CAD 372

FATIGUE MANAGEMENT FOR FLIGHT CREW MEMBERS

Guidance Document

In accordance with

(1) ICAO Document 9966 – Manual for the Oversight of Fatigue Management Approaches (2nd Edition, 2016); and

(2) Fatigue Management Guide for Airline Operators (2nd Edition, 2015) issued by IATA, ICAO & IFALPA

Issue 1

Civil Aviation Department
HONG KONG, CHINA

March 2018

INTENTIONALLY LEFT BLANK

FATIGUE MANAGEMENT FOR FLIGHT CREW MEMBERS

CONTENTS

INTENTIONALLY LEFT BLANK

1. GLOSSARY

*(**Remarks:** - Asterisk * denotes an ICAO definition*
- Readers shall always refer to the latest version of AN(HK)O 1995 and CAD371 if any of the following definitions is contradictory to the aforementioned documents)

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.

Bio-mathematical model.
A computer programme designed to predict crewmember fatigue levels, based on scientific understanding of the factors contributing to fatigue. All bio-mathematical models have limitations that need to be understood for their appropriate use in an FRMS. An optional tool (not a requirement) for predictive fatigue hazard identification (ICAO Annex 6, Part 1, Appendix 8, Section 2.1.)

Circadian body clock.
A neural pacemaker in the brain that monitors 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.

****Crewmember.***
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.

Day.
The period between local midnight at home base and the subsequent local midnight at home base.

****Duty.***
Any task that 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.

****Fatigue.***
A physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair a crew member's alertness and ability to safely operate an aircraft or perform safety related duties.

Fatigue Risk Management System (FRMS) training.
Competency-based training programmes designed to ensure that all stakeholders are competent to undertake their responsibilities in the FRMS.

Fatigue safety action group (FSAG).
A group comprised of representatives of all stakeholder groups (management, scheduling, crew representatives) together with specialist scientific, data analysis, and medical expertise as required), that is responsible for coordinating all fatigue management activities in the organization.

Fatigue risk management (FRM).
The management of fatigue in a manner appropriate to the level of risk exposure and the nature of the operation, in order to minimize the adverse effects of fatigue on the safety of operations.

Fatigue risk management system policy.
A required component of an FRMS (ICAO Annex 6, Part 1, Appendix 8, Section 1.1). THE FRMS Policy must: identify the elements of the FRMS and its scope; reflect the shared responsibility of all stakeholders in the FRMS; state the safety objectives of the FRMS; be signed by the accountable executive of the organization; be communicated throughout the organization; declares management commitment to effective safety reporting, to providing adequate resourcing for the FRMS, and to continuous improvement of the FRMS; identify clear lines of accountability for the functioning of the FRMS; and require periodic reviews of the FRMS.

****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.

Fatigue safety assurance.
FRMS safety assurance processes monitor the entire FRMS to check that it is functioning as intended and meeting the safety objectives in the FRMS policy and regulatory requirements. FRMS safety assurance processes also identify operational and organizational changes that could potentially affect the FRMS, and identify areas where the safety performance of the FRMS could be improved (continuous improvement).

****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 and the engines are shut down at the end of the last flight on which he/she is a crew member.

****Flight time.***
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.

Home Base.
The location, assigned by the Air Operator's Certificate (AOC) holder to the Flight Crew Member (FCM), from where the FCM normally starts and ends a duty period or a series of duty periods.

Homeostatic sleep pressure. See ***Sleep homeostatic process.***

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. 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. Resolves when sufficient time is spent in the new time zone for the circadian body clock to become fully adapted to local time.

Nap.
A brief period of sleep, usually defined as less than half of a full night time sleep period. Naps as short as 5 minutes have been shown to provide (temporary) relief from the cumulative effects of sleep loss.

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 slowdown 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 4 stages, based on the characteristics of the brainwaves. Stages 1 and 2 represent lighter sleep. Stages 3 and 4 represent deeper sleep and are 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.

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 woken 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). Recovery sleep may be slightly longer than usual, but lost sleep is not recovered hour-for-hour. Two nights of unrestricted sleep (when a crewmember is fully adapted to the local time zone) are typically required for recovery of normal sleep structure (non-REM/REM cycles). Recent laboratory research suggests that recovery of optimal waking function may take more than two nights of recovery sleep.

****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/rostering.
Assignment of crewmembers to a schedule.

Safety management.
The systematic management of the operational risks associated with flight, engineering and ground activities in order to achieve as high a level of safety performance as is reasonably practicable.

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

Safety performance.
The level of safety achieved in a risk controlled environment measured against a safety level deemed as low as reasonably practicable**.**

Schedule.
Sequence of flights designed to meet operational requirements and effectively manage resources including crewmembers.

Shift work.
Any work pattern that requires a crewmember to be awake at a time in the circadian body clock cycle that they would normally be asleep. Problematic because the circadian body clock is sensitive to light and tends to remain 'locked on' to the day/night cycle rather than adapting to the work pattern. Shift work is usually associated with sleep restriction, together with a requirement to work during times in the circadian body clock cycle when performance and alertness are sub-optimal (for example, through the **window of circadian low**).

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. A complex series of processes characterized by alternation between two different brain states: ***non-REM sleep*** and ***REM sleep***.

Sleep disorders.
A range of problems that make it impossible to obtain restorative sleep, even when enough time is spent trying to sleep. More than 80 different sleep disorders have been identified, that can cause varying amounts of sleep disruption. 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 stages 3 and 4), that builds up across waking and discharges exponentially across sleep.

Sleep inertia.
Transient disorientation, grogginess and performance impairment that can occur as the brain progresses through the process of waking up. Sleep inertia can occur on waking from any stage of sleep but may be longer and more intense on waking from **slow-wave sleep** (non-REM stages 3 and 4), or after sleep periods or naps containing a high proportion of slow-wave sleep.

