

Understanding Fatigue Risk Management



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This paper aims to explain the principles of fatigue risk management, and why the approach is increasingly being regulated for around the world.

What are fatigue risk management approaches, and why do we need them?

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Introduction

What is the aim of this white paper?

This paper forms the first in a series of linked papers that explore fatigue risk management, and what it means for those in different industries.

1. What are fatigue risk management approaches, and why do we need them? (This paper)
2. Fatigue Risk Management in European and UK-based Part 145 maintenance organisations
3. Fatigue Risk Management in the Energy Industry
4. Fatigue Risk Management in the UK Rail Industry
5. Increasing the maturity of airline Fatigue Risk Management, and undertaking fatigue safety cases

This paper aims to explain the principles of fatigue risk management, and why the approach is increasingly being regulated for around the world. The subsequent linked papers will provide industry specific detail of the terminology and regulations relevant to each sector.

Who is this white paper for?

This white paper provides guidance for individuals who are responsible for managing safety and/or fatigue and are seeking to ensure that their system is effective, or those who are new to fatigue risk management.

What is fatigue?

If we are going to discuss fatigue risk management, it is important to have a common understanding of fatigue. There are numerous definitions, but one that is particularly useful to enable the management of fatigue risk has been published by ICAO, the International Civil Aviation Organisation. They define fatigue as:

*'a physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, and/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.'*¹

This biological definition highlights fatigue as a **physiological state** – i.e., something that naturally occurs, but must be treated physiologically, rather than perception, or a state we can remove ourselves from due to willpower or professionalism. The definition also highlights four main biological causes of fatigue (sleep loss, extended wakefulness, circadian phase – i.e., the body clock, and workload), which can be used to aid in risk identification and to ensure that risk mitigations are appropriately targeted. Finally, the definition focuses on safety outcomes, rather than any other consequences of fatigue. This enables us to concentrate on the risk management element.

¹ ICAO (2011), Annex 6, Part 1

What is Fatigue Risk Management?

Fatigue Risk Management (FRM) is a specialist function of the safety management system (SMS), utilising a performance-based approach to the management of fatigue-specific hazards and risks. It follows the same core pillars (safety policy, risk management, risk assurance and safety promotion) as the safety management system, but with specialist data streams and risk management approaches that are required to ensure that the risk of fatigue is appropriately managed.

Different industries have different definitions of FRM or Fatigue Risk Management Systems (FRMS), with one such being published by ICAO, who 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 operating experience that aims to ensure relevant personnel are performing at adequate levels of alertness'

Other common elements of fatigue risk management across industries include that:

- The FRMS relies on data, both to identify hazards, and to ensure that mitigations and controls that are implemented are effective.
- The FRMS should be evidence-based, with that evidence considering scientific principles of sleep and fatigue, the experience of the operator and best practice within the industry, and the experience of the workforce.

For example, the International Maritime Organisation (IMO) describes the following as *'necessary elements to an effective fatigue management system'*:

- *'objective measurement of the causes and effects of fatigue'*
- *'comprehensive programmes comprise several elements'*
 - *'training and education on fatigue and shift work for all stakeholders (watchkeeping);'*

- *'planning tools such as fatigue modelling or rosters (watchkeeping systems) and work arrangements'*
- *'Impairment testing programs, auditing the results of previous initiatives'*²

FRM differences between safety critical industries

Different safety critical industries have different regulatory requirements and guidelines relating to fatigue risk management, and may also use slightly different terms (e.g., FRMS, Fatigue Risk Management Plan/Programme (FRMP)). This is understandable, there is no global 'arbiter' of FRM.

In some industries, there is a degree of standardisation – for example provided by the ICAO Standards and Recommended Practices (SARPs) setting an international standard for aviation regulators worldwide, or by the International Maritime Organisation (IMO) for the shipping industry. However, for most industries, there is no global standard and different industries have different levels of maturity when it comes to fatigue risk management. For example, FRMS was first implemented by a commercial air transport (CAT) operator (i.e. an airline) in 1995 by Air New Zealand, well in advance of any globally published regulations. In contrast, Fatigue Risk Management in Part-145 maintenance organisations has only been specifically outlined within regulations enforced by EASA and the UK CAA as part of the requirement to introduce Safety Management Systems³. Measuring FRM maturity will be explored further in the fifth paper in this series.

Importantly, outside aviation, FRM is a means of complying with requirements, such as health and safety regulation (e.g., in the UK, the Management of Health and Safety at Work Regulations, 1999), to demonstrate that all risks, including the risk of fatigue, are managed within the operation. It is the approach recommended to ensure that the risk of fatigue is managed in the UK Rail industry, for example, and is considered best practice in many industries.

