when determining and implementing an appropriate fatigue management approach.

Contextual factors can be categorized as relating either to the specific operations context or to the broader organizational context. Arguably, however, some factors belong in both categories and clearly the two contexts interact in their effects on fatigue management. These are discussed further below.

3.1. OPERATIONAL CONTEXT

Aspects of the local environmental and working conditions can affect fatigue levels. Operational context covers factors that the individual is faced with on a daily basis, for example the weather, traffic delays, airspace complexity, irregular operations, interactions with other aviation professionals within and outside their type of operations, and managing operational demands. Operational context is very industry sector-specific and States need to be aware of the particular factors that can affect fatigue in the different industry sectors for which they provide oversight. Specific operational contexts are discussed further in corresponding sections of the Implementation Manuals.

3.2. ORGANIZATIONAL CONTEXT

States' understanding of the context within which the service provider operates can provide insights to the pressures on the service provider, the type of organizational culture it fosters and the likely behaviours and customs of the workforce. These factors will affect how an organization is able to address fatigue issues. States should also recognize that the influence of organizational context will differ depending on the service provided (e.g. flight operations, air traffic services).

Table 3-1 presents an open list of contextual elements that States should consider reviewing as part of the development of fatigue management regulations and in their oversight.

Table 3-1. Contextual factors which may affect fatigue levels and the ability of service providers to address them

Factor	
Legal framework	• The ability to maintain the integrity of the safety reporting system and reporter confidentiality • The legal consequences of reporting different types of fatigue hazards
Commercial pressures	• Organizational mergers bringing together different labour agreements and different attitudes to fatigue management responsibilities • Bankruptcy and receivership
Staffing arrangements	• The ability to offer adequate recovery opportunities to avoid cumulative fatigue • Career stability • Changing employment arrangements (e.g. use of contractors and contractual obligations and constraints) • Sufficient staff to cover sickness and other absences • Sufficient staff to cover the specific operational demands
Staff demographics	• Age • Gender • Educational levels • Cultural background • Health standards
Acceptance of shared responsibilities for fatigue management	• Design of schedules to manage fatigue or for maximum time at work only? • Development of fatigue management policies • Ability to detect hazards and assess fatigue risk • An operational person's ability to be removed from their safety relevant task if they consider themselves to be a safety risk
Fatigue management structure	• Fatigue is managed consistently using standard processes across the organization
Geographical location	• Topography • Remoteness • Weather • Time spent in commuting
Level of isolation of aviation professional during a duty period	• Pressures (commercial and personal) to complete the "mission" • Geographic separation from the support team - immediate support and supervision is not always readily available
Work conditions	• The quality of rest facilities and policies for their use • Standard of layover accommodation • Level of automation • Level of authority and responsibility • Availability of support staff • Environmental factors (noise, temperature, lighting) • Availability of food and water

Continued on next page…

Factor (continued)	
Irregular operations	• Frequency of the need to use discretionary extensions to prescribed limits • Frequency of disruption to schedules and the assignment of unscheduled duties
Workload	• Airport traffic density • Task intensity
Interactions with other aviation professionals	• Use of standard phraseology • The need to communicate in multiple languages
Experience levels	• Similar operational demands can result in higher workload levels for inexperienced aviation professionals than for experienced aviation professionals • Experienced aviation professionals may need to support and oversee inexperienced personnel, adding to their workload
Lifestyle influences	• Social opportunities • Cultural differences

3.3. SHARED RESPONSIBILITIES

Fatigue is affected by all waking activities, not only work demands. This means that effective fatigue management in the workplace requires recognition of the shared responsibility between the service provider and the individual, even though the means by which these responsibilities are met may differ according to the fatigue management approach used. Aspects of the organizational context will influence how individuals discharge their fatigue management responsibilities. The service provider should be able to demonstrate to the State how well that shared responsibility is understood and implemented.

The service provider is responsible for providing:

- adequate resourcing for fatigue management;
- a working environment that has appropriate emphasis on controls and/or mitigations for fatigue-related risk;
- robust fatigue reporting mechanisms;
- evidence of appropriate responses to fatigue reports;
- schedules that enable fatigue on duty to be maintained at an acceptable level, as well as providing adequate opportunities for rest and sleep; and
- training for all organizational stakeholders on how the organization's fatigue management approach works and how individuals can better manage their own fatigue.

Individuals are responsible for:

- making optimum use of non-work periods to get adequate sleep;
- coming to work fit for duty;
- using personal fatigue mitigation strategies while on duty;
- reporting fatigue issues; and
- responsible use of individual authority (e.g. pilot in command discretion).

3.3.1. FATIGUE REPORTING

The operational and organizational context has particular influence on whether individuals consider the identification of fatigue hazards as part of their professional role and on whether they are prepared to report fatigue hazards. For this purpose a service provider must establish reporting processes. For a State, knowledge of the operational and organizational context can therefore provide information about how responsive to fatigue hazards a service provider may be.

To ensure the availability of fatigue reports (as for all safety data or safety information), States need to establish a legal framework that protects sources and their reports (Annex 19 refers).

At the same time, a service provider must establish reporting processes that comply with those laws. These reporting processes should enable operational personnel to raise legitimate concerns regarding fatigue without fear of retribution or punishment from both within and outside the organization. The causes and consequences of fatigue are difficult to detect if people are unwilling or unable to report them.

To encourage an ongoing commitment by staff to reporting fatigue hazards, the service provider should:

- make it easy to report fatigue hazards;
- establish clear expectations for individuals to report fatigue hazards;
- establish a process for what to do when an individual considers him/herself too fatigued to perform safety-critical tasks to an acceptable standard;
- identify the implications for individuals of submitting a fatigue hazard report;
- identify how the organization 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 consistent with stated policy;
- maintain the integrity of the safety reporting system and reporter confidentiality; and
- provide timely feedback on changes made in response to identified fatigue hazards.

3.4. SUMMARY

This chapter identifies the contextual elements to be considered when developing and overseeing fatigue management regulations. These elements often require a different means of verification than a simple compliance check. The means by which these can be verified by the State within a prescriptive approach and within FRMS is described in subsequent chapters.

CHAPTER 4. THE PRESCRIPTIVE APPROACH

In recognizing fatigue as a safety issue, ICAO SARPs require States to establish prescriptive flight and/or duty limitations regulations for particular professional groups.

In a prescriptive approach to fatigue management, the service provider is expected to schedule within prescribed limits, according to their specific context and to the risks that generate fatigue within their operation. The effectiveness of their scheduling practices is then monitored as part of their SMS. Through their oversight practices, the State ensures that the service provider is managing their fatigue risk to an acceptable level within the constraints of the prescriptive limitations and requirements using existing SMS processes.

As fatigue is an issue that will affect safety within an organization, a service provider's safety management system should include fatigue of safety critical workers as a hazard regardless of whether that group of workers are governed by prescriptive regulations.

The prescriptive approach to fatigue management is summarized in Figure 4-1.

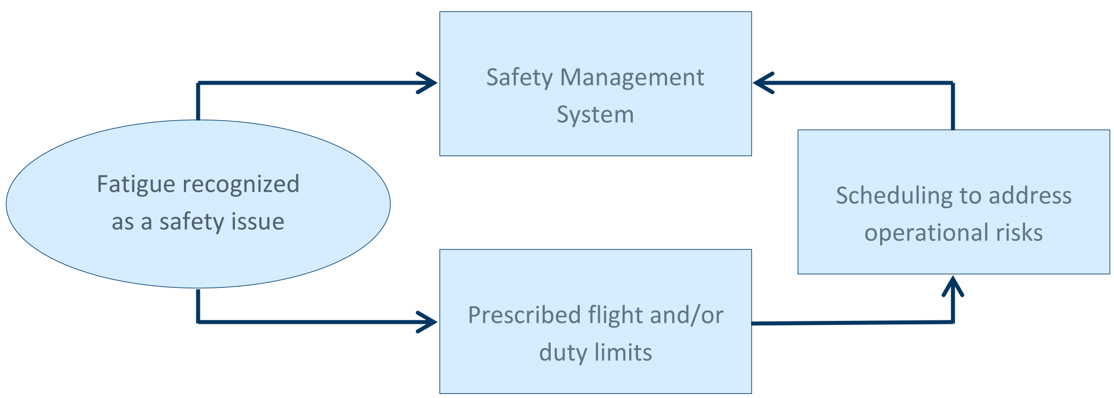


Figure 4-1. The prescriptive approach to fatigue management.

This chapter addresses the establishment and oversight of the prescriptive approach to fatigue management under the following headings:

1. Developing prescriptive limitations and requirements;
2. Developing regulations for variations;
3. Regulatory oversight of service providers using a prescriptive approach to fatigue management; and
4. State Safety Programme (SSP) considerations.

4.1. DEVELOPING PRESCRIBED LIMITS AND ASSOCIATED REQUIREMENTS

When establishing prescribed limits and associated requirements for a particular group of aviation professionals (e.g. air traffic controllers, airline pilots, helicopter pilots, cabin crew members on fixed wing operations and cabin crew members on rotary wing operations) the State necessarily takes into account the variety of types of work, operational contexts and conditions in their region (e.g. climate, geography and infrastructure). The State should also consider its legal, economic and socio-political context to the extent that it may impact on the ability of those professionals to maintain an adequate level of alertness when performing safety-related duties. While States may choose to review other States' prescriptive limits and requirements, it is important that States develop prescriptive limits that specifically address the needs and context of their aviation industry.

A State could take the approach of regulating for the most difficult operational conditions and identifying very restrictive limits for everyone. However, this is likely to place unnecessary costs and resource burdens in those operations where there are less significant fatigue risks. It may also result in undesirable "regulation by variation" or, where FRMS regulations are offered, implementation of FRMS when the operator (or the State) does not have the necessary resources, knowledge or experience with performance-based approaches. Alternatively, overly generous prescriptive limitations and requirements may not provide an acceptable level of safety performance.

Safety issues are not the only drivers for limiting work periods and identifying non-work minima. Industrial agreements and social legislation also limit work periods and may unintentionally impact on fatigue management. Therefore, all limits identified through these different processes need to be assessed for their contribution to safety outcomes. This allows the State to assess the extent to which their current prescriptive limitations need to be reviewed in order to ensure that they provide comprehensive fatigue mitigation.

Fatigue management regulations focus on safety. The State should determine to what extent, if any, limits identified through industrial agreements and social legislation should be incorporated into their fatigue management regulations, so as not to confuse the focus of the limits being identified.

One way to guide the selection of a set of limits and requirements for a specific sector of operational personnel is to develop an assessment of the safety implications to support an objective decision-making process. This requires the State to:

- determine the safety relevance;
- identify the generic fatigue hazards associated with that sector of operational personnel and assess the associated risks;
- propose a set of maxima for work periods and minima for non-work periods that best addresses the most significant risks; and
- establish any additional requirements necessary to support the prescribed limits.

4.1.1. DETERMINING SAFETY RELEVANCE

The role that different operational personnel play in the aviation safety chain determines the extent to which their fatigue-related performance degradation could compromise the overall safety of the system. However, not all tasks carried out by operational personnel are equally safety relevant. It should be noted, though, that undertaking additional non-safety duties also contributes to fatigue.

EXAMPLES

1. Transferring non-operating crew members from one place to another, as required by the service provider, is a task that might have an impact on fatigue but is not directly relevant to operational safety.
2. Assessing procedures in a simulator may have an impact on fatigue but unless it is followed by a duty period, it is not directly relevant to operational safety.

To develop limitations and requirements that address high-risk areas while allowing the positive development of a State's aviation industry, it is important to identify which activities undertaken by the different groups of aviation professionals have the greatest impact on safety outcomes.

4.1.2. ASSESSING FATIGUE RISKS

The overall risk for a specific group of operational personnel is the combination of the consequences (see safety relevance above) and the likelihood of all fatigue-related hazards for all tasks undertaken by those personnel. A list of generic fatigue hazards and mitigation alternatives associated with a particular operational context may be developed based on consideration of the scientific principles and relevant research findings from studies, including operationally-based studies.

However, while careful consideration of research findings provides an important basis for establishing a set of prescriptive limitations, no single study will provide the complete solution that will necessarily be the best fit in the specific context to which they will be applied.

Taking into consideration the associated risks, the State has to draw informed boundaries, designed to maintain an acceptable level of safety performance in the majority of situations across an industry sector. For example, research on the fatigue hazards associated with pilots on short-haul operations in a particular region may identify common fatigue-related hazards such as frequent early starts and high workload associated with multiple stops.

It should be noted that such a high-level fatigue risk assessment is more general in nature than that required by service providers to assess their specific risks within an FRMS. More information on the assessment of a service provider's fatigue risk assessment is provided in Chapter 5.

Existing limits and work practices used by various service providers can be reviewed to assess mitigation options identified from relevant research, scientific principles and operational knowledge. Operational knowledge may relate to such elements as:

- additional scheduling policies to address likely disruption on the day;
- mitigations used to address seasonal weather conditions;
- mitigations used to address known fatiguing combinations of working patterns; and
- practices for allocating unscheduled duties.

Other mitigations or defences include such things as the level of support available through reliable technology. The day-to-day operational reality of a specific operating environment plays an important role, particularly when determining appropriate mitigations for workload related fatigue hazards.

EXAMPLES

1. A State might advise adjusting limits on flight time in single pilot operations if the auto pilot becomes inoperative.
2. In an air traffic control context, a State might advise adjusting limits for time in position if technology that a controller normally uses to undertake his tasks is unavailable, for example short-term conflict detection tools.

Existing limits and requirements should then be assessed to determine to what extent such mitigating measures are covered.

4.1.3. IDENTIFYING LIMITS

States must base their prescriptive limitations and requirements on scientific principles. In general, this means they:

- provide adequate sleep opportunities prior to duty periods;
- limit the duration of work periods and identify minima for non-work periods to allow for adequate recovery;
- limit consecutive and total work periods over defined periods of time, in order to prevent cumulative fatigue;
- consider the impact of commencing duties at different times of the day;
- consider the number and direction of time zone changes experienced (where relevant);
- consider the impact of undertaking duties within a WOCL;
- consider whether the duty is being undertaken by a single operational person or a team;
- consider the impact of workload during the work period; and
- avoid extended periods of being awake when assigning unscheduled duties (e.g. standby).

Identifying limits based on scientific principles and knowledge is therefore more than simply identifying a maximum work duty period and a minimum rest period. Instead, States who have recently amended their prescriptive limitations regulations have established integrated “sets of limits”, where limits may change in different conditions.

For example, in the case of flight and cabin crew, many State regulations identify maximum flight duty periods that differ according to the number of sectors to be flown, the number of flight crew, the time when the flight duty period started and whether the crew member is time zone acclimatized at the time of the flight period. Parameters that may be considered in the development of prescriptive limitations for flight and cabin crew are provided in Appendix C. (for commercial air transport aeroplanes) and Appendix E (for helicopter operations).

In the case of air traffic controllers, limits may differ according to the duration and number of consecutive early start duty periods and consecutive night duty periods as well as the number of standby duties during non-duty periods within a specific period of time. Parameters that may be considered in the development of prescriptive limitations for air traffic controllers are provided in Appendix D.

The application of a bio-mathematical model in the prescriptive limitations development process may be a useful exercise to look at the relative risk of different scenarios possible under the proposed rule-set. States must not rely solely on the outputs of a bio-mathematical model to determine limitations but need to consider the specific hazards and risks within their operational and regional context. Further details on bio-mathematical models are discussed in Appendix H.

While different types of operational personnel will require different sets of prescriptive limits, in all cases their development will require consideration of the operational relevance, and where necessary the appropriate way to address, the following areas:

- breaks taken during duty periods;
- stability of work patterns;
- assignment of unscheduled duties (including those associated with managing operational disruptions on-the-day);
- recovery value associated with non-work periods; and
- meeting other physiological needs.

These are discussed further below.

BREAKS TAKEN DURING DUTY PERIODS

Within different disciplines, breaks taken during duty periods are intended to fulfil different recuperative purposes:

- breaks to limit a period of continuous wakefulness; and
- breaks to provide relief from periods of intense workload which have high potential for workload-fatigue related performance degradation.

With regards to prescriptive limits, breaks to limit a period of continuous wakefulness are not limited to, but are often associated with, flight and cabin crew (e.g. inflight sleep or split duties in operations). When identifying limits and associated requirements for such breaks, the State should consider:

- the relationship between the duration of such breaks and the overall length of the duty period;
- the timing of the break relative to the worker's circadian rhythm for optimal sleep recovery;

- the suitability of available sleeping facilities; and
- the need for napping protocols to be established.

Requiring specified breaks to provide relief from periods of intense workload are generally associated with air traffic controllers (e.g. breaks between periods of time-in-position within a duty period). When identifying limits and associated requirements for this type of break, the State should consider:

- The nature and amount of work to be done (including time on task, task difficulty and complexity, and work intensity).

This is a particularly difficult limit to prescribe for a whole industry sector as there are many individual factors which would also affect workload such as:

- time constraints (including whether timing is driven by task demands, external factors, or by the individual); and
- factors relating to the performance capacity of an individual (for example experience, skill level, effort, sleep history, and circadian phase).

Therefore, States may require that a service provider propose their own breaks to provide relief from periods of intense workload.

STABILITY OF WORK PATTERNS

Changes within patterns of work for operational personnel may have an impact on fatigue. An example of this would be rapid changes between work periods during the day and during the night.

States should consider how they require their service providers to demonstrate their management of changes to patterns of work and irregular duty period start and finish times especially where they infringe or overlap the WOCL.

ASSIGNMENT OF UNSCHEDULED DUTIES

Within the prescribed limits, assignment of unscheduled duties to meet unpredictable operational needs is commonly managed through different approaches (e.g. on-call periods, standby, reserve and last-minute roster changes). For the purposes of this section, the term “on-call” will be used to cover all of these approaches.

The specific challenges associated with unscheduled duties relate to their inherent unpredictability and the likelihood of being assigned unscheduled duties. In many cases controlling the likelihood of being called in to undertake an unscheduled duty may be impossible.

> ***NOTE**. Without specific context, this is an area that is very difficult to provide specific details for developing regulations. States should assess the different approaches in conjunction with the scientific principles (Chapter 2) and the operational context (Chapter 3) when developing provisions related to unscheduled duties.*

Therefore, requirements for the assignment of unscheduled duties should aim to ensure that the operational person is adequately rested to undertake unscheduled duties and to limit the potential for extended periods of wakefulness during unscheduled duties. Such requirements may include State-identified limits and associated requirements or simply the requirement for the service provider to develop procedures.

Regardless of which approach a State takes, the following elements can guide the development of this area of the regulations:

- the need for protected sleep opportunities prior to and after unscheduled duties;
- adjusting the length of the standby period in relation to the length of the notification period (e.g. airport standby versus long call reserve);
- duty length may need to be adjusted in relation to the time spent on call or standby depending on the length of the notification period; and
- consideration of the extent to which an on-call period is counted as a work period is related to the degree to which it induces fatigue.

As for any other duty period, the operational person needs an opportunity to plan their rest to enable them to perform to a satisfactory level. Key to this is the length of time given from notification of the duty to the time of commencement of that duty. Longer notification periods can afford the individual the opportunity to rest in preparation for the duty, allowing them to remain available to be assigned an unscheduled duty for longer. Short notification periods require operational personnel to be fully rested and immediately ready to undertake the duty. Therefore the length of the period on-call should be directly related to the length of the notification period.

It follows that where operational personnel are required to report immediately on notification, the ability for the individual to be fully rested declines over time. Therefore, States should consider how the time elapsed from commencement of the on-call period impacts on the length of the duty the operational person can be assigned. This is particularly so in the case of last-minute duty extensions to manage unexpected operational disruptions. This topic is discussed further in *Section 4.2.1 - Variations to Meet Unexpected Operational Circumstances and risks.*

In making the judgement on the extent to which an on-call period counts as work, the following considerations may be useful, considering that sleep during on-call periods may be less restorative:

- the location of the on-call period (e.g. at home vs. at the workplace vs. at a hotel);
- the length of the notification period (e.g. does it afford an opportunity to sleep prior to reporting?)
- the inclusion of protected periods during which the operational person will not be disturbed; and
- the possibility for the operational person to sleep during the on-call period (e.g. at home during either of the windows of circadian low).

RECOVERY VALUE OF NON-WORK PERIODS

The recovery value of non-work periods is also dependent on when they take place in relation to the WOCL and the facilities that promote sleep (e.g. a quiet, dark environment at an appropriate temperature). There are some instances where the service provider may be responsible for providing sleeping facilities during the non-work period (e.g. crew members away from home base). To ensure that adequate sleep can be obtained, the State may develop regulations to explicitly outline requirements on the quality of the sleep facilities or may simply include the requirement for the service provider to demonstrate that the facilities they provide allow adequate sleep to be obtained.

As discussed in Chapter 2, at least two nights of unrestricted sleep are needed to dissipate the cumulative sleep debt acquired over consecutive duty days. States, therefore, need to consider methods for ensuring that safety-critical personnel have regular periods of at least two nights of unrestricted sleep to allow recovery of a normal sleep pattern. Some operational circumstances might exacerbate the cumulative sleep debt and require additional recovery time. These include:

- operating during the window of circadian low (WOCL);
- circadian desynchronization; and
- the combination of consecutive maximum duty periods separated by minimum non-duty periods.

Therefore, it may be necessary for the State to develop requirements for additional recovery time based on the circumstance above, considering the scientific principles and the operational context.

MEETING OTHER PHYSIOLOGICAL NEEDS

In order to avoid any detriment to individuals' performance, opportunities to eat, drink and meet biological needs should also be provided. The State should require that service providers have work practices that allow for these basic needs to be met.

4.1.4. ESTABLISHING ADDITIONAL REQUIREMENTS ASSOCIATED WITH PRESCRIBED LIMITS

Other than prescribing limits, additional regulations may be needed to ensure that the service provider demonstrates the effective management of fatigue risks within the constraints of the prescribed limits. Such requirements may address:

1. Construction of schedules (rosters) using scientific principles and operational knowledge through:
   - comparison of actual work and non-work periods with what was originally planned, to identify times in a schedule when fatigue levels might be higher than expected; and
   - adjustment of limits and schedules to accommodate any unique factor(s) associated with higher fatigue risks (e.g. duties or tasks that could significantly increase fatigue)
2. The use of existing SMS processes to identify and mitigate fatigue risks, such as:
   - processes for reporting fatigue-related issues including non-fitness for duty because of fatigue;
   - processes for keeping records on working and non-working times and the analysis of such data; and
   - processes for reporting and recording the use of flexibility provisions within the prescribed limits;

3. Inclusion of fatigue management-related topics within the service provider's awareness and/or training programmes to an appropriate level. Topics should cover:
    - the underlying scientific principles;
    - personal strategies for the mitigation of fatigue; and
    - operator-specific policies related to the mitigation of fatigue (e.g. napping policy, augmented crew procedures, etc.).

4.2. DEVELOPING REGULATIONS FOR VARIATIONS TO A PRESCRIBED LIMIT

While regulation through variation is undesirable, ICAO fatigue management SARPs allow for States to offer some limited flexibility to the service providers complying with the prescribed limits by way of variations. Variations may be necessary to meet operational needs and risks in:

- unexpected circumstances beyond the control of the service provider; and
- expected but exceptional circumstances.

4.2.1. VARIATIONS TO MEET UNEXPECTED OPERATIONAL CIRCUMSTANCES AND RISKS

Unexpected operational circumstances refer to those that do not occur on a regular basis or cannot be reasonably predicted to occur, based on past experience. If they are able to be reasonably predicted (e.g. known seasonal conditions that increase flight times or require additional air traffic control resources), the service provider should be expected to schedule accordingly. The service provider should use mitigations (e.g. schedule "buffer periods" (scheduling additional time to allow for operational variability) or provide additional resources within the prescribed limits, and not rely on the use of variation)s.

However, it is recognized that unexpected operational circumstances can occur to which a service provider must respond immediately, which can necessitate extending beyond prescribed limits. To enable such on-the-day extensions, the State may establish regulations which:

- prescribe outer limits and the circumstances in which they can be used;[37] or
- permit a service provider flexibility to manage on-the-day disruptions by requiring them to develop their own on-the-day response protocol.

[37] While discussed under the heading of "variations" in this manual, these prescribed outer limits and conditions may be considered part of the prescribed limits and not variations *per se* (i.e. captain's discretion for extending flight duty periods).

Whether identified by the State or proposed by a service provider, the following will need to be identified:

- the circumstances in which the variations may be used;
- the operations to which the variations may be applied;
- the necessary mitigations to address the increased fatigue risks; and
- the variation limits.

The variation limits are dependent upon the operational circumstances and the operational person making an assessment of their fitness for duty.

4.2.2. VARIATIONS TO MEET EXPECTED OPERATIONAL NEEDS AND RISKS

A State may permit *minor* variations to the prescribed limits to meet expected operational needs and risks in exceptional circumstances, without the need for the service provider to develop a full FRMS. Examples of expected, but exceptional, operational circumstances include ensuring the provision of adequate services for the duration of a short-term event, or to meet a specific operational need requiring very minimal variations for extended periods of time.

The State should have a process for accepting variations to prescribed limits that ensures the service provider demonstrates how they will actively manage their specific fatigue risks when the variations are in place. This requires the service provider to provide a safety case (risk assessment) that demonstrates a level of safety equivalent to, or better than, the prescriptive fatigue management regulations. It also requires the State to have personnel with the knowledge and experience to be able to assess such safety cases. Without them, a State should not approve variations.

A State needs to have personnel with the knowledge and experience to assess safety cases before they can approve variations.

A framework to support the assessment of such safety cases is discussed below.

4.2.3. ASSESSING SAFETY CASES TO SUPPORT VARIATIONS

A safety case required to support a service provider's proposed fatigue management approach consists of more than just the argument that 'we have always done it this way'. It must document what the service provider wants to do, what has been done to assess the risk, the supporting documentation for why it offers an acceptable level of risk, and what mitigations will be used.

Before assessing a safety case, the State evaluates the service provider's capability and willingness to manage safety, based on previous oversight experience. In the case of an application for a variation to prescribed work limits, the State needs to be confident that the variation will be managed safely.

The effort expected of the service provider in developing a safety case (or risk assessment) should reflect the safety risk it aims to address. Safety cases to support minor and temporary variations to prescribed limits should be proportionate to the risk and not make the same demands as the establishment of an FRMS. In some cases the capability of the service provider making the change and the low safety impact of the change may mean that the information provided in the safety case is quite brief.

While not all safety cases require the same level of preparation, they can all be evaluated using the following interrelated steps:

1. assessing the nature, scope and impact of the proposed variation;
2. assessing the applied risk assessment methodology;
3. evaluating how the risk assessment is used and how the decision to accept risk has been made;
4. assessing the appropriateness of the risk mitigation measures;
5. assessing whether the claims, arguments and evidence made in the risk assessment are valid; and
6. assessing plans for continued monitoring of the safety impact of the changes.

The steps for assessing safety cases are discussed below in relation to applications for variations to prescribed limits.

1. ASSESSING THE NATURE, SCOPE AND IMPACT OF THE PROPOSED VARIATIONS

Objective	The State is assured that the service provider understands the change it is proposing including the direct or indirect impact of the change on the fatigue levels of those who will work to the new limits.
Methods	• Submitted documentation clearly identifies which element(s) of the prescriptive regulations that it is seeking to vary, the proposed changes, and the operations to which they are intended to apply. • Other areas of regulation that are affected by the proposal are identified. • Submitted documentation demonstrates that the service provider has considered any direct or indirect impacts the proposed variations will have on those operations and other services.

2. ASSESSING HAZARD AND CONSEQUENCE IDENTIFICATION

Objective	The State is assured that a hazard identification process has been carried out with regard to the proposed variation and that the consequences of the hazards have been documented.
Methods	• Review the method used to identify and assess the fatigue hazards and their consequences for the proposed variation. • Review any other direct or indirect hazards identified in relation to the variation and their consequences. • Transitional risks to the operation associated with the variation are considered.

3. EVALUATING THE WAY THE RISK HAS BEEN ASSESSED AND ACCEPTED

Objective	The State is assured that the level of risk associated with the proposed variation is acceptable.
Methods	• Examine the record of the risk assessment . • Assess if the risk assessment appears reasonable both before and after mitigations have been applied using personal experience and judgement. • Evidence is provided that existing fatigue controls and mitigations are effective. • Confirm that an appropriately authorized person has accepted the remaining risk level and that this has been recorded.

4. ASSESSING THE RISK MITIGATION MEASURES

Objective	The State is assured that the mitigations identified are sufficient to manage the fatigue risk expected when operating up to the fullest extent of the variation to the fatigue management limitations being proposed.
Methods	• Determine who was involved in the process of identifying and establishing the mitigations to ensure that this was conducted at the correct level within the organizational structure of the service provider and with the involvement of the relevant people. • Carefully examine the proposed fatigue mitigations using knowledge of the service provider proposing the variations and of other service providers in similar situations to establish if the mitigations are appropriate and likely to be effective. • Review the service provider's processes and procedures to evaluate the appropriateness of their plan for risk management and training. • Consider other aspects of human performance that may be affected by the mitigations. • Ensure that the service provider is not relying only on training to mitigate fatigue risks. *States need to be assured that a service provider is not over-reliant on training and awareness programmes to mitigate fatigue risks.*

5. ASSESSING THAT THE CLAIMS, ARGUMENTS AND EVIDENCE MADE IN THE RISK ASSESSMENT ARE VALID

Objective	The State is assured that the claims and arguments are robust and supporting evidence is accurate and correctly interpreted.
Methods	• Review the safety arguments to confirm that a justification for the continuation of an acceptable level of safety performance has been demonstrated. • Safety arguments are supported by well-validated research or best practices. • Transitional risks are mitigated. • Clear conclusions are included in the risk assessment • Proposed mitigations have considered all the legal requirements applicable to the worker (national, international, safety, social). Ensure they have been captured and addressed.

6. ASSESSING PLANS FOR CONTINUED MONITORING OF THE SAFETY IMPACT OF THE VARIATIONS

Objective	The State is assured that the hazards associated with the variations have been correctly identified and the mitigations are performing as expected.
Methods	• The service provider has processes in place and demonstrated the capability to allow continued monitoring through existing SMS activities. • Specific safety performance indicators related to the variation are established. • A review process is identified to assess the impact of organizational changes to the operating environment.

As for all safety cases, the State needs to develop a process to record all elements of this assessment. This should include what evidence (documentation) was reviewed, any safety concerns that were not acceptably addressed and the rationale for the decision to accept or reject the variation, as well as the period of time that the variation remains applicable. This process should also include scheduling a review of the variation once it is operational within the State's oversight programme.

4.3. REGULATORY OVERSIGHT

Through their oversight practices, States must ensure compliance with all the prescriptive limitations regulations and variation requirements, as well as the management of fatigue risk through SMS processes and training obligations. Oversight also includes the establishment of appropriate corrective action mechanisms and enforcement strategies that can be enacted should a service provider (or individual) exhibit non-compliance.

The following sections describe how compliance should be demonstrated by a service provider with regards to requirements for:

- prescriptive limitations;
- variation processes;
- meeting SMS obligations; and
- training.

4.3.1. COMPLIANCE WITH PRESCRIBED LIMITS AND ASSOCIATED REQUIREMENTS

States must assess a service provider's compliance with prescribed limits and associated requirements. The nature and extent of this assessment will depend on:

- the level of granularity/complexity of their prescriptive rule set;
- the maturity of the service provider's SMS; and
- the extent to which the service provider's uses the full range of the prescriptive limitations.

States should ensure that a service provider has documented work and non-work period practices, based on scientific principles, which comply with the prescriptive limitations and associated requirements set by the State.

States should also require service providers to retain records of work and non-work periods. This should include planned and actual work and non-work periods, with significant deviations from prescribed limits and minima noted. Significant deviations are those that exceed the outer limits or reduced minima of any flexibility provisions (4.2.1 refers).

Analysis of such records, including trending the use of any flexibility provisions by the service provider, allows the State to monitor compliance. Further, analysis of these records, coupled with fatigue reports, may help to identify fatigue risk associated with a service provider's rostering practices. These records must remain auditable for a period of time as determined by the State.

Service providers may choose to use a bio-mathematical model to assist in preparing schedules with fatigue management principles in mind. Such models provide a means for predicting the relative fatigue levels associated with one work pattern compared to another. However, model predictions should not be used without reference to operational knowledge, when making decisions about work pattern design. Personnel overseeing a service provider who utilizes a bio-mathematical model in their rostering process should ensure they understand the capabilities and limitations of the model used by the service provider and what the output metrics represent.

It is important that the State is satisfied that the service provider publishes an individual's work schedules sufficiently in advance to allow planning for work and rest periods. While late changes to an individual's work schedule are sometimes unavoidable, it is important that the service provider take steps to keep changes at short notice to a minimum and minimize their impact.

If a service provider allows individuals to engage in 'shift swapping', specific procedures should exist for this to ensure:

- prescriptive limitations are not exceeded at the time of the shift swap or at a later time during the work schedule; and
- shift swapping is monitored to avoid conflict with scheduling principles or practices developed by the service provider.