Sleep quality.
Capacity of sleep to restore waking function. Good quality sleep has minimal disruption to the non-REM/REM cycle. 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 ('trimming' sleep) across at least two consecutive nights. 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 two deepest stages of non-REM sleep (stages 3 and 4), characterized by high amplitude slow brainwaves (EEG dominated by 0.5-4 Hz).

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

Ultra long range operations (ULR).
An operation by a Two Crew Aircraft that includes a Sector with a Scheduled Sector Time greater than 16 hours, and where four pilots are boarded so that in flight Relief can be provided.

Unrestricted sleep.
Sleep which is not restricted by duty demands. Sleep can begin when a crewmember feels sleepy, and does not have to be delayed because of duty demands. In addition, the crewmember can wake up spontaneously and does not have to set the alarm to be up in time for duty.

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 03:00-05:00 when a person is fully adapted to the local time zone. However, there is individual variability in the exact timing of the WOCL, which is earlier in morning-types (larks) and later in evening-types (owls), and may move a few hours later after consecutive night shifts. In CAD 371(2nd edition), WOCL is defined as the period 0200-0559 individual body clock time.

2. ACRONYMS

AOC	Air Operator's Certificate
FDP	Flight Duty Period
FRMS	Fatigue Risk Management System
FTL	Flight and Duty Time Limits
HKCAD	Hong Kong Civil Aviation Department
ICAO	International Civil Aviation Organization
ODP	Off-Duty Period
REM	Rapid Eye Movement
SMS	Safety Management System
WOCL	Window of Circadian Low

3. INTRODUCTION

3.1 With the increasing demand of the international air travel, it imposes a challenge to the aviation industry in Hong Kong to cope with the demands and to ensure the flight safety. Fatigue is one of the topics catches the regulator and the stakeholders' attention.

3.2 In November 2011, the International Civil Aviation Organisation (ICAO) released an amendment Annex 6 *Operation of Aircraft*, Part 1, Section 4 Flight Operations and Appendix 8 FRMS Requirements. The amendment introduced a science-based approach to flight and duty time limitations (FTLs) and provided a framework to regulators to facilitate regulations to oversee FRMS.

3.3 The traditional regulatory approach to manage crewmember fatigue has been to prescribe limits on maximum flight and duty hours, and required minimum breaks within and between duty periods. It is a one-size-fits-all approach that does not take into account operational differences. FRMS is an enhancement to FTLs, enabling an operator to customize FTLs to better manage fatigue risk to the operation. There is scientific and operational support that FRMS will become a means for effectively mitigating fatigue risks.

3.4 ICAO defines an FRMS as 'A data-driven means of continuously monitoring and managing fatigue-related safety risks, based on scientific principles and knowledge as well as operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness.' (ICAO, 2011)

3.5 FRMS, by applying the Safety Management System (SMS) principles of risk identification, assessment, mitigation and monitoring, provides a performance-based approach to manage fatigue risk. Like SMS, FRMS seeks to achieve a realistic balance between safety, productivity and costs. Both SMS and FRMS rely on the concept of an "effective safety reporting culture", where personnel have been trained and are constantly encouraged to report hazards whenever observed in the operation environment.

3.6 FTL is simple and easy to follow for different sizes of air companies. It forms the basis of the prescriptive approach in managing the fatigue. With better understanding of the importance of adequate sleep and human beings daily rhythms in the ability to perform mental and physical tasks, FRMS approach is therefore proposed to supplement the FTL and to provide a "tailor-made" measure to mitigate crewmember fatigues.

4. LEGAL BACKGROUND

4.1 Part VI of the Air Navigation (Hong Kong) Order 1995 comprises Articles 53 to 56 and addresses the Fatigue of Crew. Operators and crew members are expected to be aware of the provisions of this legislation and their responsibilities in accordance with these Articles.

4.2 In general terms the legislation is applicable to the operator and crew of an aircraft registered in Hong Kong which is either:

4.2.1 Engaged on a flight for the purpose of public transport; or

4.2.2 Operated by an air transport undertaking.

4.3 In fact, a key feature of FRMS is that responsibility for managing fatigue risk is shared between operators and individual crewmembers and that the AOC holder is managing their fatigue related risks to achieve an acceptable level of safety performance.

4.3.1 The AOC holder 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 (such as AOC's managers, rostering staff, crew controllers, etc.) on how the organization's fatigue management approach works and how individuals can better manage their own fatigue.

4.3.2 Individuals are responsible for:

- making optimum use of non-work periods to get adequate sleep;
- coming to work fit for duty;
- managing their own fatigue levels;
- reporting fatigue issues; and
- responsible use of individual authority (e.g. pilot in command discretion).

4.4 The contents of this booklet are mainly for flight crew members. However, AOC holders are encouraged to establish a FRMS, based on the information provided by this document, for cabin crew members as well. With the information provided in this guidance booklet, the AOC holders should develop a programme according to their needs.

5. SLEEP SCIENCE

5.1 Sleep is not a tradable commodity. Adequate sleep is the only way to combat sleep deprivation. Currently technology could differentiate two types of sleep, Rapid Eye Movement (REM) and Non-Repaid Eye Movement (Non-REM) Sleep.

5.2 Non-REM Sleep

Compared to the waking brain activity, non-REM sleep involves gradual slowing of the brainwaves. Heart rate and breathing tend to be slow and regular. It could be divided into 4 stages:

5.2.1 Stages 1 and 2 represent lighter sleep. It is usual to enter sleep through Stage 1 and then Stage 2.

5.2.2 Stages 3 and 4 represent deeper sleep. In these stages, the person is in deep sleep and the brain waves showed typical "slow-wave" pattern.

5.3 Slow wave sleep is essential for the consolidation memory, and is therefore necessary for learning. Pressure for slow-wave sleep builds up across waking period, which is known as homeostatic sleep pressure and discharges across sleep. When someone is woken up abruptly from this phase, the brain will have difficulty transitioning out of it. This is known as sleep inertia – feeling of grogginess and disorientation, with impaired short-term memory and decision-making.