² International Maritime Organisation. MSC/Circ.1014 Annex. Guidelines on Fatigue. Module 6. Shipboard Fatigue and the Owner/Operator/Manager

³ EASA Continuing Airworthiness Regulation (EU) 1321/2014, adopted into UK law by the UK CAA in the Aviation Safety (Amendment) Regulations 2023

Within aviation, FRMS allows **specific** operations to be conducted outside published flight time limitations – this will be explored in more detail in the fifth paper in this series.

Why can't we rely on hours of work limitations?

Historically, the dominant method for controlling fatigue has been via compliance with hours of work limitations. These rules typically limit the number of weekly or monthly hours of work, consecutive shifts, shift and break length, and require minimum rest period durations. An example of this is the EU Working Time Directive⁴, Flight Time Limitations (FTLs), and driver's working hours. However, there is increasing consensus that hours of work limitations alone are insufficient to control the risks of fatigue⁵, and evidence that organisations are exposed to fatigue risk despite compliance with all hours of work regulations (AAIB, 2013)⁶.

One problem with hours of work limitations, in isolation, is that they assume a safe/ non-safe dichotomy – i.e., everything that is permitted is safe, and everything that is not safe is not permitted. Across the range of operations and individuals governed by prescriptive limits, this is impossible – there will be an overlap (Figure 1). For example,

prescriptive hours of work limitations cannot ensure that an adequate sleep opportunity is provided. As an example:

- Prescriptive hours of work rules may require an 11h rest between two consecutive work periods
- However, the amount of sleep possible during this 11h will be very different if this rest period is during the night compared to during the day – as our body clock makes sleep during the day lower quality and less likely to occur at all
- Travel to/from work, whether that is the usual place of work, or another site that the worker is required to travel to occasionally can significantly erode the time available to sleep
- Where workers remain on-site (for example offshore oil rigs, or fly in fly out mining sites, or on board a ship) overtime may erode rest time, particularly amongst those in supervisory roles who may have high workloads

FRM allows the collection of data across the operation, meaning that rest periods (in this case) can be adjusted to ensure that the workforce are able to obtain the amount of sleep required to operate safely. This may differ between different sites or populations, depending on the evidence.

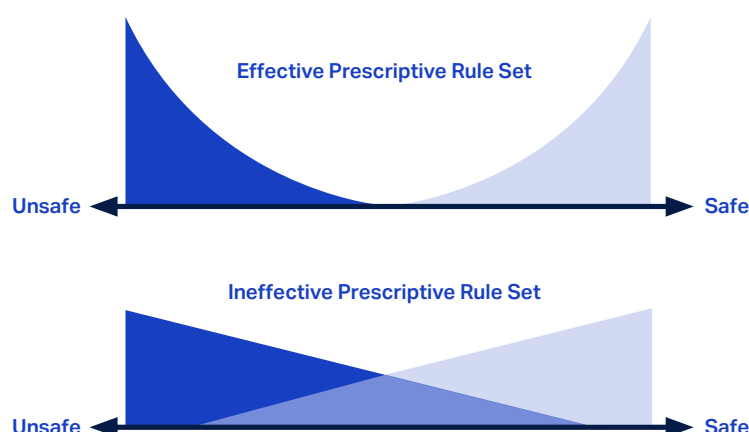


Figure 1 – Effective 'ideal' prescriptive rule sets compared with ineffective 'realistic' prescriptive rule sets. Adapted from Honn et al, 2019.

⁴ European Working Time Directive, (EUWTD) 2003/88/EC

⁵ Honn, K. A., van Dongen, H. P., & Dawson, D. (2019). Working Time Society consensus statements: Prescriptive rule sets and risk management-based approaches for the management of fatigue-related risk in working time arrangements. *Industrial Health*, 57(2), 264-280.

⁶ Aircraft accident report 1/2015 – Airbus A319-131, G-EUOE, 24 May 2013

We also know that fatigue and performance varies across the shift. FRM approaches allow the identification of the most appropriate time for certain tasks, for example, or when tasks may require mitigation against fatigue. This reduces the likelihood of error, which may reduce safety, or cause rework and associated delays and expense.

The importance of managing workload

Hours of work limitations also struggle to effectively manage workload. Workload can be mental or physical, and whilst high workload may cause fatigue, low workload (particularly low mental workload) can unmask fatigue making falling asleep unintentionally more likely. Workload must be managed using methods that are organisationally specific, as it is very context dependent, and can vary between individuals based on different factors, such as experience.