The State should also require that the assignment of unscheduled duties is actively managed by operational processes and procedures which contain elements such as:

- minimizing the extent of disruption to the timing of a planned duty;
- providing protected sleep opportunities (prior to, during and after unscheduled duties);
- identifying minimal notification periods for changes to planned duties; and
- limiting the number of consecutive days that they may be subject to being assigned unscheduled duties.

4.3.2. COMPLIANCE WITH VARIATION PROCESS REQUIREMENTS

Compliance with approved processes for extending work periods in sudden unforeseen operational circumstances should be monitored to ensure that such extensions are used only as appropriate. Such monitoring can be achieved through:

- analysis of the proportion of duties which necessitated such extensions; and
- examination of reports which the State should require to be generated each time such extensions are used. These reports should contain sufficient information to identify the reason for the use of the extension, the effectiveness of any fatigue mitigations employed and subsequent changes to the schedule to ensure realignment with prescribed limits.

Where variations have been approved to meet expected operational circumstances, compliance with the associated mitigations, processes and procedures also needs to be monitored. Such monitoring can be achieved through:

- including the assessment of the use of the variations as part of regular oversight visits;
- reviewing the safety performance indicators that were agreed within the variation approval; and
- reviewing any safety reports (either mandatory or voluntary) associated with the agreed variation.

4.3.3. COMPLIANCE WITH SMS REQUIREMENTS

Complying with the prescriptive limitations does not relieve the service provider of the responsibility to manage its risks, including fatigue-related risks, using its SMS. However, they are less onerous and have fewer specific obligations for fatigue-related risk management than with FRMS, particularly with regards to collecting data. Despite this, States should still be satisfied that the evidence of SMS processes applied to fatigue-related risks is sufficiently robust to manage the fatigue risk expected when operating up to the fullest extent of the prescriptive limitations.

Minimum expectations for managing fatigue risk using existing SMS processes are provided as follows.

IDENTIFYING FATIGUE RISKS

For operations that remain within the prescriptive flight and duty time limits, there are a number of sources of data already available to a service provider that can be used to identify where fatigue might constitute a hazard. Most, but not all, involve "reactive hazard identification", which means that fatigue is identified after it has occurred. Depending on the size of a service provider and the maturity of its SMS processes, some or all of the following examples might be acceptable for use:

- gathering information from previous accidents and incidents (internal and external);
- considering hazard reports that may be associated with fatigue;
- considering fatigue-related results of internally or externally conducted safety assessments/audits;
- considering fatigue-related safety information from external sources (i.e. similar service providers, media, accident investigation bodies, audit reports etc.);
- considering results from generic fatigue hazard checklists; and
- active participation with the service provider's Safety Committee or having a small group of suitably experienced members of the service provider meet to consider the service provider's operations and identify possible fatigue hazards in this manner.

Note.— Larger, more complex operations may additionally include confidential reporting processes, bio-mathematical modelling, and formal data analysis techniques.

Voluntary reporting systems offer particular opportunities for identifying fatigue hazards through the inclusion of fatigue-related fields on existing report forms. 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. Where a service provider does not provide opportunity to report fatigue hazards, this may indicate to a State service provider a lack of genuine commitment to the management of fatigue risks.

An effective reporting mechanism requires:

- forms that are easy to access, complete and submit;
- clearly understood rules about confidentiality of reported information;
- clearly understandable voluntary reporting protection limits;
- regular analysis of the reports; and
- the provision of regular feedback to individuals about decisions or actions taken based on the reports and lessons learned.

Voluntary hazard report forms (either paper-based or electronic) should include information on recent sleep history (minimum last 72 hours), time of day of the event, and measures of different aspects of fatigue-related impairment (for example, validated alertness or sleepiness scales). It should also provide space for written commentary so that the person reporting can explain the context of the event and give their view of why it happened. An example of fatigue-related fields for inclusion on hazard report forms can be found in Appendix I.

Service providers should encourage individuals to use the voluntary reporting system to identify fatigue hazards when:

- a duty period has not commenced or is not completed, due entirely or in part, to fatigue. Filing of such reports should be included as part of an established process for reporting 'not fit for duty' due to fatigue identified by the service provider. Also identified should be the subsequent service provider actions that will be enacted in such situations;

- a duty period has been completed in which the individual believes that the level of fatigue they or other individuals were suffering meant sufficient safety margins had not been maintained throughout the operation or were only maintained following some unplanned mitigating action (e.g. task rotation, reducing the workload of the duty, delaying the reporting time, creating the opportunity for a nap, increasing supervision/monitoring etc.); and
- the individual notices something in their operating environment that is likely to impact on alertness to such an extent that safety margins could be reduced to unsatisfactory levels.

MITIGATING FATIGUE RISKS

Where a fatigue risk is identified while complying with prescribed limits, the service provider will put in place a safety action plan identifying appropriate mitigations and controls according to its current safety management practices.

Fatigue risk can only be managed in part by States limiting the hours of duty and commensurately providing for sufficient non-duty periods. There may still remain a need for a service provider to control fatigue risk by further limiting prescriptive limitations promulgated by the State due to their unique operating environment and workload considerations, or other factors.

As well as working to more restrictive limits than those prescribed, other typical risk mitigations which may also be considered by a service provider include the adjustment of scheduling practices and policies, provision of controlled napping opportunities, provision of protected sleep opportunities, or augmenting staffing levels (discussed in Chapter 2).

SMS processes should require that such risk mitigations are regularly reviewed and assessed to ensure their desired outcome continues.

TRAINING

As part of their SMS, service providers are responsible for maintaining a safety training programme that ensures that personnel are trained and competent to perform their SMS duties (Annex 19, Appendix 2 refers). While most Annexes with Fatigue Management SARPs also include a specific requirement for fatigue management-related training, the pre-existing SMS training Standard already requires that service providers offer awareness and training programmes over and above those that are part of approved training programmes for licensing purposes. SMS therefore places an expectation on service providers to incorporate basic fatigue management topics in their awareness and training programmes. This is discussed further in 4.3.4 below.

4.3.4. COMPLIANCE WITH TRAINING REQUIREMENTS

It will be necessary for the State to ensure that fatigue management-related topics are included in a service provider's training programme and on safety information circulars, as appropriate. All individuals who are implicated in the realm of fatigue management, including the organization's management personnel, rostering personnel and the individuals at the front-line, need training and information related to fatigue management.

The fatigue management-related content in training programmes for these individuals should be appropriate to their role in managing fatigue within the service provider's SMS activities. It should comprise basic scientific principles related to fatigue management and general sleep hygiene as well as content specific to the service provider's type of service and unique operational characteristics. This will include information on options for personal mitigation strategies and familiarization with service provider procedures for activities such as "shift swapping", reporting "not fit for duties" due to fatigue, or assigning unscheduled duties. Suggestions for fatigue management training topics can be found in Appendix J.

Service provider fatigue management training should be conducted on an initial and recurrent basis. The interval between training should be determined by the service provider given their operational characteristics and training needs analysis driven by the SMS processes. This means that the State should ensure that the training programme, and the way in which the service provider assesses the effectiveness of its training programme, is commensurate and sufficient for its needs.

Effective coverage of fatigue topics may be confirmed through reviewing trends in fatigue reporting rates and the quality of information provided in fatigue reports. This information could provide insights into how well fatigue hazards are recognized. Another indicator of how well fatigue concepts have been understood, is the appropriateness of fatigue mitigations used.

4.4. STATE SAFETY PROGRAMME CONSIDERATIONS

The aviation industry is continually changing. Volumes of traffic continue to increase, as does the complexity and sophistication of the system as new tools and technologies are employed. It is essential that any change be assessed against the potential of new risks being introduced and the impact of known risks such as fatigue. A State is required to continually review its own legislation, policies and processes as part of its State Safety Programme, under ICAO Annex 19 Standards. As such, considerations surrounding the potential impact of fatigue on the different operational personnel within aviation will form part of the State's requirements to review its safety performance.

The State's Safety Programme needs to review or adjust the requirements set out in its prescriptive fatigue management regulations just as it would expect a service provider to review its safety performance under an SMS. To do so, a State should review its prescriptive limitation regulations in the light of recent scientific and operational advances in fatigue management knowledge, at regular periods.

Further, as part of the SSP, results of industry audits that examine compliance with prescribed limits and associated requirements should be used to enhance a State's analysis of its safety performance related to fatigue management. Areas of higher risk may indicate that limitations need adjustment. State SPIs that rely on accident and incident reports alone as a means of monitoring fatigue management performance are limited because issues surrounding fatigue are often under-reported or not identified in the broader State safety data collection methods such as mandatory occurrence reporting.

CHAPTER 5. THE FRMS APPROACH

The ICAO SARPs define FRMS as "a data-driven means of continuously monitoring and managing fatigue-related safety risks, based upon scientific principles and knowledge as well as operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness".

Therefore, the effectiveness of an FRMS depends on the availability of the necessary fatigue data and information. Much of this data and information is provided voluntarily by individuals. Without a framework that protects data, information and their sources, it will be difficult for a service provider to obtain the data needed for an FRMS. Unless a service provider has a willing and engaged workforce, the full benefits of an FRMS will not be realized.

IMPLICATIONS FOR THE STATE:
The State needs to be assured that the service provider has been able to engage its workforce to participate actively in the FRMS.

Such 'buy-in' requires a level of confidence amongst the workforce that the service provider will:

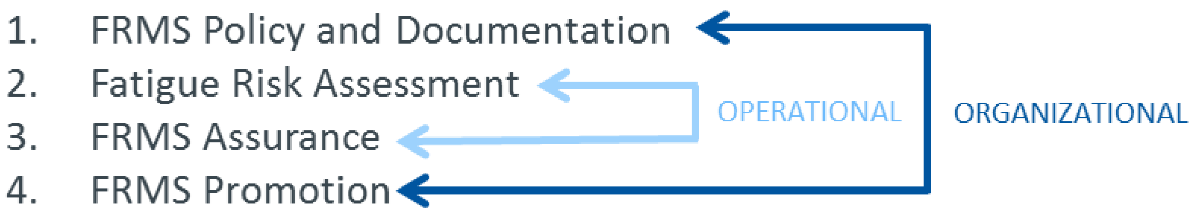
- meet their FRMS responsibilities with the necessary level of commitment, skills and resources;
- use an individual's fatigue data and information for the express purpose of managing fatigue risks;
- maintain confidentiality of personal information; and
- involve operational personnel in the identification of appropriate fatigue mitigation strategies (see Section 5.3.1).

However, in turn, the service provider also requires a level of confidence that the workforce will:

- meet their individual responsibilities for managing their fatigue level prior to and during work periods;
- provide unbiased feedback on the effectiveness of the mitigation of fatigue risks; and
- be receptive to the intent of the FRMS to improve safety and efficiency rather than for personal, financial or industrial gain.

5.1. OVERVIEW OF A FULLY FUNCTIONING FRMS

An FRMS has four components, two of which are operationally focused and two which are organizationally focused.



Fatigue Risk Assessment and FRMS Assurance make up the operational FRMS activities:

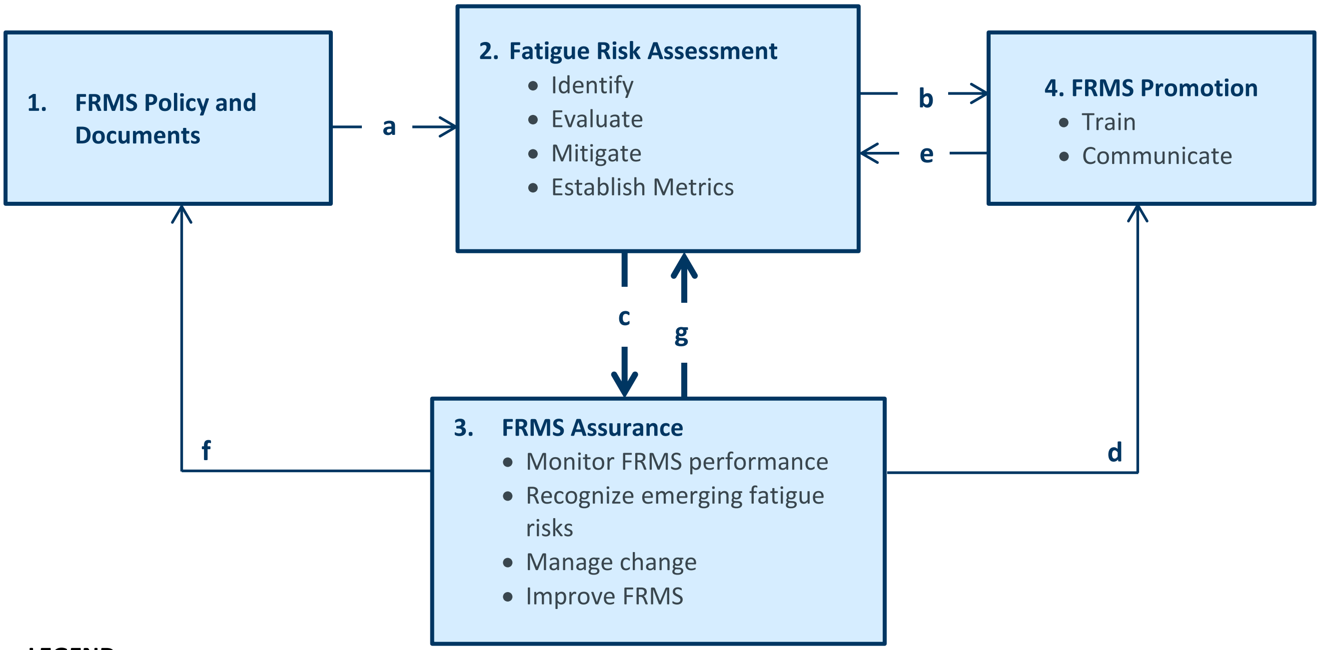
> Fatigue Risk Assessment (FRA) – Component 2: This component includes the process of identifying and evaluating fatigue risks, deciding what and how to mitigate, and establishing the fatigue metrics to allow the effectiveness of the mitigations to be assessed.
>
> FRMS Assurance – Component 3: Here, fatigue metrics and FRMS performance are monitored to assess if the system is delivering the expected levels of safety performance against the identified fatigue related risks.

The operational activities are defined, documented and supported by organizational FRMS activities:

> FRMS Policy and Documentation – Component 1: The FRMS policy identifies the structure and scope of the FRMS and points to supporting FRMS documentation detailing the processes and procedures associated with the other FRMS components.
>
> FRMS Promotion – Component 4: This component focuses on informing and training individuals in order to engage and encourage the type of behaviours necessary to support the FRMS.

The ICAO SARPs (see Appendix A.) have detailed minimum requirements for each of these four FRMS components. These components are described further in Sections 5.2 to 5.5.

A fully functioning FRMS requires interactions between these four components. How the components interact are summarized in Figure 5-1.



LEGEND:

a) FRMS documents state all of the policies and procedures required for an approved FRMS, including: the methods used to identify fatigue risks; how the need for mitigations and the method of mitigation was determined; and the measures (i.e. fatigue metrics) used to determine the effectiveness of the mitigations and the overall functioning of the FRMS.

b) Additional training or guidance for individuals to understand their specific individual requirements under an FRMS, including the use of mitigations identified through fatigue risk assessment.

c) *Metrics are monitored to determine whether the mitigations used are delivering the expected results. Metrics are also monitored to determine whether the policy and procedures remain applicable and relevant to address existing fatigue risks as well as to determine whether the FRMS promotion activities are delivering the expected benefits.

d) Findings from the monitoring of the fatigue assurance processes can be used to where FRMS training and promotional activities are being effective in delivering understanding and raising awareness. Lessons learnt through assurance activities can be shared among other stakeholders to support operational understanding. Where the training is not being effective changes to the training and promotional activities can be developed.

e) Information gathered by stakeholders is used to inform fatigue risk assessment processes.

f) Where the mitigations are found to be effective, they become part of normal operations and if necessary, the FRMS documentation is updated. Also, should a process, procedure or identified mitigation or metric be identified as no longer relevant or effective, then the FRMS document will be updated.

g) *Where the mitigations are found to be ineffective or to have generated unintended consequences, the fatigue risks are then reassessed through the fatigue risk assessment process. This will review the risk again in order to propose additional or alternative mitigations / risk treatment.

* *The interaction between FRA and FRMS Assurance (c and g) represent the continuous day-to-day functions of the FRMS. They drive changes in the other components.*

Figure 5-1. Interactions between the four components of a fully functioning FRMS.

5.1.1. FATIGUE SAFETY ACTION GROUP

Although not required by the SARPs, it is recommended that service providers establish a Fatigue Safety Action Group (FSAG) with responsibility for coordinating FRMS activities. Since fatigue management must be based on shared responsibility (Section 3.3 refers) and requires data and information provided voluntarily, it is also recommended that the FSAG includes representatives of all stakeholder groups (management, scheduling staff, and representatives of the "frontline" individuals) with input from other individuals as needed to ensure appropriate access to scientific, statistical, and medical expertise. Inclusion of all stakeholders is an important strategy for promoting engagement in the FRMS.

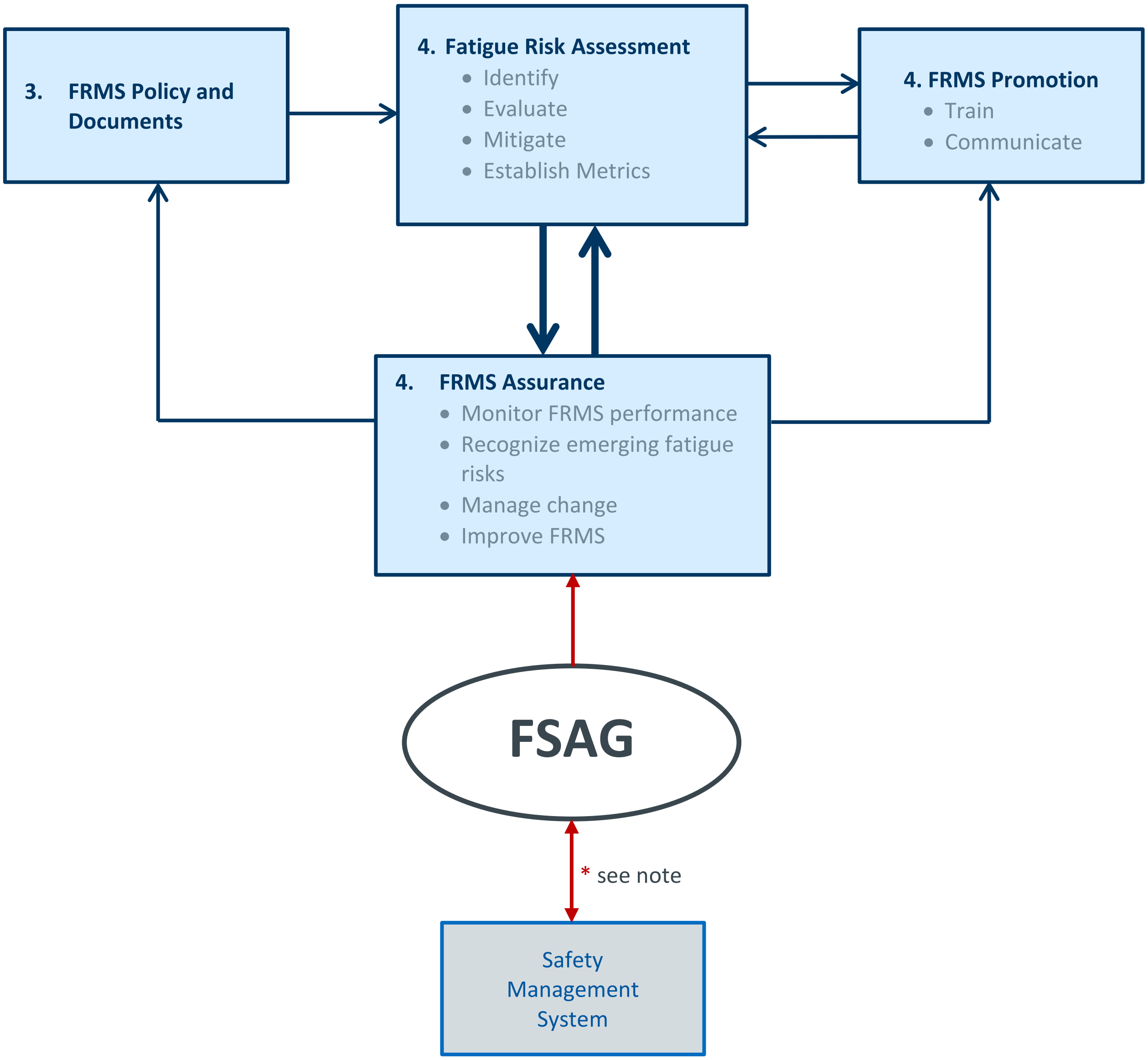
__Implications for the State:__ The State needs to be assured that the service provider has considered its operational and organizational profile in deciding the composition of the FSAG activities, and its interactions with other parts of the service provider's organization.

The size and composition of the FSAG will vary for different service providers, but should be appropriate to the size and complexity of the operations covered by the FRMS, and to the level of fatigue risk in those operations. In small organizations, a single individual may represent more than one stakeholder group, for example the chief pilot or the manager of the ATC group may also be the primary scheduler. Larger organizations will have specialized departments that interact with the FSAG (e.g. "day-of-operations" scheduling and business development).

The principle functions of the FSAG are to:

- oversee the development of the FRMS;
- assist in FRMS implementation;
- oversee the ongoing operation of the fatigue risk assessment processes;
- contribute as appropriate to the FRMS assurance processes;
- maintain the FRMS documentation;
- be responsible for ongoing FRMS training and promotion; and
- provide necessary input on all aspects of fatigue risk to the SMS.

Figure 5-2 highlights the FSAG's role with regards to the FRMS and to its role as a contributor to the SMS.



* In some situations, fatigue affects broader operational outcomes. This can require the involvement of expertise outside the FSAG. The SMS should also seek the expertise of the FSAG for fatigue assessment and mitigation in any operation.

Figure 5-2. The role of the FSAG between the FRMS and the SMS.

The FSAG should operate under the terms of reference that are included in the FRMS documentation and which specify its activities, interactions with other parts of the organization, and the lines of accountability between the FSAG and the service provider's SMS. An example of the terms of reference for an FSAG is provided in Appendix G.

The civil aviation safety inspector (CASI) is not a member of the FSAG. However, as part of their oversight activities, the CASI may take an opportunity to attend FSAG meetings, review minutes of their meeting and follow up on FSAG action items to assure that these are being addressed (see Chapter 6).

While the FSAG is responsible for the day-to-day running of an FRMS, an FRMS should undergo routine quality audits by a third party provider or by an area of the organization that is independent of the FSAG to ensure that the organization is following its own FRMS policies and procedures.

5.2. COMPONENT 1: POLICY AND DOCUMENTATION

The FRMS policy and underpinning documentation define the organizational arrangements that support the operational activities of the FRMS (fatigue risk assessment and FRMS assurance).

5.2.1. FRMS POLICY

The FRMS policy clearly specifies the service provider's commitment and approach to the management of their fatigue risks and defines all elements of the service provider's FRMS. It is unique to the organization that develops it and reflects its particular organizational context and operational needs.

An FRMS builds on an operator's SMS. In some cases it may be appropriate for the service provider to incorporate its FRMS policy with its SMS policy. However, having an SMS does not mean that a service provider has an FRMS as a matter of consequence. An FRMS requires explicit approval before it can be implemented (Chapter 1 refers). For that reason, ICAO SARPs require that a service provider have an FRMS policy that is easily identifiable, is clearly distinguishable from other safety policy statements, and is able to be reviewed in its entirety.

IMPLICATIONS FOR THE STATE:

Any changes in the scope of the FRMS must be acceptable to the State. All operations not covered by the FRMS must operate under the applicable prescriptive limitation regulations.

ICAO SARPs also require that the FRMS policy must indicate the scope of the operations to which the FRMS applies. This means that the policy should define to whom and to what type of operation it applies (e.g. air traffic controllers in the control tower versus the approach unit or area control centre; flight operations with in-flight sleep opportunities). However, because a policy statement is typically a short and stable document, it does not have to detail the specific routes or specific work places operating under the FRMS. It does have to identify where these are detailed (e.g. the Operations Manual). This means that any changes in scope, which are all subject to the State's approval, do not require a rewrite of the initial FRMS policy statement.

Other requirements for an FRMS policy are that it must:

- reflect the shared responsibility of management, the individuals covered under the FRMS Policy, and others involved in the functions of the FRMS;
- clearly state the safety objectives of the FRMS (the safety objectives in the FRMS policy specify the standards that the service provider and the State have agreed must be achieved by the FRMS. The FRMS policy also needs to identify safety performance indicators and targets that will be used to measure how well the FRMS is meeting its safety objectives). (Examples of safety performance indicators can be found in *Section 5.4.1 Monitoring FRMS Performance*);
- be signed by the accountable executive of the organization;
- be communicated, with visible endorsement, to all the relevant areas and levels of the organization;
- declare management commitment to effective safety reporting;
- declare management commitment to the provision of adequate resources for the FRMS;
- declare management commitment to maintain or continuously improve the FRMS;
- require that clear lines of accountability for management, individual professionals, and all other involved personnel are identified; and
- require periodic reviews to ensure it remains relevant and appropriate.

> ***IMPLICATIONS FOR THE STATE:***
> *A periodic review of the FRMS policy is needed to ensure that it is adequate to meet changing operational demands. Any changes to FRMS policy should be approved by the State.*

5.2.2. FRMS DOCUMENTATION

The documentation describes all the elements of the FRMS and provides a record of FRMS activities along with any changes to the FRMS. It is essential for internal and external audits of the FRMS. The documentation can be centralized in an FRMS manual, or the required information may be integrated into a service provider's SMS manual. However, it needs to be accessible to all personnel who may need to consult it, and to the State for audit.

The service providers' FRMS documentation describes and records:

- FRMS policy and objectives;
- FRMS processes and procedures – including details of FRA and FRMS assurance methods;
- accountabilities, responsibilities and authorities for these processes and procedures;
- mechanisms for ongoing involvement of management, flight and cabin crew members, and all other involved personnel;
- FRMS training programme, training requirements and attendance records;
- scheduled and actual flight times, duty periods and rest periods with deviations and reasons for deviations noted;

> ***IMPLICATIONS FOR THE STATE:***
> *FRMS documentation will develop iteratively during the approval process and be guided by the State's and service provider's combined experience.*

- FRMS outputs including findings from collected data, recommendations, and actions taken; and
- FSAG terms of reference.

5.3. COMPONENT 2: FATIGUE RISK ASSESSMENT

Fatigue risk assessment (FRA) processes are one part of the day-to-day operations of the FRMS. They enable the service provider to achieve the safety objectives defined in its FRMS policy and involve:

1. identification of situations or conditions where fatigue may constitute a hazard;
2. evaluation of the level of fatigue risk;
3. introduction of risk mitigations when needed; and
4. establishing metrics to measure the effectiveness of the risk mitigations and the overall FRMS.

Each of these steps is described in the following sections.

5.3.1. FATIGUE HAZARD IDENTIFICATION

FRA processes are data driven. The fatigue monitoring data required as part of the FRA process are more comprehensive than what is required for managing fatigue in operations that comply with the prescriptive limits and are managed under an operator's SMS.

A range of types of data can be useful, and the key is choosing the right combination of measures for each operation covered by the FRMS, both for routine monitoring and when additional information is required about a potential hazard that has been identified. A list of tools used to provide different types of data is provided in Appendix B. of this manual and more detailed descriptions of the various methods for monitoring fatigue levels, with examples, are described in the associated implementation manuals.

In assessing which measures are appropriate for a given situation, the following should be considered:

> ***IMPLICATIONS FOR THE STATE:***
> *Civil aviation safety inspectors (CASIs) will need an understanding of the strengths and weaknesses of different types of data sources to assess the appropriateness of those used by the service provider.*

- there is no single measurement that gives a total picture of an individual's current fatigue level because fatigue related impairment affects many skills and has multiple causes;
- the expected level of fatigue risk *should guide the choice of measurements*. All measures require resources (financial and personnel) for data collection and analysis. Limited resources need to be used effectively to identify fatigue hazards and to help the FSAG prioritize where controls and mitigations are most needed;
- a core set of measures should be selected for routine monitoring. For example, fatigue reports and regular analyses of planned versus actual schedules could be used for ongoing monitoring of fatigue hazards;
- additional measures can be used if a potential hazard is identified and the FSAG decides that more information is needed. Again, the measures selected need to reflect the expected level of risk; and

- balance needs to be maintained between gathering enough data for the FSAG to be confident about its decisions and actions, and the additional demands that data collection can place on individuals (sometimes described in science as "participant fatigue").

From the ICAO SARPs, an FRMS necessarily involves three types of hazard identification:

1. Predictive

- Fatigue hazards identified by examining planned work schedules (rosters), taking into account factors known to affect sleep and fatigue.

2. Proactive (monitored during operations)

- Fatigue hazards identified by measuring fatigue levels in current operations.

3. Reactive (gathered after an event or incident)

- Fatigue hazards identified by assessing the contribution of fatigue to safety reports and events that have occurred.

ICAO SARPs identify types of data and information than can be monitored:

HAZARD IDENTIFCATION

PREDICTIVE

- Previous experience
- Evidence based scheduling practices
- Bio-mathematical modeling

PROACTIVE

- Self-reported fatigue risks
- Fatigue surveys
- Performance data
- Safety databases and scientific studies
- Planned vs. actual time worked analysis
- Sleep monitoring

REACTIVE

- Hazard reports
- Operational audits
- Event investigations

The service provider will need to identify their fatigue hazards using all of these methods to ensure availability of the various kinds of information and data needed by an FRMS to continuously monitor the levels of fatigue risk. They enable data-driven decisions based on scientifically valid principles and measurements.

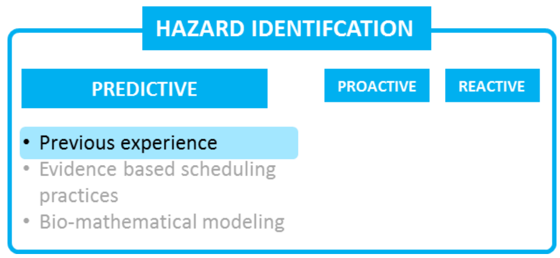
The following sections describe each of these types of data.

PREDICTIVE HAZARD IDENTIFICATION

Predictive processes are designed to identify likely fatigue hazards before they occur. ICAO FRMS SARPs list three possible methods to predict fatigue levels associated with planned work schedules (rosters). These involve the use of:

- previous experience (of the service providers or others in the industry);
- evidence-based scheduling practices; and
- bio-mathematical models.

PREVIOUS EXPERIENCE



As identified in Chapter 3, the collective experience of managers, schedulers, and individual operational personnel is an important source of information for identifying fatigue hazards relating to scheduling. For example, crew members may recognize a particular trip as generating a high level of fatigue because of regular delays caused by heavy traffic; or air traffic controllers may recognize a pattern of shifts as particularly fatiguing. The value of this collective experience can be enhanced by having staff 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).

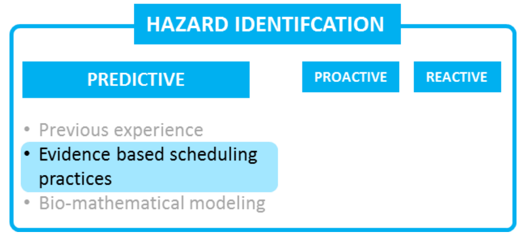
When operational demands are changing, reliance on previous experience can have limitations. Scheduling based only on previous experience may not give the most robust or innovative solutions for new situations. It may also be important to collect data on actual levels of workers' fatigue, to check whether the lessons from previous experience are still valid in the new context.

Another way to identify fatigue hazards related to scheduling is to look for information on similar schedules. This could include incident reports and fatigue reports, or published scientific research and other information available on similar operations. The amount of confidence that can be placed in this approach depends directly on how similar these other operations are to the operation in question.

IMPLICATIONS FOR THE STATE:

States should give more weight to empirical evidence, rather than anecdotal evidence, when considering the service provider's previous experience.

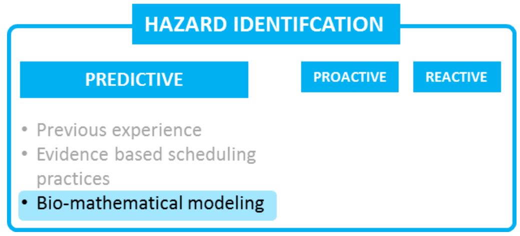
EVIDENCE-BASED SCHEDULING PRACTICES



As summarized in Chapter 2 (Operational Implication 7), fatigue hazards relating to scheduling can also be predicted when fatigue science is applied in the building of schedules. Evidence-based scheduling rules can be developed by an expert reviewer, for example by a scheduler trained in fatigue hazard identification, or by the FSAG. The scientific basis for the scheduling rules should be recorded in the FRMS documentation. The ongoing monitoring of fatigue levels in the FRM processes provides a mechanism for continuous improvement of evidence-based scheduling rules for an operation.

Potential fatigue hazards may be identified by gathering information on schedules that approach or exceed evidence-based scheduling rules. This could occur due to operational disruptions, sickness or due to roster swaps and trades.