5.4 REM Sleep

In this phase of sleep, the eyes move around under the closed eyelids and this is often accompanied by muscle twitches and irregular heart rate and breathing. People woken 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". REM sleep is sometimes described as 'a highly activated brain in a paralysed body'. Most adults normally spend about a quarter of their sleep time in REM sleep.

5.5 Non-REM/REM Cycles

For a typical night of sleep, non-REM sleep and REM sleep alternate in a cycle that lasts about 90 minutes. Sleep is entered through Stage 1 non-REM and then progresses deeper and deeper into non-REM. About 80-90 minutes into sleep, there is a shift out of slow-wave sleep (non-REM stage 3 and 4). After a fairly short period of REM, the sleeper progresses back down again through lighter non-REM sleep and into slow-wave sleep, and so the cycle repeats.

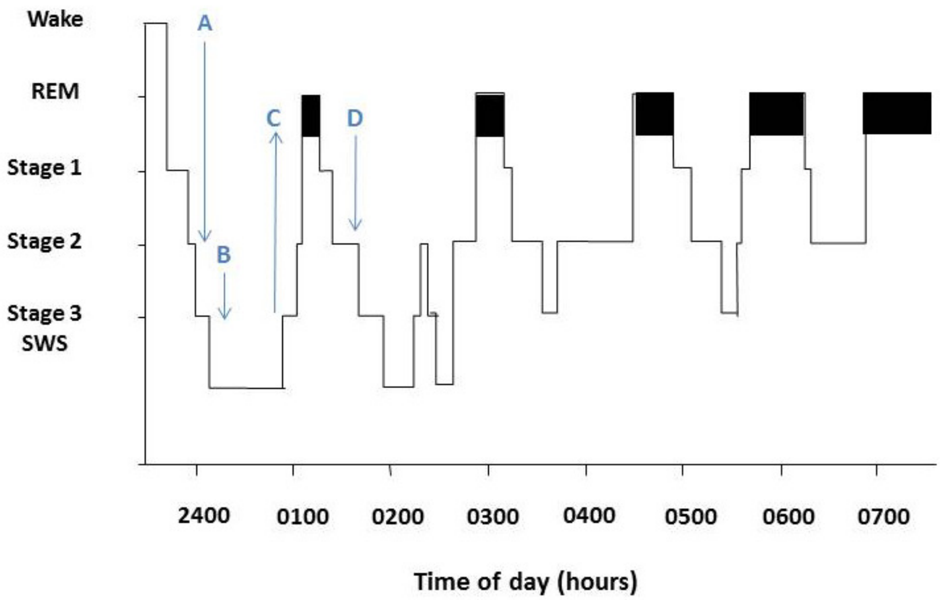

Fig. 1 The Non-REM/REM cycle across the night for a healthy young adult (adopted from ICAO Doc 9966 (2016 edition) page 2-4)

5.6 It is noted that slow-wave sleep always predominates at the beginning of a sleep period, regardless of when sleep occurs in the day/night cycle. On the other hand, the time from sleep onset to the first bout of REM and the duration of each REM bout varies markedly across the circadian body clock cycle. The bio-mathematical models are using parameters from the homeostatic sleep pressure and the circadian body clock cycle in predicting crewmember fatigue levels.

5.7 Sleep Quality

It is depends on going through unbroken 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 the crewmember feels and functions next day. Because uninterrupted non-REM/REM cycles are the key to good quality sleep, AOC holders should develop procedures that minimize interruptions to crewmembers' sleep.

5.8 Inflight Sleep

Crewmembers' sleep in onboard crew rest facilities is lighter and more fragmented than sleep on the ground. Nevertheless, there is good evidence that in-flight sleep improves subsequent alertness and reaction speed. Despite of this, it could not be used as a replacement of the uninterrupted rest period.

5.9 Consequences of Not Getting Enough Sleep

The amount of sleep is very important for restoring waking function. The effects of restricting sleep night after night accumulate, so that people become progressively less alert and less functional day after day. We called this sleep debt.

5.10 In case of chronic sleep restriction, it may have effects on the brain that affect alertness and performance days to weeks later. Full recovery of waking function after sleep restriction can take longer than two nights of recovery sleep. Because the effects of sleep restriction are cumulative, schedules must be designed to allow periodic opportunities for recovery. (The usual recommendation for a recovery opportunity is for a minimum of two consecutive nights of unrestricted sleep.)

6. CIRCADIAN RHYTHM

6.1 Human beings have been working at day time and resting at night since ancient times. The human circadian clock is therefore evolved to be light sensitive, and enables it to stay in step with the day/night cycle.

6.2 A lot of physiological activities are running in cycles or rhythms, such as the core body temperature or self-rated fatigue, are driven by the circadian body clock.

6.3 The interaction between the homeostatic pressure for sleep and the circadian variation in sleepiness driven by the body clock results in two times of peak sleepiness in 24 hour:

6.3.1 A peak in the early hours of the morning – the so-called window of circadian low (WOCL), which occurs around 3:00-5:00 am for most people, and

6.3.2 A peak in the early afternoon – sometimes called the afternoon nap window (around 3:00-5:00 pm for most people). Restricted sleep at night, or disturbed sleep makes it harder to stay awake during the next afternoon nap window.

6.4 The precise timing of the two peaks in sleepiness is different in people who are morning types (larks – whose circadian rhythms and preferred sleep times are earlier than average) and evening types (owls – whose circadian rhythms and preferred sleep times are later than average).

6.5 The WOCL can occur in flight during domestic night operations and during long haul and ULR operations when the duty/rest cycle is out of step with crewmembers' circadian body clock cycles. AOC holders should therefore pay much attention in adjusting the schedule and/or the number of crewmembers to mitigate the hazards arising out of such operations.

6.6 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 social time cues, the circadian body clock will eventually adapt to a new time zone. A number of factors would influence the rate of adaption to new time zone, they include:

6.6.1 The number of time zones crossed – adaptation generally takes longer when more time zones are crossed.

6.6.2 The direction of flight – adaptation is usually faster after westward flight than after eastward flight across the same number of time zones.

