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INTERNATIONAL FEDERATION OF AIR TRAFFIC CONTROLLERS' ASSOCIATIONS

FATIGUE

A short guide to human fatigue and associated risk based management Systems for air traffic control

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GUIDANCE MATERIAL

IFATCA is the recognised international organisation representing air traffic controller associations. It is a non-political, not-for-profit, professional body that has been representing air traffic controllers for more than 50 years, and has more than 50,000 members in over 120 countries.

Frequently Asked Questions

What is fatigue?

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

What are some effects of fatigue?

- Tiredness
- Slow performance
- Hard to make decisions
- Grumpy
- Antisocial
- Distracted

How does it affect our work as a controller?

- Not seeing a conflict or important detail
- Slow scanning
- Forgetfulness
- Not hearing something around you (Phone, coordination)
- Ineffective/unclear coordination
- Poor decision making
- Unprofessional behaviour (shouting, aggression, etc.)

Does fatigue cause incidents?

Fatigue is increasingly recognised as a contributing factor in aviation safety occurences. As current and past events are reviewed retrospectively, it is also being recognised as a causal factor in many previous incidents.

Most of the current incident data available refers to flightcrew fatigue, however, as ANSPs recognise the importance, more data is becoming accessible. Many ANSPs do not release incident investigations or fatigue data, so it may be hard to source data within ATC.

Principles behind ICAO's Fatigue Resource Management Systems

ICAO Standards & Recommended Practices 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 managing fatigue hazards using the SMS processes that are in place for managing safety hazards in general ; and
2. **a performance-based approach** that requires the Service Provider to implement a Fatigue Risk Management System (FRMS) that is approved by the State. ICAO guidance applies scientific principles to fatigue management.

There are two areas of science that are central to this:

1. **Sleep science** – How your body rests and recovers. What affects sleep and sleep loss.
2. **Circadian Rhythms** – Physiological behaviour that aligns the body with the day. Evolutionary process that is incredibly hard to work against.

ICAO requires that regulations are established based upon scientific principles which relate to:

1. The need for sleep
2. Sleep loss and recovery
3. Circadian effects on sleep and performance
4. Influence of workload

THE NEED FOR SLEEP

Everyone needs sleep but what actually happens when we sleep?

Sleep periods allow your body to recover and repair and your brain processes the data it has gathered during the wake period. During sleep, the brain creates and forms new memories, linking them to current memories, so that you start the next day with the most up to date mental picture of the world. The optimal amount of sleep varies per individual but is usually 7-9 hours.

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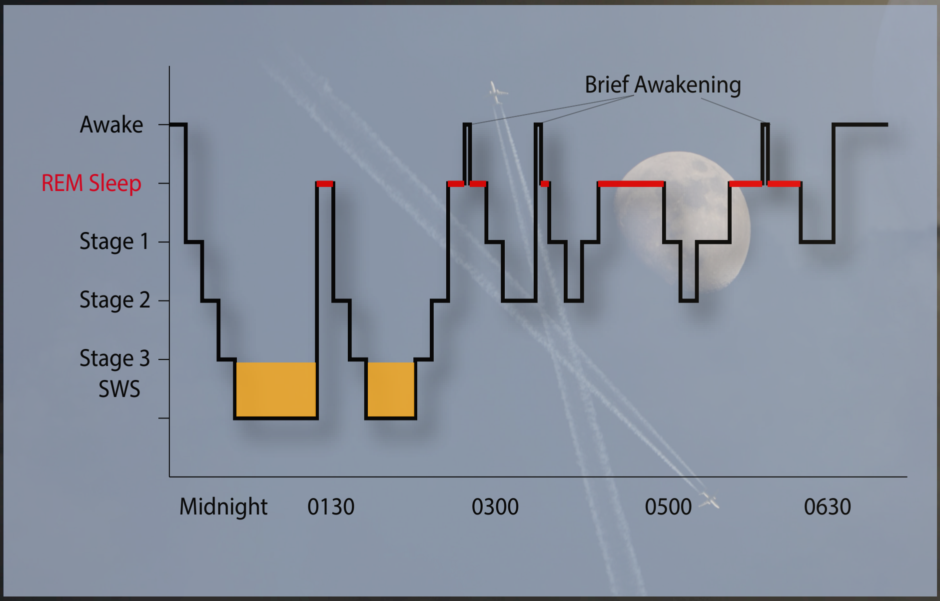
Types of sleep