BIO-MATHEMATICAL MODELS



Bio-mathematical models, made available mostly as computer software, provide predictions of the level of fatigue associated with certain schedules. Models are an example of a tool that can be used to estimate fatigue within an operation governed by an FRMS, and do not by themselves constitute an FRMS. They should not be used to make decisions about schedule design without reference to operational experience. The benefits and limitations of bio-mathematical models are discussed in Appendix K. The Australian Civil Aviation Safety Authority has also published valuable guidance on the use of bio-mathematical models in FRMS..[38]

IMPLICATIONS FOR THE STATE:

States should not rely on bio-mathematical models as the sole means of evaluating the effectiveness of a service provider's FRMS.

PROACTIVE HAZARD IDENTIFICATION

Proactive processes are designed to identify fatigue hazards by measuring fatigue levels in current operations. The success of proactive processes (and of the FRMS) depends on the willingness of individuals to participate in data collection. This makes it important to consider the demands placed on individuals by different types of fatigue measurement (for example, measures such as filling out a questionnaire once, keeping a sleep/duty diary and wearing a simple device to monitor sleep every day before, during and after a trip or series of shifts, doing multiple performance tests and fatigue ratings across flights of a shift period, etc.).

The willingness of individuals to participate will also reflect their level of understanding of their roles and responsibilities in FRMS, their confidence that the purpose of the data collection is to improve safety and the feedback they receive. Measuring fatigue levels may involve monitoring individuals both on duty and off duty, because fatigue levels on duty are affected by prior sleep patterns and by waking activities outside of duty hours. There are ethical considerations around issues such as the privacy of individuals, confidentiality and use of data, and whether individuals are really free to refuse to participate (voluntary participation is a requirement in scientific studies involving human participants). Many countries have specific legislation around privacy and workplace responsibilities for safety that may need to be considered, in addition to conditions specified in industrial agreements.

Because fatigue-related impairment affects many skills and has multiple causes, there is no single measurement that gives a total picture of an individual's current fatigue level and multiple sources of data are necessary for proactive hazard identification.

[38] Biomathematical Fatigue Models: Guidance Document. http://www.casa.gov.au/wcmswr/_assets/main/aoc/fatigue/fatigue_modelling.pdf

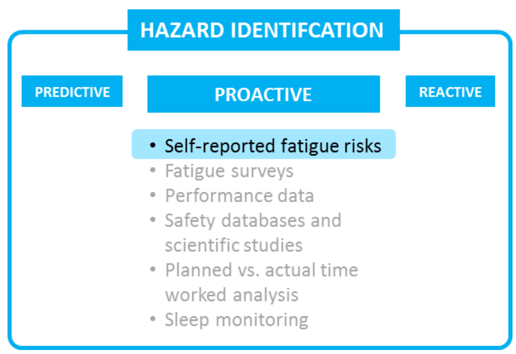
To decide on which types of data to collect, the most important thing to consider is the expected level of fatigue risk. More intensive fatigue monitoring should be targeted at operations where the risk is expected to be higher.

The ICAO SARPs list six possible methods of proactive fatigue hazard identification:

- self-reporting of fatigue risks;
- fatigue surveys;
- relevant performance data;
- available safety databases and scientific studies;
- analysis of planned versus actual time worked; and
- monitoring sleep.

These methods are discussed further below.

SELF-REPORTING OF FATIGUE RISKS



Reports of being unable to operate due to fatigue, experiences of fatigue when operating or identifying fatigue hazards (e.g. a noisy rest facility) provide vital information about fatigue hazards in the day-to-day running of an operation. Reports can come from individuals or other operational staff.

Depending on a service provider's SMS hazard reporting process, an existing form (e.g. an air safety report form) may be adapted, or a separate form may need to be developed, for individuals to report fatigue. Information collected on the form should include the severity of fatigue, recent sleep history (timing and duration of sleep over the last <u>three days</u> as a minimum), and time of day of the safety event (if the report involves a safety event). Fatigue reports should also provide space for individuals to describe the cause and consequences of fatigue and to provide contextual information[39]. Individuals should be made aware of the procedures for reporting fatigue (discussed in Section 5.5 of this chapter).

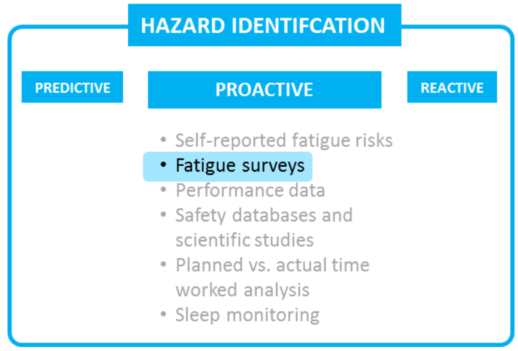
IMPLICATIONS FOR THE STATE:

The absence of fatigue reports may suggest that the service provider is unable or unwilling to support adequate mechanisms for reporting.

Fatigue reports should be analyzed regularly by the FSAG and feedback provided as appropriate to individuals and groups about any actions taken, or why no action was considered necessary. A series of fatigue reports on a particular route or in particular series of shifts can be a trigger for further investigation by the FSAG.

[39] In addition to providing operational personnel with a form to report fatigue, there are other forms such as mandatory incident/accident reporting forms that need to be adjusted to collect the necessary information to identify fatigue as a contributing factor. The evaluation of the contribution of fatigue to safety events is addressed in Appendix I.

FATIGUE SURVEYS



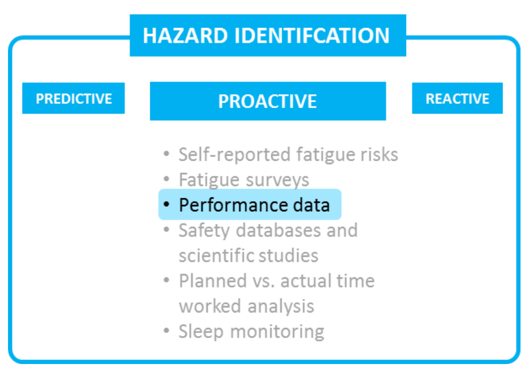
Fatigue surveys are of two basic types:

- retrospective surveys that ask individuals to recall (e.g. over the last 3 months, their fatigue levels, the factors which contributed to their fatigue levels, and the amount of sleep they obtained). These surveys are often web-based and can be relatively detailed, so they are usually completed at long time intervals (for example, once a year); and
- prospective surveys that ask individuals to record, in real time, their sleepiness or alertness, fatigue level and timing and duration of sleep. These are typically short and can be completed multiple times to monitor fatigue (e.g. before and after a schedule change or across a duty period, trip, or roster).

Appendix B. lists some examples of fatigue, alertness and sleepiness rating scales that can be used for retrospective surveys, and others that can be used for prospective monitoring. These are further described in the series of Implementation Manuals. These scales have been validated and are widely used in aviation operations. Using standard scales enables the FSAG to compare fatigue levels between different parts of their operation, with other operators, and published scientific studies. These comparisons can be helpful in making decisions about where controls and mitigations are necessary.

Compared to some other types of fatigue monitoring, fatigue surveys can be conducted relatively quickly and inexpensively to provide a "snapshot" of fatigue levels and their potential causes. If a high proportion of individuals participate in a survey (ideally more than 70 per cent), it gives a more representative picture of the range of fatigue levels and opinions across the whole group. The information gathered in surveys is subjective (individuals' personal recall and views), so getting a representative picture can be important for guiding the decisions and actions of the FSAG.

Fatigue surveys can be focused on a particular operation or issue. For example, a series of fatigue reports about a particular pattern of duties might trigger the FSAG to undertake a survey of all individuals undertaking that duty pattern (retrospective or prospective), to see how widespread the problem is. The FSAG might also undertake a survey (retrospective or prospective) to get feedback about the effects of a schedule change. Surveys can also be more general, for example providing an overview of the causes and consequences of fatigue across a particular ATC unit, aircraft fleet or operation type.



INDIVIDUAL PERFORMANCE DATA

Performance measurements provide objective data that can be used to supplement the subjective data collected in fatigue reports and surveys. Currently there are three main approaches to monitoring performance, each with strengths and weaknesses.

First, a range of simple tests developed and validated in the laboratory can be adapted for use in operations.

These measure aspects of an individual's performance (for example, reaction time, vigilance, short-term memory, etc.). Things to consider when choosing a performance test for measuring an individual's fatigue include the following:

a. How long does the test last? Can it be completed at multiple time points (for example, across a work duty or across a flight) without compromising an individual's ability to meet duty requirements?
b. Has it been validated? For example, has it been shown to be sensitive to the effects of sleep loss and the circadian body clock cycle under controlled experimental conditions?
c. Is the test predictive of more complex tasks, e.g. performance in a simulator? (Unfortunately, there is very little research addressing this question at present.)
d. Has it been used in other similar aviation operations, and are the data available to compare fatigue levels between operations?

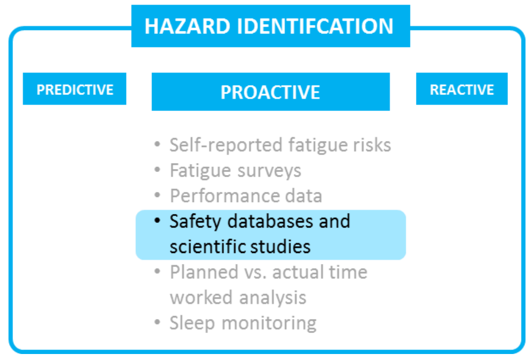
These "added performance measures" have the disadvantage that they interrupt the normal flow of work. In addition, little is known about how an individual's performance on simple laboratory tests relates to their performance on more complex tasks, or to their contribution to the performance of a team. However, this is currently the most practical approach available.

Second, there is considerable interest in finding ways to link individual fatigue levels to data collected systematically through the use of an automated system (e.g. flight data analysis (FDA)). Such data has the advantages that it is routinely collected, does not interrupt the normal flow of work, and is relevant to operational safety. The difficulty is that a multitude of factors contribute to deviations from planned parameters. For example, to use FDA data as a measure of crew member fatigue would require demonstrating consistent changes in FDA data that are reliably linked to other measures of crew member fatigue (for example sleep loss in the last 24 hours, time in the circadian body clock cycle, etc). Research in this area is ongoing.

The third approach involves having trained observers rating the performance of operational personnel undertaking their duties (e.g. Line-Oriented Safety Audit (LOSA) for pilots; Normal Operations Safety Survey (NOSS) for air traffic controllers). However, this is very labor-intensive and expensive. Having the observer present may also have an alerting effect and place additional demands on the individual. These factors currently limit the usefulness of this approach for proactive fatigue hazard identification in an FRMS.

AVAILABLE SAFETY DATABASES AND SCIENTIFIC STUDIES

Other information about fatigue hazards may be available from external safety databases, such as Aviation Safety Reports (ASRs) and Mandatory Occurrence Reports (MORs) maintained by safety authorities and databases maintained by service providers or research institutions. Because safety events are relatively rare, the analysis of safety event databases are an important additional source of information that complements direct measurement of fatigue levels in the operation(s) covered by the FRMS.



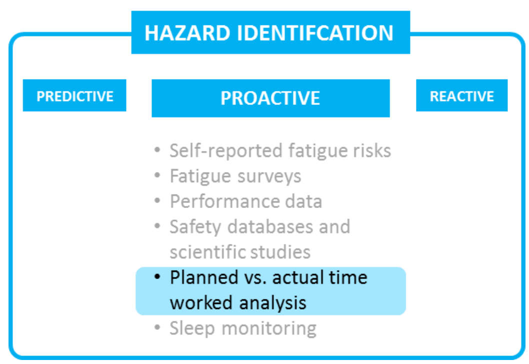
IMPLICATIONS FOR THE STATE:

States should consider providing access to publicly available fatigue material, or references to relevant literature, for service providers to access.

Operationally-based fatigue research is expanding. The particular value of these studies is in their use of more rigorous scientific approaches, which increases the reliability of their findings. The level of detail in some studies may be more than is needed for proactive identification of fatigue hazards. However, most reports and published papers have executive summaries or abstracts that outline the key findings.

ANALYSIS OF PLANNED VERSUS ACTUAL TIME WORKED

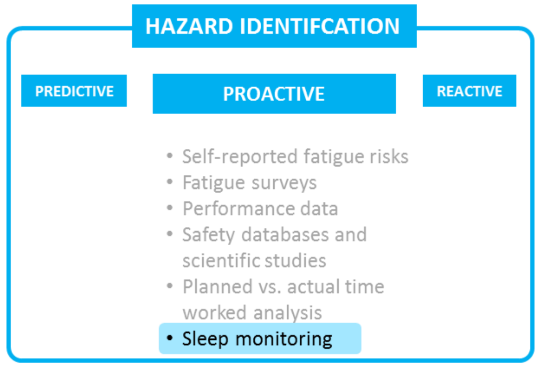
Predictive identification of fatigue hazards is possible during the planning of schedules (see above). However, numerous unforeseen circumstances can cause changes to planned schedules, for example weather conditions, unexpected automation or mechanical failures, or staffing unavailability due to illness. Fatigue relates to what is actually worked, not what is planned. Data on actual work periods can identify times when fatigue might have been higher than expected from the planned schedule.



Data on planned and actual work periods is required under both prescriptive limitation regulations and FRMS. For proactive hazard identification under FRMS, the FSAG might use planned and actual duties to track how often each month:

- duty periods end at least 30 minutes later than scheduled;
- the maximum scheduled duty day specified in the FRMS policy is exceeded; and
- shift/trip swapping occurs.

MONITORING SLEEP



Given the primary importance of sleep loss and recovery in the dynamics of fatigue, another valuable and commonly used method for proactive fatigue hazard identification is sleep monitoring. Sleep can be monitored in a variety of ways, all of which have advantages and disadvantages (see Appendix C).

The simplest and cheapest method of monitoring sleep is to have individuals complete a daily sleep diary before, during, and after the pattern of work or part of the roster being studied. They are typically asked to record when they sleep, and to rate the quality of their sleep, as soon as possible after waking up. This can be done using a paper diary or tablets or electronic devices (e.g. smart phones).

A more objective measure of sleep/wake patterns can be obtained by continuously monitoring movement, using a medical grade “actigraph”. This is a wristwatch-like device that is worn continuously (except when showering or bathing). Data on the amount of movement is recorded regularly (typically every minute) and is downloaded to a computer after several weeks, for subsequent analysis. Because actigraphs are not cheap (yet), usually only a sample of individuals would have their sleep monitored in this way. The medical grade actiwatch data must be processed and analyzed by a person trained to do so.

Cheaper, commercially available fitness and activity trackers containing actigraphy monitors are also available and are used by individuals to monitor their own sleep patterns. This information may be useful for an individual to manage their own fatigue levels for personal use although the output of these devices is less accurate than that from medical grade devices. Until the outputs of such devices have been scientifically validated, their results should not be used as a basis for fatigue management regulations or operational decisions.

IMPLICATIONS FOR THE STATES:

States should be familiar with the limitations of fatigue data collection mechanisms, and be satisfied that the service provider makes use of these data appropriately.

In rare cases, where the expected fatigue risk is high or uncertain (for example in new types of operations), portable polysomnographic recordings may be used to monitor sleep both across a pattern of work. This involves applying electrodes to the scalp and face to record electrical signals coming from the brain (electroencephalogram or EEG), eye movements (electro-oculogram or EOG) and jaw muscles (electromyogram or EMG). Polysomnography is the “gold standard” method for evaluating sleep quality and quantity, but it is relatively invasive for participants and expensive both in terms of equipment and because it currently requires manual scoring and analysis by a trained technician.

REACTIVE HAZARD IDENTIFICATION

Reactive processes are designed to identify the contribution of an individual's fatigue to safety reports and events that have occurred. The aim is to identify how the effects of fatigue could have been mitigated, to reduce the likelihood of similar occurrences in the future.

The following lists examples of triggers for reactive processes:

- fatigue reports;
- confidential safety reports;
- audit reports;
- incidents; and
- in the case of pilots, Flight Data Analysis (FDA) events (also known as Flight Operations Quality Assurance or FOQA). The links between pilot fatigue and FDA events cannot be made without comprehensive discussion with the involved crew to understand contextual elements.

Depending on the severity of the event, a fatigue analysis could be undertaken by the FSAG, the service provider's safety department, or an external fatigue expert or accident investigation agency. The findings of any fatigue investigation should be recorded as part of the FRMS documentation.

There is no simple test (such as a blood test) for fatigue-related impairment. To establish that fatigue was a contributing factor in an event, it has to be shown that:

- the person or team was probably in a fatigued state;
- the person or team took particular actions or decisions that were causal in what went wrong; and
- the actions or decisions are consistent with the type of behavior expected of a fatigued person or team.

A basic method for fatigue investigation is summarized in Appendix I. of this guidance.

5.3.2. EVALUATION OF FATIGUE RISK

Once a fatigue hazard has been identified, the level of risk that it poses has to be evaluated as part of the assessment process and a decision made about whether or not that risk needs to be mitigated. For service providers managing fatigue risk within prescribed limits through their SMS, existing SMS risk assessment methodologies may be sufficient. Using an FRMS requires more effort on fatigue-specific risk assessment processes.

Where a service provider operates under FRMS, more effort on fatigue-specific risk evaluation is expected, with particular focus on assessing the time in a duty period or pattern of work where potential fatigue impairment poses the greatest risk.

Evaluating the risks associated with the hazard of "fatigue" can be challenging because:

- fatigue can diminish an individual's ability to perform almost all operational tasks; and
- there are many factors which can contribute to an individual's level of impairment. Many of these factors may be unpredictable.

Further, not only does an individual's ability to perform safety-related tasks decline with increasing fatigue but their capacity to respond to unexpected increases in task complexity also diminishes. Such increases in task complexity can be associated with managing threats, such as a flight crew member landing in unfavourable weather conditions, a cabin crew member dealing with an unplanned evacuation, or an air traffic controller presented with an unexpected surge in air traffic. Conversely, low workload can unmask physiological sleepiness. Fatigue is rarely the sole cause of an event but it is regularly a likely contributor to varying degrees. The level of risk that fatigue presents is dependent on the task and the context in which the task is being performed.

Evaluating fatigue risks using any methodology is limited because it is unclear how the complex interactions that exist between fatigue factors should be weighted. All methods need to be used with full recognition of their limitations.

Because of these factors, current methodologies for evaluating the level of risk, when applied to fatigue, are all limited to some degree. Further, the usefulness in application of all risk assessment methodologies is directly related to the knowledge and experience of the user. However, with growing maturity of SMS and more operational FRMS experience around the world, advances are continuing to be made in the way fatigue risks are assessed.

USING RISK MATRICES TO EVALUATE FATIGUE RISKS

Typically, safety risk is defined as the projected likelihood and severity of the consequence or outcome from an existing hazard or situation. A likelihood and severity matrix is commonly used by many service providers to assess all types of risk and assist them to decide whether it is necessary to invest resources in mitigation. The level of the risk associated with a hazard and whether that risk level is "tolerable" is determined by plotting its position on the matrix. The main disadvantage of using matrices to assess risks is that controls and mitigations are not systematically taken into account.

Table 5-1 presents an example of severity classification categories from ICAO's *Safety Management Manual* (Doc 9859, 2018, 4th Edition). Table 5-2 presents an example of an associated risk assessment matrix.

Table 5-1. Example safety risk severity table (from ICAO SMM, 4th Edition)

Severity	Meaning	Value
Catastrophic	- Aircraft / equipment destroyed - Multiple deaths	A
Hazardous	- A large reduction in safety margins, physical distress or a workload such that operational personnel cannot be relied upon to perform their tasks accurately or completely - Serious injury - Major equipment damage	B
Major	- A significant reduction in safety margins, a reduction in the ability of operational personnel to cope with adverse operating conditions as a result of increase in workload, or as a result of conditions impairing their efficiency - Serious incident - Injury to persons	C
Minor	- Nuisance - Operating limitations - Use of emergency procedures - Minor incident	D
Negligible	- Few consequences	E

Table 5-2. Example safety risk matrix (adapted from ICAO SMM, 4th Edition)

Likelihood		Fatigue Severity							
		Catastrophic A		Hazardous B		Major C		Minor D	Negligible E
Frequent	5	**5A**	Accident	**5B**	Large safety reduction	**5C**	Significant safety reduction	**5D**	**5E**
Occasional	4	**4A**		**4B**		**4C**		**4D**	**4E**
Remote	3	**3A**		**3B**		**3C**		**3D**	**3E**
Improbable	2	**2A**		**2B**		**2C**		**2D**	**2E**
Extremely Improbable	1	**1A**		**1B**		**1C**		**1D**	**1E**

When using risk matrices, service providers are expected to customize the severity and likelihood categories. The value of using the severity classifications from Table 5-1 to assess fatigue risks is limited because the worst foreseeable consequence of fatigue-affected performance when performing a safety critical task is always catastrophic.

With regards to fatigue risks:

- To understand the severity of consequences, it is necessary to consider not just how fatigued an individual may be, but also the resulting impact on the individual's performance and how that diminished performance will manifest itself in the workplace.
- It is the task being undertaken (when fatigued) that determines the severity of the consequences. For example, if an operational person falls asleep in the office while performing a routine administrative task, there are no immediate safety consequences. However, if the same operational person falls asleep on the flight deck or at their work station while performing a safety critical task, it can lead to an accident.

In other words, to assess different types of fatigue risks using a matrix, different severity classifications are needed to better reflect the variety of possible consequences of fatigue-affected performance. Likelihood classifications will depend on the type of fatigue severity classification used. Therefore, when using risk assessment matrices in an FRMS, it is necessary for fatigue subject matter experts to customize their matrices by carefully selecting how severity and likelihood are classified. The following provide simple examples of how severity and likelihood classifications can be adapted in order to assess different fatigue risks.

Implications for the State:

Risk-assessment methodology will vary between service providers. Regulators should ensure that the method employed by each service provider for their FRMS is consistent with the service provider's methodology used in its SMS, but adapted for fatigue risk assessment.

SEVERITY CLASSIFICATIONS:

As mentioned above, different severity classifications are needed to better reflect the variety of possible consequences of fatigue-affected performance. Examples of methods for classifying severity classifications include:

- Severity classifications may reflect "perceived fatigue levels" on the basis that the more fatigued an individual feels, the more likely their performance will decline. In Table 5-3, the subjective Samn-Perelli Scale is used, although other subjective measures may also be used (see Appendix B of this manual and more detailed description in any of the associated Implementation Manuals).
- Bio-mathematical models aim to predict the average individual's fatigue level at different points across a planned roster. Once the user is able to relate the model's results to the operational context of their organization, severity classifications may be based on defined bio-mathematical model thresholds.
- Severity classification may reflect the number of relevant fatigue factors associated with a specific duty or work pattern, as described in the next section (Assessing a Specific Duty or Work Pattern for Fatigue Risks).

Table 5-3. Example of fatigue severity classification: perceived levels of fatigue.

Samn-Perelli Score	Meaning	Value
7	Completely exhausted, unable to function effectively	A
6	Moderately tired, very difficult to concentrate	B
5	Moderately tired, let down	C
4	A little tired	D
3	Okay, somewhat fresh	E
2	Very lively, responsive, not at peak	E
1	Fully alert, wide awake	E

LIKELIHOOD CLASSIFICATIONS

Generally, fatigue likelihood is based on subjective estimations of how often a particular consequence of fatigue-affected performance might occur. Because this is contextually dependent, there are infinite variables that influence the operational consequences.

Where a specific fatigue factor related to a type of shift or work schedule is being assessed (e.g. less than 7h between duties; commencement of duties prior to 07:00), the measurable frequency with which an individual may experience or be exposed to it may be preferred to determine likelihood classifications.

ASSESSING A SPECIFIC DUTY OR WORK PATTERN FOR FATIGUE RISKS

In an FRMS, a service provider will need to consider the fatigue risks associated with a specific duty or work pattern in order to determine appropriate mitigation strategies. Many different tools and methods are available to assess risks and often they are used in combination.

One way of estimating the fatigue risk associated with a particular work pattern is through the use of a bio-mathematical model. Current models are generally designed to predict levels of average operator fatigue (performance and/or subjective ratings), not the safety consequences of that fatigue in specific operational environments. While informed use of models can make them very helpful for the purposes of risk assessment, operational decisions should not be based solely on bio-mathematical thresholds.

An alternative method to assess fatigue in relation to a particular duty or work pattern has been described[40] and is summarized below. It is based on the recognition that fatigue results from sleep loss, extended wakefulness, circadian influences and workload (see Scientific Principles presented in Chapter 2). In this methodology, "fatigue factors" (i.e., factors that have been found to be associated with increased fatigue) are identified through internal scientific studies, relevant scientific literature, internal surveys and fatigue management experience of the service provider.

This type of methodology may be used:

- to identify the causes of fatigue associated with a single duty/type of shift;
- to give a single duty or type of shift a specific and comparable "fatigue value";
- to identify effective mitigations for a single duty/type of shift (part of the risk mitigation process);
- to be able to compare the same trip or tasks undertaken at different times; and
- as a starting point for a safety case.

Thorough research and informed operational input is essential to the identification of a meaningful list of fatigue factors and is critical to the successful use of this methodology. By using customized lists generated for the specific circumstances of the service provider, this methodology can be adapted to any operations.

In the first step of this methodology, for a particular type of work duty or work pattern, all possible fatigue factors are determined to be either present or absent in the "worst-case scenario" under existing conditions.

In the second step, each factor present is assessed to determine if it can be avoided through mitigation. The number of remaining fatigue factors is used to determine if the mitigated scenario is acceptable.

A third step can be added using risk assessment matrices that present an additional risk assessment of the fatigue factors to examine the cumulative fatigue-related risk over a period of time. This introduces a "frequency of exposure" dimension, allowing categorization of fatigue risk according to the number of times a trip with a particular score is scheduled.

Figure 5-3 and matrices below (Tables 5-4 to 5-6) present an example of the use of this methodology.

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[40] Tritschler, K. (2015), "Fatigue risk assessment methodologies". Paper presented at the EASA FRMS Workshop, Cologne.

Type of Shift/Specific Duty: CGN-TFS-CGN: Check in 1600LT, Checkout 0300LT; FDT: 11:00h				
	Fatigue Factor:	**Worst Case:**	**Mitigated**	**Comments:**
Sleep debt	Previous night sleep ** reduced < 4h (night: 22-08LT)	1**	1**	Not relevant if 1st duty day
	Previous night sleep ** reduced > 4h	1**	0	Avoid previous day checkout after midnight
	Reduced night sleep > 4h before previous night ***	1***	0	Avoid any previous day checkout after midnight
	Previous "night duty"** (day sleep only)**	1**	0	Avoid any previous day checkout after midnight
Wakefulness	Time since awake > 2h prior C/I*	1	1	
	Time since awake > 6h prior C/I*	1	(1)	Recommend nap before duty
	Time on task > 10h (FDT)	1	1	FDT > 10h at night (!)
	Time on task > 12h < 14h (FDT)	--	--	
Circadian Factors	Circadian disruption > 4h **	1	0	Previous duties shall be late duties
	Flight after 2300LT or last landing during darkness	1	1	
	Flight time <2h during WOCL	1	1	
	Flight time > 2 h during WOCL	--	--	
Workload	3 or 4 consecutive flights/sectors	--	--	
	5 or 6 flights / or 3 flights during night	--	--	
	Known hassles	--	--	
	Training flights	1	0	Avoid training on this duty
	Sum of fatigue factors	**11**	**6**	
Assessment of fatigue factors: 0-3 relevant factors: accept 4-6 relevant factors: check 7-9 relevant factors: mitigate >10 relevant factors: not acceptable		* Crew member's responsibility ** Depending on preceding duty *** The night before, 2 consecutive nights are relevant		
Note. Factors are not fully weighted! Most important factors are sleep debt, wakefulness, circadian factors then workload, in this order.				

Figure 5-3. Example of fatigue factor assessment and mitigation table

Table 5-4. Example of categories for assessment of fatigue factor scores under existing conditions (Step 1)

Assessment of Fatigue Factors under Existing Conditions (Step 1):		
Relevant factors	**Acceptability**	**Action**
0-3	Accept	No mitigation required
4-6	Check	Identify mitigations to reduce relevant fatigue factors
7-9	Mitigate	Identify mitigations to reduce the remaining fatigue factors to the minimum
> 9	Not Acceptable	Identify mitigations to reduce the remaining fatigue factors to an acceptable minimum. If not possible this duty is not permissible

Table 5-5. Example of categories for acceptability of fatigue factor scores after mitigating actions (Step 2)

Acceptability of Fatigue Factors after Mitigating Actions (Step 2):		
Relevant factors	**Fatigue Impairment**	**Acceptability**
0-3	Low	Acceptable, no further mitigation required
4-6	Increased	Acceptable, but keep remaining fatigue factors as low as reasonably practicable. Monitor operation
7-9	Significant	Acceptable if remaining fatigue factors are kept at the minimum (all avoidable fatigue factors are avoided). The number of times this duty can be scheduled is limited per crew member per time-period. Monitoring of this work period required
> 9	High	Not acceptable

Table 5-6. Example of risk assessment matrix for cumulative fatigue

Frequency of Exposure per Crew Member per Working Period (week)				
Relevant fatigue factors	**May be scheduled every day**	**May be scheduled twice per week**	**May be scheduled once per week**	**Unexpected circumstances**
0-3	low	low	low	low
4-6	moderate	moderate	low	low
7-9	high	moderate	moderate	moderate
> 9	high	high	high	high

In this example, the methodology has been applied to short-haul flight operations on a specific flight duty from Cologne to Tenerife to Cologne. Each fatigue factor identified is relevant for this type of operation and linked to a scientific study.

Step 1:

- The form shown in Figure 5-3 presents a Fatigue Factor Assessment and Mitigation Table which lists the fatigue factors identified by the short-haul carrier. In the first step, these have been scored as present (1) or absent (--) in the "Worst Case" column.
- Table 5-4 categorizes the assessment of different numbers of fatigue factors under existing conditions (i.e. no mitigations). In the example provided, a fatigue factor score of 11 means that under existing conditions and in the worst case scenario, this duty is not permissible if the number of factors cannot be reduced through mitigation.

Step 2:

- The form shown in Figure 5-3 is again used to score each of the fatigue factors present (n=11) as either avoidable (0) or not (1) in the "Mitigated" column. A description of how it can be avoided (the mitigation) is noted in the "Comment" column. In the example provided, there are six remaining fatigue factors.
- Table 5-5 categorizes the acceptability of the mitigated fatigue factor score. The example score of 6 means that with the extra mitigations identified, fatigue impairment is expected to be increased, but acceptable.

Step 3:

- Table 5-6 presents an additional risk assessment of the fatigue factors in order to examine the cumulative fatigue-related risk over a period of time. Here, a "frequency of exposure" dimension has been added to a matrix, allowing categorization of fatigue risk according to the number of times a trip with a particular score is scheduled. Again, the categories should be defined by each operator for their specific context.

5.3.3. MITIGATION

The risk-evaluation process determines whether or not a fatigue hazard requires mitigation. The most important thing to consider in choosing fatigue mitigations is the estimated level of associated fatigue risk. All mitigations require resources (effort, time, costs). Limited resources need to be prioritized where mitigations are most needed to effectively control fatigue risk.

Careful selection of effective fatigue mitigations is based on data, rather than an uninformed urge to "do something". Identifying suitable mitigations comes from sources such as scientific studies, relevant scientific literature and FRMS experience of the service provider or other similar service providers.

Effective controls and mitigation strategies go beyond rest- and duty-times. For duties that are either very long, start very early in 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. Therefore, the identification of fatigue mitigations requires a broad understanding of scientific knowledge, operational experience and applicable regulations. While a service provider’s safety management structure will influence who makes the decision about whether or not a fatigue hazard requires mitigation, it is recommended that the FSAG identify the appropriate mitigations and be consulted in all fatigue mitigation decisions.

5.3.4. ESTABLISHING FATIGUE METRICS

Already identified data sources can be used to establish fatigue metrics. Fatigue metrics provide a means to monitor the effectiveness of fatigue controls and mitigations. If trends in fatigue metrics 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 service provider’s processes and new mitigations proposed where necessary.

For fatigue metrics to be useful, acceptable values and targets need to be set. These acceptable values and targets need to be appropriate to the level of risk in a given operation, and in the “tolerable” or “acceptable” regions of risk assessments. Together, the fatigue metric and the acceptable value/target can be used as a fatigue safety performance indicator (SPI). Having a variety of fatigue metrics is expected to give a more reliable indication of fatigue levels and of the performance of the FRMS. It is also important to note that different fatigue metrics may be appropriate in different types of operations.

Examples of these fatigue metrics are presented in the relevant Implementation Manuals.

Fatigue metrics are a critical source of information for FRMS assurance (see Section 5.4 below).

5.4. COMPONENT 3: FRMS ASSURANCE

FRMS assurance monitors how well the entire FRMS is functioning. Using fatigue metrics identified in the FRA processes along with information and expertise from other sources, FRMS assurance has three main functions:

1. to monitor that the FRMS is delivering an acceptable level of fatigue risk that meets the safety objectives defined in the FRMS policy and any other regulatory requirements;
2. to monitor changes in the operational environment and the organization that could affect fatigue risk in the operations covered by the FRMS, and to identify ways in which FRMS performance can be maintained or enhanced prior to the introduction of changes; and
3. to provide ongoing feedback that maintains and where necessary, improves, the FRMS.

