

Worker Fatigue Risk Management in Practice: Benefits and Challenges

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As the Health and Safety Executive's (HSE) Health and Safety Laboratory (HSL), HSL has worked with companies from across industry to assess and manage fatigue risk as part of their risk management system. The work is aligned with current industry guidance such as the Energy Institute's 'Managing Fatigue Using a Fatigue Risk Management Plan', 2014. It includes the use of self-report measures, predictive tools such as the Fatigue Risk Index (FRI) and fatigue investigative methods. The aim of this paper is to share some of the key benefits and challenges associated with developing a fatigue risk management system. This will include a discussion on using fatigue risk management tools in practice - getting buy-in from senior managers and staff, maintaining momentum, accounting for individual differences in bio-mathematical models and over-reliance on the numerical outputs from models. The paper draws upon examples of work with major hazard sites to illustrate how challenges can be overcome to develop an effective Fatigue Risk Management Plan. It also highlights gaps in scientific knowledge where greater understanding could potentially impact positively on safety performance. The paper invites industry representatives to comment on our thoughts about where additional research is needed and how this might be achieved.

INTRODUCTION

Over the last 25 years, there has been a gradual increase in the number of people who undertake shift work in the UK. This growing 24-hour culture means that approximately 5-20 per cent of the working population is now engaged in shift work that involves night work, and this equates to 3-6 million workers (HSE, 2017). The risk of errors, accidents and injuries has been found to be higher on night shifts, rising with increasing shift length and successive shifts. This risk is greater and potentially more serious when work is safety critical, and shift schedules are poorly managed or designed. The HSE's Health and Safety Laboratory (HSL), has worked with companies from across industry to assess and manage fatigue risk as part of their risk management system. Additionally, our human factors specialists provide expert witness statements to inform HSE prosecutions and provide specialist support within HSE on the assessment of safety cases. The aim of this paper is to share some of the key benefits and challenges associated with developing a fatigue risk management system and the limitations associated with some fatigue assessment tools that are apparent in practice. This includes consideration of the use of various predictive, proactive and reactive methods used to manage fatigue including bio-mathematical tools such as the Fatigue Risk Index (FRI), self-report measures, and fatigue investigative methods.

DEVELOPING A FATIGUE RISK MANAGEMENT SYSTEM: THEORY

According to the Energy Institute (2014), a Fatigue Risk Management System (FRMS) is a risk-based plan or system of controls that identifies, monitors and manages fatigue risk, with the aim of ensuring that, so far as reasonably practicable, employees are performing with an adequate level of alertness. Managing fatigue by specifying hours of work and rest periods is not considered sufficient. Furthermore, a FRMS should be risk and evidence-based but grounded by operational experience and practicalities. Therefore, there is no generic 'one size fits all' FRMS; it should be integrated into existing corporate safety and health management systems and built on the principle of shared responsibility (Rail Safety and Standards Board, 2012).

There is considerable guidance now available on what a FRMS or Plan (FRMP) should comprise of in safety critical industries (Energy Institute; 2014; International Civil Aviation Organisation, 2016a; Office of Rail Regulation, 2012). The management of fatigue risk should be considered in the same way as any other risk in a safe system of work, and the key components of a FRMS, as listed by the Energy Institute (EI), are based around that premise. The EI provides the detail necessary to develop a FRMS but, generally, the approach calls for at least the following:

1. A documented commitment to managing fatigue risk in a systematic manner. This is organisational recognition of the issue and *is most effective when employees have been consulted in the development of the policy, standard or recommended practice.*
2. A statement of scope of application of the plan. For the documented commitment to be meaningful, a clear scope of application is needed that is *specific to the organisation* and their specific fatigue risk profile, based on their hours, their workload and working environment.
3. A *clear description of the roles and responsibilities* of the various stakeholders within the organisation who have a part to play in managing fatigue. All of those working in the organisation, and who are within scope, are responsible for the management of the fatigue risk; this includes employees being responsible for being fit for duty as well as the organisation providing a safe system of work.
4. A *statement of working hours and overtime limits*, setting out the procedures to be followed when employees are required to work beyond standard hours. Such statements can be used to ensure everybody is clear about their responsibilities and appropriate controls and mitigation measures to be used.
5. Fatigue risk management promotion: *training, awareness & communications*. This is necessary for all to understand their role in managing the fatigue risk, for them to be aware of procedures and the organisational expectations. Individual responsibility is particularly important to understand, because the first line of defence

against fatigue is sleep optimisation. There might be a reluctance to do this on the part of employer because such guidance crosses the boundary between work and home (Langer, 2016).

6. Fatigue risk management processes: hazard identification, risk assessment, control & evaluation. This is a key building block of the FRMS, because it is about *ensuring an organisation understands their fatigue risks and has established suitable ways to remove or minimise the risk potential.*

7. A procedure for employees to self-report fatigue. This is something that will require a culture change for many organisations because, as Langer (2016) notes, "*Fatigue is pervasive as it is under-reported … how many train drivers would admit to micro sleeping at the controls to their manager*?" For employees to report fatigue issues, they need to be confident that the system is fair and that all stakeholders are committed to the management of fatigue.

