

Understanding Fatigue Risk Management

Fatigue Risk Management (FRM) in European and UK-based Part 145 maintenance organisations



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Introduction

What is the aim of this white paper?

This paper is designed to provide an overview of fatigue risk management for operators in Part 145 maintenance organisations with a focus on understanding fatigue risk. It follows from the introductory paper in this series – ‘What are fatigue risk management approaches, and why do we need them?’

Which Regulations and Guidance materials are relevant to Part 145 organisations?

In Europe, regulatory requirements for managing fatigue in maintenance are outlined in Regulation (EU) No 2021/1963 amending the ‘EASA Continuing Airworthiness Regulation (European Union [EU]) 1321/2014’¹ in points:

- 145.A.47 Production planning;
- AMC (Acceptable Means of Compliance) 1 145.A.47(b) Production planning;
- GM (Guidance Material) 1 145.A.47(b) Production planning.

For full text of these points, please see the appendix of this paper.

Regulation (EU) 1321/2014 has been retained and amended in UK domestic law.² The applicable date for complying with the FRM regulation depends on where organisations have their approval in the UK only or in both the UK and the EU.

These regulations require fatigue risk to be considered within production planning, and managed as part of the management system (145.A.47 (b) and (d)). As shown in the appendix, AMC include:

- Providing fatigue training and education
- Implementing fatigue reporting systems
- Conducting regular fatigue risk assessments
- Considering fatigue in the planning of maintenance
- Ensuring schedules provide adequate sleep opportunities and do not cause serious disruption to the sleep/wake cycle associated with alternating night/day duties
- Putting controls in place to reduce fatigue risk identified.

As stated by the regulation, fatigue should be managed within the SMS (Safety Management System). As SMS is a new regulatory requirement for European and

¹ Council Regulation (EU) 2021/1963 amends Regulation (EU) No 1321/2014 of 26 November 2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks. Annex II (Part 145), SECTION A – TECHNICAL AND ORGANISATION REQUIREMENTS. The amendment came into force 2nd December 2022 with a 2-year transition period for compliance. https://www.easa.europa.eu/en/document-library/easy-access-rules/online-publications/easy-access-rules-continuing-airworthiness?page=24#_Toc256000385 (accessed 6th July 2023)

² Aviation Safety (Amendment) Regulations 2023, No. 588. Amendment of Section A of Annex II (Part 145) of Commission Regulation (EU) No 1321/2014. Regulation 22(12), 145.A.47, point b and point d. <https://www.legislation.gov.uk/uksi/2023/588/regulation/22/made> (accessed 6th July 2023). The UK CAA amendment for Regulation 22(12) comes into force 1 July 2024 with a 2-year transition period <https://www.legislation.gov.uk/uksi/2023/588/regulation/14/made> (accessed 6th July 2023).

UK-based Part 145 organisations, managing fatigue risk may be seen as an additional challenge. However, managing fatigue should not be seen as a separate set of systems and approaches. Fatigue is simply another hazard which needs to be quantified, evaluated and managed using the same principles (assessment, management and monitoring) as the rest of the SMS.

How do I know fatigue may be a problem in my operation?

It is not reasonable to assume that because you are compliant with the European Working Time Directive (EUWTD)³, your operation is safe. One problem is that the EUWTD was originally designed to improve worker welfare. It is too generic to control fatigue risk in safety critical industries due to the type of work being carried out and the different contexts in which organisations operate. This means that fatigue contributors may also be different and cannot be effectively controlled by broad prescriptive regulations.

It cannot be assumed that a particular shift schedule is safe because it is compliant and/or it has been in place for a number of years or because there are no or few reports of fatigue-related incidents or accidents. The lack of fatigue-related incidents or accidents may be due to the lack of a reporting system or workers avoiding reporting as fatigue may be seen as an individual problem and the fear of being blamed (see later reference to Just Culture) rather than a shared responsibility between the organisation and employees.

Prescriptive limits on hours of work cannot control for the impact of fatigue that workers 'bring' to the workplace from home. The assumption that having 12 hours off between shifts for example guarantees adequate sleep is flawed. Next, the question is: what happens if workers report to work having only obtained 5 hours of sleep? Using FRM allows us to understand how spread out inadequate levels of sleep may be in the operation and

how to mitigate its impact on performance, paramount in safety critical settings.

What does understanding fatigue risk involve?

Understanding fatigue risk involves collecting data that indicate where the fatigue hotspots may be in the operation and where they come from. There are two main approaches to data collection:

1) Identifying safety risks from events that have occurred in the past (reactive)

Safety reporting scheme

Fatigue-related events are required to be reported through the internal safety reporting scheme. Reports need to be supplemented with relevant fatigue-related questions to help people complete a report successfully. Training in how to complete a report needs to be provided.

What kind of fatigue-related events can be reported?