There are two main types of sleep, REM and non-REM. REM stands for Rapid Eye Movement, as during this type of sleep, our eyes move rapidly under our closed eyelids. During REM sleep, the brain is repairing itself and consolidating information. During this time, your body is isolated from your brain signals to prevent you from acting out your dreams. There are 3 types of non-REM sleep but the most significant is 'stage 3' known as Slow Wave Sleep (or SWS). This is what we know as 'deep sleep'. During this type of sleep, your brainwave activity is slower and your body is prioritising muscle growth and repairing tissue damage.

Does the type of sleep matter?

The diagram above shows the different types of sleep throughout the night. As you can see, our body adjusts the type of sleep throughout the sleep period. Early on, we spend more time repairing the body in SWS but this changes as the sleep period progresses, to REM, where we process data.

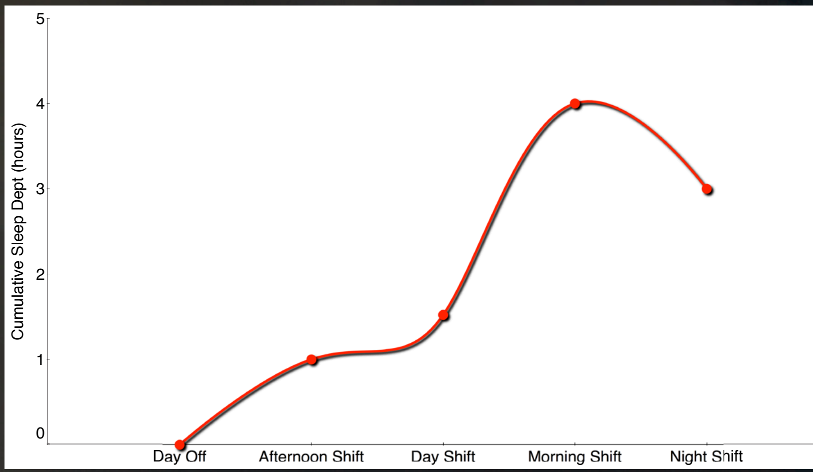
The quality of our sleep is very dependant on the brain being able to change, **without interruption**, between REM/non-REM cycles. This means our bodies will only recover when we are allowed full, uninterrupted sleep.

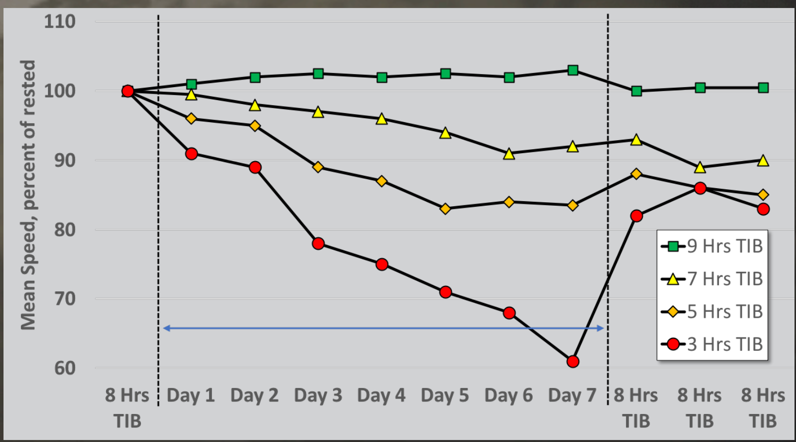
SLEEP LOSS AND DEBT

Many people believe that losing an hour or two of sleep will not impact their performance, however, this is not the case. A reduction of sleep by an hour or two, known as **sleep restriction**, will reduce alertness and degrade our performance in many tasks.

Sleep Debt

Every time our sleep is restricted, we accumulate **sleep debt**. In ATC, this will often happen during periods of consecutive shifts with minimal off-duty periods or when there are multiple early morning shifts. One type of rostering with a high sleep debt accumulation is backward rotation, where the next shift begins at an earlier time on the following day, than the previous one. The diagram to the right shows sleep debt accumulation over a backward rapidly rotating shift pattern.