8. A commitment to ensure fatigue is *properly considered in incident investigations*, because it tends to be a contributory rather than a direct causal factor. It might require specific fatigue-related questions to be included in standard investigation methods to ensure that investigators look for root causes.

9. Management of *health issues* that can influence fatigue. The relationship between fatigue, health, fitness and wellbeing will be different and have different implications between organisations but must be considered in a FRMS.

10. A process for the audit and continuous improvement of the FRMS. As with any management system, a FRMS should *not be treated as a one-off activity*, it will need periodic review to ensure it is fit for purpose and takes account of any organisational changes that might impact the FRMS.

DEVELOPING A FATIGUE RISK MANAGEMENT SYSTEM: PRACTICE

Although some of the elements needed for a FRMS are already considered by high hazard organisations (e.g. a policy to direct the management of fatigue, a statement of working hours) and so can readily form part of the plan, Wilkinson (2013) comments *"... the current enthusiasm for FRMS among safety practitioners often seems overly complex. FRMS can delay effective action and result in risk management becoming an end in itself …"*. While the process might seem overly complex, the underpinning principles are appropriate and should be applied proportionately. When working with organisations to implement a FRMS, the authors have identified a number of challenges in applying the principles in practice, which can be overcome but require a pragmatic approach. These challenges often relate to organisational constraints and cultural difficulties (e.g. getting buy-in to manage fatigue) that are not easily or quickly addressed. They also relate to the complexity of fatigue and to the limitations in the scientific understanding of fatigue: Such limitations and complexity translate into limitations and usability issues in available fatigue assessment and management tools/methods.

Challenges of implementing a Fatigue Risk Management System

According to the Energy Institute (2014), it can take between one and two years to develop a "*fully functional*" FRMS. In the authors' experience of working with numerous organisations across industrial sectors that are implementing a FRMS, one to two years may be an underestimation of the time required to develop such a system, and the reasons for this are numerous. Firstly, in order to develop an FRMS, an organisation needs to have a good understanding of what their fatigue risk is so that they can ensure that their FRMS is, as recommended, based on assessed risk and evidence. In the authors' experience, it is not uncommon for organisations to have limited insight into their fatigue risk profile or any real understanding of what the potential is for employees to be affected by fatigue. So the starting point for many is to gain an understanding of their fatigue risk.

Secondly, many organisations struggle to get buy-in from senior management to dedicate resource to proactive fatigue assessment and management. Unfortunately, all too often, recognition of the importance of dedicating resource to fatigue management is a reactive response by senior management, because a fatigue related incident/accident has occurred or there is regulator action.

Thirdly, when an organisation does get senior-management buy-in to implement a FRMS, a common starting point is a safety management system that does not go beyond stating compliance with Working Time Regulations, and there is no fatigue policy or system in place for active monitoring of working hours.

There can be numerous challenges for organisations associated with developing and customising their FRMS to fit with their operational needs. These can include: the practicalities around aligning their fatigue policy with their HR department; identifying which tools to use that will facilitate all aspects of fatigue management (predictive, proactive and reactive management of fatigue); customising tools such that they are meaningful for their users; finding measures that are feasible to implement; understanding the limitations of tools. Furthermore, the integration of new methods into their current safety management system can extend the timeline for organisations: There may be a standard organisational process that has to be followed for such new methods to be recognised organisation-wide, and this may involve numerous levels of organisational approval. Finally, in the authors' experience, a fundamental aspect that is often overlooked is the cultural change that may be required to have a functional FRMS. Safety culture develops and evolves gradually in response to numerous factors including local conditions and leadership style. These fundamental changes needed to promote an informed and a just culture, two key aspects of safety culture and a successful FRMS, take time. But as Reason (1998) argues, provided an organisation understands what these key aspects of a safety culture look like for them, such a culture can be engineered through day-to-day changes in operations.

Overcoming challenges of FRMS implementation

In the authors' experience of working with organisations, it is evident that there are a number of factors that can be helpful in tackling some of the cultural and organisational buy-in challenges. It is evident from practice that a helpful starting point is getting an understanding of the fatigue risk profile of an organisation. This involves identifying standard working hours, planned extended working hours and exceptional, unforeseen circumstances. This includes the extent to which employees work beyond planned, standard working hours when they carry out planned routine work, the extent of unplanned working hours in exceptional circumstances where workload is greater and/ or more complex (higher fatigue risk potential), how often exceptional circumstances occur and where in an organisation this occurs. In practice, it is beneficial for an organisation to invest in gaining this understanding of its fatigue risk profile, so they can take a proportional approach to the design of their FRMS. This evidence can help to contribute to the business case to senior management for greater investment in fatigue management e.g. greater resources on shift.