The State should consider the assurance functions of the FRMS as the critical component for assessing the performance of the FRMS and focus on this area as part of ongoing oversight (see Section 6.2.4 below). It is through FRMS assurance that the State, working with the service provider, may identify specific limits or patterns of work that may need to be changed or stopped. The State may also choose to require additional measures or limits to those proposed by the service provider should they consider this necessary.

The following subsections describe the functions of FRMS assurance further.

IMPLICATIONS FOR THE STATE:
The State's oversight of the FRMS will require the ongoing monitoring of safety assurance outcomes. These outcomes may also be an indicator of the effectiveness of the service provider's FSAG and SMS team.

5.4.1. MONITORING FRMS PERFORMANCE

Fatigue metrics can be used to generate fatigue safety performance indicators (SPIs). Fatigue SPIs need to be identified in consultation with the State during the FRMS approval process (see Section 6.2) and they may change as experience with FRMS builds and as operational circumstances alter. The service provider must be able to identify and justify their choice of fatigue SPIs that it is using and the State must be able to make an assessment of the robustness of the measures proposed.

Monitoring of fatigue SPIs allows the FSAG to assess whether the mitigations they have put in place perform to an acceptable standard (i.e. the relevant fatigue SPIs reach their pre-defined acceptable values or targets). If they do, they become part of normal operations. If the controls and mitigations do not reduce the fatigue hazard to an acceptable level, the controls and mitigations in use may need to be modified via the FRA processes (see Figure 5-1). This could require: gathering of additional information and data, re-evaluation of the safety risks associated with the hazard, and/or implementing and evaluating new controls and mitigations.

Fatigue SPIs also allow the FSAG to monitor the overall performance of the FRMS. Investigation of how hazard reports are followed up or examination of trends in fatigue-related hazards or incidents may be required. Audit findings may need to be reviewed, checks may need to be made to determine whether FSAG recommendations are followed or whether fatigue-related training is being delivered as expected. It may also be appropriate to review the fatigue SPIs to ensure that they are still appropriate measures of the safety performance of the FRMS.

Various types of fatigue SPIs which can be used are described below.

IMPLICATIONS FOR THE STATE:
FRMS SPIs should be discussed and agreed on between the service provider and the CASI. These may need to be reviewed at intervals.

TRENDS IN FATIGUE SAFETY PERFORMANCE INDICATORS FROM THE FRA PROCESSES AND THE SMS

Fatigue SPIs are identified by the Fatigue Safety Action Group as part of the FRA processes to monitor the efficacy of controls and mitigations (see 5.3.4 above). The nature of these will differ for different industry sectors. Common types of fatigue SPIs include:

- operational SPIs that monitor the duty-related causes of fatigue;
- SPIs based on proactive monitoring of actual levels of crew member fatigue; and
- Bio-mathematical model thresholds.

Specific examples of fatigue SPIs are presented in the associated service providers' implementation manuals.

As previously mentioned (see 5.3.4), acceptable values or targets need to be set for fatigue SPIs, and these must always be within the tolerable region defined in the service provider's risk assessment process. For example, a service provider could set an FRMS safety performance target of no more than 10 duty day exceedances per month. Trends in the service provider's ability to maintain acceptable values or achieve targets over time can then be used to assess FRMS performance. Trends may be identified: over individual duties; patterns of work; shorter periods of time (e.g. weekly trends); longer periods of time (e.g. seasonal trends, yearly trends); and in relation to specific locations, types of operations or groups of workers.

As the FRMS matures, and as part of the continuous review requirements, more sophisticated performance indicators and targets may need to be identified to better monitor the performance of the FRMS.

FATIGUE REPORTS

Trends in fatigue reporting rates can be monitored to assess the effectiveness of mitigations. However, the FSAG should also analyze and follow-up contextual information provided by individuals on fatigue reports. The FSAG should record all fatigue hazards identified in the FRA processes, together with any actions taken to mitigate those hazards, in the FRMS documentation. The documentation of fatigue hazards should be regularly evaluated to ensure that it contains current, valid fatigue hazards and appropriate mitigation measures, as part of the FRMS safety assurance processes.

Trends in voluntary fatigue reports by individuals can also be monitored as indicators of the effectiveness of the FRMS.

AUDITS AND SURVEYS

Audits and surveys can provide measures of the effectiveness of the FRMS without having to rely on fatigue levels being high enough to trigger fatigue reports or fatigue-related safety events (both of which may be relatively rare events).

Audits can be used by the FSAG to periodically assess the effectiveness of the FRMS. They should address questions such as:

- Are all relevant departments implementing the recommendations of the FSAG?
- Are all the targeted operational personnel using mitigation strategies as recommended by the FSAG?
- Is the FRMS training programme effective?

However, other routine quality audits of the FRMS need to be conducted by a unit in the service provider's organization that is external to the FSAG. Such quality audits address questions like:

- Is the FSAG maintaining the required documentation of its activities?
- Are all fatigue SPIs being actively monitored and managed by the FSAG in accordance with documented processes?

Feedback from regulatory audits can provide useful information for FRMS safety performance monitoring. Another type of audit that can be used in this context is to have an independent scientific review panel that periodically reviews the activities of the FSAG and the scientific validity of their decisions. A scientific review panel can also provide the FSAG with periodic updates.

Surveys can provide a "snapshot" of the effectiveness of the FRMS. For example they can document how schedules and work patterns are affecting individuals, either by asking about their recent experiences (retrospective) or tracking them across time (prospective). Surveys for this purpose should include validated measures, such as standard rating scales for fatigue and sleepiness, and standard measures of sleep timing and quality (see Appendix B of this guidance). Note that a high response rate (ideally more than 70%) is needed for survey results to be considered representative of the entire group, and response rates tend to decline when people are surveyed too frequently ('participant fatigue').

REVIEWS AND FATIGUE STUDIES

A safety review would be carried out to evaluate whether the FRMS is likely to be adequate to deal with a change[41], for example the introduction of a new type of operation or a significant change to an existing operation covered by the FRMS. The review evaluates the likely effects of the change on fatigue risk and the appropriateness and effectiveness of the FRM processes to manage those effects.

IMPLICATIONS FOR THE STATE:

If a CASI is concerned about a particular issue with operations conducted under an FRMS, they may request that the service provider undertakes a formal review or study about that particular issue.

In FRMS assurance, fatigue studies are mainly used as a source of broader information from external sources about common issues in FRMS (whereas in the FRA processes they are carried out to evaluate specific fatigue hazards). They are undertaken when a service provider is either concerned about a broad fatigue-related issue for which it is appropriate to look at external sources of information or where a new operation is being introduced where there is no other specific information. Sources of information can include the experience of other operators, industry-wide or State-wide studies, or scientific studies. Such information can be particularly valuable in situations where the service provider needs to build a safety case but has limited experience and knowledge.

5.4.2. RECOGNIZING EMERGING FATIGUE RISKS

Analysis of trends in fatigue safety performance indicators may indicate the emergence of fatigue hazards that have not previously been recognized. For example, changes in one part of the organization may increase workload and fatigue risk in another part of the organization. Identifying emerging fatigue risks is an important function of FRMS safety performance processes, which take a broader system perspective than purely FRA processes. Any newly identified fatigue risk, or combination of existing risks for which current controls are ineffective, should be referred back to the Fatigue Safety Action Group for evaluation and management using FRA processes (risk evaluation, design and implementation of effective controls and mitigations).

5.4.3. MANAGING CHANGE

A service provider's FRMS safety assurance processes should provide a formal process for the management of change that provides for:

1. identification of changes in the operational environment that may introduce fatigue risks;
2. identification of changes within the organization that may introduce fatigue risks; and
3. consideration of available tools which could be used to maintain or improve FRMS performance prior to implementing changes.

[41] ICAO *Safety Management Manual (SMM)* (Doc 9859).

Examples of changes include: bringing new operations under the scope of the FRMS; making adjustments to training programmes; altering the workforce profile; fluctuating numbers of employees.

When a planned change is identified, the service provider should:

- use the FRA and SMS processes to identify fatigue hazards, assess the associated risk, and propose controls and mitigations;
- obtain appropriate regulatory agreement that use of the proposed controls and mitigations will result in an acceptable level of residual risk; and
- document the strategy for managing any fatigue risk associated with changes.

During the period of implementation of the change, FRMS assurance monitoring (described in Section 5.4.1 above) provides periodic feedback that the FRMS is functioning as intended in the new conditions. Examples include having validation period for:

- a new route, during which additional monitoring of crew member fatigue is undertaken, together with more frequent assessment of SPIs as part of the FRMS safety assurance processes; and
- an extension in duty hours within a particular pattern of work, during which additional monitoring of individuals' fatigue is undertaken, together with more frequent assessment of fatigue SPIs as part of the FRMS safety assurance processes.

5.4.4. IMPROVING THE FRMS

As the safety assurance processes provide a means to monitor the overall performance of an FRMS, they not only offer the means to ensure that adequate fatigue management is maintained but also the means for continued improvement of the FRMS.

FRMS assurance processes provide for the continuous improvement of the FRMS through:

- the elimination and/or modification of risk controls have had unintended consequences or that are no longer needed due to changes in the operational or organizational environment;
- routine evaluations of facilities, equipment, documentation and procedures; and
- identifying the need to introduce new processes and procedures to mitigate emerging fatigue-related risks.

IMPLICATIONS FOR THE STATE:

States should set out an appropriate process that enables service providers to make changes under the FRMS that improve aviation safety without unreasonably delaying its implementation.

It is important that changes made to the FRMS are documented so that they are available for internal and regulatory audit.

5.5. COMPONENT 4: PROMOTION

Along with the FRMS policy and documentation, the FRMS promotion processes support the operational activities of the FRMS (FRA processes and safety assurance processes). Promotion processes are an essential component of an FRMS because FRMS, like SMS, relies on effective communication throughout the organization[42]. In fact, while the FRA processes and FRMS assurance processes may be the "engine" of the FRMS, the promotion processes form its foundations. On the one hand, there needs to be regular communication about the activities and safety performance of the FRMS to all stakeholders. Depending on the structure of the organization, this may come from the Fatigue Safety Action Group, the SMS, or from an accountable executive responsible for the FRMS communication plan. On the other hand, the operational personnel concerned and other stakeholders need to communicate promptly and clearly concerns about fatigue hazards to the Fatigue Safety Action Group or other relevant management. In all cases, all stakeholders need to have an appropriate understanding of fatigue and their role within the FRMS.

In addressing the need for effective communication, FRMS promotion processes require the implementation of:

- fatigue-related training programmes; and
- an effective FRMS communication plan.

5.5.1. FRMS TRAINING PROGRAMMES

For an FRMS to be effective, all personnel who contribute to FRMS safety performance need to have appropriate training. This includes the targeted operational personnel, schedulers, any other member of the organization with direct or indirect influence on individuals' planned and actual work periods, operational decision-makers, all members of the Fatigue Safety Action Group, and personnel involved in overall operational risk assessment and resource allocation. It also includes senior management, in particular the executive accountable for the FRMS and senior leadership in any department managing operations within the FRMS.

The content of FRMS training programmes should be adapted according to the different competencies and tasks required for each group to play its part effectively in the FRMS. All groups require basic education about the dynamics of sleep loss and recovery, the effects of the daily cycle of the circadian body clock, the influence of workload, and the ways in which these factors interact with operational demands to produce fatigue (see Chapter 2 above). In addition, it is useful for all groups to have information on how to manage their personal fatigue and sleep issues. A special feature of FRMS training is that key principles of fatigue science — managing sleep and understanding the effects of the circadian body clock — are relevant not only to individuals' roles in the FRMS at work but also to their lives outside of work, for example, in safe motor vehicle driving and in staying healthy.

IMPLICATIONS FOR THE STATE:
It is recommended that States have competency requirements for FRMS training instructors, who may be part of a service provider's internal training department or an external contractor.

[42] ICAO *Safety Management Manual (SMM)* (Doc 9859), Section 9.1.

Thus FRMS training covers issues that everyone can identify with, and this can help promote the concept of shared responsibility in an FRMS. Suggestions for FRMS training topics can be found in Appendix J.

Service providers are required to maintain records of their FRMS training programme and monitor its effectiveness.

5.5.2. COMMUNICATION PLAN

Effective communication is crucial for the successful implementation and maintenance of an FRMS. A service provider's FRMS communication plan should:

- explain FRMS policies, procedures and responsibilities to all stakeholders; and
- describe communication channels used to gather and disseminate FRMS-related information.

The FRMS training programmes are clearly an important part of the communication plan. However, training generally occurs at fairly long intervals (for example, annually). In addition, there needs to be ongoing communication to stakeholders about the activities and safety performance of the FRMS, to keep fatigue "on the radar" and encourage the continuing commitment of all stakeholders. A variety of types of communication can be used, including electronic media (websites, on-line forums, e-mail), newsletters, bulletins, seminars, and periodic poster campaigns in strategic locations.

Communications about the activities and safety performance of the FRMS (from the Fatigue Safety Action Group or other designated management) need to be clear, timely and credible (i.e., consistent with the facts and with previous statements). The information provided also needs to be tailored to the needs and roles of different stakeholder groups, so that people are not swamped by large quantities of information that is of little relevance to them.

Communications from the targeted operational personnel or those who have access to relevant information are vital for fatigue hazard identification, for feedback on the effectiveness of controls and mitigations, and in providing information for FRMS safety performance indicators (for example, by participating in surveys and fatigue monitoring studies). For these communications to be open and honest, all FRMS stakeholders need to have a clear understanding of the policies governing data confidentiality and the ethical use of information provided by those who report. There also needs to be clarity about the thresholds that separate non-culpable fatigue-related safety events from deliberate violations that could attract penalties.

IMPLICATIONS FOR THE STATE:
States should look for evidence of service providers giving timely feedback to those who submit fatigue reports as this encourages appropriate reporting behaviour.

The communication plan needs to be described in the FRMS documentation and assessed periodically as part of FRMS safety assurance processes.

CHAPTER 6. THE FRMS IMPLEMENTATION

For a State, FRMS implementation requires the development of the necessary regulations, guidance and oversight processes to ensure that the service provider's FRMS provides a level of safety acceptable to the State. For a service provider, FRMS implementation refers to the development of an FRMS to the point of approval and the continued maintenance of an approved FRMS. Implementation by service providers is discussed in detail in the each of the sector-specific Fatigue Management Guides that support this Regulators' Manual.

This chapter addresses the implementation of FRMS from a State's perspective under the following sections:

- Deciding to offer FRMS regulations;
- Establishing an FRMS approval process; and
- FRMS Oversight.

6.1. DECIDING TO OFFER FRMS REGULATIONS

The oversight of FRMS, as a performance-based approach, requires extra resources, and a well-trained State inspectorate. Prescriptive fatigue management regulations provide the baseline, in terms of safety equivalence, from which an FRMS is assessed. Therefore, before providing FRMS regulations, the State needs to be confident that it has robust, scientifically-based prescriptive limitation regulations appropriate to the context in which they are to be used and that their civil aviation safety inspectors (CASIs) can adequately oversee the prescriptive limitation regulations, including the use of SMS processes to manage any identified fatigue risks (see Chapter 4).

The State is not obliged to offer FRMS regulations. Consideration should be given to whether the relevant service providers within that State want or need to implement FRMS, or whether it is more appropriate in their context to offer only the prescriptive limitations regulations. Further, FRMS requires the proactive and predictive management of fatigue-related risks based on the analysis of relevant data and information. Much of this data must be provided by individuals and be considered both confidential and sensitive. Careful consideration needs to be given as to whether the State's legal protections currently in place facilitate the collection and protection of such information before deciding to offer FRMS regulations.

Finally, while FRMS can offer considerable safety and efficiency benefits, potential safety benefits may be reversed if the State does not have the resources to develop the supporting regulatory processes and provide the necessary oversight (described further in Sections 6.2 and 6.3 below).

Before deciding to offer FRMS regulations, consideration should be given to the resources needed to:

- develop and maintain currency of "in house" subject matter expertise;
- access specialist scientific expertise;
- develop a collaborative network with other States;

- develop guidance for service providers describing the State's FRMS regulatory processes;
- develop a regulatory database to track FRMS surveillance activities;
- develop the necessary FRMS application and approval process; and
- provide the necessary ongoing oversight processes and procedures of an FRMS.

Perhaps the most critical aspect of all of these elements relates to educating the regulatory personnel involved.

TRAINING FOR REGULATORY PERSONNEL

FRMS oversight requires a move from checking compliance with prescribed limits and associated regulations to assessing how well the FRMS processes work separately and interactively. This means that personnel involved in developing and overseeing FRMS regulations will need to have experience with risk-based approaches as well as acquire specific fatigue-related knowledge. CASIs will need to know how to assess the effectiveness of the FRMS through employing work practices and approaches that are system-oriented. They will need to know how to ask questions and observe behaviours of individuals, teams, and managers involved in fatigue management. In particular, they will need to be able to:

- demonstrate specific knowledge of fatigue management scientific principles (as discussed in Chapter 2);
- analyze the relevant research and outline the operational implications of the findings;
- interpret analysis of data and know when to access expert input;
- assess safety cases and make risk assessments;
- assess the appropriateness of different fatigue-related mitigations within specific operational contexts;
- describe the difference between the managing of fatigue risks using an SMS and using an FRMS; and
- understand the proper use and detect the improper use of bio-mathematical models if used within an FRMS.

It will therefore be necessary to develop specialist training requirements for all regulatory personnel involved. There will also be a need to consider recurrent training needs in order to keep up to date.

6.2. ESTABLISHING AN APPROVAL PROCESS AND CONTINUED OVERSIGHT

Once the State has decided that it will offer FRMS regulations, the State will need to document in detail the requirements for obtaining approval of an FRMS. Having an FRMS still requires having maximum duty times and minimum rest (or non-work periods), but these as proposed by the service provider, may differ from the prescribed limits and must be approved by the State. To get approval, the service provider must demonstrate to the regulator that it has appropriate processes and mitigations to achieve an acceptable level of risk.

This section describes a documented FRMS approval process.

A service provider necessarily implements an FRMS in phases, and the State will need to review and accept each phase before the next one can begin. The phases are:

1. Preparation;
2. Trial;
3. Launch; and
4. Maintenance and improvement

Table 6.1. provides an overview of the differing aims of the State and the service provider during these phases of FRMS implementation by a service provider. The approval process covers Phases 1 to 3 and is addressed in this section, while Phase 4 constitutes the continued oversight of an approved FRMS and is addressed in Section 6.2.4.

Table 6-1. Aims of State and service provider during different phases of FRMS implementation

		Service Provider	State
Approval process	Phase 1. Preparation	Developing FRMS capability	Assessment of feasibility
	Phase 2. Trial	Validation of FRMS capability	Assessment of FRMS capability
	Phase 3. Launch	Getting approval	Approval of FRMS
Continued oversight	Phase 4. Maintain and Improve	Embedding FRMS into normal operations	Embedding FRMS into normal regulatory oversight

The time taken to full approval of an FRMS will depend on a range of factors including: the complexity of the FRMS; the anticipated level of fatigue risk; and the capability and resources of both the State and the service provider. It may take two to three years for a large and complex service provider, or one with significant risks to be managed, to gain full approval of their FRMS. However, the operational conditions that motivate service providers to seek an FRMS usually require timely resolution and, from a regulatory point of view, a service provider cannot be allowed to operate outside of the prescriptive limits for an indefinite period using an "FRMS in progress". A State needs to have a series of timely interventions and requirements that the service provider undertakes to bring the FRMS up to full approval requirements.

Figure 6-1 outlines the implementation steps undertaken by service providers within each of these phases. Figure 6-2. then integrates the associated regulatory steps (in blue). The regulatory steps associated with the approval process (phases 1-3) and continued oversight (phase 4) are described in detail below.

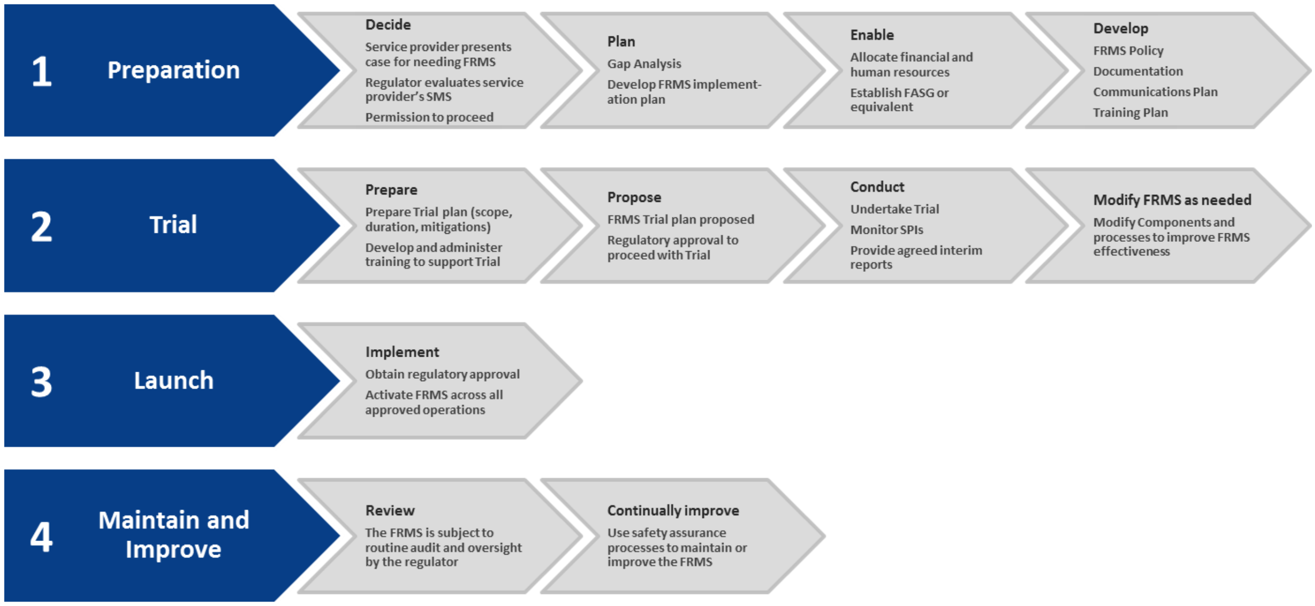


Figure 6-1. Four phases in FRMS implementation

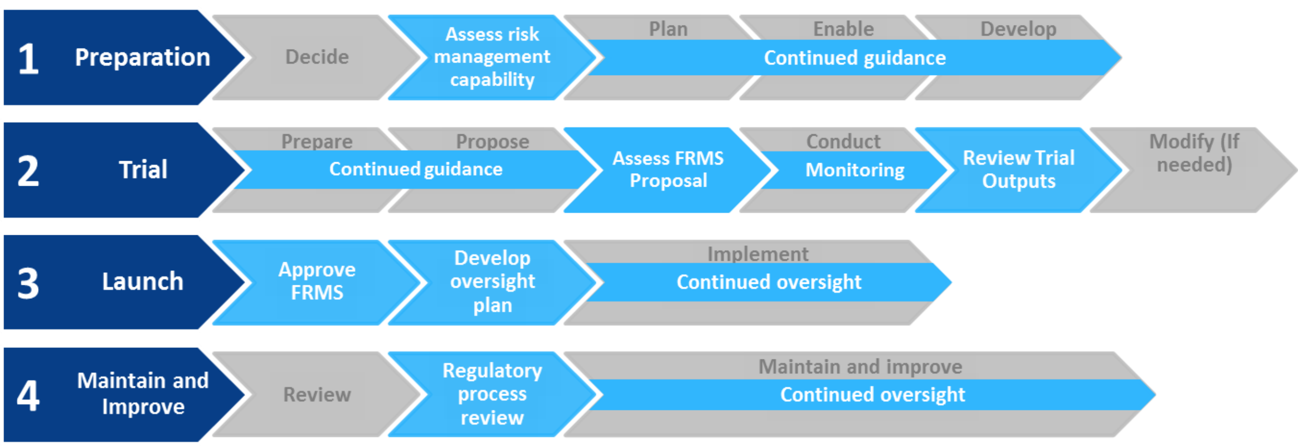


Figure 6-2. Integrated steps undertaken by service providers (grey) and States (blue) in the implementation of an FRMS

6.2.1. PHASE 1: PREPARATION

The objective of Phase 1 is for the service provider to establish an overall implementation plan that is acceptable to the State and addresses how the FRMS will function, how it will be integrated with other parts of the service provider's organization, who will be accountable for the FRMS, and who will be accountable for making sure that FRMS implementation is successfully completed.

ASSESSMENT OF RISK MANAGEMENT CAPABILITY TO PREPARE FOR FRMS

Before preparing to implement an FRMS, a service provider should inform the State of its intentions. Such early interaction helps establish an open and informed working relationship between the State and the service provider. One way the State can encourage early contact with a service provider planning to develop an FRMS is to require written notification of intent.

This initial involvement of the State with the service provider is an opportunity for the CASI to assess the service provider's overall risk management capacity, a crucial element of determining their capability to prepare for FRMS. At this very early point, a service provider needs to be able to demonstrate an effective safety reporting system and that they have acquired the necessary background knowledge to allow further development of their FRMS plans.

Since FRMS uses similar methodologies as SMS and the two must inform one another, the State should assess the safety performance and risk management capability of the service provider before encouraging further investments in an FRMS. A good indicator of the service provider's capability to develop FRMS is that they have been able to demonstrate that they have effectively used their SMS processes to manage fatigue-related risks within the prescriptive limitations and requirements. This may have been demonstrated through such things as:

- the timeliness and efficiency of follow-up and closing of findings;
- the willingness of the staff to report safety issues;
- offering suitable fatigue awareness training;
- the identification of suitable methods to monitor fatigue risks;
- evidence of stable work schedules (through examination of planned versus actual work periods); and
- an effective process to investigate and trend safety performance indicators in the safety reporting processes.

In providing such evidence, the service provider will have demonstrated its capability to collect and analyze data on fatigue and, most importantly, draw the appropriate conclusions to design effective mitigations and monitor the continued efficiency of these measures.

Once the CASI is confident that the service provider is able to create operational mitigations and continuously prove their effectiveness based on reliable data collection and analysis processes, the State may agree that the service provider can proceed with an application for an FRMS.

At this stage, the CASI should discuss with the service provider how the trial will demonstrate an equivalent (or reduced) level of fatigue risk on operations under the FRMS compared to operations that remain within the prescriptive limits. This will require the regulator and the service provider to identify and agree to measures (SPIs) of the level of safety under the prescriptive limits. In some cases, this may require accessing appropriate scientific expertise to help develop a robust scientific study design to reliably compare levels of fatigue risk in different operations.

CONTINUED REGULATORY GUIDANCE DURING THE PLANNING, ENABLING AND DEVELOPING OF FRMS PROCESSES

Throughout this period, while the service provider is establishing their FRMS plan that describes how the development of each of the FRMS processes will proceed, the State needs to provide an increased level of guidance and support

In particular, the regulatory focus will be related to:

- the service provider’s gap analysis;
- identification of key personnel and the constituency of the FSAG; and
- the review of FRMS policy and documentation.

These are discussed further below.

THE SERVICE PROVIDER’S GAP ANALYSIS

Many elements needed for an FRMS may already be in place in a service provider’s organization. To support FRMS planning, the service provider should conduct a gap analysis to:

- identify elements of the FRMS that are already available in existing systems and processes;
- identify existing systems and processes that could be modified to meet the needs of FRMS (to minimize “re-inventing the wheel”); and
- identify where new systems and processes need to be developed for the FRMS.

States may supply the service provider with tools to assist with a gap analysis. An example of such a tool is the checklist provided in Appendix K. Such tools are also very helpful in the regulator’s audit processes and consideration should be given to using the same checklist provided to the service provider as a basis for approval and oversight.

The results of the gap analysis are used as the basis for the development of the service provider’s FRMS implementation plan.

IDENTIFYING THE METHOD FOR ESTABLISHING THE BASELINE FOR THE EQUIVALENT LEVEL OF SAFETY

In order to agree on meaningful SPIs, it is necessary to establish a baseline of safety. The baseline of safety is identified through fatigue-related metrics associated with the prescriptive limitation regulations under the service provider's SMS processes in specific operational circumstance (e.g. average sleep obtained in a normal non-work period in relation to average alertness and performance at the end of the safety-related work period).

The State and the service provider will need to agree to the method used by the service provider to demonstrate an equivalent level of safety for the proposed FRMS trial operation. This will allow comparison of baseline measures of safety to those expected under the proposed FRMS limits. Possible SPIs include the average sleep achieved in the 24 hours before top of descent (in the case of pilots) or average sleep achieved in the 24 hours before a work period (in the case of air traffic controllers).

IDENTIFICATION OF KEY PERSONNEL AND THE CONSTITUENCY OF THE FSAG

To conduct the gap analysis, a service provider will need personnel who are able to:

- assess the fatigue training needs;
- provide rostering expertise and have detailed knowledge of the rostering system;
- provide detailed knowledge of the general operational context including the operations envisaged to be covered by the FRMS; and
- provide knowledge of the legal and regulatory requirements associated with fatigue management.

Therefore, an important part of the service provider's planning will include the identification of key personnel. Some or all of these key personnel may be included in a Fatigue Safety Action Group (or equivalent).

While consultants can offer invaluable assistance within an FRMS at certain times, they do not have the operational knowledge and experience of the service provider. Therefore, they should not be seen as responsible for the development of an FRMS plan, nor should they be the sole point of contact. An FRMS requires ownership, commitment and understanding by the people who will be using it, and the State needs to see evidence of that from the early stages of its inception.

During Phase 1, the FSAG or equivalent (perhaps with the assistance of a consultant depending on the complexity of the intended FRMS), will be tasked with:

- developing the FRMS policy and documentation;
- identifying their own and the service providers' training needs; and
- developing the FRMS promotion and communication plan.

REVIEW OF FRMS POLICY AND DOCUMENTATION

To determine whether the service provider should be allowed to progress to Phase 2 and start preparing a trial proposal, the State should be satisfied that the service provider (through the work of the FSAG or equivalent) has completed and provided:

- a gap analysis;
- an FRMS Policy Statement signed by the accountable executive. Developing the policy at the beginning of the FRMS implementation process will assist in defining the scope of the FRMS;
- an appropriate allocation of financial and human resources. The accountable executive for the FRMS needs to have the authority and control to ensure that this happen;
- an FRMS implementation plan;
- an FRMS documentation plan. This can be expected to evolve as the FRMS becomes operational;
- an FRMS communication plan. This can be expected to evolve as the FRMS becomes operational;
- training programme ready for all personnel who will be involved in the FRMS trial in Phase 2; and
- an established Fatigue Safety Action Group (FSAG or equivalent) able to undertake Phase 2.

Since preparation of these documents and processes requires substantial time and resources, it is advised that the service provider present evidence of their progress throughout this phase. This should ensure early identification of State concerns.

Using the FRMS evaluation form (mentioned under *The service provider's gap analysis* in this section; see Appendix K.), the CASI should conduct a desktop review of the policy and documentation to determine whether the service provider's initial preparation adequately addresses the regulatory requirements. This will include evaluating:

- policy content;
- the organizational structure adequately addresses the risks specific to the FRMS;
- the deviation recording process that will document the extent and reason for significant exceedances of scheduled work periods, significant reductions of rest periods and the number of uses of individuals' agreement to extend a work period beyond the prescriptive limitations;
- the proposed fatigue risk assessment process;
- the proposed safety assurance processes including methods for monitoring and managing changes to the FRMS;
- integration of FRMS processes with the day-to-day functions of the service provider;
- quality control audit procedures;
- initial training plan and procedures (including fatigue reporting);
- terms of reference for the Fatigue Safety Action Group; and
- details of the safety promotion activities.

At the end of Phase 1, the CASI has established open communication lines with the service provider and is confident that the service provider has the basic FRMS processes in place, has allocated appropriate resources to develop an FRMS, and will be ready to activate those processes and resources in the FRMS trial in Phase 2.

6.2.2. PHASE 2: TRIAL

The purpose of this phase is the service provider's demonstration of their FRMS capability through a trial period. This will involve preparing a detailed plan for a trial of the FRMS in the specific operations for which it is being sought.

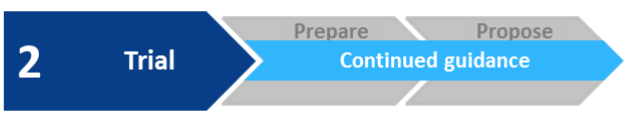
The proposed plan must be acceptable to the State and include agreed safety performance indicators (SPIs) that will be monitored to evaluate the trial. Once the FRMS trial proposal has been accepted, the trial is conducted with the State evaluating the trial outputs and changes made to the FRMS trial as necessary.

In the Phase 2 (trial) phase, the regulatory focus is related to:

- guidance during the preparation of the trial proposal;
- assessing the trial proposal;
- monitoring the trial; and
- reviewing the trial outputs.

These are discussed further below.

REGULATORY GUIDANCE DURING THE PREPARATION OF THE TRIAL PROPOSAL



The increased level of regulatory guidance and support established during Phase 1 should continue to the point where the service provider submits a trial FRMS proposal. This is particularly important as the service provider develops their safety case as part of the trial proposal. The FRMS evaluation form again may be a useful tool for the service provider during this step.