The shorter the time available for sleep, the faster our alertness and performance will decline. The diagram on the left shows how the reaction time decreases with increasing sleep debt. Even restricting the subjects to 7 hours 'Time In Bed' (TIB) showed a marked reduction in reaction times. Restricting sleep to 5 hours TIB leads to a performance of around 80-85%, a staggering reduction of around 15-20%.

For the first few days of sleep restriction, people are aware that they are getting progressively sleepier. However, after several days, they no longer notice any difference, despite a continuing decrease in performance.

This means that we must be aware of the effects of sleep restriction over prolonged periods but also that our judgement of our own functional status may be unreliable.

It is also important to note that the pressure for sleep increases over successive days of sleep restriction. Eventually it becomes overwhelming and people will begin falling asleep, uncontrollably, for short periods. This is known as micro-sleep. During micro-sleep, the brain disengages from the environment (it stops processing visual information and sounds). While driving home from a night shift, this could mean failing to turn a corner. There are recorded events of this occurring in flightcrew and ATC, particularly after night shifts.

SLEEP RECOVERY

The effects of restricted sleep impacts the brain and continues to affect performance for days, even weeks, after the restriction occurs.

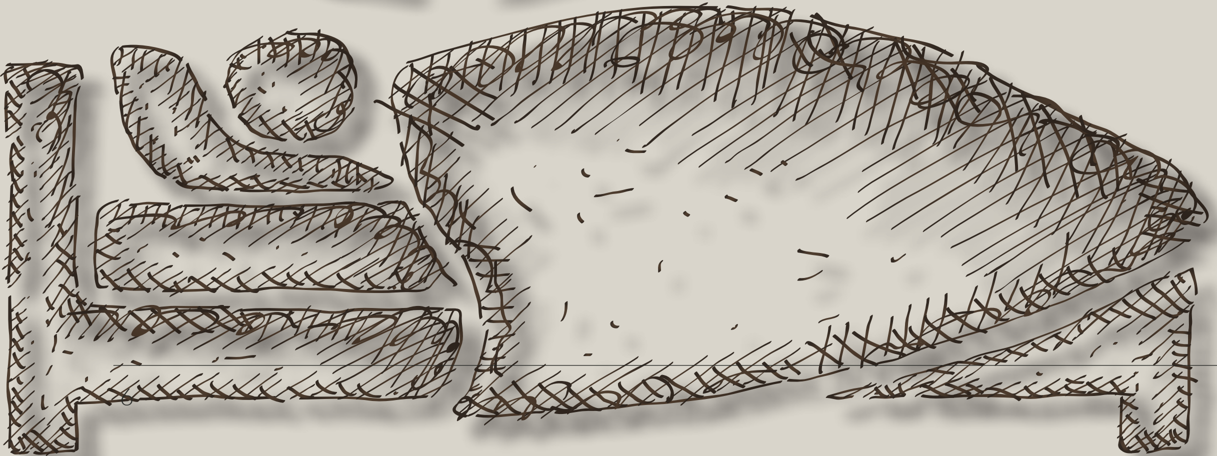
While studies have not yet been able to quantify how long recovery takes, the following findings are reliable.

At least two consecutive nights are required for non-REM/REM cycle to recover. If sleep restriction occurs over multiple nights, recovery to full performance and wakefulness will normally require more than 2 consecutive nights of uninterrupted sleep.

Three 8-hour sleep opportunities at night are not enough to recover from 7 nights of sleep restricted to 7 hours. This point is particularly important. How many rosters allow for recovery sleep for three nights or more?

Lost sleep is not recovered hour-for-hour and recovery sleep may require slightly longer.