How fatigue risk management provides another layer of protection to prescriptive hours of work limitations

The potential causes of fatigue are myriad and complex. This means that, to manage fatigue risk we must consider information from multiple sources. Equally important, fatigue risk management is a shared responsibility between the individual and the organisation. Both have important roles to play to ensure that fatigue is effectively managed.

As outlined above, FRM is a specialist function of the safety management system, where hazards and risks are identified and managed using a systematic approach. One framework, to ensure that the risks associated with sleep loss is managed has been outlined by Dawson and McCulloch⁷, whilst others with a more holistic fatigue-focus are contained within regulation or guidance material in different industries (for example ICAO, IMO, and ORR guidance materials).

Using a systematic approach to FRM allows the identification of hazards and

appropriate mitigations from across the operation. Because fatigue can come from many different sources, we must collect different forms of data to inform our hazard identification, for example using fatigue reports, roster-metrics, safety or near miss reporting data, sickness absence and surveys. Each forms one piece of the overall 'jigsaw' picture of the fatigue landscape. Mitigations can then be implemented, using experience from across the business to identify the most effective strategy. For example, if fatigue reporting and near miss data indicates that there is elevated fatigue on 'swing' or transition shifts (i.e., for people moving between day-time and night-time working), mitigations would need to be applied to reduce the risk. If the overall risk is still relatively low, returning to a risk level that is As Low As Reasonably Practicable (ALARP) may be as simple as increased cross-checking, whereas in a high risk environment, it may be necessary to change the shift pattern to reach that ALARP position.

Frequently asked FRM questions

Q: Is the safety department or the rostering/planning department responsible for FRM?

A: In most organisations, the rostering or scheduling department or team is responsible for compliance with working time regulations, so often FRM is also given to people in these roles, as FRM also concerns hours of work. However, fatigue risk management is ultimately a safety function – it requires risk management principles, risk assessments, and safety assurance processes to be implemented. Those overseeing the FRMS must also be independent of the rostering role, as rostering can be both a cause and solution to elevated fatigue. Those in rostering will have a key role to play and be a member of the fatigue safety action group (where formed), but do not 'run' the FRM. For smaller organisations, this may be welcome news – where those in rostering roles are already very busy.

⁷ Dawson, D., & McCulloch, K. (2005). Managing fatigue: it's about sleep. *Sleep medicine reviews*, 9(5), 365-380.

Just like safety management, all operational departments are responsible for implementing fatigue risk management principles and providing data to allow monitoring of the risk.

Q: Does FRM mean we can ignore all the regulatory limits on hours of work?

A: No. In most industries, FRM is a requirement on top of prescriptive working hour limitations. The operator must still comply with these outer limits.

A slight exception is for certain operators within the aviation sector. Whilst airline operators may be able to use their FRMS to support working specific parts of the operation outside published limitations, in most regulatory environments world-wide all other limitations must be followed.

Because the FRMS is an evidence-based approach, it may also result in greater restrictions, as you identify elevated fatigue levels, and bring in appropriate controls to manage that risk.

Q: How substantial should my FRM be?

A: The same principle as other areas of performance-based safety management applies to FRM – that the system in place must be suitable for the size, nature and risk within the organisation. The complexity and extent of FRM that you need to implement depends on the fatigue risk inherent in your operation. For a relatively low risk organisation, with limited shift work, or consistent manageable workload, the FRM and controls for fatigue will likely be simple. Where the risk is higher, for example combining rotating shifts, crossing time zones, variable workload and/or long hours of safety critical work through the night, your FRM approaches must be greater to reflect this increased risk.

Conclusion

Fatigue Risk Management is an evolution and specialism of Safety Management Systems. The approach acknowledges that, in isolation, hours of work limitations are insufficient to manage the risk of fatigue. Instead, a holistic, data-driven systematic approach is required, the complexity of which depends on operational risk.

Key components of FRM include:

- Using a data-driven approach to identify, mitigate and manage fatigue risks
- Ensuring competence across the workforce, both for those who may experience fatigue, and those who may influence the fatigue of others
- A shared responsibility for managing fatigue

In all industries, FRM is implemented in addition to prescriptive hours of work regulation, to ensure that fatigue risk is appropriately managed.

What's next?

The other white papers in this series explore specifics of FRM in different industry sectors. If you are looking for further guidance, we recommend reading those that are relevant to you.

FRM is a process that is still evolving and improving across industries. In order to reduce the risk of fatigue, in many areas increased competence is required. Increasing the competence of operators and regulators across industries worldwide would reduce risk and provide effective oversight and confidence.