A report can be completed by any employees to raise a concern about:

- the fatiguing feature of a working pattern, e.g., whether timings allow for adequate sleep to be obtained
- the fatiguing feature of a task, e.g., low or high workload, whether it occurred in the WOCL with no controls or controls were not effective
- a possible fatigue-related error that may have happened to the person completing the report or to others.

Trust in a Just Culture⁴ is key for developing an open and honest reporting system. Effective fatigue reporting processes allows the organisation to identify when and where in the operation fatigue is elevated, and how spread out the occurrence of fatigue-related errors/events may be so that fatigue risk can be managed in the operation.

³ The Working Time Regulations (1998) implement the European Working Time Directive (EUWTD) into UK law: EUWTD (2003). 2003/88/EC. It applies to employees, workers, agency workers, apprentices, casual and seasonal workers, doctors in training, zero-hours workers, non-mobile workers in road, sea, inland waterways and lake transport, to all workers in the railway and offshore sectors, and to all workers in aviation who are not covered by the Civil Aviation (Working Time) Regulations 2004. <https://www.legislation.gov.uk/ukssi/2003/1684/contents/made> (accessed 6th July 2023)

⁴ A Just Culture is founded on the idea that 'people will make mistakes and errors' and treat instances where they occur as opportunities to learn vital safety lessons. Trust in a Just Culture occurs when we trust that the leadership team is committed to the principles of a fair culture and trust that the processes will be consistently applied.



Within FRM, we may ask the following questions:

- Do our current shift patterns support adequate sleep opportunities between shifts?
- What are the predicted fatigue levels when overtime is worked?
- What is the lowest level of fatigue predicted during a shift and when does it occur?

Investigations

You may be already conducting safety investigations. Fatigue investigations are similar in principle in that the aim is to understand the factors that lead to an incident to minimise the likelihood of them recurring. In FRM, it involves understanding whether fatigue played a role in an incident or accident by asking questions to ascertain whether:

- people involved were fatigued – e.g., the sleep obtained was reduced or disrupted (sleep history) and the possible contributors
- performance at the time of the event was consistent with fatigue-related performance
- fatigue contributed to the event.⁵

2) Identifying safety risks within the system before events occur

If only reactive data were used, we could only reduce fatigue risk after accidents and incidents occur and are investigated. This approach is limited as it is reliant on past events and cannot account for the impact of changing operations and context and variability in performance in the present. Within FRM, we may ask the following questions:

- Do our current shift patterns support adequate sleep opportunities between shifts?
- What are the predicted fatigue levels when overtime is worked?
- What is the lowest level of fatigue predicted during a shift and when does it occur?

Fatigue modelling

Bio-mathematical or fatigue models can be used to estimate (predict) the fatigue level (low, moderate, high, severe) associated with different types of schedules and at any given time during a shift.

Fatigue models use scientific principles of sleep and the circadian rhythm to estimate fatigue levels based on working timings as input. The output of the model provides metrics which can be used to quantify and evaluate shift-related fatigue and develop schedules that promote alertness and mitigate fatigue risk.

Although the GM in Regulation (EU) 1321/2014 does not list the use of fatigue models to predict fatigue, this methodology is being increasingly used (in flight operations) and is recognised as a valuable tool to support FRM as a multi-layered approach.

Fatigue surveys

A well designed and anonymised fatigue survey can also be used to quantify fatigue by offering a snapshot of fatiguing aspects across the operation. There are two basic types of surveys:

1. Retrospective surveys ask people about sleep and fatigue in the past. They are usually completed once a year and can capture the following:

- workers' approach to FRM, e.g., sleep and alertness strategies used
- fatigue contributors in the operation
- commitment and engagement with the organisation's FRM strategies and procedures

2. Prospective surveys assess real-time sleep and fatigue (e.g., how sleepy or fatigued you feel right now). An example is measuring fatigue on night shift (start, middle and end) across a week using a validated scale like the Karolinska Sleepiness Scale or monitoring sleep patterns across a period of time using research grade sleep monitors. Again, the use of such data and the scale of data collection will be dependent on operational questions and needs.

⁵Clockwork Research (2017). A framework for investigating fatigue. White paper 17/01.

Who is responsible for FRM?

FRM is a joint responsibility between the individual and organisation. Sleep can be affected by factors at work and outside of work (stress, commuting time, illness, lifestyle). The organisation needs to ensure schedules and the environment are optimal for sleep and individuals are responsible to use recovery time (before a block of work and between shifts) to obtain sufficient sleep and employ strategies to reduce fatigue risk.

The following are some examples of work-related and individual factors that affect fatigue.