6.6.3 Adaption is faster when the circadian body clock is more exposed to the time cues that it needs to lock onto in the new time zone.

6.6.4 Beginning a trip with a sleep debt seems to increase the duration and severity of jet lag symptoms.

6.7 The situation for long haul and ULR flight crew is different to that for the passenger who plans to spend long enough at the destination to adapt fully to local time. Typically, layover in each destination last only 1-2 days, after which crewmembers are asked to operate a return flight or additional flights in the destination region, followed by return flight(s) to their city of origin. This seems that the circadian body clock does not have enough time to adapt to any of the destination time zones.

7. PRESCRIPTIVE APPROACH IN MANAGING FATIGUE

7.1 An operation that is managed within the prescriptive flight and duty time limits should meet the following requirements:

7.1.1 The Operations Manual must record the rules relating to flight time, flight duty period, duty period limitations, and rest requirements for crew members (ICAO Annex 6 Part 1, Appendix 2, Section 2.1.2). Within the applicable regulatory limits, an operator may use more stringent limits, such as those negotiated in industrial agreements or established to manage an identified fatigue-related risk.

7.1.2 The operator's SMS should include crew member fatigue as one of the hazards it manages. An appropriate level of information on fatigue management should be included in general safety training.

7.2 Fatigue management training

7.2.1 As part of their SMS, operators must have a safety training programme to ensure that staff are competent to perform their safety duties (ICAO Annex 19). Operators managing fatigue using a prescriptive approach are expected to provide basic fatigue management training as part of their SMS safety training. Training records need to be kept and recurrent training is also recommended. The interval between training sessions and the level of training provided needs to be related to the expected level of fatigue risk in the operations.

7.2.2 A special feature of fatigue management training is that key principles of fatigue science, i.e. managing sleep and understanding the effects of the circadian body clock, are relevant not only to people's roles in the fatigue management but also to their lives outside of work, for example in safe motor vehicle driving and in staying healthy. Thus fatigue management training covers issues that everyone can identify with personally, and this can help promote the concept of shared responsibility for fatigue management.

7.3 Identifying Fatigue Hazards

7.3.1 For operations that remain within the prescriptive flight and duty time limits, there are a number of sources of data already available to an operator that can be used to identify where fatigue might constitute a hazard. These all involve what ICAO calls 'reactive hazard identification', which means that fatigue is identified after it has occurred. The following are some recommended examples.

- Planned versus Actual Duties –
    - To provide evidence of compliance with prescriptive limits, operators are required to keep records of crew members' flight times, flight duty periods, duty periods, and rest periods for a period of time specified by their regulator (ICAO Annex 6 Part 1, Section 4.10.8).
    - Comparing data on planned versus actual work periods can be used to identify times when fatigue might have been higher than expected. These kinds of metrics point to possible mitigations if needed, for example changes to scheduled flight times or increasing the number of crew members at a given base. As part of routine SMS processes, the data need to be monitored regularly to evaluate whether the hazards identified warrant additional action.

- Fatigue Reporting

  Hazard reporting has an essential role in SMS. To encourage open and honest reporting of hazards, an operator must clearly distinguish between:

  - unintentional human errors, which are accepted as a normal part of human behaviour and are recognized and managed within the SMS; and

  - deliberate violations of rules and established procedures. An operator should have processes independent of the SMS to deal with intentional non-compliance.

  - To encourage ongoing commitment of personnel to reporting hazards, operators should take appropriate and timely action in response to hazard reports. In a mature safety reporting culture, the majority of safety reports from operational personnel relate to identified or perceived hazards, instead of errors or adverse events.

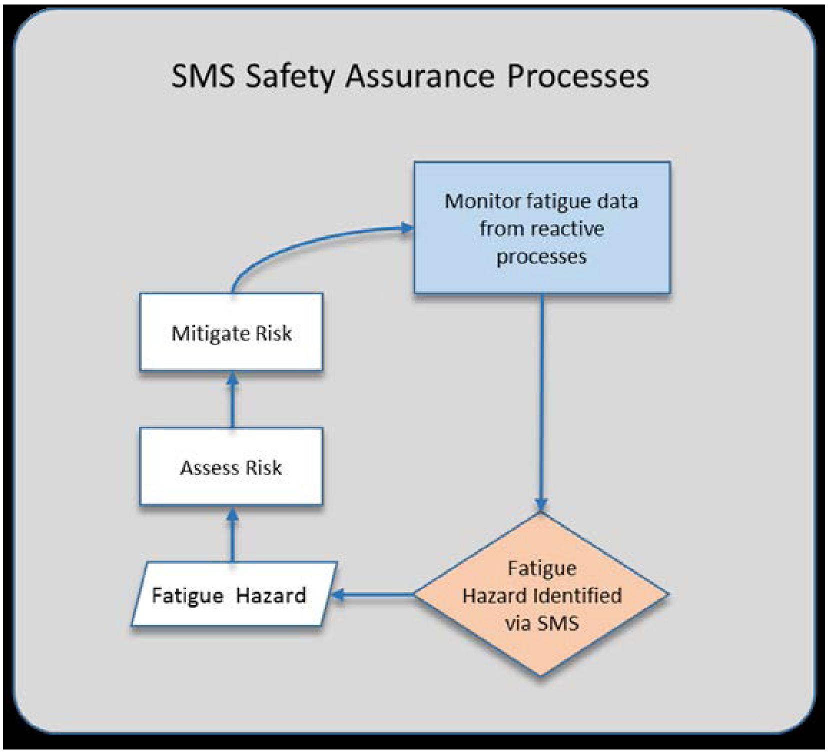

Fig. 2 - Showing the use of reactive processes for identifying fatigue hazards as part of an operator's SMS, for operations that comply with the prescriptive flight and duty time limits (Adopted from the ICAO Doc 9966 (2016 edition) page 4-15)

8. FRMS APPROACH

8.1 An FRMS is a specialized system that uses SMS principles and processes to manage the hazard of crew member fatigue. Consistent with SMS, FRMS seeks to achieve a realistic balance between safety, productivity, and costs. However, there are some important features of an FRMS approach that distinguish it from managing fatigue risks using an SMS within prescriptive limits only.