The State may wish to identify specific elements that need to be included by the service provider in the trial proposal. Essential elements of the trial proposal include identification of:

- *The scope, outer limits; and an assessment of the likely additional risk and how that likely additional risk will be monitored and mitigated.*

  The monitoring tools proposed need to be adequate to convince the State that the trial is a robust evaluation of the FRMS. To reach this decision, the CASI may need to have access to outside scientific or technical expertise.

- *A time limit for the trial period*.

  While adequate time needs to be given to allow the service provider to demonstrate that all components of an FRMS (including the safety assurance processes) are functioning, a service provider cannot be allowed to operate outside of the prescriptive limits for an indefinite period. Protracted trial periods diminish the value of having an approved FRMS. A service provider cannot continue using an "FRMS in progress" that is not actively trying to achieve all the approval requirements.

As the development of the FRMS trial proposal nears completion, the State should develop a monitoring programme that will allow appropriate resource planning and provide for the additional oversight resources required across the course of the trial.

ASSESSING THE TRIAL PROPOSAL

The FRMS trial proposal should include a safety case. To assess the FRMS trial proposal, the State can use the same steps used to evaluate safety cases to support variations to prescribed limits (Chapter 4, Section 4.2.3 refers). However, in the case of assessing an FRMS safety case proposal, the assessment will be conducted in greater depth and will necessarily include oversight and audit visits to the organization. These steps are:

1. assessing the nature, scope and impact of the proposed change;
2. assessing hazard and consequence identification;
3. evaluating the fatigue-risk assessment methodology and how the decision to accept risk has been made;
4. assessing the appropriateness of the risk mitigation measures;
5. assessing whether the claims, arguments and evidence made in the safety case are valid;
6. assessing plans for continued monitoring of the safety impact of the proposed limits, work schedules and mitigations; and
7. assessing the previous safety behaviours demonstrated throughout the organization (including safety reporting policies and practices).

These steps are discussed further below:

1. ASSESSING THE NATURE, SCOPE AND IMPACT OF THE PROPOSED FRMS TRIAL

Objective	The State is assured that the service provider understands the limitations and methods it is proposing, including the direct or indirect impact on the fatigue levels of those who will work under the arrangements described in the FRMS trial proposal.
Methods	• Submitted documentation clearly identifies the proposed limitations and methods and how these differ from the prescribed limits, and the operations to which they are intended to apply. • Submitted documentation demonstrates that the service provider has considered any direct or indirect impacts the proposed FRMS trial will have on those operations and other services.

2. ASSESSING HAZARD AND CONSEQUENCE IDENTIFICATION

Objective	The State is assured that a fatigue hazard identification process has been carried out and that the consequences of the hazards documented.
Methods	• Review the method used to identify and assess the fatigue hazards and their consequences for the proposed FRMS trial. • Review any other direct or indirect hazards identified in relation to the FRMS trial and their consequences. • Transitional risks to the operation associated with the FRMS trial are considered.

3. EVALUATING THE FATIGUE RISK ASSESSMENT METHODOLOGY AND HOW THE RISK HAS BEEN ACCEPTED

Objective	The State is assured that the level of risk associated with the FRMS trial is acceptable to the State.
Methods	• Examine the record of the risk assessment. • Review how the consequences were classified with regard to severity and likelihood definitions. • Review the qualifications of the individual(s) who made these classifications. • Determine whether the risk assessment appears reasonable both before and after organizational mitigations have been applied. • Evidence is provided that existing fatigue controls and mitigations are effective. • Confirm that an appropriately authorized person has accepted the remaining risk level and that the acceptance has been recorded.

4. ASSESSING THE RISK MITIGATION MEASURES

Objective	The State is assured that the mitigations identified are sufficient to manage the fatigue risk expected.
Methods	• Determine who was involved in the process of identifying and establishing the mitigations to ensure the process was conducted at the correct level within the organizational structure of the service provider, with the involvement of the relevant people. • Carefully examine the proposed fatigue mitigations using knowledge of the service provider proposing the FRMS trial as well as other service providers in similar situations to establish if the mitigations are appropriate and likely to be effective. • Review the service provider's processes and procedures to evaluate the appropriateness of their plan for risk management and training. • Consider other aspects of operational personnels' performance that may be affected by the mitigations. *States need to be assured that a service provider is not over-reliant on training and awareness programmes to mitigate fatigue risks.*

5. ASSESSING THE CLAIMS, ARGUMENTS AND EVIDENCE MADE IN THE RISK ASSESSMENT ARE VALID

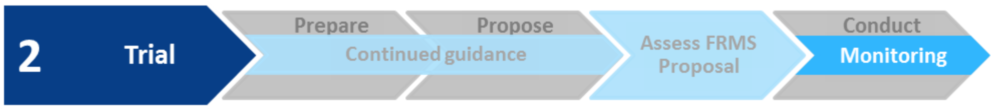
Objective	The State is assured that the claims and arguments are robust and supporting evidence is accurate and correctly interpreted.
Methods	• Review the safety arguments to confirm that a justification of an acceptable level safety has been demonstrated. • Safety arguments are supported by well-validated research or best practices. • Transitional risks are mitigated. Look to see if the management of wider organizational risks may be detrimentally affected by the proposed FRMS trial. • Clear conclusions are included in the risk assessment. • Proposed mitigations have considered all the legal requirements applicable to the worker (national, international, safety, social). Ensure they have been captured and addressed.

6. ASSESSING PLANS FOR CONTINUED MONITORING OF THE SAFETY IMPACT OF THE PROPOSED LIMITS, WORK SCHEDULES AND MITIGATIONS

Objective	The State is assured that the hazards associated with the FRMS trial proposal have been correctly identified and the effectiveness of the mitigations will be measured using agreed SPIs.
Methods	• The service provider has processes in place and demonstrated the capability to allow continued monitoring through existing SMS activities. • Agreed FRMS safety performance indicators are established for monitoring throughout the trial. Common types of SPIs include: – operational SPIs that monitor the duty-related causes of fatigue (e.g. use of captain's discretion); – SPIs based on reactive fatigue data (e.g. numbers of fatigue reports on a particular work pattern); – SPIs based on proactive monitoring of actual levels of fatigue levels of relevant operational personnel (e.g. high levels of subjective sleepiness at the end of a work period). • A review process is identified to assess the impact of changes to the service provider or the operating environment.

Once the trial proposal has been agreed to, the service provider may then commence the trial in accordance with the agreed timeline.

MONITORING THE TRIAL



The State will need to closely monitor the progress of the trial throughout the agreed timeline through:

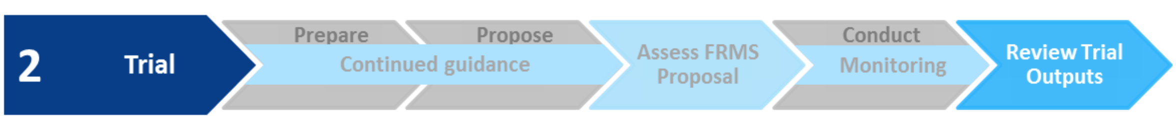
- frequent feedback (e.g. e-mail updates, following trial outputs);
- undertaking desktop reviews of the agreed operational SPIs for the trial;
- examination of progress reports at set times of the trial period;
- evaluation of the development of the full suite of the service provider's FRMS process and procedure documentation;
- evaluation of FRMS training programme and its effectiveness;
- conducting on-site visits (e.g. attending FSAG meetings, discussions with operational staff, interviews of key personnel, discussion with internal and external subject matter experts); and
- direct inspection of the trial operation.

Agreed SPIs will be monitored throughout the trial by the State. If, during the monitoring of the trial, a service provider observes data or reports of excessive deviations from expectations, the State should be notified and immediately conduct a review of the FRMS operation for potential unintended consequences not previously anticipated.

Having a variety of SPIs is expected to give a more reliable indication of fatigue levels and of the performance of the FRMS. Common types of fatigue SPIs include:

- operational SPIs that monitor the duty-related causes of fatigue (e.g. disruption through the use of captain's discretion);
- SPIs based on reactive fatigue data (e.g. numbers of fatigue reports on a particular work pattern);
- SPIs based on proactive monitoring of actual levels of fatigue levels of targeted operational personnel (e.g. high levels of subjective sleepiness at the end of a work period).

REVIEWING TRIAL OUTPUTS



Before proceeding, the service provider must show that the trial is delivering the required safety outcomes. This may be demonstrated through a final report on the trial that includes an analysis of the agreed SPIs and any associated compulsory safety reports. The State should also check if there have been any operational and organizational changes during the trial period that might have impacted the trial findings. Further, the State should review any other relevant information (e.g. through State audits of the service provider in other areas, or findings of studies on similar operations).

The result of the State's review will determine whether there is a need for adjustment of any of the trial's limits or requirements, including enhancements to mitigations. Aspects of the trial may need to be redone according to the nature and severity of the State's concerns.

6.2.3. PHASE 3: LAUNCH

Once the State is satisfied that the trial FRMS is fully functioning and delivering an acceptable level of safety performance, the State approves the FRMS and Phase 3 begins.

APPROVING AN FRMS

Giving approval for the FRMS means that the service provider can now activate the FRMS across all the specified operations and may now embed the approved FRMS as part of its normal operations.

Any changes to the approved FRMS (e.g. extending the scope of the FRMS to cover additional operations or increasing values for maximum flight and duty periods and minimum rest periods), results in an amended FRMS. The State will need to base their approval of the amended FRMS on the service provider presenting an additional or modified safety case. Depending on the extent of the change, a trial period may again be required to demonstrate that the additional route or operation delivered the level of safety that the safety case predicted (i.e. return to Phase 2). Once demonstrated, an updated approval would be issued.

DEVELOPING AN FRMS OVERSIGHT PLAN

For the purposes of resource planning, the State needs to develop an FRMS oversight plan that will ensure appropriate continued oversight. This will include scheduling of formal audits, general inspections, desk-top reviews and periodic updates on SPIs. Allowance for ad hoc visits and increased oversight demands during any changes in scope to the FRMS should also be considered when developing the oversight plan.

During Phase 3, the level of regulatory oversight will typically be lower than during the "Trial" but must be sufficient to assure the State that the FRMS is functioning as intended in all the operations to which it applies. However, immediately post-approval the States may wish to maintain an initial increased level of oversight than for routine regulatory oversight to ensure that the service provider continues to manage their FRMS appropriately. Continued FRMS oversight is discussed further in Section 6.2.4 below.

6.2.4. PHASE 4: MAINTAIN AND IMPROVE

During Phase 4, the State will need to embed the oversight of the service provider's approved FRMS as part of their normal oversight programme. Regulatory oversight demands are reduced to routine levels. As in Phase 3, any extensions to the scope of the FRMS will require the service provider to present an additional or modified safety case and may require a new trial (i.e. return to Phase 2). This is discussed further below.

REGULATORY PROCESS REVIEW

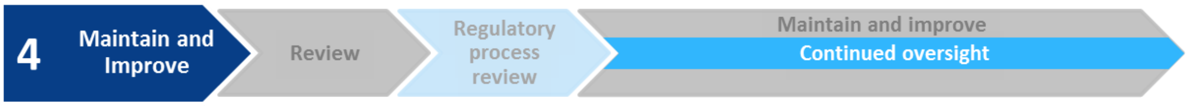
At a predetermined time after the initial implementation of an approved FRMS, the State may wish to conduct a review of their oversight processes and procedures with a view to improvement based on lessons learned over the service provider's FRMS implementation process thus far.

The terms of reference for the review should address as a minimum:

- the continued fitness for purpose of the four components of the FRMS (i.e. whether fatigue risks are being appropriately controlled);
- compliance with system demands; and
- the effectiveness of training, promotion and assurance mechanisms.

Recommendations to improve oversight processes and procedures should be made to assure that these are subject to continual improvement.

CONTINUED FRMS OVERSIGHT



In overseeing the service provider's FRMS, the State is seeking to ensure that all of the FRMS processes are functioning in a cohesive manner with regard to the specific operations to which they have been applied and that an acceptable level of safety performance is maintained. The CASI will need to be aware of any new studies or research that may provide further information about risk in the types of operations for which they are providing oversight.

In overseeing the service provider's FRMS, the CASI will examine evidence of the service provider's FRMS safety assurance functions by assessing any trends in the SPIs and reviewing the agreed FRMS safety performance targets. It will need to be confirmed that the service provider is, where necessary, identifying potentially adverse trends and managing them appropriately as part of the risk assessment functions.

Such evidence can be gained through assessing:

- any corrections or additions that have been made post-approval;
- adjustments to outer limits and mitigations in response to data;
- any organizational and operational changes that may have an impact on the FRMS;
- the current training package and training practices, including all staff training records; and
- the standard of internal auditing of the FRMS processes.

As part of normal oversight, the CASI will conduct interviews with a variety of people involved with the FRMS and monitor changes of key FRMS personnel. Where key personnel have changed, the CASI should seek to ensure the new personnel are included in his list of interviewees. Occasionally, a CASI might also ask to attend a service provider's FSAG meeting to gain better insight in its FRMS processes, although the CASI cannot be part of the FSAG activities. The CASI may also choose to audit some of the primary sources of input into the system (for example, fatigue reports, records of planned and actual work periods). The content and effectiveness of FRMS training and education programmes should be periodically evaluated by the State.

In the same way that normal oversight audit functions are recorded, the State will need to ensure that it has an adequate FRMS record-keeping process. Such records will store the outcomes, findings and rectification notifications of the approval process and ongoing oversight.

OPTIONS FOR ADDRESSING FRMS DEFICIENCIES

States will need to establish a process to be used when deficiencies in an FRMS are identified. The withdrawal of privileges by the State should be commensurate to the level of risk resulting from the deficiency. These actions may range from administrative changes or FRMS operational changes, to a withdrawal of FRMS approval.

The three alternatives, in increasing severity, are:

1. Service provider on notice to improve FRMS processes

Where the State's oversight produces concerns that the service provider's FRMS may not meet regulatory requirements, then the service provider should first be given an opportunity to improve the specific aspects of its FRMS so that it does meet regulatory requirements. Based on the findings of the audit process, the State will need to provide advice to the service provider and identify a mutually-agreed corrective action plan.

2. State-mandated lowering of maximum values (and/or increasing minimum values)

Where the State's oversight produces concerns that an element of a service provider's FRMS may be ineffective, the State may need to revise a service provider's maximum and minimum values. These State-set limits should remain in place until the service provider can provide evidence that its FRMS processes are effective and the State has regained regulatory confidence in the service provider.

3. Withdrawal of FRMS approval

Where there is a significant safety concern that has not been addressed by the above enforcement alternatives, it is the State's obligation to withdraw the FRMS approval and require the service provider to operate within prescriptive limitation regulations. While complying with the prescribed limits, the service provider may attempt to improve its FRMS processes, in order to re-establish regulatory confidence and re-apply for FRMS approval. Should the State consider that the service provider's FRMS meets its requirements at this point, the State may approve the FRMS on restricted conditions (for example, decreased maximum values for flight and duty periods and minimum values for rest periods) until such time as it is confident of the maturity and effectiveness of the system.

APPENDIX A. ICAO FATIGUE MANAGEMENT SARPS AND THEIR INTENT

Fatigue management-related SARPs (in blue), followed by details to clarify their intent, are presented below according to the Annex in which they appear:

- Annex 6 - *Operation of Aircraft*, Part I.- *International Commercial Air Transport - Aeroplanes*
- Annex 6 - *Operation of Aircraft*, Part II- *International General Aviation - Aeroplanes*
- Annex 11 - *Air Traffic Services*

A1. ANNEX 6, PART I

SARPs related to fatigue management in Annex 6, Part I are found in:

- Chapter 4, Section 4.10 – *Fatigue Management*;
- Appendix 2. Organization and contents of an operations manual, Section 2.1.2 – *Operations Manual Content*; and
- Appendix 7 – *FRMS Requirements*

A1.1. CHAPTER 4, SECTION 4.10 – FATIGUE MANAGEMENT

4.10.1 *The State of the Operator shall establish regulations for the purpose of managing fatigue. These regulations shall be based upon scientific principles and knowledge, with the aim of ensuring that flight and cabin crew members are performing at an adequate level of alertness. Accordingly, the State of the Operator shall establish:*

a) regulations for flight time, flight duty period, duty period and rest period limitations; and

b) where authorizing an operator to use a Fatigue Risk Management System (FRMS) to manage fatigue, FRMS regulations.

Intent: Standard 4.10.1 stipulates the State's responsibilities for establishing regulations for fatigue management. The establishment of regulations for prescriptive limitations remains mandatory, while the establishment of regulations for FRMS is necessary only where the State chooses to allow operators to apply for FRMS approval. Developing FRMS regulations is therefore optional for the State. However, both types of regulations need to address the known scientific principles (discussed in Chapter 3).

4.10.2 *The State of the Operator shall require that the operator, in compliance with 4.10.1 and for the purposes of managing its fatigue-related safety risks, establish either:*

a) flight time, flight duty period, duty period and rest period limitations that are within the prescriptive fatigue management regulations established by the State of the Operator; or

b) a Fatigue Risk Management System (FRMS) in compliance with 4.10.6 for all operations; or

c) an FRMS in compliance with 4.10.6 for part of its operations and the requirements of 4.10.2 a) for the remainder of its operations.

Intent: Standard 4.10.2 aims to make clear that, where the State has established regulations for FRMS, operators then have three options for managing their fatigue risks: a) they can do so solely within their State's flight and duty time limitations regulations using existing SMS processes; b) they can choose to implement an FRMS for all operations; or c) they can implement an FRMS in part of their operations and in other operations comply with the prescriptive flight and duty time limitations. Therefore, this Standard intends to allow the operator to decide which method of fatigue management is most appropriate for its specific types of operations.

Where the State does not have FRMS regulations, operators must manage their fatigue-related risks, as part of their existing safety management processes, within the constraints of their State's prescribed flight and duty time limitations or State-approved variations to those limitations. As fatigue is not the only hazard managed through an SMS, as is the case when using an FRMS, the expected concentration of resources to manage fatigue-related risks is significantly less.

4.10.3 *Where the operator adopts prescriptive fatigue management regulations for part or all of its operations, the State of the Operator may approve, in exceptional circumstances, variations to these regulations on the basis of a risk assessment provided by the operator. Approved variations shall provide a level of safety equivalent to, or better than, that achieved through the prescriptive fatigue management regulations.*

Intent: It is recognized that prior to the FRMS Standards, many States had approved variations to the prescribed flight and duty time limitations for operators. In some cases, these variations relate to very minor extensions, and Standard 4.10.3 allows an operator to continue to have minor extensions in certain operations and manage their fatigue risks through their SMS processes without having to develop and implement a full FRMS. Approval of the variation is subject to the provision of a risk assessment acceptable to the State.

The intent of Standard 4.10.3 is to minimize "regulation through variations" and to avoid the approval of variations that meet operational imperatives in the absence of a risk assessment. It is not intended to offer a quick and easy alternative to an FRMS when a more comprehensive fatigue risk management approach is required. Importantly, it applies only in "exceptional circumstances." The type of circumstances considered "exceptional" are discussed further in Chapter 4, *Section 4.2 - Developing regulations for variations to a prescribed limit.*

4.10.4 *The State of the Operator shall approve an operator's FRMS before it may take the place of any or all of the prescriptive fatigue management regulations. An approved FRMS shall provide a level of safety equivalent to, or better than, the prescriptive fatigue management regulations.*

Intent: Standard 4.10.4 clarifies the need for the State to have a transparent FRMS approval process that requires an operator to demonstrate, as final evidence, effectively functioning FRMS processes. It aims to prevent the approval of an FRMS based only on the provision of a documented plan or a desktop review of an FRMS manual. The process for seeking and gaining approval of an FRMS from a State must be made transparent to the operator (see Chapter 6).

This Standard also makes clear that prescriptive Fatigue Management regulations provide the baseline, in terms of safety equivalence, from which an FRMS is assessed.

4.10.5 *States that approve an operator's FRMS shall establish a process to ensure that an FRMS provides a level of safety equivalent to, or better than, the prescriptive fatigue management regulations. As part of this process, the State of the Operator shall:*

a) require that the operator establish maximum values for flight times and/or flight duty periods(s) and duty period(s), and minimum values for rest periods. These values shall be based upon scientific principles and knowledge, subject to safety assurance processes, and acceptable to the State of the Operator;

b) mandate a decrease in maximum values and an increase in minimum values in the event that the operator's data indicates these values are too high or too low, respectively; and

c) approve any increase in maximum values or decrease in minimum values only after evaluating the operator's justification for such changes, based on accumulated FRMS experience and fatigue-related data.

Intent: 4.10.5 is a "change management" SARP aiming to address concerns of the potential use of unconstrained flight and duty times under the guise of an FRMS and to assist the State in the successful introduction of the performance-based regulations that FRMS requires. It sets clear expectations amongst all stakeholders, highlighting the State's ability to contain the range of flight and duty hours in which the operator using FRMS may operate.

4.10.5 a) requires the operator to identify an upper boundary which flight and duty times will not exceed and a lower boundary under which no rest period will be shortened even when using mitigations and processes within an FRMS.

4.10.5 b) provides States with a less drastic alternative to withdrawing approval for an FRMS when an adjustment will suffice to ensure that an equivalent level of safety is maintained. It intends to be proactive, in that it addresses less serious situations where an operator's data indicates a trend that suggests the values may be too high or too low.

4.10.5 c) ensures that operators who have demonstrated the responsible and comprehensive management of their fatigue-related risks through a mature FRMS are not prevented from gaining its full benefits by unnecessarily restrictive constraints.

4.10.6 *Where an operator implements an FRMS to manage fatigue-related safety risks, the operator shall, as a minimum:*

a) incorporate scientific principles and knowledge within the FRMS;

b) identify fatigue-related safety hazards and the resulting risks on an ongoing basis;

c) ensure that remedial actions, necessary to effectively mitigate the risks associated with the hazards, are implemented promptly;

d) provide for continuous monitoring and regular assessment of the mitigation of fatigue risks achieved by such actions; and

e) provide for continuous improvement to the overall performance of the FRMS.

Note 1.— Detailed requirements for an FRMS are in Appendix 7.

Note 2.— Provisions on the protection of safety data, safety information and related sources are contained in Appendix 3 to Annex 19.

Intent: 4.10.6 identifies the high level requirements of an FRMS, and directs the reader to Appendix 7 of Annex 6, Part I which details the necessary components (see Chapter 5 for further details). This Standard is presented in a similar format to that of the SMS framework (Annex 19, Appendix 2) to reflect the consistencies between FRMS and SMS.

4.10.7 ***Recommendation****.— States should require that, where an operator has an FRMS, it is integrated with the operator's SMS.*

Intent: 4.10.7 recognizes the relationship between FRMS and SMS. Because FRMS has a safety function, it needs to complement existing safety management processes within an operator's SMS in order to maximize their combined effectiveness, to ensure resources are being distributed appropriately across the systems and, where possible, to reduce duplicated processes for greater system efficiency. Information from an FRMS should inform an operator's SMS and vice versa.

However, it is important to recognize that they are not one and the same system. Where an operator does not wish to implement an FRMS or has had its FRMS approval revoked, the operator must use its SMS to manage fatigue-related risks within prescriptive limitations.

4.10.8 *An operator shall maintain records for all its flight and cabin crew members of flight time, flight duty periods, duty periods, and rest periods for a period of time specified by the State of the Operator.*

Intent: Irrespective of which method of fatigue management is used (i.e., compliance with prescriptive flight and duty limitations or implementation of an approved FRMS), all operators are required to maintain records of working periods, with or without flight duties, for flight and cabin crew. It is up to each State to stipulate the period of time which these records much be kept.

A1.2. APPENDIX 2, SECTION 2.1.2 – OPERATIONS MANUAL CONTENT

2. Contents

The operations manual referred to in 1 shall contain at the least the following:

2.1 General

……….

2.1.2 *Information and policy relating to fatigue management including:*

a) rules pertaining to flight time, flight duty period, duty period limitations and rest requirements for flight and cabin crew members in accordance with Chapter 4, 4.10.2 a); and

b) policy and documentation pertaining to the operator's FRMS in accordance with Appendix 7.

Intent: 2.1.2 aims to ensure that the operations manual identifies the fatigue management policies of the organization. It requires that operator-adjusted flight and duty time limits for particular operations (either within the constraints of prescribed regulations or in accordance with their FRMS) be identified.

It is not expected that the operations manual contain the entire set of FRMS documentation, but provides a high level description and references the necessary FRMS documentation.

A1.3. APPENDIX 7 – FRMS REQUIREMENTS

A Fatigue Risk Management System (FRMS) established in accordance with Chapter 4, 4.10.6, shall contain, at a minimum:

1. FRMS policy and documentation

1.1 FRMS policy

1.1.1 The operator shall define its FRMS policy, with all elements of the FRMS clearly identified.

1.1.2 The policy shall require that the scope of FRMS operations be clearly defined in the operations manual.

1.1.3 The policy shall:

- *a) reflect the shared responsibility of management, flight and cabin crews, and other involved personnel;*
- *b) clearly state the safety objectives of the FRMS;*
- *c) be signed by the accountable executive of the organization;*
- *d) be communicated, with visible endorsement, to all the relevant areas and levels of the organization;*
- *e) declare management commitment to effective safety reporting;*
- *f) declare management commitment to the provision of adequate resources for the FRMS;*
- *g) declare management commitment to continuous improvement of the FRMS;*
- *h) require that clear lines of accountability for management, flight and cabin crews, and all other involved personnel are identified; and*
- *i) require periodic reviews to ensure it remains relevant and appropriate.*

Note.— Effective safety reporting is described in the Safety Management Manual (SMM) (Doc 9859).

1.2 FRMS documentation

An operator shall develop and keep current FRMS documentation that describes and records:

- *a) FRMS policy and objectives;*
- *b) FRMS processes and procedures;*
- *c) accountabilities, responsibilities and authorities for these processes and procedures;*
- *d) mechanisms for ongoing involvement of management, flight and cabin crew members, and all other involved personnel;*
- *e) FRMS training programmes, training requirements and attendance records;*
- *f) scheduled and actual flight times, duty periods and rest periods with significant deviations and reasons for deviations noted; and*

  Note.— Significant deviations are described in the Manual for the Oversight of Fatigue Management Approaches (Doc 9966).
- *g) FRMS outputs including findings from collected data, recommendations, and actions taken.*

2. Fatigue risk management processes

2.1 Identification of hazards

Note.— Provisions on the protection of safety data, safety information and related sources are contained in Appendix 3 to Annex 19.

An operator shall develop and maintain three fundamental and documented processes for fatigue hazard identification:

2.1.1 Predictive

The predictive process shall identify fatigue hazards by examining crew scheduling and taking into account factors known to affect sleep and fatigue and their effects on performance. Methods of examination may include but are not limited to:

- *a) operator or industry operational experience and data collected on similar types of operations;*
- *b) evidence-based scheduling practices; and*
- *c) bio-mathematical models.*

2.1.2 Proactive

The proactive process shall identify fatigue hazards within current flight operations. Methods of examination may include but are not limited to:

- *a) self-reporting of fatigue risks;*
- *b) crew fatigue surveys;*
- *c) relevant flight and cabin crew performance data;*
- *d) available safety databases and scientific studies; and*
- *e) analysis of planned versus actual time worked.*

2.1.3 Reactive

The reactive process shall identify the contribution of fatigue hazards to reports and events associated with potential negative safety consequences in order to determine how the impact of fatigue could have been minimized. At a minimum, the process may be triggered by any of the following:

- *a) fatigue reports;*
- *b) confidential reports;*
- *c) audit reports;*
- *d) incidents; and*
- *e) flight data analysis events.*

2.2 Risk assessment

2.2.1 An operator shall develop and implement risk assessment procedures that determine the probability and potential severity of fatigue-related events and identify when the associated risks require mitigation.

2.2.2 The risk assessment procedures shall review identified hazards and link them to:

- *a) operational processes;*
- *b) their probability;*
- *c) possible consequences; and*
- *d) the effectiveness of existing safety barriers and controls.*

2.3 Risk mitigation

An operator shall develop and implement risk mitigation procedures that:

- *a) select the appropriate mitigation strategies;*
- *b) implement the mitigation strategies; and*
- *c) monitor the strategies' implementation and effectiveness.*

3. FRMS safety assurance processes

The operator shall develop and maintain FRMS safety assurance processes to:

- *a) provide for continuous FRMS performance monitoring, analysis of trends, and measurement to validate the effectiveness of the fatigue safety risk controls. The sources of data may include, but are not limited to:*
  - *1) hazard reporting and investigations;*
  - *2) audits and surveys; and*
  - *3) reviews and fatigue studies;*
- *b) provide a formal process for the management of change which shall include but is not limited to:*
  - *1) identification of changes in the operational environment that may affect FRMS;*
  - *2) identification of changes within the organization that may affect FRMS; and*
  - *3) consideration of available tools which could be used to maintain or improve FRMS performance prior to implementing changes; and*
- *c) provide for the continuous improvement of the FRMS. This shall include but is not limited to:*
  - *1) the elimination and/or modification of risk controls that have had unintended consequences or that are no longer needed due to changes in the operational or organizational environment;*
  - *2) routine evaluations of facilities, equipment, documentation and procedures; and*
  - *3) the determination of the need to introduce new processes and procedures to mitigate emerging fatigue-related risks.*

4. FRMS promotion processes

FRMS promotion processes support the ongoing development of the FRMS, the continuous improvement of its overall performance, and attainment of optimum safety levels. The following shall be established and implemented by the operator as part of its FRMS:

- *a) training programmes to ensure competency commensurate with the roles and responsibilities of management, flight and cabin crew, and all other involved personnel under the planned FRMS; and*
- *b) an effective FRMS communication plan that:*
  - *1) explains FRMS policies, procedures and responsibilities to all relevant stakeholders; and*
  - *2) describes communication channels used to gather and disseminate FRMS-related information.*

Intent: Appendix 7 of Annex 6, Part I details the minimum requirements for each of the four components of an FRMS: 1) FRMS policy and documentation; 2) Fatigue Risk Management processes; 3) FRMS safety assurance processes; and 4) FRMS promotion processes. This Standard is presented in a similar format to that of the SMS framework (Annex 19, Appendix 2) to reflect the consistencies between FRMS and SMS.

A2. ANNEX 6 PART II

SARPs related to fatigue management in Annex 6, Part II are found in:

- Section 2, Chapter 2.2- Flight operations, 2.2.5 – Duties of Pilot-in-Command
- Section 3, Chapter 3.4 - Flight operations, 3.4.2 – Operations Management

A2.1. CHAPTER 2.2, SECTION 2.2.5 – DUTIES OF PILOT-IN-COMMAND

2.2.5.2 *The pilot-in-command shall be responsible for ensuring that a flight:*

a) will not be commenced if any flight crew member is incapacitated from performing duties by any cause such as injury, sickness, fatigue, the effects of any psychoactive substance; and

b) will not be continued beyond the nearest suitable aerodrome when flight crew members' capacity to perform functions is significantly reduced by impairment of faculties from causes such as fatigue, sickness or lack of oxygen.

Intent: This performance-based Standard specifies the broad responsibility of the pilot-in-command to ensure that flight crew members are not fatigued at the commencement of a flight, or are not suffering the effects of fatigue to a degree that would significantly impair their capacity to perform their functions during a flight.

To meet this Standard it is expected that Sates will prescribe such pilot-in-command responsibilities and provide pilots with information on fatigue and its effects on human performance. Operators are expected to provide clear procedures to their pilots for meeting these responsibilities.

A2.2. CHAPTER 3.4, SECTION 3.4.2 – OPERATIONAL MANAGEMENT

3.4.2.8 *Fatigue management programme*

An operator shall establish and implement a fatigue management programme that ensures that all operator personnel involved in the operation and maintenance of aircraft do not carry out their duties when fatigued. The programme shall address flight and duty times and be included in the operations manual.

Intent: This Standard does not require the State to prescribe specific flight and duty limitations or rest time minimums for general aviation operations, nor does it require operators to have an FRMS.

Rather, States are expected to require operators to establish a Fatigue Management Programme that will include flight and duty time limitations and minimum rest periods for aircraft crew members and duty time rules for other employees involved in the operation and maintenance of aircraft where fatigue may be an issue, and include those provisions in their operations manual. These limitations should be used to implement scheduling practices based on scientific principles (see Chapter 2).

As GA operators are also required to have an SMS, consideration of their fatigue risk through assessment, identification and appropriate use of mitigations and some fatigue management training as part of their existing SMS processes is also expected.

It must be noted that this Standard refers to “operator personnel”. It is intended to include personnel directly employed by the operator and is not intended to include personnel employed by organizations that the operator has contracted with to perform operational and maintenance functions. However, operators are responsible for managing risks to their operations, and may address the issue of fatigue of contractor personnel, as part of their normal SMS activities.

A3. ANNEX 6 PART III (SECTION II)

SARPs related to fatigue management in Annex 6, Part III (Section II) are found in:

- Chapter 2. Flight Operations, Section 2.8 – Fatigue management;
- Appendix 6 – FRMS requirements; and
- Appendix 7 – Contents of an operations manual.