NOT ALL THINGS ARE EQUAL

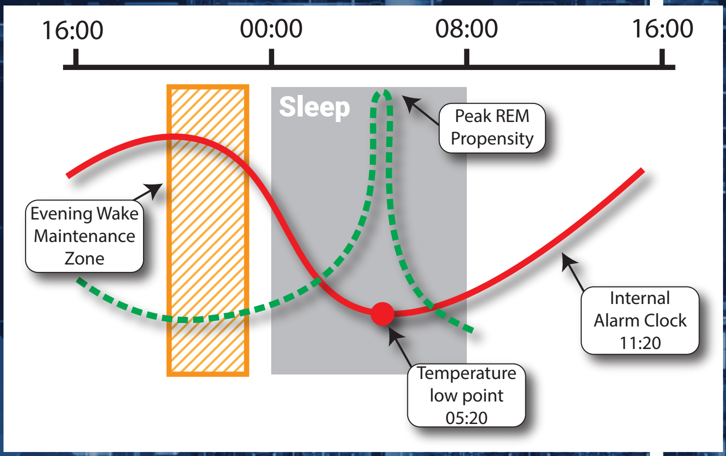


IT'S SCIENCE...

CIRCADIAN EFFECTS ON SLEEP

Our circadian clock is our own time keeping mechanism, located in the brain. It follows a rhythm, firing more signals during the day than at night. The 'biological day' that it produces actually operates slightly longer than 24 hours. It has a direct connection to the eye and uses light sensitivity to determine daytime, which realigns the clock. This means that shifts which cause us to be awake earlier or later, in darkness hours, affects the way our body feels. This is also the reason for jet-lag, as your body struggles to adjust to the rapid change in day/night times.

The circadian rhythm is also linked to body temperature, where studies show a fluctuation of about 1 degree Celsius across a 24-hour period. The body temperature is lower at night, during natural sleep periods, and higher during the day. In fact, the body uses our core temperature to control when we wake and when we feel the need to sleep. The diagram on the right shows the changes of core temperature (red line) on a day with a normal night's sleep. It shows the relationship between the circadian body clock and the normal sleep cycle.



The diagram highlights the following relationships in a normal sleep pattern:

- Sleep normally begins about 5 hours before minimum core body temperature.
- Wakeup normally begins around 3 hours after minimum core body temperature. Peak REM sleep occurs just after minimum core body temperature.
- As the core body temperature begins to rise, the circadian body clock sends an increasingly strong signal to the brain areas that promote wakefulness. About 3 hours after waking, the pressure for sleep is low and the circadian alerting signal is strong enough to make it very hard to fall asleep. This is sometimes known as the 'Internal alarm clock'.
- The circadian alerting signal is strongest just before usual bedtime. It makes is very difficult to fall asleep a few hours earlier than usual. This is known as the 'Evening wake maintenance zone'.

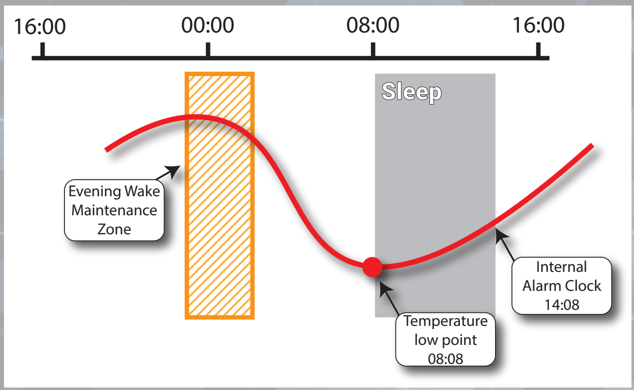
The circadian cycle also reduces the core body temperature during the day, although the effects are not as strong as at night. The daytime low occurs around 3-5pm, compared to the night low around 3-5am. If you have had restricted sleep the night before, this will make it harder to stay awake during the following afternoon.

SLEEP & PERFORMANCE

Shift work

The further that sleep is displaced from the usual circadian cycle, the harder it is to obtain adequate sleep. The diagram below shows what happened to the previous subject but after they worked over a night and tried to sleep the next day. The minimum core body temperature occurred at 08:08 (compared to 05:20 on a normal cycle). This is a difference of 2 hours and 48 minutes, yet the circadian clock did not fully adapt to this duty. They woke within 5 minutes of the predicted internal body clock time, at 14:08, resulting in only 6 hours sleep.