8.2 With a prescriptive approach, fatigue is one of the possible hazards that the SMS should consider. The AOC holder reacts when a fatigue hazard is identified. With FRMS, the AOC holder must additionally identify and assess potential fatigue risks prior to conducting operations under the FRMS as well as identifying and assessing actual fatigue risks proactively during operations.

Necessary Components of FRMS

8.3 An FRMS has 4 components, two of which are operationally focused and two which are organizationally focused: The FRM processes and the FRMS safety assurance processes make up the operational FRMS activities.

8.3.1	FRMS Policy and Documentation	(Organizational)
8.3.2	FRM Processes	(Operational)
8.3.3	FRMS Safety Assurance	(Operational)
8.3.4	FRMS Promotion Processes	(Organizational)

8.4 These operational activities are governed by the FRMS policy and documentation, which are supported by FRMS promotion processes (organizational activities). Documentation must be kept of all FRMS activities.

Fatigue Safety Action Group (FSAG)

8.5 Although not required by the ICAO Standards and Recommended Practices (SARPs), it is recommended that AOC holders establish a Fatigue Safety Action Group (FSAG) with responsibility for coordinating FRMS activities. Since fatigue management must be based on shared responsibility and requires an effective safety reporting culture, it is strongly 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 that it has appropriate access to scientific, statistical, and medical expertise.

8.6 The principle functions of the FSAG are to:

8.6.1 oversee the development of the FRMS;

8.6.2 assist in FRMS implementation;

8.6.3 oversee the ongoing operation of the FRM processes;

8.6.4 contribute as appropriate to the FRMS safety assurance processes;

8.6.5 maintain the FRMS documentation; and

8.6.6 be responsible for ongoing FRMS training and promotion.

8.7 The FSAG should operate under 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 AOC holders' SMS.

FRMS Policy and Documentation

8.8 The policy and documentation define organizational arrangements that support the core operational activities of the FRMS. Linkage between policy and documentation and other FRMS components are outlined below:

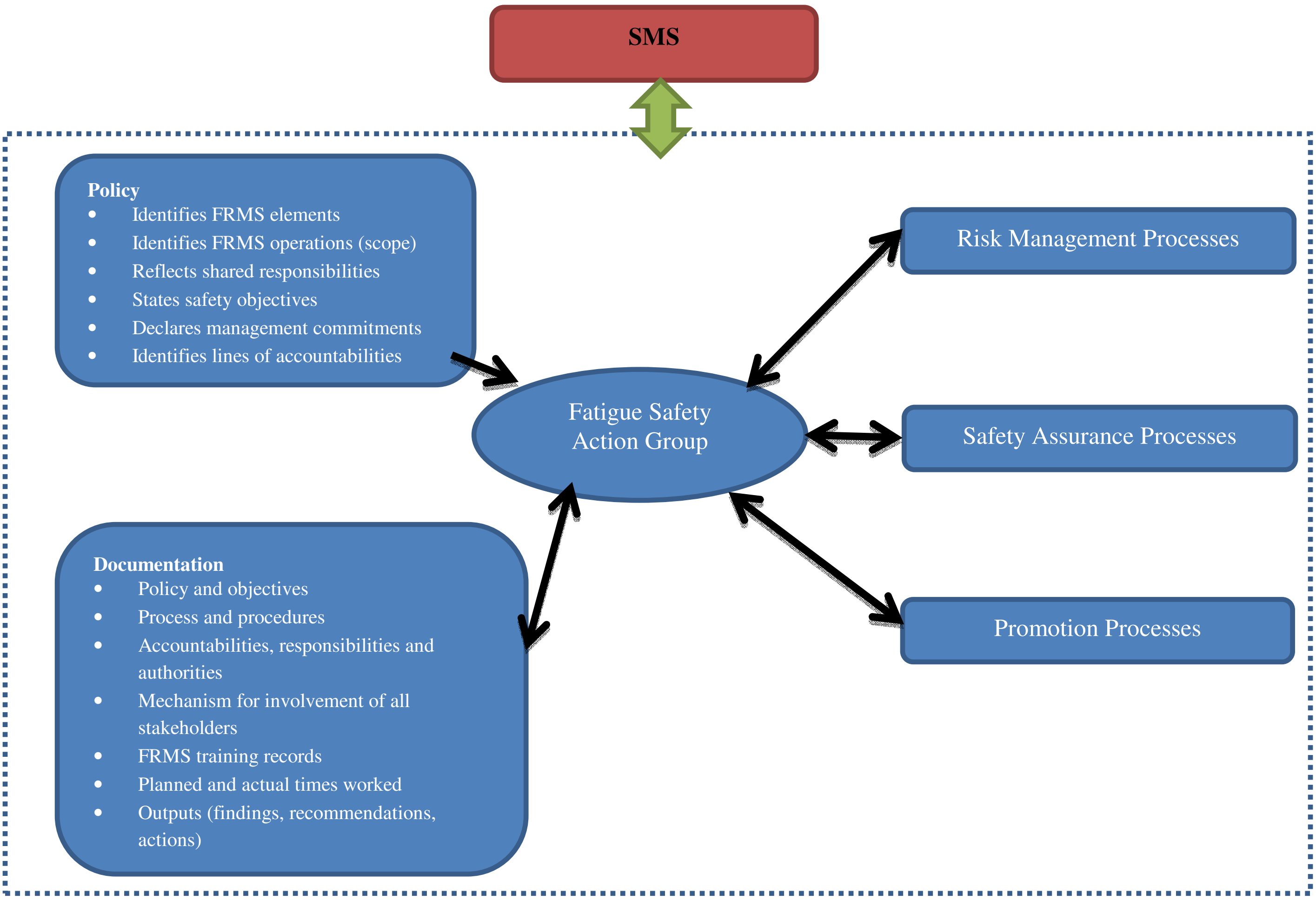

Figure 3 - Linkages between FRMS policy and documentation and other FRMS components
(Adopted from ICAO Doc 9966 (2011 edition), page 3-1)

8.9 The FRMS policy specifies the AOC holders' commitment and approach to the management of fatigue risk. The FRMS documentation describes the components and activities of the entire FRMS. It makes it possible for the effectiveness of the FRMS to be audited (internally and externally) to check whether it is meeting the safety objectives defined in the FRMS policy. (The ICAO requirements for FRMS policy and documentation are stipulated in Annex 6, Part I, Appendix 8)

<u>FRM processes</u>

8.10 FRM processes are data driven. 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, for example by a series of fatigue reports or a change in marketing strategy.