A3.1. CHAPTER 2, SECTION 2.8 – FATIGUE MANAGEMENT

2.8.1 *The State of the Operator shall establish regulations for the purpose of managing fatigue. These regulations shall be based upon scientific principles, knowledge and operational experience, with the aim of ensuring that flight and cabin crew members are performing at an adequate level of alertness. Accordingly, the State of the Operator shall establish:*

a) prescriptive regulations for flight time, flight duty period, duty period limitations and rest period requirements; and

b) where authorizing an operator to use a Fatigue Risk Management System (FRMS) to manage fatigue, FRMS regulations in accordance with Appendix 6.

Intent: Standard 2.8.1 stipulates the State's responsibilities for establishing regulations for fatigue management with respect to international commercial helicopter air transport operations. The establishment of regulations for prescriptive limitations for flight and cabin crew is mandatory, while the establishment of regulations for FRMS is necessary only where the State chooses to allow operators to apply for FRMS approval. Developing FRMS regulations is therefore optional for the State. However, where these are established, they must comply with FRMS requirements presented in Appendix 6.

Both types of regulations (prescriptive limitations and FRMS) need to consider the known scientific principles (discussed in Chapter 2) as well as address the context of the helicopter operations within their region.

2.8.2 *The State of the Operator shall require that the operator, in compliance with 2.8.1 and for the purposes of managing its fatigue-related safety risks, establish one of the following:*

a) flight time, flight duty period, duty period limitations and rest period requirements that are within the prescriptive fatigue management regulations established by the State of the Operator; or

b) a Fatigue Risk Management System (FRMS) in compliance with regulations established by the State of the Operator for all operations; or

c) an FRMS in compliance with regulations established by the State of the Operator for a defined part of its operations with the remainder of its operations in compliance with the prescriptive fatigue management regulations established by the State of the Operator.

Note.— Complying with the prescriptive fatigue management regulations does not relieve the operator of the responsibility to manage its risks, including fatigue-related risks, using its Safety Management System (SMS) in accordance with the provisions of Annex 19.

Intent: Standard 2.8.2 aims to make clear that, where the State has established regulations for FRMS, operators then have three options for managing their fatigue risks and can choose on the basis of which is most appropriate for its specific types of operations.

Where the State does not have FRMS regulations, operators must comply with their State's prescribed flight and duty time limitations or State-approved variations to those limitations.

The note is a reminder that when complying with prescribed flight and duty time limits, international commercial air transport helicopter operators still have obligations to use their existing SMS processes to manage their fatigue risks.

2.8.3 *The operator shall maintain records of flight time, flight duty periods, duty periods, and rest periods for all its flight and cabin crew members for a period of time specified by the State of the Operator.*

Intent: Irrespective of which method of fatigue management is used, all operators are required to maintain records of working periods, with or without flight duties, for flight and cabin crew. It is up to each State to stipulate the period of time which these records much be kept.

The intent is for States to examine whether an operator allows adequate "buffers" within its schedules and to check that deviations from scheduled hours consistently resulted in appropriate actions by the operator.

In a prescriptive approach, this Standard aims to ensure that compliance with the prescribed limits is not confirmed only through examining what is scheduled, but by comparing these with what is actually worked.

2.8.4 *Where the operator complies with prescriptive fatigue management regulations in the provision of part or all of its services, the State of the Operator:*

a) shall require that the operator familiarize those personnel involved in managing fatigue with their responsibilities and the principles of fatigue management;

b) may approve, in exceptional circumstances, variations to these regulations on the basis of a risk assessment provided by the operator. Approved variations shall provide a level of safety equivalent to, or better than, that achieved through the prescriptive fatigue management regulations.

Intent: Standard 2.8.4 identifies additional requirements that must be addressed within prescriptive fatigue management regulations, other than simply prescribing limits.

The intent of Standard 2.8.4 a) is <u>*not*</u> to increase pilot training requirements, but rather to ensure that flight and cabin crew are aware of the safety implications of fatigue in their operations and their role in identifying and managing fatigue hazards. This Standard is considered important as without an explicit requirement, increasing flight and cabin's crew's awareness of fatigue management may not be considered as part of the operator's SMS.

The intent of Standard 2.8.4 b) is to minimize "regulation through variations" and to avoid the approval of variations that meet operational imperatives in the absence of a risk assessment. It is not intended to offer a quick and easy alternative to an FRMS when a more comprehensive fatigue risk management approach is required. States are expected to establish criteria to identify conditions suitable for operators to seek variation approvals. The development of regulations for variations to prescribed limits is discussed further in Chapter 4, Section 4.1.

2.8.5 *Where an operator implements an FRMS to manage fatigue-related safety risks in the provision of part or all of its services, the State of the Operator shall:*

a) require the operator to have processes to integrate FRMS functions with its other safety management functions;

b) require that the operator establish maximum values for flight times, flight duty periods and duty periods, and minimum values for rest periods; and

c) approve an operator's FRMS before it may take the place of any or all of the prescriptive fatigue management regulations. An approved FRMS shall provide a level of safety equivalent to, or better than, the prescriptive fatigue management regulations.

Intent: Standard 2.8.5 identifies additional requirements associated with FRMS regulations, other than those contained in Appendix 6.

2.8.5 a) reflects a general acceptance that an FRMS cannot be implemented unless an operator has first developed a mature SMS. It aims to ensure that the management of fatigue risks is considered within the context of other operational risks and that the management of other operational risks does not have the unintended consequence of introducing unacceptable fatigue risks.

2.8.5 b) highlights that an FRMS does not result in an uncontained range of flight and duty hours. Having an FRMS still requires having maximum duty times and minimum rest (or non-work periods), but these are identified through the operator's FRMS processes and must be acceptable to the State. The values for maximum duty times and minimum rest (or non-work periods) identified by the operator form part of the FRMS and are included in the FRMS approval process (see 2.8.5 c)). If the operator wanted to alter the approved values, the amended values would need to be considered within the context of the existing processes, essentially requiring approval of a "new" FRMS.

The intent of 2.8.5 c) is to ensure that States identify a clear FRMS approval process and that only operators with an approved FRMS are able to move outside prescribed limits. While operators may identify themselves as using an FRMS approach, they must comply with prescriptive limitation regulations unless the State has approved their FRMS through an established approval process. The approval process allows the State to confirm that the operator's FRMS is at least as safe as compliance with the prescribed limits. The FRMS approval process is described in Chapter 6, Section 6.2.

A3.2. APPENDIX 6 – FRMS REQUIREMENTS

A Fatigue Risk Management System (FRMS) shall contain, as a minimum:

1. FRMS POLICY AND DOCUMENTATION

1.1 FRMS policy

1.1.1 The operator shall define its FRMS policy, with all elements of the FRMS clearly identified.

1.1.2 The policy shall require that the scope of the FRMS be clearly defined in the operations manual.

1.1.3 The policy shall:

- *a) reflect the shared responsibility of management, flight and cabin crews, and other involved personnel;*
- *b) clearly state the safety objectives of the FRMS;*
- *c) be signed by the accountable executive of the organization;*
- *d) be communicated, with visible endorsement, to all the relevant areas and levels of the organization;*
- *e) declare management commitment to effective safety reporting;*
- *f) declare management commitment to the provision of adequate resources for the FRMS;*
- *g) declare management commitment to continuous improvement of the FRMS;*
- *h) require that clear lines of accountability for management, flight and cabin crews, and all other involved personnel be identified; and*
- *i) require periodic reviews to ensure it remains relevant and appropriate.*

Note.— Effective safety reporting is described in the Safety Management Manual (SMM) (Doc 9859).

1.2 FRMS documentation

An operator shall develop and keep current FRMS documentation that describes and records:

- *a) FRMS policy and objectives;*
- *b) FRMS processes and procedures;*
- *c) accountabilities, responsibilities and authorities for these processes and procedures;*
- *d) mechanisms for ongoing involvement of management, flight and cabin crew members, and all other*

involved personnel;e) FRMS training programmes, training requirements and attendance records;

f) *scheduled and actual flight times, flight duty periods, duty periods and rest periods with significant deviations and reasons for deviations noted; and*

Note.— Significant deviations are described in the Manual for the Oversight of Fatigue Management Approaches (Doc 9966).

g) *FRMS outputs including findings from collected data, recommendations, and actions taken.*

2. FATIGUE RISK MANAGEMENT PROCESSES

2.1 Identification of hazards

Note.— Legal guidance for the protection of information from safety data collection and processing systems is contained in Attachment B to the first edition of Annex 19.

An operator shall develop and maintain three fundamental and documented processes for fatigue hazard identification:

2.1.1 Predictive

The predictive process shall identify fatigue hazards taking into account factors known to affect sleep and fatigue and their effects on performance. Methods of examination may include but are not limited to:

a) *operator or industry operational experience and data collected on similar types of operations;*

b) *evidence-based scheduling practices; and*

c) *bio-mathematical models.*

2.1.2 Proactive

The proactive process shall identify fatigue hazards within current flight operations. Methods of examination may include but are not limited to:

a) *self-reporting of fatigue risks;*

b) *crew fatigue surveys;*

c) *relevant flight and cabin crew performance data;*

d) *available safety databases and scientific studies; and*

e) *analysis of planned versus actual time worked.*

2.1.3 Reactive

The reactive process shall identify the contribution of fatigue hazards to reports and events associated with potential negative safety consequences in order to determine how the impact of fatigue could have been minimized. As a minimum, the process should be triggered by any of the following:

a) fatigue reports;

b) confidential reports;

c) audit reports;

d) incidents; and

e) flight data analysis events.

2.2 Risk assessment

2.2.1 An operator shall develop and implement risk assessment procedures that determine the probability and potential severity of fatigue-related events and identify when the associated risks require mitigation.

2.2.2 The risk assessment procedures shall review identified hazards and link them to:

a) operational processes;

b) their probability;

c) possible consequences; and

d) the effectiveness of existing safety barriers and controls.

2.3 Risk mitigation

An operator shall develop and implement risk mitigation procedures that:

a) select the appropriate mitigation strategies;

b) implement the mitigation strategies; and

c) monitor the strategies' implementation and effectiveness.

3. FRMS SAFETY ASSURANCE PROCESSES

The operator shall develop and maintain FRMS safety assurance processes to:

a) provide for continuous FRMS performance monitoring, analysis of trends, and measurement to validate the effectiveness of the fatigue safety risk controls.

The sources of data may include, but are not limited to:

1) hazard reporting and investigations;

2) audits and surveys; and

3) reviews and fatigue studies;

b) provide a formal process for the management of change which shall include but is not limited to:

1) identification of changes in the operational environment that may affect FRMS;

2) identification of changes within the organization that may affect FRMS; and

3) consideration of available tools which could be used to maintain or improve FRMS performance prior to implementing changes; and

c) provide for the continuous improvement of the FRMS. This shall include but is not limited to:

1) the elimination and/or modification of risk controls that have had unintended consequences or that are no longer needed due to changes in the operational or organizational environment;

2) routine evaluations of facilities, equipment, documentation and procedures; and

3) the determination of the need to introduce new processes and procedures to mitigate emerging fatigue-related risks.

4. FRMS PROMOTION PROCESSES

FRMS promotion processes support the ongoing development of the FRMS, the continuous improvement of its overall performance, and attainment of optimum safety levels. The following shall be established and implemented by the operator as part of its FRMS:

a) training programmes to ensure competency commensurate with the roles and responsibilities of management, flight and cabin crew, and all other involved personnel under the planned FRMS; and

b) an effective FRMS communication plan that:

1) explains FRMS policies, procedures and responsibilities to all relevant stakeholders; and

2) describes communication channels used to gather and disseminate FRMS-related information.

Intent: Appendix 6 of Annex 6, Part III details the minimum requirements for each of the four components of an FRMS: 1) FRMS policy and documentation; 2) Fatigue Risk Management processes; 3) FRMS safety assurance processes; and 4) FRMS promotion processes. This Standard is presented in a similar format to that of the SMS framework (Annex 19, Appendix 2) to reflect the consistencies between FRMS and SMS.

A3.3. APPENDIX 7 – CONTENTS OF AN OPERATIONS MANUAL

2. CONTENTS

The operations manual referred to in 1.1 shall contain at the least the following:

2.1 General

2.1.1 *Information and policy relating to fatigue management including:*

a) policies pertaining to the flight time, flight duty periods, duty period limitations and rest requirements for flight and cabin crew members in accordance with Section II, Chapter 2, 2.8; and

b) where applicable, policy and documentation pertaining to the operator's FRMS in accordance with Appendix 6.

…….

Intent: 2.1.1 aims to ensure that the operations manual identifies the fatigue management policies of the organization. It requires that operator-adjusted flight and duty time limits for particular operations (either within the constraints of prescribed regulations or in accordance with their FRMS) be identified.

It is not expected that the operations manual contain the entire set of FRMS documentation, but provides a high level description and references the necessary FRMS documentation.

A4. ANNEX 11

SARPs related to fatigue management in Annex 11 for implementation by 2020, will be found in:

- Chapter 2. General, Section 2.28 – Fatigue Management
- Appendix 6 – Prescriptive Fatigue Management Requirements
- Appendix 7 – FRMS Requirements

A4.1. CHAPTER 2, SECTION 2.28 – FATIGUE MANAGEMENT

2.28.1 *States shall establish regulations for the purpose of managing fatigue in the provision of air traffic control services. These regulations shall be based upon scientific principles, knowledge and operational experience, with the aim of ensuring that air traffic controllers perform at an adequate level of alertness. To that aim, States shall establish:*

a) regulations that prescribe scheduling limits in accordance with Appendix 6; and

b) where authorizing air traffic services providers to use a fatigue risk management system (FRMS) to manage fatigue, FRMS regulations in accordance with Appendix 7.

Intent: Standard 2.28.1 stipulates the State's responsibilities for establishing regulations for fatigue management. The establishment of regulations for prescriptive limitations is mandatory, while the establishment of regulations for FRMS is necessary only where the State chooses to allow ATSPs to apply for FRMS approval. Developing FRMS regulations is therefore optional for States. However, both types of regulations need to address the known scientific principles (see Chapter 2).

The prescriptive regulations must be in accordance with Appendix 6 to Annex 11 (see following table) while Appendix 7 to Annex 11 outlines the minimum requirements of an FRMS (see Chapter 5).

2.28.2 *States shall require that the air traffic services provider, for the purposes of managing its fatigue-related safety risks, establish one of the following:*

a) air traffic controller schedules commensurate with the service(s) provided and in compliance with the prescriptive limitation regulations established by the State in accordance with 2.28.1 a); or

b) an FRMS, in compliance with regulations established by the State in accordance with 2.28.1 b), for the provision of all air traffic control services; or

c) an FRMS, in compliance with regulations established by the State in accordance with 2.28.1 b), for a defined part of its air traffic control services in conjunction with schedules in compliance with the prescriptive limitation regulations established by the State in accordance with 2.28.1 a) for the remainder of its air traffic control services.

Intent: Standard 2.28.2 identifies the options the ATS provider has for the management of its fatigue-related safety risks, depending on whether their State offers FRMS regulations.

Where the State has established regulations for FRMS, ATS providers have three options for managing their fatigue risks: a) they can comply with the prescriptive limitation regulations in all operations; b) they can choose to implement an FRMS for all operations; or c) they can implement an FRMS in parts of their operations and in other operations comply with the prescriptive limitation regulations. Therefore, this Standard offers the ATS provider the opportunity to decide which method of fatigue management is most appropriate for its specific types of operations.

Where the State does not have FRMS regulations, air traffic service providers must manage their fatigue-related risks, as part of their existing safety management processes, within the constraints of their State's prescribed duty time limitations or State-approved variations to those limitations. As fatigue is not a specific focus of an SMS, as is the case when using an FRMS, the concentration of resources required to manage fatigue-related risks using SMS processes is significantly less (see Chapter 4).

Regardless of the fatigue management approach used, the State must take these practices into account in its ATS capacity analysis, to ensure consistency in system design, and to make the necessary updates (see Doc 4444, 3.1 .1).

2.28.3 *Where the air traffic services provider complies with prescriptive limitation regulations in the provision of part or all of its air traffic control services in accordance with 2.28.2 a), the State:*

a) shall require evidence that the limitations are not exceeded and that non-duty period requirements are met;

b) shall require that the air traffic services provider familiarize its personnel with the principles of fatigue management and its policies with regard to fatigue management;

c) shall establish a process to allow variations from the prescriptive limitation regulations to address any additional risks associated with sudden, unforeseen operational circumstances; and

d) may approve variations to these regulations using an established process in order to address strategic operational needs in exceptional circumstances, based on the air traffic services provider demonstrating that any associated risk is being managed to a level of safety equivalent to, or better than, that achieved through the prescriptive fatigue management regulations.

Note.— Complying with the prescriptive limitations regulations does not relieve the air traffic services provider of the responsibility to manage its risks, including fatigue-related risks, using its SMS in accordance with the provisions of Annex 19.

Intent: 2.28.3 lists additional Standards for prescriptive fatigue management regulations outside of those that are contained in Appendix 6 relating specifically to aspects impacting on work schedules under a prescriptive scheme.

2.28.3 a) aims to ensure that compliance with the prescriptive limits is not just determined through examination of schedules, which are planned work periods, but also through examination of the periods of time actually worked by air traffic controllers.

2.28.3 b) distinguishes basic fatigue-related training as mandatory for air traffic controllers, whether or not it is incorporated in the training elements of an air traffic service provider's SMS.

2.28.3 c) recognizes the need for air traffic service providers to have some flexibility to make tactical decisions that may require going outside of the prescribed limits in order to meet both operational needs and address overall risk, such as needing to maintain adequate ATC coverage to manage high traffic in association with unexpectedly severe weather conditions. This Standard requires the State to develop a clear process so that an air traffic service provider knows exactly what is required of them to make immediate and appropriate changes to address such unexpected operational circumstances.

In contrast to 2.28.3 c) above, 2.28.3 d) relates to the possibility of more strategic responses by air traffic service providers to address expected by minor changes to usual air traffic service demands in exceptional circumstances, such as planning for increased traffic during an Olympics, or to meet limited seasonal demands, without the need for the ANSP to develop a full FRMS. This Standard requires air traffic service providers to seek approval for any variations or exceptions to the prescriptive limits that they wish to schedule air traffic controllers to work. These variations should be for a defined period of time(s) and made in association with identified mitigation strategies.

The intent of Standard 2.28.3 d) is to minimize "regulation through variations" and to avoid the approval of variations that meet operational imperatives in the absence of a risk assessment. It is not intended to offer a quick and easy alternative to an FRMS when a more comprehensive fatigue risk management approach is required.

The Note is a reminder of current obligations that, when complying with prescriptive limitations regulations, ATS providers must continue to use their existing safety management processes to address any fatigue-related risks that may be identified.

2.28.4 *Where an air traffic services provider implements an FRMS to manage fatigue-related safety risks in the provision of part or all of its air traffic control services in accordance with 2.28.2 b), the State shall:*

a) require the air traffic services provider to have processes to integrate FRMS functions with its other safety management functions; and

b) approve an FRMS, according to a documented process, that provides a level of safety acceptable to the State.

Note.— Provisions on the protection of safety information, which support the continued availability of information required by an FRMS, are contained in Annex 19.

Intent:

2.28.4 lists additional Standards for FRMS regulations outside of those that are contained in Appendix 7 relating specifically to the minimum requirements for an FRMS.

2.28.4 a) recognizes the relationship between FRMS and SMS. Because FRMS has a safety function, it needs to complement existing safety management processes within an service provider's SMS in order to maximize their combined effectiveness, to ensure resources are being distributed appropriately across the systems and, where possible, to reduce duplicated processes for greater system efficiency. This Standard means that information from an FRMS will inform an ATSP's SMS and vice versa.

2.28.4 b) clarifies the need for the State to have a transparent FRMS approval process that requires an ATS provider to demonstrate, as final evidence, effectively functioning FRMS processes. It aims to prevent the approval of an FRMS based only on the provision of a documented plan or a desktop review of an FRMS manual. The process for seeking and gaining approval of an FRMS from a State must be made transparent to the air traffic service provider(see Chapter 6).

The note serves to highlight that the collection of safety information is essential in implementing an FRMS and needs to be accorded protection in accordance with existing provisions in Annex 19.

A4.2. APPENDIX 6 – PRESCRIPTIVE FATIGUE MANAGEMENT REGULATIONS

1. *States shall establish prescriptive limitation regulations that take into account acute and cumulative fatigue, circadian factors and the type of work being undertaken. These regulations shall identify:*

a) the maximum:

i) number of hours in any duty period;

ii) number of consecutive work days;

iii) number of hours worked in a defined period; and

iv) time-in-position;

b) the minimum:

i) duration of non-duty periods;

ii) number of non-duty days required in a defined period; and

iii) duration of breaks between periods of time-in-position in a duty period.

Intent: Appendix 6 - 1 identifies those roster features for which the State must prescribe limits, ensuring that prescriptive limitation regulations address basic conditions that will impact on the air traffic controller's ability to maintain an adequate level of alertness throughout work periods occurring across a 24-h day.

Limiting the maximum number of hours worked in any duty period allows provision of an adequate opportunity for sleep recovery to address transient fatigue. Limiting the number of consecutive work days and the number of hours worked in a defined period is a mechanism for providing adequate recovery from cumulative sleep loss. While it is recognized that time spent in-position may be associated with varying workloads, the intent of limiting time-in-position is to specifically address the difficulties of maintaining performance under high workload conditions. For operations where time-in-position is related to only moderate and low workloads, the State may choose to prescribe time-in-position limits for specified operations or may require the ATS provider to seek a variation to the prescribed limits.

Identifying minimum non-duty periods ensures that duty hours cannot be consistently split across a defined period in such a way as to prevent unbroken periods of recovery sleep. Identifying a minimum number of non-duty days in a defined period provides further opportunity for recovery from cumulative sleep loss. Identifying minimum duration of breaks between periods of time-in-position aims to specifically address the need to recover from periods of high workload in order to maintain performance.

2. States shall require that the air traffic services provider identifies a process for assigning unscheduled duties that allows air traffic controllers to avoid extended periods of being awake.

Intent: To address broader aviation safety risks, controllers sometimes have to be available to undertake unscheduled duties, regardless of whether or not they are on standby. This Standard aims to minimize the likelihood of such unscheduled duties being undertaken when the controller has not had the opportunity to sleep for a long period of time, resulting in a high sleep drive (see Scientific Principle # 2 in Chapter 2). Such processes could focus on limiting the duration of the unscheduled duties, allowing controller's to obtain sleep prior to commencement of unscheduled duties, and/or providing the opportunity for napping during the unscheduled duties.

3. *The processes established by States in accordance with 2.28.3 c) and d) to allow variations from 1 a) and b) above shall include the provision of:*

a) the reason for the need to deviate;

b) the extent of the deviation;

c) the date and time of enactment of the deviation; and

d) a safety case, outlining mitigations, to support the deviation.

Intent: This Standard identifies the minimum requirements of any request for variation to prescribed limits, when the ATS provider is not implementing an FRMS. It aims to ensure that ATS providers complying with prescriptive limits, identify and mitigate fatigue risks when varying from prescriptive limits for tactical or strategic reasons.

A4.3. APPENDIX 7 – FRMS REQUIREMENTS

States shall require that an FRMS contain, at a minimum:

1. FRMS policy and documentation

1.1 FRMS policy

1.1.1 The air traffic services provider shall define its FRMS policy, with all elements of the FRMS clearly identified.

1.1.2 The policy shall:

- *a) define the scope of FRMS operations;*
- *b) reflect the shared responsibility of management, air traffic controllers, and other involved personnel;*
- *c) clearly state the safety objectives of the FRMS;*
- *d) be signed by the accountable executive of the organization;*
- *e) be communicated, with visible endorsement, to all the relevant areas and levels of the organization;*
- *f) declare management commitment to effective safety reporting;*
- *g) declare management commitment to the provision of adequate resources for the FRMS;*
- *h) declare management commitment to continuous improvement of the FRMS;*
- *i) require that clear lines of accountability for management, air traffic controllers, and all other involved personnel are identified; and*
- *j) require periodic reviews to ensure it remains relevant and appropriate.*

Note.— Effective safety reporting is described in the Safety Management Manual (SMM) (Doc 9859).

1.2 FRMS documentation

An air traffic services provider shall develop and keep current FRMS documentation that describes and records:

- *a) FRMS policy and objectives;*
- *b) FRMS processes and procedures;*
- *c) accountabilities, responsibilities and authorities for these processes and procedures;*
- *d) mechanisms for ongoing involvement of management, air traffic controllers, and all other involved personnel;*
- *e) FRMS training programmes, training requirements and attendance records;*
- *f) scheduled and actual duty and non-duty periods and break periods between times in position in a duty period with significant deviations and reasons for deviations noted; and*

Note.— Significant deviations are described in the Manual for the Oversight of Fatigue Management Approaches (Doc 9966).

g) FRMS outputs including findings from collected data, recommendations, and actions taken.

2. Fatigue risk management processes

2.1 Identification of fatigue-related hazards

Note.— Provisions on the protection of safety information are contained in Annex 19.

An air traffic services provider shall develop and maintain three fundamental and documented processes for fatigue hazard identification:

2.1.1 Predictive

The predictive process shall identify fatigue hazards by examining air traffic controller scheduling and taking into account factors known to affect sleep and fatigue and their effects on performance. Methods of examination may include but are not limited to:

a) air traffic services or industry operational experience and data collected on similar types of operations or from other industries with shift work or 24-hour operations;

b) evidence-based scheduling practices; and

c) bio-mathematical models.

2.1.2 Proactive

The proactive process shall identify fatigue hazards within current air traffic services operations. Methods of examination may include but are not limited to:

a) self-reporting of fatigue risks;

b) fatigue surveys;

c) relevant air traffic controller performance data;

d) available safety databases and scientific studies;

e) tracking and analysis of differences in planned and actual worked times; and

f) observations during normal operations or special evaluations.

2.1.3 Reactive

The reactive process shall identify the contribution of fatigue hazards to reports and events associated with potential negative safety consequences in order to determine how the impact of fatigue could have been minimized. At a minimum, the process may be triggered by any of the following:

a) fatigue reports;

b) confidential reports;

c) audit reports; and

d) incidents.

2.2 Fatigue-related risk assessment

2.2.1 An air traffic services provider shall develop and implement risk assessment procedures that determine when the associated risks require mitigation.

2.2.2 The risk assessment procedures shall review identified fatigue hazards and link them to:

- *a) operational processes;*
- *b) their probability;*
- *c) possible consequences; and*
- *d) the effectiveness of existing preventive controls and recovery measures.*

2.3 Risk mitigation

An air traffic services provider shall develop and implement fatigue risk mitigation procedures that:

- *a) select the appropriate mitigation strategies;*
- *b) implement the mitigation strategies; and*
- *c) monitor the strategies' implementation and effectiveness.*

3. FRMS safety assurance processes

The air traffic services provider shall develop and maintain FRMS safety assurance processes to:

- *a) provide for continuous FRMS performance monitoring, analysis of trends, and measurement to validate the effectiveness of the fatigue safety risk controls. The sources of data may include, but are not limited to:*
  - *1) hazard reporting and investigations;*
  - *2) audits and surveys; and*
  - *3) reviews and fatigue studies (both internal and external);*
- *b) provide a formal process for the management of change. This shall include but is not limited to:*
  - *1) identification of changes in the operational environment that may affect the FRMS;*
  - *2) identification of changes within the organization that may affect the FRMS; and*
  - *3) consideration of available tools which could be used to maintain or improve FRMS performance prior to implementing changes; and*
- *c) provide for the continuous improvement of the FRMS. This shall include but is not limited to:*
  - *1) the elimination and/or modification of preventive controls and recovery measures that have had unintended consequences or that are no longer needed due to changes in the operational or organizational environment;*
  - *2) routine evaluations of facilities, equipment, documentation and procedures; and*
  - *3) the determination of the need to introduce new processes and procedures to mitigate emerging fatigue-related risks.*

4. FRMS promotion processes

FRMS promotion processes support the ongoing development of the FRMS, the continuous improvement of its overall performance, and attainment of optimum safety levels. The following shall be established and implemented by the air traffic service provider as part of its FRMS:

a) training programmes to ensure competency commensurate with the roles and responsibilities of management, air traffic controllers, and all other involved personnel under the planned FRMS; and

b) an effective FRMS communication plan that:

1) explains FRMS policies, procedures and responsibilities to all relevant stakeholders; and

2) describes communication channels used to gather and disseminate FRMS-related information.

Intent: Appendix 7 of Annex 11 details the minimum requirements for each of the four components of an FRMS: 1) FRMS policy and documentation; 2) Fatigue Risk Management processes; 3) FRMS safety assurance processes; and 4) FRMS promotion processes. This Standard is presented in a similar format to that of the SMS framework (Annex 19, Appendix 2) to reflect the consistencies between FRMS and SMS.

APPENDIX B. MEASUREMENT TOOLS

FRM processes and FRMS safety assurance processes (Chapter 5) will sometimes require the measurement of an individual's fatigue, sleep, performance or workload. For most of these concepts there is no single "right" or "gold standard" measurement method. Because fatigue-related impairment affects many skills and has multiple causes a broad range of measures are often used in scientific research to provide a more comprehensive picture of fatigue. When considering whether a measure is appropriate for use the following should be taken into account:

a) the measure has been shown to be sensitive for measuring what it claims to measure (that is, it has been scientifically validated);
b) the measure does not jeopardize an individual's ability to perform their operational duties; and
c) the measure has previously been used in aviation, so data can be compared between different types of operations.

New ways to measure fatigue, sleep, performance or workload are always being developed and some will become valuable tools to add to the list below, once they have been validated for use in aviation operations. Meanwhile, in an FRMS it is important to use measures that are accepted by States, service providers, operational personnel and scientists as being meaningful and reliable. This avoids the unnecessary cost and inconvenience of collecting data that is of doubtful value.

Measurement tools can range from being subjective (based entirely on an individual's recall or perceptions) to objective (such as performance tests and different types of physiological monitoring). Each type of measure has strengths and weaknesses. To decide which types of data to collect, the most important consideration should be the expected level of fatigue risk. For example, if the risk of fatigue is expected to be low then simpler, less invasive and less costly measures may be adequate, whereas if the fatigue risk is thought to be high then the measures chosen for use might need to be more comprehensive and consequently they may also be more labour intensive and costly.

Table B-1 below provides a summary of possible measures fatigue, sleep, performance and workload and their known strengths and weaknesses. Further details on the use of these measures in specific operational contexts can be found in the various implementation manuals.

Table 6B-1. Summary of fatigue, sleep, performance and workload measures

	Measurement Tool	Subjective / Objective	Strengths	Weaknesses
Fatigue	Fatigue reports	Subjective	Simple, cost-effective, possibly completed online, allow immediate identification of possible fatigue risk	Subject to possible bias, requires an effective reporting culture
	Retrospective surveys	Subjective	Simple, cost-effective, large amounts of data can be collected	Subject to recall bias, items not always well validated
	Rating scales (e.g. KSS, SP, VAS)	Subjective	Simple, cost-effective, quick to complete, large amounts of data can be collected, many scales well used in aviation	Subject to possible bias
	Physiological measures (e.g. EEG, EOG)	Objective	Objective and not subject to bias	Intrusive, burden on individual, time consuming, labour intensive, expensive, artefact (noise) in data can be a problem
Sleep	Retrospective surveys	Subjective	Simple, cost-effective, large amounts of data can be collected, some well used in aviation	Subject to recall bias, items not always well validated
	Sleep diaries	Subjective	Simple, cost-effective, can obtain multiple measures at once (e.g. sleep and fatigue ratings), diaries well used in aviation	Subject to recall bias, most diaries not well validated, multiple days of data need to be collected, some burden on individuals
	Actigraphy	Objective	Objective and not subject to bias, well used in aviation	Moderately intrusive, burden on individual, analysis time consuming, labour intensive, moderate costs
	Polysomnography	Objective	Objective and not subject to bias, has been used in aviation	Intrusive, burden on individual, time consuming, expensive, labour intensive
Circadian rhythms	Physiological measures (e.g. core body temperature, melatonin)	Objective	Objective and not subject to bias, have been used in aviation	Intrusive, burden on individual, time consuming, expensive, labour intensive, artefact (noise) in data can be a problem
Performance	Retrospective surveys	Subjective	Simple, cost-effective, large amounts of data can be collected	Subject to bias, items not always well validated
	Performance tests (e.g. PVT)	Objective	Objective and not subject to bias, some measures have been well used in aviation	Moderately intrusive, burden on individual, analysis time consuming, labour intensive, moderate costs, distraction in testing environment may be an issue
Workload	Ratings scales (e.g. NASA TLX[43], Overall Workload Scale, VAS)	Subjective	Simple, cost-effective, some scales have been used in aviation	Subject to bias, items not always well validated
	Physiological measures (e.g. EEG, ECG)	Objective	Objective and not subject to bias	Invasive, time consuming, expensive, labour intensive, artefact (noise) in data can be a problem

43 http://humansystems.arc.nasa.gov/groups/tlx/

APPENDIX C. PRESCRIPTIVE LIMITATION PARAMETERS FOR AIRLINE FLIGHT AND CABIN CREW

Designed to be read in association with Section 4.1 in Chapter 4, this Appendix presents a set of parameters that may be considered in the development of prescriptive limitations for flight and cabin crew. This is only one example of how prescriptive limitations for fatigue management may be defined.