This does not only apply to night shifts. Early morning shifts also have consequences for sleep, due to the Evening wake maintenance zone. Going to sleep earlier than usual will not work for most people. Studies into this have shown that, compared to day and afternoon shifts, ATC obtain the least sleep before morning shifts. The changing pattern of shifts also causes circadian disruption, where different rhythms in the body become out of step with one another. This results in individuals experiencing fatigue, poor moods and reduced performance.



Influence of workload

The ICAO definition of fatigue describes workload as "mental or physical activity" and identifies it as a potential form of fatigue. However, it is a complicated area and there are no defined measures for it, at the present time.

Three aspects of workload are commonly identified relating to fatigue:

- The nature and amount of work to be done.
- Time constraints (whether by outside influence or the individual themselves)
- Performance capacity of the individual (experience, skill level, effort, sleep levels, circadian phase)

It is important to note that intensity can cause fatigue at low levels, not just high. However, fatigue levels rapidly increase after 2 hours, when conducting high intensity work, with the effects also being stronger the longer a person is awake. As such, adequate length breaks, at regular frequency, are an important way of reducing the decline in performance with increasing time-on-task.

ENVIRONMENTAL EFFECTS

Our fatigue levels are affected by the environment around us. This includes both the rate at which we gain fatigue and at which we recover.

This extends from your home, your commute to work, your work environment and the commute back home. Factors that contribute and which need to be considered include:

- The length of commute, the type of commute and the traffic levels.
- The quality of rest facilities
- Air quality, temperature and humidity at work
- Ergonomic factors, including the comfort of chairs, sofas, beds.
- Disturbances of other activities and people nearby, including young children at home.

PREVENTING FATIGUE

ICAO's FRMS Guide refers to operational and strategic measures to manage fatigue to the best of our ability. Most methods rely on a level of self-analysis, so it is important to understand the way that sleep and recovery works, as mentioned in previous sections, in order to best develop methods which work for you.

Operational

Controllers @ work

- Coffee, tea, energy drinks or other approved stimulants
- Food, including fruit, nuts, high energy foods
- Environment: lights, temperature, air quality
- Ensure adequate breaks are taken
- Advise supervisor if you are tired or require extra breaks

Strategic

Before your shift

- Adequate sleep and rest
- Environment at home
- Minimising workload prior to the shift
- Allow sufficent travel time for commute to work location
- Consider a rest period after commute, before shift begins

Organisational

Controlling fatigue

- Restricting time conducting operational tasks (time on console, admin tasks, training)
- Limit consecutive duties
- Ensuring an adequate minimum time between shifts (considering travel time and work/life balance)
- Restrict types of shifts worked following night shifts
- Sleep facilities at units
- Quality of rest facilities

JUST CULTURE PRINCIPLES SHOULD APPLY TO FATIGUE MANAGEMENT

AN FRMS SHOULD ALLOW FOR OPEN AND GENUINE REPORTING WITHOUT FEAR OF RETRIBUTION OR PUNISHMENT

An FRMS should always be subject to review, in order ensure it is fit for purpose. This process can only occur if staff are able to provide honest feedback about the system. Moreover, it is a safety risk if controllers are expected to work despite being in a fatigued state or feeling unfit to control.

DEVELOPING AN FRMS

The **ICAO Fatigue Management Guide for Air Traffic Service Providers** provided the basis for this document. As such, it is the best place to begin the first steps towards developing a robust FRMS.

It is also useful to take a look at already established FRMS to use for reference. It is important to note that no FRMS is perfect and it is important to speak to controllers who use those systems to find out what the advantages and disadvantages are, with their FRMS.

An example of a robust, publically available FRMS is the one created by the UK CAA. It can be found in UK CAA document **CAP670**, Air Traffic Safety Requirements, under part D-Human Resources.

About this guide

The purpose of this document is to provide an introduction for controllers on the importance of Fatigue Management, a critical area of aviation which is often overlooked. Most of the research information in this document has been taken directly from the ICAO FRMS Guide and references to the research can be found within that guide.

Produced by

International Federation of Air Traffic Controllers' Associations

The IFATCA Office
360 St. Jacques, Suite 2002
Montreal (Quebec) H2Y 1P5, Canada

Phone: +1 514 866 7040
Fax: +1 514 866 7612
E-mail: office@ifatca.org

IFATCA

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