8.11 To be able to identify fatigue hazards, the FSAG needs to have a good understanding of the operational factors that are likely to cause crew member fatigue, which vary across different types of operations. Therefore, FRM processes require different sorts of data, including:

8.11.1 measures of the fatigue level of crewmembers; and

8.11.2 measures of operational performances.

(The ICAO requirements for FRM processes are stipulated in Annex 6, Part I, Appendix 8)

8.11.1 *Identify the operations covered*

The AOC holders should clearly identify which operations the FRMS pertains. It is because different types of flight operations can involve different causes of crewmember fatigue and may require different controls and strategies to mitigate the associated risks. Within its FRMS, an organization may need to develop multiple sets of different FRM processes for different operations.

8.11.2 *Gather data and information*

The FSAG gathers required data and information to be confident that they can identify the likely fatigue hazards in operations that are covered by the FRM processes.

8.11.3 Hazard Identification

ICAO Annex 6, Part I, Appendix 8 requires that an operator develop, maintain, and document three types of processes for fatigue hazard identification:

- Predictive processes
  - Shall identify fatigue hazards by examining crew scheduling and taking into account factors known to affect sleep, fatigue and their effects on performance. Methods may include but are not limited to:
    - Operator or industry operational experience and data collected on similar types of operations;
    - Evidence-based scheduling practices, and
    - Bio-mathematical models
- Proactive processes
  - Shall identify fatigue hazards within current flight operations. Methods may include but are not limited to:
    - Self-reporting of fatigue risks;
    - Crew fatigue survey;
    - Relevant flight and cabin crew performance data;
    - Available safety databases and scientific studies; and
    - Analysis of planned versus actual time worked
- Reactive processes
  - 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. It may be triggered by any of the following:
    - Fatigue reports;
    - Confidential reports;
    - Audit reports;
    - Incident reports; and

- Flight data analysis events

(Further details please refer to the Fatigue Management Guide for Airline Operator 2nd Edition)

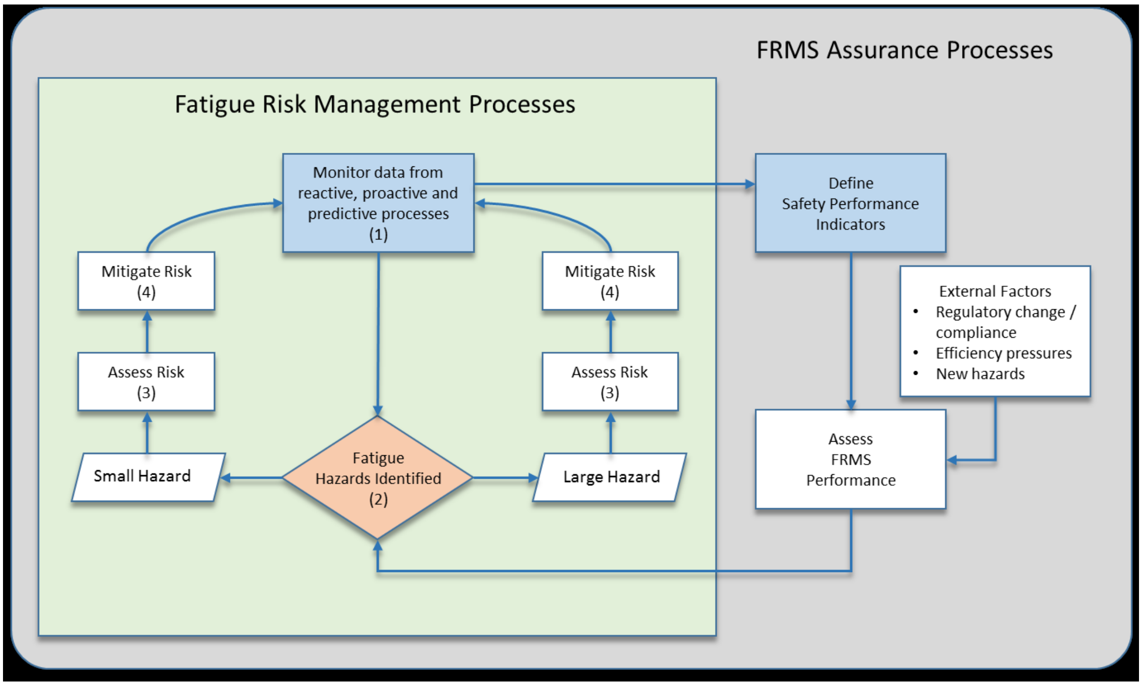

Figure 3 - Operational activities of an FRMS (Adopted from the Fatigue Management Guide for Airline Operator 2nd Edition 2nd Edition, page 48)

8.12 The FRM processes form a closed loop with:

8.12.1 ongoing monitoring of fatigue levels;

8.12.2 identification of situations where fatigue may constitute a hazard;

8.12.3 risk assessment; and

8.12.4 introduction of additional risk mitigations when needed.

8.12.5 The effectiveness of current mitigations is all captured in the ongoing monitoring of the fatigue data, so the FRM processes form a closed loop.