No numerical values are shown in this example because different regional and cultural contexts can lead States to identify different scientifically valid, optimal limits for their international airlines. In the text that follows, the symbol (*) is used to indicate where each State may insert a value it considers appropriate to manage fatigue, and square brackets [ ] to indicate a typical value. States are encouraged to examine the numerical values of other States' systems for further guidance and assess these for suitability within their own context.

C1. RELATED DEFINITIONS

ICAO definitions for terms used in the following sections are repeated here to assist States to establish or amend their prescriptive fatigue management regulations.

The following are ICAO definitions taken from Annex 6, Part I:

***Duty*.** Any task that a flight or cabin crew members are required by the operator to perform, including, for example, flight duty, administrative work, training, positioning and standby when it is likely to induce fatigue.

***Duty period*.** A period which starts when a flight or cabin crew member is required by an operator to report for or to commence a duty and ends when that person is free from all duties.

Flight duty period. A period which commences when a crew member is required to report for duty that includes a flight or a series of flights and which finishes when the aeroplane finally comes to rest at the end of the last flight on which he/she is a crew member.

***Flight time – aeroplanes*.** The total time from the moment an aeroplane first moves for the purpose of taking off until the moment it finally comes to rest at the end of the flight.

Other terms not defined by ICAO, but used in the following sections are presented in blue call-out boxes within the text of the subsequent sections.

C2. THE OPERATOR'S RESPONSIBILITIES

- Duty rosters should be prepared and published sufficiently in advance to provide flight and cabin crew members the opportunity to plan adequate rest. Consideration should be given to the cumulative effects of undertaking long duty hours interspersed with minimum rest, and of avoiding rosters that result in the serious disruption of an established pattern of working and sleeping. Rosters should cover a period of at least (*) days.
- Flights should be planned to be completed within the allowable flight duty period taking into account the time necessary for pre-flight duties, the flight and turn-around times, and the nature of the operation. Minimum rest periods needed to provide adequate rest should be based upon the actual operation.
- In order to avoid any detriment to a flight or cabin crew member's performance, opportunities to consume a meal must be arranged when the flight duty period exceeds (*) hours.
- The operator should nominate a home base for each flight and cabin crew member, from where the flight and cabin crew member will normally start and end a duty period or a series of duty periods. The home base should be assigned with a degree of permanence.
- The operator should not require a flight crew member to operate an aeroplane if it is known or suspected that the flight crew member is fatigued to the extent that the safety of flight may be adversely affected.
- To provide evidence of compliance with prescriptive limits, records will be kept for (*) months of the duties performed and rest periods achieved so as to facilitate inspection by the operator's authorized personnel and audit by the State of the Operator.
- The operator should ensure that these records include for each flight and cabin crew member, at least:
  a) the start, duration and end of each flight duty period;
  b) the start, duration and end of each duty period;
  c) rest periods; and
  d) flight time.

Home base. *The location nominated by the operator to the crew member from where the crew member normally starts and ends a duty period or a series of duty periods.*

C3. FLIGHT CREW MEMBERS' RESPONSIBILITIES

- A flight crew member should not operate an aeroplane when he or she knows that he or she is fatigued or feels unfit to the extent that the safety of flight may be adversely affected.
- Flight crew members should make best use of the facilities and opportunities that are provided for rest and for the consumption of meals, and should plan and use rest periods to ensure that they are fully rested.
- Flight crew members should maintain a personal record of their daily flight time.

C4. FLIGHT AND DUTY LIMITATIONS PARAMETERS

C4.1. MAXIMUM FLIGHT TIME

- The maximum flight time may not exceed:
  a) (*) hours in any flight duty period;
  b) (*) hours in any [7] consecutive days or (*) hours in any [28] consecutive days; and
  c) (*) hours in any [365] consecutive days.

- The limitations in b) and c) may alternatively be calculated in a calendar week, month or year. In such a case other limitations over a period of two or three calendar months should be specified.

C4.2. MAXIMUM DUTY HOURS

- Duty hours may not exceed:
  a) (*) hours in any [7] consecutive days or in a week; and
  b) (*) hours in any [28] consecutive days or in a calendar month.

- Duty includes all tasks carried out at the behest of the operator. These include, but are not limited to: pre-flight preparation; conduct of the flight (whether or not this is commercial air transport); post-flight actions; training given or received (classroom, flight simulator or aeroplane); rostered office/management time; and positioning. Standby should be included to the extent that it is likely to induce fatigue.
- All time spent positioning counts as duty, and positioning followed by operating without an intervening rest period also counts as flight duty. However, positioning should not count as an operating sector when planning or calculating a flight duty period.

Positioning. *The transferring of a non-operating crew member from place to place as a passenger at the behest of the operator.*

C4.3. MAXIMUM FLIGHT DUTY PERIOD

- The maximum flight duty period for a single pilot crew is (*) hours.
- The maximum flight duty period for a two pilot crew is (*) hours.
- These limitations should vary in relation to matters known to impact fatigue such as: the number of sectors planned; the local time at which duty begins; the pattern of resting and sleeping relative to the crew member's circadian rhythm; the organization of the working time; whether the crew is augmented; and the type of in-flight rest facilities available to them.
- Crew report times should realistically reflect the time required to complete pre-flight duties, both safety- and service-related (if appropriate), and a standard allowance of (*) minutes is to be added at the end of flight time to allow for the completion of checks and records. For record purposes, the pre-flight report time should count both as duty and as flight duty, and the post-flight allowance should count as duty.
- The maximum flight duty period for cabin crew may be longer than that applicable to the flight crew because of the difference in reporting time between flight crew and cabin crew.
- Flight duty periods may be extended in unforeseen operational circumstances by no more than (*) hour(s) only at the discretion of the pilot-in-command. Before exercising this discretion, the pilot-in-command should be satisfied that all members of the crew required to operate the aeroplane consider themselves fit to do so.
- The composition and number of flight crew members carried to provide in-flight relief, and the quality of rest facilities provided, should determine the amount by which the basic flight duty period limitations may be extended. A sensible balance should be kept between the division of in-flight duty and rest. The number of the cabin crew should be determined taking into account the rest facilities provided and other parameters linked to the operation of the flight.

Report time. *The time at which flight and cabin crew members are required by an operator to report for duty.*

C4.4. IN-FLIGHT REST

- Standards for in-flight rest facilities must be adequate to allow sleep;
- The operator should establish a protocol for deciding how in-flight rest breaks will be scheduled;
- Where the in-flight rest periods are used to extend the flight duty period, the crew member must utilise the rest period and the sleep facility as intended.

C4.5. CONTROLLED REST ON THE FLIGHT DECK

- Where acceptable to the State, protocol for using napping in the cockpit (otherwise known as "controlled rest on the flightdeck") as a mitigation should be established (see *Fatigue Management Guide for Airline Operators* for detailed information).

C4.6. MINIMUM REST PERIODS (OUTSIDE DUTY HOURS)

- The minimum rest period immediately before commencing a flight duty period may not be less than (*) hours.
- Rest provisions should be introduced to take into account the impact of time zone crossings and night operations.
- Longer rest periods should be granted on a regular basis to preclude cumulative fatigue.
- Minimum rest periods may be reduced in unforeseen operational circumstances by no more than (*) hour(s) only at the discretion of the pilot-in-command.
- Travelling time spent by a flight or cabin crew member in transit between the place of rest and the place of reporting for duty is not counted as duty, even though it is a factor contributing to fatigue. Excessive travelling time undertaken immediately before commencing a flight duty period could therefore detract from a flight or cabin crew member's ability to counter fatigue arising whilst on duty, and should therefore be taken into account when deciding where pre-flight rest should be taken.

> ***Rest period**. A continuous and defined period of time, subsequent to and/or prior to duty, during which flight or cabin crewmembers are free of all duties.*

C4.7. STANDBY AND AVAILABILITY

- The start time and end time of standby should be defined and notified at least (*) hours in advance, and the maximum length of any standby should not exceed (*) hours.
- Where airport standby is immediately followed by a flight duty period, the relationship between such airport standby and the assigned flight duty should be defined. In such a case, airport standby, if it is likely to induce fatigue, should be considered as part of a duty period and should be taken into account to calculate the minimum rest preceding a subsequent flight duty period.
- When flight and cabin crew members are required to be on standby at an accommodation arranged by the operator, then adequate rest facilities should be provided.
- When flight and cabin crew members are required to be available for contact over a brief period of time to receive instructions concerning a possible change of roster, that requirement should not prevent that crew member from having a rest period before reporting for duty. The time spent being available should not be counted as duty.

> ***Standby**. A defined period of time during which a flight or cabin crew member is required by the operator to be available to receive an assignment for a specific duty without an intervening rest period.*

C4.8. PILOT DISCRETION

- The pilot-in-command, at his or her discretion in consideration of unexpected circumstances that could lead to unforeseen levels of fatigue and after discussion with flight or cabin crew members affected, may reduce an actual flight duty period and/or increase a minimum rest period in order to remove any adverse effect on flight safety.
- The pilot-in-command should report to the operator the use of discretion to extend or reduce duty or rest.
- The operator must keep records of occasions when a pilot-in-command has exercised his or her discretion. If discretion has to be applied for similar reasons on more than (*) per cent of occasions when a particular route or route pattern is flown, the operator will notify the State using an established process and make arrangements to change the schedule or the crewing arrangements so as to reduce the frequency at which such events occur.

APPENDIX D. PRESCRIPTIVE LIMITATION PARAMETERS FOR AIR TRAFFIC CONTROLLERS

This Appendix should be read in association with the overarching requirements in Chapter 4 where the areas to be considered when developing prescriptive regulations are described more generally. The following material comprises a set of parameters that may be considered in the development of prescriptive limitations for ATCOs. This is only one example of how prescriptive limitations for fatigue management may be defined.

No numerical values are shown in this example because different regional and cultural contexts can lead States to identify different scientifically valid, optimal limits for their air traffic controllers. In the text that follows, the symbol (*) is used to indicate where each State may insert a value it considers appropriate to manage fatigue, and square brackets [ ] to indicate a typical value. States are encouraged to examine the numerical values of other States' systems for further guidance.

D1. THE SERVICE PROVIDER'S RESPONSIBILITIES

- Duty rosters should be prepared and published sufficiently in advance to provide ATCOs the opportunity to plan adequate rest. Consideration should be given to the cumulative effects of undertaking long duty hours interspersed with minimum non-work periods, and of avoiding rosters that result in the serious disruption of an established pattern of working and sleeping. Rosters should cover a period of at least (*) days.
- Minimum non-work periods need to provide adequate rest such that the ATCO can achieve a suitable sleep period, as well as allowing for consideration of other physiological requirements and any associated travelling or commuting time.
- In order to avoid any detriment to an ATCO's performance, opportunities to consume a meal must be arranged when the duty period exceeds (*) hours.
- The service provider should not require an ATCO to undertake any safety related task if it is known or suspected that the ATCO is fatigued to the extent that safety may be adversely affected.
- To provide evidence of compliance with prescriptive limits, records will be kept for (*) months of the duties performed and non-duty periods achieved so as to facilitate inspection by the service's authorized personnel and audit by the State of the service provider.

D2. AIR TRAFFIC CONTROLLERS' RESPONSIBILITIES

- An ATCO should not perform any safety relevant tasks when he or she knows that he or she is fatigued or feels unfit to the extent that safety may be adversely affected.
- ATCOs should make best use of the facilities and opportunities that are provided for rest and for the consumption of meals. They should plan and use rest periods to ensure that they are fully rested.

D3. DUTY LIMITATION PARAMETERS

D3.1. DUTY PERIOD

- The duty period may not exceed (*) [12] hours.
- The aggregate of duty period hours may not exceed (*) [200] hours within a defined period of (*) [720] consecutive hours or (*) [30] consecutive days.
- There must be at least (*) [12] hours between the end of one duty period and the beginning of the next.
- No more than (*) [6] consecutive days of duty shall be worked.
- If the maximum number of consecutive days of duty is rostered, there shall be a minimum interval of (*) [60] hours between the end of one consecutive period of duty days and the next.

Scientific and operational factors for consideration: There may be variable limits of duty period throughout the day which reflect task complexity and workload requirements as well as time of day and circadian disruption. There must be sufficient time between duty periods for suitable sleep. The cumulative effects of fatigue over a period of days should be considered.

D3.2. OPERATIONAL DUTY

- No period of operational duty shall exceed (*) [2] hours.
- No operational duty shall exceed (*) [2] hours without there being a break taken during or at the end of that period.
- A break should total not less than (*) [30] minutes.

Scientific and operational factors for consideration: Time in the controlling position should be limited based on complexity of task and workload. Breaks should provide sufficient time away from tasks to allow individuals to resume work with a sufficient level of performance. Breaks could be structured to allow napping or sleeping opportunities if appropriate.

D3.3. NIGHT DUTIES

- A period of night duty shall be defined as starting at (*) [0130 local] and ending at (*) [0529 local].
- A duty which covers all or part of the period of night duty shall not exceed (*) [10] hours.
- No more than (*) [3] consecutive duties shall be worked which cover all or part of the period of night duty.
- A minimum period of (*) [54] hours shall occur between the end of duties which cover all or part of the period of night duty and the commencement of the next period of duty.

Scientific and operational factors for consideration: A night duty shall be wholly or partly between the window of circadian low. Consideration should be given to the research with regard to shift length and night work. Recovery time from night duties should allow recovery from any sleep debt accumulated and reversion to normal sleep cycle rhythms.

D3.4. ON CALL DUTIES

- No more than (*) [3] on-call duties shall be worked in a (*) [7] day period.
- The maximum length of on call period of duty where the ATCO does not attend the place of work shall be (*) [20] hours.

Scientific and operational factors for consideration: Continuous hours of wakefulness and opportunities available to take sleep during the on-call period.

APPENDIX E. PRESCRIPTIVE LIMITATION PARAMETERS FOR HELICOPTER FLIGHT AND CABIN CREW (COMMERCIAL AIR TRANSPORT)

This Appendix should be read in association with the overarching requirements in Chapter 4, where the areas to be considered when developing prescriptive regulations are described more generally.

The following material comprises a set of parameters that may be considered in the development of prescriptive limitations for flight and cabin crew of helicopter operations. This is only one example of how prescriptive limitations for fatigue management may be defined.

Most helicopter flight and cabin crew are exposed to irregular patterns of work and frequent changes in the pattern of their work due to operational requirements. States should consider how they require their helicopter operators to demonstrate their management of disruptive patterns of work especially where they infringe or overlap the WOCL.

No numerical values are shown in this example because different regional and cultural contexts can lead States to identify different scientifically valid, optimal limits. In the text that follows, the symbol (*) is used to indicate where each State may insert a value it considers appropriate to manage fatigue, and square brackets [ ] to indicate a typical value. States are encouraged to examine the numerical values of other States' systems for further guidance and assess these for suitability within their context.

E1. RELATED DEFINITIONS

ICAO definitions for terms used in the following sections have been incorporated here to assist States to establish or amend their prescriptive fatigue management regulations.

The following are ICAO definitions taken from Annex 6, Part I:

Duty. Any task that flight or cabin crew members are required by the operator to perform, including, for example, flight duty, administrative work, training, positioning and standby when it is likely to induce fatigue.

Duty Period. A period which starts when a flight or cabin crew member is required by an operator to report for or to commence a duty and ends when that person is free from all duties.

Flight duty period. A period which commences when a flight or cabin crew member is required to report for duty that includes a flight or a series of flights and which finishes when the aircraft finally comes to rest at the end of the last flight on which he/she is a crew member.

Flight time — helicopters. The total time from the moment a helicopter's rotor blades start turning until the moment the helicopter finally comes to rest at the end of the flight, and the rotor blades are stopped.

Definitions of other terms used in the following sections are presented in blue call-out boxes within the text of the subsequent sections.

E2. THE OPERATOR'S RESPONSIBILITIES

- Duty rosters should be prepared and published sufficiently in advance to provide flight and cabin crew members the opportunity to plan adequate rest. Consideration should be given to the cumulative effects of undertaking long duty hours interspersed with minimum rest, and of avoiding rosters that result in the serious disruption of an established pattern of working and sleeping. Rosters should cover a period of at least (*) days.
- Flights should be planned to be completed within the allowable flight duty period taking into account the time necessary for pre-flight duties, the flight and turn-around times, and the nature of the operation. Minimum rest periods needed to provide adequate rest should be based upon the actual operation.
- In order to avoid any detriment to a flight or cabin crew member's performance, opportunities to consume a meal must be arranged when the flight duty period exceeds (*) hours.
- The operator should nominate a home base for each flight and cabin crew member, from where the flight and cabin crew member will normally start and end a duty period or a series of duty periods.
- The operator should not require a flight crew member to operate a helicopter if it is known or suspected that the flight crew member is fatigued to the extent that the safety of flight may be adversely affected.
- To provide evidence of compliance with prescriptive limits, records will be kept for (*) months of the duties performed and rest periods achieved so as to facilitate inspection by the operator's authorized personnel and audit by the State of the Operator.
- The operator should ensure that these records include for each flight and cabin crew member, at least:
  - a) the start, duration and end of each flight duty period;
  - b) the start, duration and end of each duty period;
  - c) rest periods; and
  - d) flight time.

E3. FLIGHT CREW MEMBERS' RESPONSIBILITIES

- A flight crew member should not operate a helicopter when he or she knows that he or she is fatigued or feels unfit to the extent that the safety of flight may be adversely affected.
- Flight crew members should make best use of the facilities and opportunities that are provided for rest and for the consumption of meals, and should plan and use rest periods to ensure that they are fully rested.
- Flight crew members should maintain a personal record of their daily flight time.

E4. FLIGHT AND DUTY LIMITATIONS PARAMETERS

E4.1. MAXIMUM FLIGHT TIME

- The maximum flight time may not exceed:
  a) (*) hours in any flight duty period;
  b) (*) hours in any [7] consecutive days or (*) hours in any [28] consecutive days; and
  c) (*) hours in any [365] consecutive days.

- The limitations in b) and c) may alternatively be calculated for a calendar week, month or year. In such a case, other limitations over a period of two or three calendar months should be specified.
- *Flight time – helicopters* is defined in relation to when the rotor blades start and stop turning. The State should provide guidance in those cases where the definition of *flight time – helicopters* does not describe or permit normal practices. Examples are: crew change without stopping the rotors; and rotors running engine wash procedure following a flight. In any case, the time when rotors are running between sectors of a flight is included within the calculation of flight time.
- Additional limits on flight time based on the workload within the flight duty period (intensity of number of sectors, operational task intensity, use of specialised equipment) may need to be considered, according to the different types of helicopter operations subject to the prescribed limits.

E4.2. MAXIMUM DUTY HOURS

- Duty hours may not exceed:
  a) (*) hours in any [7] consecutive days or in a week; and
  b) (*) hours in any [28] consecutive days or in a calendar month.

- Duty includes all tasks carried out at the behest of the operator. These include, but are not limited to: pre-flight preparation; conduct of the flight (whether or not this is commercial air transport); post-flight actions; training given or received (classroom, flight simulator or aircraft); rostered office/management time; and positioning. Standby should be included to the extent that it is likely to induce fatigue.
- All time spent positioning counts as duty, and positioning followed by operating without an intervening rest period also counts as flight duty. However, positioning should not count as an operating sector when planning or calculating a flight duty period.

E4.3. MAXIMUM FLIGHT DUTY PERIOD

- The maximum flight duty period for a two pilot crew is (*) hours.
- The maximum flight duty period for a single pilot crew is (*) hours.
- This limitation should allow variation to account for matters known to impact fatigue such as: the number of sectors planned; the pattern of resting and sleeping relative to the crew member's circadian rhythm; the organization of the working time; and for single pilot crew the autopilot status of the helicopter.
- Crew report times should realistically reflect the time required to complete pre-flight duties, both safety- and service-related (if appropriate), and a standard allowance of (*) minutes is to be added at the end of flight time to allow for the completion of checks and records. For record purposes, the pre-flight report time should count both as duty and as flight duty, and the post-flight allowance should count as duty.
- The maximum flight duty period for cabin crew may be longer than that applicable to the flight crew by the difference in reporting time between flight crew and cabin crew.
- Flight duty periods may be extended in unforeseen operational circumstances by no more than (*) hour(s) only at the discretion of the pilot-in-command. Before exercising this discretion, the pilot-in-command should be satisfied that all members of the crew required to operate the helicopter consider themselves fit to do so.
- Where survival suits are worn by the crew then there should be an additional break within the flight duty period of (*) minutes every (*) hours (due to the fatiguing nature of operating the helicopter while wearing the suit).
- Crew flying repetitive short sectors, averaging (*) or more landings per hour, should have an additional break of (*) minutes within any continuous period of (*) hours. This could include tasks such as pleasure flying, offshore short sectors, or emergency medical services. This requirement should also be applied for other demanding work such as surveillance work, winching and external load carrying.

E4.4. MINIMUM REST PERIODS (OUTSIDE DUTY HOURS)

- The minimum rest period immediately before commencing a flight duty period may not be less than (*) hours.
- Additional rest provisions should be introduced to take into account the impact of intensive operations (such as high frequency short sectors or external load carrying, etc) and/or night operations.
- Longer rest periods should be granted on a regular basis to preclude cumulative fatigue.
- Minimum rest periods may be reduced in unforeseen operational circumstances by no more than (*) hour(s) only at the discretion of the pilot-in-command.
- Travelling time spent by a flight or cabin crew member in transit between the place of rest and the place of reporting for duty is not counted as duty, even though it is a factor contributing to fatigue. Excessive travelling time undertaken immediately before commencing a flight duty period could therefore detract from a flight or cabin crew member's ability to counter fatigue arising whilst on duty, and should therefore be taken into account when deciding where pre-flight rest should be taken.
- Certain operations may require the crew member to be contacted while on rest. There should be a process to manage any interruptions especially where the crew member is interrupted during a rest period between 2300- 0700. The State may: a) choose to prescribe how such interruptions to rest will be dealt with (e.g. by requiring that the time elapsed from the interruption to the report time, minus (*) hour will count as part of the flight duty period); or b) may require that the operator establish notification practices that are acceptable to the State.

E4.5. STANDBY AND AVAILABILITY

- The start time and end time of standby should be defined and notified at least (*) hours in advance, and the maximum length of any standby should not exceed (*) hours.
- Where airport standby is immediately followed by a flight duty period, the relationship between such airport standby and the assigned flight duty should be defined. In such a case, airport standby, if it is likely to induce fatigue, should be considered as part of a duty period and should be taken into account to calculate the minimum rest preceding a subsequent flight duty period.
- When flight and cabin crew members are required to be on standby at an accommodation arranged by the operator, then adequate rest facilities should be provided.
- When flight and cabin crew members are required to be available for contact over a brief period of time to receive instructions concerning a possible change of roster, that requirement should not prevent that crew member from having a rest period before reporting for duty. The time spent being available should not be counted as duty.
- Flight crew may be required to be on long periods of readiness, especially at remote locations, this requirement needs to demonstrate that the crew members have had sufficient rest and notification of duties to enable them to be able to carry out short notice duties. This process needs to consider the method used to notify the crew, the facilities provided to the crew are conducive to rest, and the frequency and timing of call out is managed to enable crew to receive sufficient rest to perform safely. The periods of readiness also need to include at least (*) pre-notified days off (including 2 local nights) every (*) days.

E4.6. PILOT DISCRETION

- The pilot-in-command, at his or her discretion in consideration of unexpected circumstances that could lead to unforeseen levels of fatigue and after discussion with flight or cabin crew members affected, may reduce an actual flight duty period and/or increase a minimum rest period in order to remove any adverse effect on flight safety.
- The pilot-in-command should report to the operator the use of discretion to extend or reduce duty or rest.
- The operator must keep records of occasions when a pilot-in-command has exercised his or her discretion. If discretion has to be applied for similar reasons on more than (*) per cent of occasions when a particular route or route pattern is flown, the operator will notify the regulator using an established process and make arrangements to change the schedule or the crewing arrangements so as to reduce the frequency at which such events occur.

APPENDIX F. PRESCRIPTIVE LIMITATION PARAMETERS FOR YYY

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Position held for any future guidance as necessary.

APPENDIX G. EXAMPLE OF FSAG TERMS OF REFERENCE

The example below is not a template. Not all the items suggested here will be needed by every service provider.

[Insert Company Name] Terms of Reference: Fatigue Safety Action Group (FSAG)

Purpose

The Fatigue Safety Action Group (FSAG) is responsible for coordinating all fatigue risk management activities at [insert Company name]. This includes responsibility for gathering, analyzing, and reporting on data that measures fatigue among flight crewmembers. The FSAG is also responsible for ensuring that the FRMS meets the safety objectives defined in the FRMS Policy, and that it meets regulatory requirements. The FSAG exists to improve safety, and does not get involved in industrial issues.

Terms of Reference

The FSAG is directly responsible to the Senior VP Flight Operations and reports through the Departmental Safety organization. Its membership will include at least one representative of each of the following groups: management, scheduling, and crewmembers, with other specialists as required.

The tasks of the FSAG are to:

- develop, implement, and monitor processes for the identification of fatigue hazards;
- ensure that comprehensive risk assessment is undertaken for fatigue hazards;
- develop, implement, and monitor controls and mitigations as needed to manage identified fatigue hazards;
- develop, implement, and monitor effective FRMS performance metrics;
- cooperate with the Safety Department to develop, implement and monitor FRMS safety assurance processes, based on agreed safety performance indicators and targets;
- be responsible for the design, analysis, and reporting of studies that measure crewmember fatigue, when such studies are needed for the identification of hazards, or for monitoring the effectiveness of controls and mitigations (such studies may be contracted out but the FSAG is responsible for ensuring that they are conducted with the highest ethical standards, meet the requirements of the FRMS, and are cost-effective);
- be responsible for the development, updating, and delivery of FRMS education and training materials (these activities may be contracted out but the FSAG is responsible for ensuring that they meet the requirements of the FRMS and are cost-effective);
- ensure that all relevant personnel receive appropriate FRMS education and training, and that training records are kept as part of the FRMS documentation;
- develop and maintain strategies for effective communication with all stakeholders;
- ensure that crewmembers and others receive response to their fatigue reports;
- communicate fatigue risks and the performance of the FRMS to senior management;
- develop and maintain the FRMS intranet site;
- develop and maintain the FRMS documentation;
- ensure that it has adequate access to scientific and medical expertise as needed, and that it documents recommendations made by these specialist advisors and the corresponding actions taken;
- keeps informed of scientific and operational advances in fatigue risk management principles and practice;
- cooperate fully with the regulator in relation to FRMS auditing; and
- manage effectively and be accountable for FRMS resources.

The FSAG will meet monthly. Minutes will be taken during meetings and distributed within 10 working days after each meeting. The FSAG will present an annual budget request in [designated part of the financial cycle] and an annual report of all xpenditures.

APPENDIX H. BIO-MATHEMATICAL MODELS

Bio-mathematical fatigue models begin life as computer programmes used by scientists to test their current understanding of how factors like sleep loss, circadian rhythms, and workload interact to affect human alertness and performance. The modeling process attempts to write a programme that can simulate a “developmental data set” – for example self-rated fatigue and performance measured during a sleep-loss experiment in the laboratory. If this works, then the model is used to predict a different situation. Data are then collected in this new situation (a “validation data set”) and model predictions are tested against the new data.

Scientific modeling is a continuous improvement process. As scientific tools, bio-mathematical models are accepted as being incomplete and transient. In scientific best practice, scientists continue designing new experiments to try to find out where their models fail. In this way, they find out where their current understanding is incomplete or possibly wrong. (This is a much more efficient way of increasing scientific knowledge than just doing random experiments.)

A range of bio-mathematical models have been commercialized and are marketed as tools for predicting fatigue hazards associated with scheduling. There are also several models available in the public domain. Used properly, these models can be helpful tools in FRMS, because it is hard to visualize the dynamic interactions of processes like sleep loss and recovery, or the circadian biological clock. To use models properly requires some understanding of what they can and cannot predict. An important question to ask about any model is whether it has been validated against fatigue data from operations similar to those in question.

Currently available models:

- predict group average fatigue levels, not the fatigue levels of individual crew members or controllers;
- do not take into account the impact of workload or personal and work-related stressors that may affect fatigue levels;
- do not take into account the effects of personal or operational mitigation strategies that may or may not be used by individuals (caffeine consumption, exercise, etc.);
- do not predict the safety risk that fatigued crew members or controllers represent in a particular operation (i.e., they are not a substitute for risk assessment (the next step in FRM processes– see below)). Several available models try to predict safety risk by merging safety data from a range of operations in different industries, but their applicability to different sectors in aviation has not yet been verified.

The most reliable use of currently available commercial models is for predicting relative fatigue levels – is the fatigue hazard likely to be greater on this schedule versus that schedule? However, model predictions should not be used without reference to operational experience, when making decisions about schedule design. On the other hand, data collected in the course of FRM processes could be a rich resource for improving the performance of bio-mathematical models, if model designers follow a continuous improvement philosophy.

The Australian Civil Aviation Safety Authority has published valuable guidance on the use of bio-mathematical models in FRM[44].

[44] Bio-mathematical Fatigue Models: Guidance Document http://www.casa.gov.au/wcmswr/_assets/main/aoc/fatigue/fatigue_modelling.pdf

APPENDIX I. EVALUATING THE CONTRIBUTION OF FATIGUE TO SAFETY EVENTS

The primary aim of investigating the role of fatigue in safety events is to identify how its occurrence or effects could have been mitigated, in order to reduce the likelihood of similar events in the future. There is no simple formula for evaluating the contribution of fatigue to a safety event. To establish that fatigue was a contributing factor, it has to be shown that:

- the person or crew/team was in a fatigued state;
- the person or crew/team took particular actions or decisions that were causal in what went wrong; and
- those actions or decisions are consistent with the type of behaviour expected of a fatigued person or crew/team.

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

I1. BASIC INFORMATION

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

1. The time of day that the event took place. If it was in the WOCL (02:00-06:00), 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 7-8 hours of sleep per 24 hours, then a crew member or controller who has had less than 21 hours sleep in the last 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.

I2. INVESTIGATING FATIGUE IN DEPTH

If answers to the four questions above suggest that the individual was fatigued at the time of the event, then more in -depth investigation requires looking at whether the person or crew/team took particular actions or decisions that were causal in what went wrong, and whether those actions or decisions are consistent with the type of behaviour expected of a fatigued person or crew/team. The following two checklists provide one example of how this can be done.

Checklist 1 is designed to establish whether the person or crew/team were in a fatigued state, based on a series of questions or probes that address key aspects of fatigue. The answer to each question is compared to the best case response, in order to build an overall picture of the fatigue hazard. Any departure from the best case response indicates increased risk of fatigue.

Checklist 2 is designed to establish whether the unsafe action(s) or decision(s) were consistent with the type of behaviour expected of a fatigued person or crew/team.