⁷ Dawson, D., & McCulloch, K. (2005). Managing fatigue: it's about sleep. *Sleep medicine reviews*, 9(5), 365-380.

References

Aircraft accident report 1/2015 – Airbus A319-131, G-EUOE, 24 May 2013

Dawson, D., & McCulloch, K. (2005). Managing fatigue: it's about sleep. *Sleep medicine reviews*, 9(5), 365-380.

EASA Continuing Airworthiness Regulation (EU) 1321/2014, adopted into UK law by the UK CAA in the Aviation Safety (Amendment) Regulations 2023

European Working Time Directive, (EUWTD) 2003/88/EC

Honn, K. A., van Dongen, H. P., & Dawson, D. (2019). Working Time Society consensus statements: Prescriptive rule sets and risk management-based approaches for the management of fatigue-related risk in working time arrangements. *Industrial Health*, 57(2), 264-280.

ICAO (2011), Annex 6, Part 1

International Maritime Organisation. MSC/Circ.1014 Annex. Guidelines on Fatigue. Module 6. Shipboard Fatigue and the Owner/Operator/Manager

Authors

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SENIOR MANAGER, BAINES SIMMONS

Sarah Booth is our Senior Manager of Fatigue Risk Management. A specialist in human performance in the aviation and aerospace environments, Sarah has worked with operators to develop and implement Fatigue Risk Management Systems (FRMS) across multiple regulatory environments, and provides scientific support to Regulators assessing FRM submissions and scientific safety cases.

Sarah specialises in the integration of key data streams into the FRMS. A highly experienced user of bio-mathematical fatigue models, Sarah develops key metrics for the analysis of roster-related-fatigue levels and roster-related fatigue contributors. Sarah also works closely with operators to implement effective, data-rich fatigue reporting systems, and to identify barriers to reporting.

In the last two years, Sarah has undertaken scientific safety cases, fatigue management diagnostics and implemented Fatigue Risk Management in some of the world's largest airlines, as well as in the rail and maritime industries and for search and rescue helicopter operations.

Sarah obtained an honours degree in Physiological Sciences from the University of Oxford, focusing on cardiovascular physiology and immunology, a Master's degree in Space Physiology and Health at King's College London, and a Master's Degree in Sleep Medicine at the University of Oxford.

Dr Cristina Ruscitto

SENIOR RESEARCHER, BAINES SIMMONS

Dr Cristina Ruscitto is a Senior Researcher in the Fatigue Risk Management Team. She specialises in the psycho-behavioural predictors of jet lag and fatigue in the aviation sector. Her role involves a wide range of tasks, including the development of fatigue surveys and survey analysis, development of fatigue investigation process, review and recommendations of procedures, scientific study of roster patterns and the use of bio-mathematical models to conduct roster analysis.

Cristina joined Clockwork Research in April 2018, having previously completed her PhD in Health Psychology exploring the psycho-behavioural predictors of jet lag amongst long-haul cabin crew at the University of Surrey, UK. Her research examined the relationship between subjective (symptom perception) and objective (shift in melatonin acrophase) jet lag in order to provide a comprehensive account of jet lag in long-haul cabin crew. The nature of subjective jet lag was further explored in terms of how long-haul crew make sense of jet lag and how this affects their adaptation to jet lag. Finally, based on recent evidence about the circadian resetting properties of food timing, Cristina also evaluated the impact of mealtimes for reducing jet lag in long-haul crew.

Cristina's interest in the field of jet lag and fatigue in aviation is not only academic but also personal having worked as long-haul cabin crew for 24 years. Cristina also works as a Visiting Researcher and Academic Tutor in Psychology for the University of Surrey. She is a Chartered member of the British Psychological Society and an Associate Fellow of the Higher Education Academy.

Reviewer

Dr Alexandra Holmes

Alexandra Holmes PhD is a fatigue risk management (FRM) specialist at Baines Simmons, an aviation safety risk management consultancy. For over 20 years, Alex has worked with operators to undertake large-scale scientific safety studies of pilot fatigue and performance, including pilots operating ultra long-range trips between the Middle East and the USA, to island hopping seaplane pilots.

Alex is currently on the EASA Scientific Committee reviewing research into the effectiveness of flight time limitations. She was on the Flight Safety Foundation (FSF), Fatigue Countermeasure Group that authored Guidance for Operators for controlled rest, and a member of the ICAO Helicopter Fatigue Management Task Force that developed the revised SARP and guidance material on fatigue management for helicopter operations.

About Baines Simmons

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