8.13 A range of data monitored in the FRM process loop is used to generate fatigue safety performance indicators (SPIs). These are used, along with data from sources outside the FRMS, in the FRMS Safety Assurance loop to check whether the FRMS is delivering an acceptable level of fatigue risk and safety. This must meet the standards set by ICAO Doc 9966 as well as the AOC holder's FRMS policy. The FRMS Safety Assurance loop also monitors external changes that could affect fatigue risk in the operations covered by the FRMS. It identifies emerging hazards and can make recommendations for mitigations and changes to the FRM processes, providing feedback that drives continuous improvement of the FRMS.

8.14 Risk Assessment and Mitigation

8.14.1 Once a fatigue hazard has been identified, the level of risk that it poses has to be assessed and a decision made about whether or not that risk needs to be mitigated. For AOC holders managing fatigue risk within prescribed limits through their SMS, existing SMS risk assessment methodologies may be sufficient.

8.14.2 It is noted that assessing fatigue risks using any methodology is limited. It is because we do not have a clear picture on the interactions that exist between fatigue factors should be weighted. All methods need to be used with full recognition of their limitations.

8.14.3 Where the AOC holder operates under FRMS, more effort on fatigue-specific risk assessment 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.

8.14.4 Careful selection of effective fatigue mitigations is based on data. Identifying suitable mitigations comes from sources such as scientific studies, relevant scientific literature and FRMS experience of the AOC holders.

8.14.5 Effective controls and mitigation strategies go beyond rest- and duty-times. 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.

8.14.6 Even though much effort has been put on to avoid fatigue, temporary flight crew tiredness may still happen in-flight. “Controlled Rest” is one of the effective countermeasures used in response to such unanticipated fatigue during operation (see Appendix 1). Once the flight crew opts to use “Controlled Rest” to combat unanticipated fatigue, it could lead to an investigation by FSAG for further improvement on crew complement, crew rest or crew rostering arrangements.

8.15 Risk Matrices to assess fatigue risks

8.15.1 Safety risk is always 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 to assess all types of risk and assist them to decide whether it is necessary to invest resources in mitigation. The main disadvantage of using matrices to assess risks is that controls and mitigations are not systematically taken into account.

Table 1- presents an example of severity classification categories from ICAO's Safety Management Manual (Doc. 9859, 2013, 3rd Edition). Table 2 - presents an associated risk assessment matrix.

Table 1 - Severity Classifications (from ICAO SMM, 3rd Edition)

Severity	Meaning	Value
Catastrophic	- Multiple deaths - Equipment destroyed	A
Hazardous	- A large reduction in safety margins, physical distress or a workload such that crew members or controllers 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 crew members or controllers 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	- Little consequences	E

Table 2-. Safety Risk Assessment Matrix (adapted from ICAO SMM, 3rd Edition)

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

(Adopted from the Fatigue Management Guide for Airline Operators 2nd Edition, page 63)

8.15.2 Particular attention has to be taken on assessing 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. (Further details may refer to the Fatigue Management Guide for Airline Operators (2nd Edition, 2015) issued by IATA, ICAO and IFALPA.)

FRMS Assurance Processes

8.16 FRMS safety assurance processes form the second closed loop of the operational activities of the FRMS (Figure 3), and monitor how well the entire FRMS is functioning. Using SPIs monitored in the FRM processes along with information and expertise from other sources, the FRMS Safety Assurance processes have three main functions (ICAO Annex 6, Part I, Appendix 7).

8.16.1 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.

8.16.2 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.

8.16.3 To provide ongoing feedback that drives continuous improvement of the FRM processes and other FRMS components.

8.17 Responsibility for FRMS safety assurance activities may be distributed differently, depending on the number and complexity of operations covered by the FRMS and the size of the operator. Typically, FRMS safety assurance processes would be the responsibility of the SMS team. Some of the FRMS safety assurance processes may be undertaken by the FSAG. However activities such as audits of the FRM processes should be undertaken by a different organizational unit.

8.17.1 *Monitoring FRMS Safety Performance*

- Performance of the FRMS should be examined through FRMS SPIs that are identified through a variety of different sources, including:
    - trends in SPIs from the FRM processes (see Section 5.2 of this document) and the operator's SMS;
    - hazard reporting and investigations;
    - audits and surveys; and
    - reviews and fatigue studies.

8.17.2 *Hazard Report and Identification*

- The FSAG should record all fatigue hazards identified in the FRM processes, together with any actions taken to mitigate those hazards, in the FRMS documentation. The fatigue hazard register should be regularly evaluated as part of the FRMS safety assurance processes.

- Trends in voluntary fatigue reports (by crew members or others) can also be monitored as indicators of the effectiveness of the FRMS. Safety events in which crew member fatigue has been identified as a contributing factor will be less common than fatigue reports. However, regular review of these events may also highlight areas where functioning of the FRMS could be improved.

8.17.3 *Audits*

- Audits periodically assess the effectiveness of the FRMS, focusing on the integrity of the FRM processes. They should address questions such as:

    - Are all departments addressing the recommendations of the FSAG?

    - Are crew members using mitigation strategies as recommended by the FSAG?

    - Is the FSAG maintaining the required documentation of its activities?

    - Are all SPIs maintaining acceptable values or being actively managed?

- Internal audits need to be conducted by a unit that is external to the FSAG. Trends in SPIs can provide valuable information in an FRMS safety assurance audit. These may include SPIs used by the FSAG in the FRM processes, as well as indicators that capture more global aspects of the safety performance of the FRMS, for example safety performance metrics within the operator's SMS.

8.17.4 *Review and Evaluation*

- The safety review evaluates the likely effects of the change on fatigue risk and the appropriateness and effectiveness of the FRM processes to manage those effects. The safety performance of the FRMS could be monitored through regular evaluation of the followings:

    - whether all SPIs are maintaining acceptable values or meeting targets, and/or are in the 'tolerable' or 'acceptable' region of risk assessments;

    - whether the FRMS is meeting the safety objectives defined in the FRMS policy; and

    - whether the FRMS is meeting all regulatory requirements, if any.

- When FRMS SPIs are not at an acceptable level, the controls and mitigations in use may need to be modified via the FRM processes. A review of relevant fatigue studies might provide new ideas. Reviews of compliance by crew members or other departments with the recommendations of the FSAG, or of the functioning of FSAG itself, may be needed to find out why the FRMS is not working as intended. It may also be appropriate to review the SPIs to ensure that they are still appropriate measures of the safety performance of the FRMS.