Checklist 1. Establishing the fatigued state

Questions	Best Case Responses	Investigator's Notes
Quantity of Sleep **establish whether or not there was a sleep debt**		
How long was last consolidated sleep period?	7.5 to 8.5 hours	
Start time?	Normal circadian rhythm, late evening	
Awake Time?	Normal circadian rhythm, early morning	
Was your sleep interrupted (for how long)?	No	
Any naps since your last consolidated sleep?	yes	
Duration of naps?	Had opportunity for restorative (1.5-2 hrs) or strategic (20 min) nap prior to start of late shift	
Describe your sleep patterns in the last 72 hours. (Apply sleep credit system)	2 credits for each hour of sleep; loss of one credit for each hour awake - should be a positive value	
Quality of Sleep **establish whether or not sleep was restorative**		
How did the sleep period relate to the individual normal sleep cycle i.e., start/finish time?	Normal circadian rhythm, late evening/early morning	
Sleep disruptions?	No awakenings	
Sleep environment?	Proper environmental conditions (quiet, comfortable temperature, fresh air, own bed, dark room)	
Sleep pathologies (disorders)	None	

Continued over page…

Checklist 1: Establishing the fatigued state (continued)

Questions	Best Case Responses	Investigator's Notes
Work History **establish whether hours worked and type of duty or activities involved had an impact on sleep quantity and quality**		
Hours on duty and/or on call prior to the occurrence?	Situation dependent - hours on duty and/or on call and type of duty that ensure appropriate level of alertness for the task	
Work history in preceding week?	Number of hours on duty and/or on call and type of duty that do not lead to a cumulative fatigue	
Irregular Schedules **establish whether the scheduling was problematic with regards to its impact on quantity and quality of sleep**		
Was crew member or controller a shift worker (working through usual sleep times)?	No (The circadian body clocks and sleep of shift workers do not adapt fully)	
If yes, was it a permanent shift?	Yes -days	
If no, was it rotating (vs irregular) shift work?	Yes - Rotating clockwise, rotation slow (1 day for each hour delayed), night shift shorter, and at the end of cycle	
How are overtime or double shifts scheduled?	Scheduled when crew members or controllers are in the most alert parts of the circadian body clock cycle (late morning, mid evening)	
Scheduling of critical safety tasks?	Scheduled when crew members or controllers are in the most alert parts of the circadian body clock cycle (late morning, mid evening)	
Has crew member or controller had training on personal fatigue mitigation strategies?	Yes	
Jet Lag **establish the existence and impact of jet lag on quantity and quality of sleep**		
Number of time zones crossed?	one	
If more than one, at what rate were they crossed?	the slower the better	
In which direction was the flight?	westward	

Checklist 2: Establishing the link between fatigue and the unsafe act(s)/decision(s)

Performance Indicators	Investigator's Notes
Attention	
Overlooked sequential task element	
Incorrectly ordered sequential task element	
Preoccupied with single tasks or elements	
Exhibited lack of awareness of poor performance	
Reverted to old habits	
Focused on a minor problem despite risk of major one	
Did not appreciate gravity of situation	
Did not anticipate danger	
Displayed decreased vigilance	
Did not observe warning signs	
Memory	
Forgot a task or elements of a task	
Forgot the sequence of task or task elements	
Inaccurately recalled operational events	
Alertness	
Succumbed to uncontrollable sleep in form of microsleep, nap, or long sleep episode	
Displayed automatic behavior syndrome	
Reaction Time	
Responded slowly to normal, abnormal or emergency stimuli	
Failed to respond altogether to normal, abnormal or emergency stimuli	
Problem-Solving Ability	
Displayed flawed logic	
Displayed problems with arithmetic, geometric or other cognitive processing tasks	
Applied inappropriate corrective action	
Did not accurately interpret situation	
Displayed poor judgment of distance, speed, and/or time	

Continued over page…

Checklist 2: Establishing the link between fatigue and the unsafe act(s)/decision(s) (continued)

Performance Indicators	Investigator's Notes
Mood	
Was less conversant than normal	
Did not perform low-demand tasks	
Was irritable	
Distracted by discomfort	
Attitude	
Displayed a willingness to take risks	
Ignored normal checks or procedures	
Displayed a 'don't care' attitude	
Physiological Effects	
Exhibited speech effects	
Exhibited reduced manual dexterity - key-punch entry errors, switch selection	

APPENDIX J. RECOMMENDED FATIGUE TRAINING TOPICS

Table J-1. Some recommended fatigue management-related topics for inclusion in training programmes when using a prescriptive approach and when using an FRMS to manage fatigue

<table>
<tr><th>Prescriptive Approach</th><th>FRMS</th></tr>
<tr><td colspan="2">Target Group: Individual operational personnel</td></tr>
<tr><td>
• The scientific principles that underpin fatigue management.
• Individual responsibilities and those of the service provider, for managing fatigue.
• Causes and consequences of fatigue in the operation(s) in which they work.
• How to identify fatigue in themselves and others.
• How to use fatigue reporting systems, including how to report that they are too fatigued to undertake safety-critical duties.
• Personal strategies that they can use to improve their sleep at home and to minimize their own fatigue risk, and that of others, while they are on duty.
• Sleep disorders and their treatment, where to seek help if needed, and any requirements relating to fitness for duty.
• The operational impact of changing hours of work, both internally and externally (e.g. noise abatement, disruption of those sleeping on base, air traffic control services, meteorological services, dispatch services, etc.)
</td><td>
• An overview of the FRMS structure and how it works in the service provider's organization, including the concepts of shared responsibility and encouraging effective reporting.
• Their responsibilities and those of the service provider, in the FRMS.
• The scientific principles that underpin FRMS.
• Causes and consequences of fatigue in the operation(s) in which they work.
• FRM processes in which they play a vital role, particularly in the use of fatigue reporting systems and implementing mitigations.
• The importance of accurate fatigue data (both subjective and objective).
• How to identify fatigue in themselves and others.
• Personal strategies that they can use to improve their sleep at home and to minimize their own fatigue risk, and that of others, while they are on duty.
• Sleep disorders and their treatment, where to seek help if needed, and any requirements relating to fitness for duty.
• The operational impact of changing hours of work, both internally and externally (e.g. noise abatement, disruption of those sleeping on base, air traffic control services, meteorological services, dispatch services, etc.)
</td></tr>
<tr><td colspan="2">Target Group: Personnel involved in schedule (roster) design and management</td></tr>
<tr><td>
• The scientific principles that underpin fatigue management.
• How scheduling affects sleep opportunities and can disrupt the circadian biological clock cycle, the fatigue risk that this creates, and how it can be mitigated through scheduling.
• Use and limitations of any scheduling tools and bio-mathematical models or other algorithms that may be used to predict an individual's fatigue across a schedule/roster.
• How to identify fatigue in themselves and others.
• How fatigue reports are generated and analysed.
• Personal strategies that they can use to improve their sleep at home and to minimize their own fatigue risk, and that of others, while they are at work.
</td><td>
• An overview of the FRMS structure and how it works in the service provider's organization, including the concepts of shared responsibility and encouraging effective reporting.
• The scientific principles that underpin FRMS.
• How scheduling affects sleep opportunities and can disrupt the circadian biological clock cycle, the fatigue risk that this creates, and how it can be mitigated through scheduling.
• Use and limitations of any scheduling tools and bio-mathematical models or other algorithms that may be used to predict the levels of an individual's fatigue across rosters/schedules.
• Their role in the FRMS in relation to fatigue hazard identification and risk assessment.
• Processes and procedures for planned schedule changes, including:
  ○ assessing the potential fatigue impact of planned changes;
  ○ early engagement of the FSAG in the planning of changes with significant potential to increase fatigue risk; and
</td></tr>
</table>

Prescriptive Approach	FRMS
	○ implementing changes recommended by the FSAG. • How to identify fatigue in themselves and others. • Personal strategies that they can use to improve their sleep at home and to minimize their own fatigue risk, and that of others, while they are at work. • Basic information on sleep disorders and their treatment, and where to seek help if needed.
Target Group: Executive decision-makers and operational risk managers	
• The scientific principles that underpin fatigue management • An overall understanding of crew member or controller fatigue and the safety risk that it represents to the organization. • The responsibilities and accountabilities of different stakeholders in fatigue management, including themselves. • Linkages between fatigue management and other parts of the service provider's safety management system. • Regulatory requirements for fatigue management. • How to identify fatigue in themselves and others. • Personal strategies that they can use to improve their sleep at home and to minimize their own fatigue risk, and that of others, while they are at work. • Basic information on sleep disorders so they can make organizational decisions about how to manage affected individuals.	• An overall understanding of the scientific principles that underpin FRMS and the safety risk that fatigue represents to the organization. • An overview of the FRMS structure and how it works, including the concepts of shared responsibility and an effective reporting culture, and the role of the FSAG. • The responsibilities and accountabilities of different stakeholders in the FRMS, including themselves. • An overview of the types of fatigue mitigation strategies being used by the organization. • FRMS safety assurance metrics used by the organization. • Linkages between the FRMS and other parts of the service provider's safety management system. • Linkages between the FRMS and other parts of the organization, for example the scheduling department, operational sections, medical department, safety department, etc. • Regulatory requirements for the FRMS. • How to identify fatigue in themselves and others. • Personal strategies that they can use to improve their sleep at home and to minimize their own fatigue risk, and that of others, while they are at work. • Basic information on sleep disorders, their treatment, and where to seek help if needed, so they can make organizational decisions about how to manage affected individuals.
Target Group: FSAG members	
Not Applicable	• All FRMS components and elements. • The responsibilities and accountabilities of different stakeholders in the FRMS. • Linkages between the FRMS and other parts of the service provider's SMS. • Linkages between the FRMS and other parts of the organization, for example the scheduling department, flight operations, medical department, safety department, etc. • Regulatory requirements for the FRMS. • The scientific principles that underpin FRMS. • How to identify fatigue in themselves and others.

Prescriptive Approach	FRMS
	• Personal strategies that they can use to improve their sleep at home and to minimize their own fatigue risk, and that of others, while they are at work. • Basic information on sleep disorders and their treatment, and where to seek help if needed, so they can make organizational decisions about how to manage affected individuals.

APPENDIX K. EXAMPLE OF FRMS EVALUATION FORM

The following example of an FRMS evaluation form can be adapted for use by both the State and the service provider at different stages of FRMS implementation (i.e. for the gap analysis, assessment of the FRMS trial, and during continued oversight):

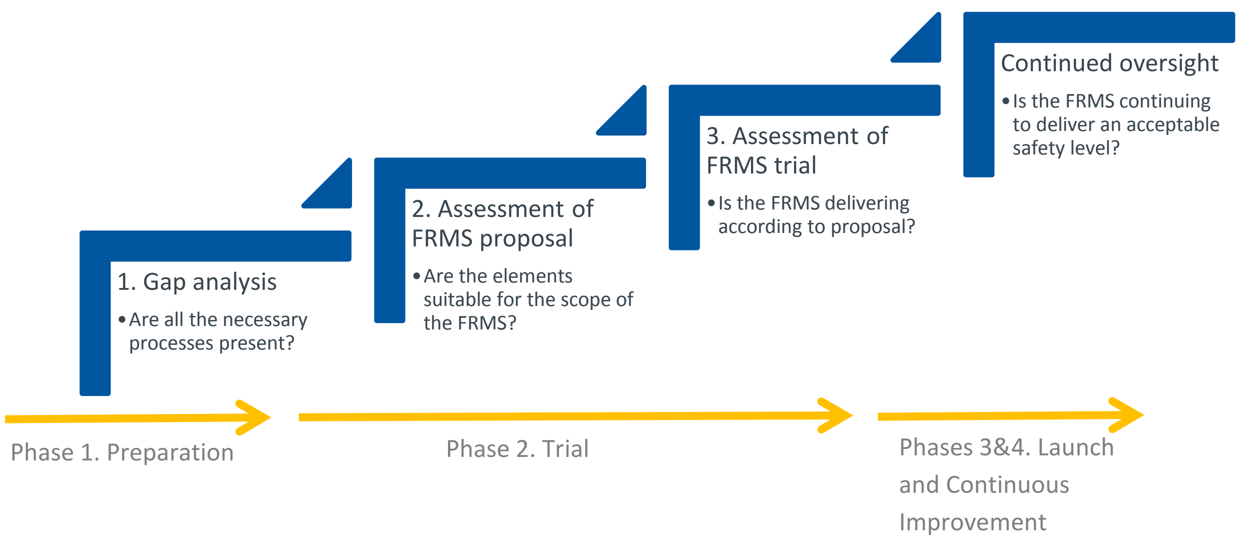

Figure K-1. Use of the FRMS evaluation form at different stages of the FRMS approval process

The example FRMS evaluation form is presented in two parts:

- Part 1 provides a summary evaluation that can be used to determine the presence of the key components of an FRMS (see Chapter 5). It provides a description of performance criteria for each of the key components, allowing evaluation of the service providers' development in each of the key component areas over time. "Excellence" markers are included to support ongoing oversight of the service provider. As the FRMS matures, the State should encourage service providers to move towards these markers as part of a performance based approach to continuous improvement.
- Part 2 builds on Part 1 by identifying a series of elements within each of the FRMS components to be evaluated for effectiveness and ongoing development.

The key components and elements identified in the following example FRMS evaluation form constitute the features of an FRMS.

K1. PART 1

FRMS Component	Initiating	Present and suitable	Operating	Effective	Excellence
The FRMS as a whole	The FRMS is still at the implementation stage.	Achieved a successful regulatory milestone 2 assessment.	The systems and processes of the FRMS are operating.	The FRMS is working in an effective way and is striving for continuous improvement.	The organization is an industry leader and embraces and shares its best practice.
FRMS Policy and Document-ation	The FRMS is still at the implementation stage.	Achieved a successful regulatory milestone two phase 1 assessment.	There is a safety policy in place and Senior Management are committed to making the FRMS work and is providing appropriate resources to safety management.	Senior Management are clearly involved in the FRMS and the FRMS Policy sets out the organization's intent to manage safety and is clearly evident in the day-to-day operations.	The organization is an industry leader and embraces best practice.
Fatigue Risk Assessment	The FRMS is still at the implementation stage.	Achieved a successful regulatory milestone 2 assessment.	The hazard and risk registers are being built up and risks are starting to be managed in proactive manner.	The organization is continuously identifying hazards and understands it biggest risks and is actively managing them and this can be seen in their safety performance. Fatigue Safety Risk management is proactive and predictive.	Key personnel throughout the organization are aware and understand the risks relative to their responsibilities and are continuously searching out new hazards and risks and re-evaluating existing risks.
FRMS Assurance	The FRMS is still at the implementation stage	Achieved a successful regulatory milestone 2 assessment	The Organization has established SPIs that it is monitoring and is auditing and assessing its FRMS and its outputs	The organization assures itself that is has an effective FRMS and is managing its risk through audit, assessment and monitoring of its fatigue safety performance.	The organization is continuously assessing its approach to FRMS, is continuously improving its performance and seeking out and embracing best practice
FRMS Promotion	The FRMS is still at the implementation stage	Achieved a successful regulatory milestone 2 assessment	The organization has trained its people and has several mediums for fatigue awareness and countermeasures promotion that it uses for passing on fatigue safety information	The organization puts considerable resources and effort into training its people and publicizing its safety culture and other safety information and monitors the effectiveness of its fatigue safety promotion	In addition the organization provides training and safety promotion to its non-operational stakeholders and actively researches fatigue risk awareness and training from other industries demonstrating continual learning.

K2. PART 2

Part 2 of the example FRMS evaluation form, which details the elements within each of the key components uses two types of markers to allow evaluation of an FRMS as it matures:

- performance and compliance markers; and
- excellence and best practice markers.

K2.1. PERFORMANCE AND COMPLIANCE MARKERS

Performance and compliance markers identify a series of elements within each of the FRMS components. These markers are evaluated according to the following criteria, to allow assessment of compliance and their effectiveness:

P ***Present*.** There is evidence that the "marker" is clearly visible and is documented within the organization's FRMS documentation.

S ***Suitable*.** The marker is not unsuitable based on the size, nature, complexity and the inherent risk in the activity that would also consider the industry sector.

O ***Operating***. There is evidence that the marker is in use and an output is being produced.

E ***Effective*.** There is evidence that the element or component is effectively achieving the desired outcome

Different criteria are more relevant at different stages of FRMS implementation:

- The P and S criteria can be used to carry out a gap analysis. These criteria simply identify existence and appropriateness of the identified markers, but do not evaluate output.
- The O and E criteria are useful for evaluation throughout the FRMS trial, at final approval and for continued oversight purposes. As the service provider moves to final approval there needs to be evidence that the markers in use are producing an output (i.e. more and more compliance and performance markers are evaluated as "O"). This may be sufficient to issue an FRMS approval. However, for continued use of the FRMS the service provider needs to be able to demonstrate that the compliance and performance markers being used are effective and can demonstrate through their outputs that fatigue risks are being actively managed (i.e. more and more compliance and performance markers are evaluated as "E"). Using the O & E elements of the evaluation form for ongoing oversight provides the regulator with a method to ensure the FRMS continues to be effective.

K2.2. EXCELLENCE AND BEST PRACTICE MARKERS

Excellence and best practice markers provide a description of elements that are considered to be excellent or best practice. They are not evaluated according to criteria. Instead, evidence of their existence should be described. These markers are included to support ongoing oversight of the service provider, providing a method for the regulator to evaluate increasing maturity and to recognize a service provider striving for constant improvement of the FRMS, as should be the goal of any performance-based approach.

K2.3. PART 2 FORM SECTIONS

Part 2 of the FRMS evaluation form is separated into sections relating to the components of an FRMS:

1. FRMS policy and documents;
2. Fatigue risk assessment processes;
3. FRMS assurance processes; and
4. FRMS promotion processes.

These sections of the form are presented on the following pages.

1. FRMS POLICY AND DOCUMENTATION

1.1 MANAGEMENT COMMITMENT AND RESPONSIBILITY

The organization should define its FRMS policy in accordance with international and national requirements. ICAO SARPs also require that it be signed by the Accountable Manager of the organization. The FRMS policy should reflect organizational commitments regarding fatigue management, including a clear statement about the provision of the necessary resources for its implementation and be communicated, with visible endorsement, throughout the organization. The FRMS policy should include the fatigue reporting procedures and clearly indicate which types of behaviours are unacceptable and shall include the conditions under which disciplinary action would not apply. The FRMS policy should be periodically reviewed to ensure it remains relevant and appropriate to the organization.

EFFECTIVENESS is achieved when the organization has defined its FRMS policy that clearly states its intentions, objectives and philosophies and there is visible evidence of safety leadership and management "walking the talk" and demonstrating by example.

COMPLIANCE & PERFORMANCE MARKERS		P	S	O	E	How it is achieved	State Remarks
1.1.1	There is a FRMS policy that includes a commitment towards achieving the highest practical management of fatigue risk signed by the Accountable/Executive Manager						
1.1.2	FRMS practice reflects the published FRMS policy						
1.1.3	The Accountable/Executive Manager and the senior management team promote and demonstrate their commitment to the FRMS Policy						
1.1.4	The FRMS policy is communicated to all employees						
1.1.5	The FRMS policy includes a commitment to observe all applicable legal requirements, standards, FRM principles and appropriate resources.						
1.1.6	The FRMS policy actively encourages fatigue reporting						
1.1.7	The FRMS policy states the organization's intentions, management principles and commitment to continuous improvement in the FRMS.						
1.1.8	The FRMS policy is reviewed periodically to ensure it remains current.						
1.1.9	There is evidence of decision making, actions and behaviours that reflect a positive safety culture.						

EXCELLENCE AND BEST PRACTICE MARKERS		Evidence	State Remarks
1.1.10	Personnel at all levels are involved in the development and maintenance of the FRMS.		
1.1.11	FRMS policy principles are implemented and respected at all levels of the organization.		
1.1.12	FRMS is visible to all personnel and is reflected appropriately in key documentation and communication initiatives.		
1.1.13	FRMS policy objectives complement the organization's goals and mission statements		
1.1.14	The organization has an ongoing assessment process that verifies that personnel throughout the organization are familiar with and have understood the policy and its message.		

1.2 SAFETY ACCOUNTABILITIES

The organization must identify the accountable executive who, irrespective of other functions, has ultimate responsibility and accountability, on behalf of the organization, for the implementation and maintenance of the FRMS. The organization shall also identify the fatigue risk management accountabilities of all members of senior management, irrespective of other functions, as well as employees, with respect to the performance of the FRMS. FRMS responsibilities, accountabilities and authorities shall be documented and communicated throughout the organization.

EFFECTIVENESS is achieved when there are clear lines of accountability throughout the organization including an accountable person who has ultimate accountability for the FRMS and the Accountable Executive/Manager and management team fully understand the fatigue risks faced by the organization.

COMPLIANCE & PERFORMANCE MARKERS		P	S	O	E	How it is achieved	State Remarks
1.2.1	An Accountable Executive/Manager has been appointed with full responsibility and ultimate accountability for the FRMS to ensure it is properly implemented and performing effectively.						
1.2.2	The Accountable Executive/Manager ensures appropriate financial and human resources required for the proper implementation of an effective FRMS						
1.2.3	The Accountable Executive/Manager is fully aware of their FRMS roles and responsibilities in respect of the fatigue policy and processes and safety culture of the organization.						
1.2.4	FRMS accountabilities, authorities and responsibilities are defined throughout the organization.						
1.2.5	Staff at all levels are aware of and understand their FRMS accountabilities, authorities and responsibilities regarding all management processes, decisions and actions that could be affected by fatigue.						
1.2.6	Fatigue risk management is shared across the organization (and is not just the responsibility of the Safety Manager and his/her team)						
1.2.7	There is evidence of employee involvement and consultation in the development and maintenance of the FRMS.						

EXCELLENCE AND BEST PRACTICE MARKERS		Evidence	State Remarks
1.2.8	There is evidence that FRMS principles have penetrated all levels of the organization and the impact of fatigue on the operation is part of the daily operations considerations.		
1.2.9	FRMS accountabilities throughout the organization are clearly documented and acknowledged by the relevant individuals.		
1.2.10	There is evidence that senior management recognizes and acknowledges the importance of FRMS engagement from all levels of the organization.		

1.3 APPOINTMENT OF KEY PERSONNEL

The organization shall identify a manager to be the responsible individual and focal point for the implementation and maintenance of an effective FRMS. In addition the committee(s) that support(s) the Accountable Manager and the Safety Manager in delivering an effective FRMS should be defined and documented.

EFFECTIVENESS is achieved when the FRMS is facilitated by the responsible individual and there is a structure of key personnel from the various operational areas of the organization.

COMPLIANCE & PERFORMANCE MARKERS		P	S	O	E	How it is achieved	State Remarks
1.3.1	A competent person with the appropriate knowledge, skills and experience has been nominated to manage the operation of the FRMS.						
1.3.2	The person managing the operation of the FRMS fulfils the required job functions and responsibilities.						
1.3.3	There is an appropriate reporting line between the FRMS manager and the Accountable Executive/Manager.						
1.3.4	The organization has allocated sufficient resources to manage the FRMS including manpower for the investigation, analysis, auditing and promotion of fatigue issues.						
1.3.5	Key staff are trained and kept current in keeping with their roles and responsibilities						
1.3.6	The organization has established a structured fatigue safety action group or committee, appropriate for the size and complexity of the organization, consisting of a full range of senior management representatives.						
1.3.7	The fatigue safety action group / committee includes all stakeholders and other experts as required.						

EXCELLENCE AND BEST PRACTICE MARKERS		Evidence	State Remarks
1.3.8	Where the FRMS is integrated into the SMS, the Safety Review Board or its equivalent monitors the FRMS performance of the operations and the effectiveness of the FRMS and is normally chaired by the accountable executive.		
1.3.9	The fatigue safety action group / committees are focused on fatigue risk management issues and all attendees fully participate.		

1.4 FRMS DOCUMENTATION

The organization shall develop and maintain FRMS documentation describing the policy and objectives, the FRMS requirements, processes and procedures, the accountabilities, responsibilities and authorities for processes and procedures, and the FRMS outputs. The organization shall develop and maintain a Fatigue Risk Management System manual to communicate its approach to the management of safety throughout the organization, or shall incorporate the FRMS documentation into its existing organization documentation.

EFFECTIVENESS is achieved when the organization has FRMS documentation that describes their approach to the management of fatigue that is used throughout the organization and is regularly reviewed and updated.

COMPLIANCE + PERFORMANCE MARKERS		P	S	O	E	How it is achieved	State Remarks
1.4.1	There is documentation that describes the FRMS and the interrelationships between all of its elements.						
1.4.2	FRMS documentation is regularly reviewed and updated with appropriate version control in place						
1.4.3	FRMS documentation is readily available to all personnel						
1.4.4	The FRMS documentation details and references the means for the storage of all relevant data.						

EXCELLENCE AND BEST PRACTICE MARKERS		Evidence	State Remarks
1.4.5	FRMS documentation is appropriately referenced or reflected in existing organizational manuals		
1.4.6	The company has analyzed and uses the most appropriate medium for the delivery of documentation at both the corporate and operational levels.		

2. FATIGUE RISK ASSESSMENT

2.1 FATIGUE RISK IDENTIFICATION

The organization shall develop and maintain a formal process that ensures that fatigue risks are identified. This should include the investigation of reportable incidents and accidents, even where fatigue was not primarily cited to identify potential fatigue risks. Fatigue risk identification shall be based on a combination of reactive, proactive and predictive methods of data collection as identified in the FRMS manual.

EFFECTIVENESS is achieved when fatigue risks are being identified and reported throughout the organization. Fatigue risks are captured in a risk register and assessed in a systematic and timely manner.

COMPLIANCE & PERFORMANCE MARKERS		P	S	O	E	How it is achieved	State Remarks
2.1.1	The organization has a fatigue reporting system to captures errors, hazards and near misses that is – practical and accessible to all staff.						
2.1.2	The organization has proactively identified all the major fatigue risks and assessed them in relation to its current activities and operational context.						
2.1.3	The fatigue reporting system provides appropriate feedback to the reporter and the rest of the organization						
2.1.4	Fatigue investigations are carried out to identify underlying causes and potential level of risk.						
2.1.5	Fatigue reports are acted on in a timely manner.						
2.1.6	Fatigue risk identification is an ongoing process and involves all key personnel and appropriate stakeholders.						
2.1.7	Personnel responsible for investigating reports are trained in investigation techniques.						
2.1.8	Investigations establish causal/contributing factors (why it happened, not just what happened)						
2.1.9	Personnel are aware of the organizations reporting policy and process.						

Continued over page…

	EXCELLENCE AND BEST PRACTICE MARKERS	Evidence	State Remarks
2.1.10	There is an active fatigue reporting system with reporting levels appropriate to the operational circumstances and related metrics.		
2.1.11	Fatigue reports include the reporter's own errors and events that the reporter would not normally report (roster and personal non-roster actions that affected fatigue)		
2.1.12	The fatigue reporting system empowers personnel to propose preventative and corrective actions.		
2.1.13	Output from the fatigue reporting system is utilized throughout the organization		
2.1.14	There is a process in place to analyze fatigue reports and risk registers to look for trends and gain useable management information.		

2.2 FATIGUE RISK EVALUATION AND MITIGATION

The organization shall develop and maintain a formal process that ensures analysis, assessment and control of fatigue risks in operations to as low as reasonably practicable.

EFFECTIVENESS is achieved when there is a formal process that ensures analysis, assessment and control of the fatigue risks in operations to as low as reasonably practicable.

COMPLIANCE & PERFORMANCE MARKERS		P	S	O	E	How it is achieved	State Remarks
2.2.1	There is a structured process for the management of fatigue risk that includes the assessment of fatigue risk, that takes into consideration scientific knowledge and operational influences.						
2.2.2	There are criteria for evaluating the level of fatigue risk the organization is willing to accept.						
2.2.3	The organization has fatigue risk control strategies that include control, avoidance, acceptance, mitigation, elimination and where applicable a corrective action plan.					.	
2.2.4	Corrective actions resulting from the fatigue risk assessment, including timelines and allocation of responsibilities are documented.						
2.2.5	Fatigue risk management is routinely applied in decision-making processes.						
2.2.6	Effective and robust mitigations and controls are implemented.						
2.2.7	Fatigue risk assessments and ratings are appropriately justified against scientific principles and operational knowledge.						
2.2.8	Senior management have visibility of medium and high fatigue risks and their mitigation and controls.						

EXCELLENCE AND BEST PRACTICE MARKERS		Evidence	State Remarks
2.2.9	There is evidence that fatigue risks are being managed to as low as reasonably practical		
2.2.10	The organization uses its fatigue risk management results to develop best-practice guidelines.		
2.2.11	The fatigue risk management processes are reviewed and improved on a periodic basis		
2.2.12	The organization engages with the industry on FRMS matters to further flight safety.		

3. FRMS ASSURANCE

3.1 FRMS PERFORMANCE MONITORING AND MEASUREMENT

The organization shall develop and maintain the means to verify the safety performance of the FRMS and to validate the effectiveness of FRMS risk controls. The safety performance of the FRMS shall be verified in reference to the safety performance indicators and targets of the FRMS.

EFFECTIVENESS is achieved when the FRMS has developed a series of safety performance indicators that are appropriate to the type of operation. There is a means to measure and monitor trends and take appropriate action when necessary.

	COMPLIANCE & PERFORMANCE MARKERS	P	S	O	E	How it is achieved	State Remarks
3.1.1	Fatigue mitigation objectives have been established						
3.1.2	Safety performance indicators relevant to fatigue mitigation objectives have been defined, promulgated and are being monitored and analyzed for trends.						
3.1.3	The above safety performance indicators are linked to the organization's safety objectives.						
3.1.4	Fatigue risk mitigations and controls are being verified/audited to confirm they are working and effective.						
3.1.5	Audits are carried out that focus on the FRMS performance of the organization.						
3.1.6	Performance indicators to evaluate the impact of fatigue mitigations.						
3.1.7	FRMS safety objectives are specific, measurable, agreed to, relevant and time-based.						
3.1.8	Fatigue Risk Assurance and Compliance Monitoring activities feed back into the hazard identification process.						

	EXCELLENCE AND BEST PRACTICE MARKERS	Evidence	State Remarks
3.1.9	When establishing and reviewing fatigue risk objectives and performance indicators, the organization considers: hazards and risks; financial, operational and business requirements; view of interested parties.		

3.2 THE MANAGEMENT OF CHANGE AFFECTING FATIGUE RISK

The organization shall develop and maintain a formal process to identify changes within the organization and its operation, which may affect established fatigue management processes, to describe the arrangements to ensure safety performance before implementing changes, and to eliminate or modify fatigue risk controls that are no longer needed or effective due to changes in the operational environment.

EFFECTIVENESS is achieved when the organization uses the safety risk management system to proactively assess all major changes to the organization and its operations to ensure appropriate fatigue mitigation is maintained.

COMPLIANCE & PERFORMANCE MARKERS		P	S	O	E	How it is achieved	State Remarks
3.2.1	The organization has established a process and conducts formal fatigue hazard analysis/risk assessment for major operational changes, major organizational changes and changes in key personnel.						
3.2.2	Fatigue safety case/risk assessments consider the influences of all the associated task and contextual factors connected to the duty or flight (such as airport, frequency, experience, etc) as well as the physiological fatigue factors.						
3.2.3	The FSAG involved in the change management process					.	
3.2.4	During the change management process previous fatigue risk assessments and existing hazards are reviewed for any possible effects (positive and negative).						
3.2.5	All organizational and operational changes which could impact fatigue risk are subject to the change management process						

EXCELLENCE AND BEST PRACTICE MARKERS		Evidence	State Remarks
3.2.6	Validation of the fatigue-related safety performance after organizational and operational changes have taken place to assure assumptions remain valid and the change was effective		
3.2.7	Fatigue risk accountabilities, authorities and responsibilities are reviewed as part of the change.		

3.3 CONTINUOUS IMPROVEMENT OF THE FRMS

The organization shall develop and maintain a formal process to identify the causes of substandard performance of the FRMS, determine the implications of substandard performance of the FRMS, determine substandard performance in operations, and eliminate or mitigate such causes.

EFFECTIVENESS is achieved when the organization routinely monitors the FRMS performance to identify potential areas of improvement and the outcomes of this process lead to improvements to the FRMS.

COMPLIANCE & PERFORMANCE MARKERS		P	S	O	E	How it is achieved	State Remarks
3.3.1	The Safety Review Board or equivalent has the necessary authority to make decisions related to the improvement and effectiveness of the FRMS.						
3.3.2	The FRMS is reviewed for improvements in safety performance.						
3.3.3	There is evidence of continuous improvement of the FRMS						

EXCELLENCE AND BEST PRACTICE MARKERS		How it is achieved	State Remarks
3.3.4	Evidence of lessons learnt are incorporated into the FRMS policy and procedures.		
3.3.5	Best practice is sought and embraced.		

4. FRMS PROMOTION

4.1 TRAINING AND EDUCATION

All personnel are trained and competent to perform their FRMS related duties and the training programme is monitored for its effectiveness and updated.

EFFECTIVENESS is achieved when all personnel are trained and competent to perform their FRMS related duties and the training programme is monitored for its effectiveness and updated.

COMPLIANCE & PERFORMANCE MARKERS		P	S	O	E	Evidence	State Remarks
4.1.1	There is a documented process to identify FRM training requirements so that personnel are competent to perform their duties						
4.1.2	There is a process in place to measure the effectiveness of training and to take appropriate action to improve subsequent training.						
4.1.3	There is a process that evaluates the individual's competence and takes appropriate remedial action when necessary					.	
4.1.4	Training includes initial and recurrent training					.	
4.1.5	A training record is maintained for each employee trained					.	
4.1.6	An annual training plan is in place.						
4.1.7	Training exercises and methods for all employees are kept current to reflect new techniques, technologies, results of investigations, corrective actions and regulatory changes.						

EXCELLENCE AND BEST PRACTICE MARKERS		Evidence	State Remarks
4.1.8	Training includes human and organizational factors including non-technical skills with the intent of reducing fatigue induced human error		
4.1.9	A training needs analysis is carried out for all staff and is regularly reviewed.		
4.1.10	Employees have a mechanism to request additional training in relation to their role in FRMS		
4.1.11	Management recognizes and uses informal opportunities to instruct employees on fatigue management		

4.2 FRMS COMMUNICATION

The FRMS shall develop and maintain formal means for safety communication that ensures that all personnel are fully aware of the FRMS, conveys fatigue-related safety critical information, and explains why particular actions are taken and why FRMS procedures are introduced or changed.

EFFECTIVENESS is achieved when all relevant personnel are aware of the FRMS, fatigue-related safety critical information and their role in respect of fatigue management.

COMPLIANCE & PERFORMANCE MARKERS		P	S	O	E	How it is achieved	State Remarks
4.2.1	FRMS plans and strategies are communicated throughout the organization to relevant staff						
4.2.2	Significant fatigue-related events and investigation outcomes are communicated to relevant staff, including those in contracted organizations where appropriate.						
4.2.3	There is an FRMS communication strategy defining appropriate methods and media.						

EXCELLENCE AND BEST PRACTICE MARKERS		Evidence	State Remarks
4.2.4	Significant events and investigation outcomes from external sources are communicated to staff including contracted organizations where appropriate.		
4.2.5	The effectiveness of FRMS communication is routinely assessed and the strategy revised as required.		
4.2.6	Fatigue-related information is appropriately shared with other parties.		

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