Work-related:

- Working pattern (start and end times, consecutive number of shifts, rotating vs fixed patterns)
- Workload and nature of tasks
- Rapid turnarounds (inadequate recovery between shifts)
- Overtime and on-call arrangements
- Environmental conditions
- Access to food and water
- Safety culture (just culture is a subset)
- Sleep environment

Individual:

- Sleep environment
- Sleep/alertness strategies
- Commute
- Health
- Domestic and social commitments
- Sleep disorders
- Illness

Conclusion

Managing fatigue within the SMS will enable maintenance organisations to better understand fatigue risk so it can be effectively mitigated. It offers a flexible approach adapted to the specific operational context, rather than the prescriptive regulations underpinned by one-size-fits-all approach.

Appendix

145.A.47 Production planning

Regulation (EU) 2021/1963

- (a) The organisation shall have a system appropriate to the amount and complexity of work to plan the availability of all necessary personnel, tools, equipment, material, maintenance data and facilities in order to ensure the safe completion of the maintenance work.
- (b) As part of the management system, the planning of maintenance tasks, and the organising of shifts, shall take into account human performance limitations, including the threat of fatigue for maintenance personnel.
- (c) When it is required to hand over the continuation or completion of maintenance tasks for reasons of a shift or personnel changeover, relevant information shall be adequately communicated between outgoing and incoming personnel.
- (d) The organisation shall ensure that aviation safety hazards associated with external working teams carrying out maintenance at the organisation's facilities are considered by the organisation's management system.

AMC1 145.A.47(b) Production Planning

Decision 2022/011/R

CONSIDERATION OF FATIGUE IN THE PLANNING OF MAINTENANCE

- (a) The way and the extent to which the organisation should consider the threat of fatigue in the planning of tasks and organising of shifts will vary from one organisation to another and from one maintenance event to another, depending on what maintenance is to be carried out, how, where, when and by whom.
- (b) Fatigue is one example of human factors issues which should be taken into account by the management system, particularly for the planning activity. In this respect, where the organisation activity is prone to fatigue issues, the organisation should:
 - (1) ensure that the safety policy required by point 145.A.200(a) gives due consideration to the aspects of fatigue;
 - (2) ensure that the internal safety reporting scheme required by point 145.A.202 enables the collection of fatigue issues;
 - (3) ensure that the threat of fatigue is adequately taken into account by the management system key processes (e.g. assessment, management, monitoring);
 - (4) provide safety promotion material and adapt safety training accordingly.
- (c) The organising of shifts should consider good practices in the maintenance domain and applicable rules. The resulting shift schedule should be shared with the maintenance staff sufficiently in advance so they can plan adequate rest.

The established shift durations should not be exceeded merely for management convenience even when staff is willing to work extended hours.

- (d) The organisation should have a procedure (including mitigations) to address cases where the working hours are to be significantly increased, or when the shift pattern is to be significantly modified, such as for urgent operational reasons. In cases not covered by that procedure, the organisation should perform a specific risk assessment and define additional mitigation actions, as applicable.

Basic mitigations may include:

- (1) additional supervision and independent inspection;
- (2) limitation of maintenance tasks to non-critical tasks;
- (3) use of additional rest breaks.

GM1 145.A.47(b) Production Planning

CONSIDERATION OF FATIGUE IN THE PLANNING OF MAINTENANCE

(a) Fatigue may be induced by:

- (i) the environment and conditions (e.g. noise, humidity, temperature, closed section, working overhead) in which the work is carried out;
- (ii) excessive hours of duty and shift working, particularly with multiple shift periods or patterns, additional overtime or night work;
- (iii) travel to the maintenance location (e.g. jetlag, duration)

Fatigue is one of the factors that may contribute towards maintenance errors when it is not properly considered as part of planning activities.

(b) Taking into account the threat of fatigue in the planning of maintenance tasks and organising of shifts refers to setting up the maintenance and the shifts in a way that enables the maintenance staff to remain sufficiently free from fatigue so they can perform the planned maintenance safely, including:

- providing rest periods of sufficient time to overcome the effects of the previous shift and to be rested by the start of the following shift;
- avoiding shift patterns that cause a serious disruption of an established sleep/work pattern, such as alternating day/night duties;
- planning recurrent extended rest periods and notifying staff sufficiently in advance.

UK CAA - The Aviation Safety (Amendment) Regulations 2023

**Amendment of Section A of Annex II to Commission Regulation (EU)
No 1321/2014**

<https://www.legislation.gov.uk/uksi/2023/588/regulation/22/made>

(12) In point 145.A.47 –

(a) for point (b) substitute –

"(b) As part of the management system described in 145.A.200, the planning and organisation of maintenance tasks must take into account human performance limitations, including the threat of fatigue for maintenance personnel during shifts.";

(b) after point (c) insert –

"(d) The organisation must ensure that aviation safety hazards associated with external working teams carrying out maintenance at the organisation's facilities are considered by the organisation's management system."

Authors

Sarah Booth

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 the team 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

We are specialists in aviation regulations, compliance and safety management and partner with the world's leading civil and defence aviation organisations to improve safety performance.

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