8.17.5 *FRMS is a dynamic process*

- The commercial aviation environment is very dynamic and changes are a normal part of flight operations. They may be driven by external factors (for example, new regulatory requirements, changing security requirements, or changes to air traffic control) or by internal factors (for example, management changes, new routes, aircraft, equipment, or procedures). Changes can introduce new fatigue hazards into an operation, which need to be managed. Changes may also reduce the effectiveness of controls and mitigations that have been implemented to manage existing fatigue hazards.

- The ICAO SARPs (Annex 6, Part I, Appendix 7 Part 3) require an operator to have formal processes for the management of change which must address, but are not limited to:

    - identification of changes in the operational environment that may affect FRMS;

    - identification of changes within the organization that may affect FRMS; and

    - consideration of available tools which could be used to maintain or improve FRMS performance prior to implementing changes.

- Changes in the operational environment may also necessitate changes in the FRMS itself. Examples include bringing new operations under the scope of the FRMS, collecting different types of data, adjustments to training programmes, etc. The FSAG would normally propose such changes and obtain approval for them from appropriate management. FRMS safety assurance monitoring will track the effects of these changes on the overall effectiveness of the FRMS.

8.17.6 Continued Improvement of FRMS

- Feedback from the FRMS safety assurance processes to the FSAG and the FRM processes provides a mechanism for continuous improvement of the FRMS The ICAO SARPs (Annex 6, Part I, Appendix 7 Section 3) require an operator to provide processes for the continuous improvement of the FRMS that must include, but are not limited to:

  - o the elimination and/or modification of risk controls that had unintended consequences or are no longer needed due to changes in the operational or organizational environment;

  - o routine evaluations of facilities, equipment, documentation and procedures; and

  - o the determination of the need to introduce new processes and procedures to mitigate emerging fatigue-related risks.

8.17.7 Identifying emerging fatigue hazards that are not the result of planned changes is also an important function of FRMS safety assurance processes, which take a broader system perspective than the FRM processes. Any newly identified fatigue hazard(s), or combination of existing hazards for which current controls are ineffective, should be referred back to the FSAG for evaluation and management using the FRM processes. Changes made to the FRMS should be documented by the FSAG so that they are available for internal and regulatory audit.

FRMS Implementation

8.18 Currently FRMS is not mandatory under ICAO. That said, HKCAD encourages the AOC holders to establish and maintain a FRMS so as to further mitigate crew's fatigue risk. For those AOC holders who decide to launch FRMS, they should follow the provisions in ICAO Doc 9966, Fatigue Management Guide for Airline Operators (2nd Edition, 2015) issued by IATA, ICAO and IFALPA, as well as this document.

- END -

Controlled rest on the flight deck is an effective fatigue mitigation for flight crews. It should not be used as a scheduling tool, but used in conjunction with other fatigue countermeasures, as needed, in response to unanticipated fatigue experienced during operations.

- Use of controlled rest on the flight deck should result in a fatigue report to enable the FSAG or Safety Management System process (as applicable) to evaluate whether existing mitigation strategies are adequate.

- It is only intended to be used during low workload phases of flight (e.g., during cruise flight) at times when it does not interfere with required operational duties.

- It should not be used as a method for extending crew duty periods.

- Procedures for controlled rest on the flight deck must be published and included in the fatigue training programme.

The following recommended procedures are based on a survey of major air carriers. They represent considerable experience in many regions of the world and include options reflecting variations between different types of operations.

Note: This is not intended to be an all-inclusive list, nor are all of these procedures necessarily required. Each operator should base on its own mode of operations to define appropriate procedures.

1) PLANNING

- Only one pilot may take controlled rest at a time in his/her seat. The harness should be used and the seat positioned to minimize unintentional interference with the controls.

- There should be a minimum of 20 minutes between two subsequent controlled rest periods in order to overcome the effects of sleep inertia and allow for adequate briefing.

- Controlled rest on the flight deck may be used at the discretion of the captain to manage both unexpected fatigue and to reduce the risk of fatigue during higher workload periods later in the flight.

- It should be clearly established who will take rest, and when it will be taken. If the captain requires it, the rest may be terminated at any time.

- The captain should define criteria for when his/her rest should be interrupted.

- Hand-over of duties and wake-up arrangements should be reviewed.

- Flight crews may only use controlled rest if they have completed the appropriate training.

- Some operators involve a third crew member (not necessarily a pilot) to monitor controlled flight deck rest. This may include a planned wake-up call, a visit to be scheduled just after the planned rest period ends, or a third crew member on the flight deck throughout controlled rest. In the absence of a third pilot the Cabin Crew (CC) must be briefed and predetermined call from the CC must be initiated.

- Controlled rest should only be planned during the cruise period from the top of climb to 30 minutes before the planned top of descent. This is to minimize the risk of sleep inertia, and allow sufficient time for operational briefings and increasing workload prior to commencing descent.

- A short period of time should be allowed for rest preparation. This should include an operational briefing, completion of tasks in progress, and attention to any physiological needs of either crew member.

- During controlled rest, the non-resting pilot shall perform the duties of the pilot flying and the pilot monitoring, and cannot leave his/her seat for any reason, including physiological breaks.

- A sufficient period of time should be allowed following the controlled rest to overcome the effects of sleep inertia and allow for adequate briefing.

- The planned rest period should be no longer than 40 minutes, to facilitate enhanced alertness but not detract from operations.

- Personal equipment (such as eye shades, neck supports, ear plugs, etc.) is permitted for the resting pilot.

2) RECOMMENDED RESTRICTIONS

- The autopilot and auto-thrust systems (if available) should be operational.

- One pilot shall be fully able to exercise control of the aircraft at all times and maintain situational awareness.

- Only one operating flight crew member may rest on the flight deck at a time.

- Both operating pilots should remain at their stations.