As suggested in guidance from a number of sectors (e.g. Energy Institute; 2014, International Civil Aviation Organisation, 2016a; Office of Rail Regulation, 2012), it is beneficial to set up a Fatigue Action Group which includes key representatives from all stakeholder groups as early as possible in work to address fatigue. In practice, early involvement from key stakeholders means there is greater appreciation and understanding from stakeholders of the time required to bring about change and, therefore, easier for those implementing the FRMS to manage expectations. A Fatigue Action Group facilitates ownership and accountability of actions in relation to FRMS implementation with the advantage that action owners become very informed about good practice in fatigue management and are willing to act as 'Fatigue Champions' promoting and/or facilitating communications around fatigue. In practice, having continuity of key stakeholders can help to build trust and foster open discussion of fatigue issues between management and staff, a good basis for bringing about cultural change. It is evident from our experience that having a committed core group of stakeholders involved in facilitating change early on helps to maintain momentum and ensure the process is not threatened by other organisational changes e.g. a change in senior management.

An initial focus on some key elements within a FRMS is a useful starting point and the approach taken to risk assessment is one of these key elements (e.g. Energy Institute; 2014, International Civil Aviation Organisation, 2016). A useful pragmatic approach is to focus on getting one process/method in place to use as a predictive fatigue method (by using a tool to examine planned work schedules), a proactive method (by using a tool to measure fatigue in current operations) and a reactive method (having a method or process in place to ensure fatigue can be identified/reported after an event or incident) and ensure users take account of the limitations and challenges associated with each.

Bio-mathematical models - predictive methods

Tools to help predict the fatigue risk are attractive, because they are seen as a way to plan working hours and tell users whether an individual is likely to be fatigued or not when working a particular shift pattern. The current generation of commercially available models can probably be used to predict the average level of work-related fatigue associated with a pattern of work if the non-work period is defined as a period where the workforce has the opportunity and facilities necessary to attempt sleep. However, it is unlikely that the current generation of fatigue models can be used in isolation to predict or manage fatigue-related risk, but they may play a part in a fatigue risk management system to supplement a range of additional measures (Dawson *et al*., 2011). RSSB has recently published research to provide knowledge and guidance on the use of bio-mathematical models (Somvang, Hayward and Cabon, 2016). Some of the key findings related to a lack of knowledge by users on fatigue and fatigue management, and this can lead to over simplistic interpretations of the numbers provided by the models. Where thresholds are provided, they should be validated for the specific activities of the company and not just assumed to be applicable. Importantly, bio-mathematical models should be used primarily for comparing different work schedules rather than for conducting direct evaluations of sleep need, because they cannot provide the necessary detail required to indicate performance issues that could contribute to safety risk.

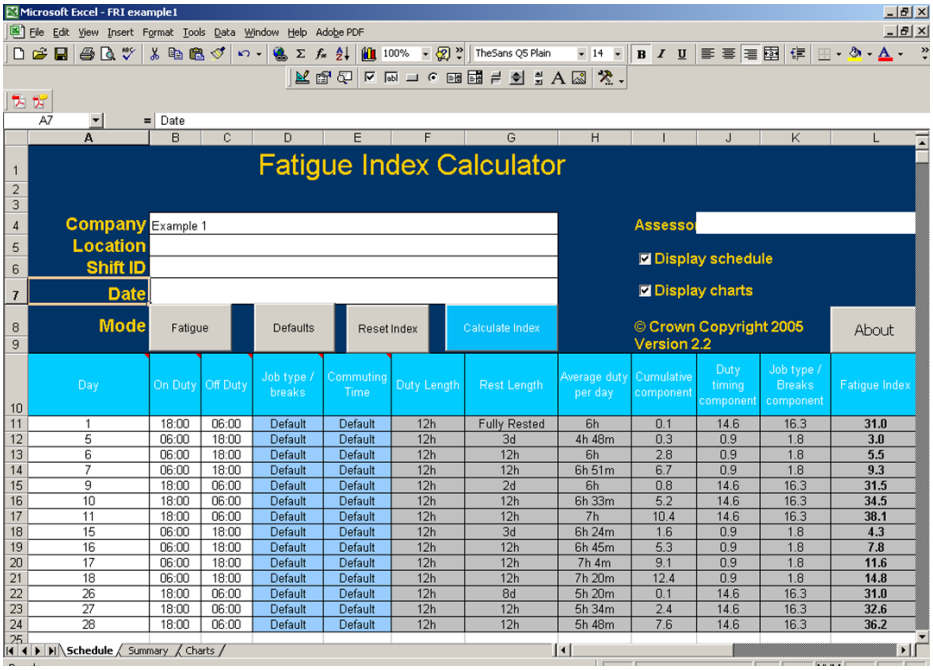

Figure 1 Fatigue Risk Index

The authors have extensive experience in use of the Fatigue Risk Index (FRI), a risk assessment tool that contains two indices, a Fatigue Index and a Risk Index (see Figure 1). The Fatigue Index incorporates factors known to be related to fatigue including shift timing, shift duration, breaks, rest periods, cumulative fatigue and workload. The output of the fatigue element of the index (shown in the last column of the image in Figure 1) relates to the probability of sleepiness as measured by the Karolinska Sleepiness Scale (KSS). Whilst the FRI is a useful tool, which can be used to help assess the risks of fatigue and injury, it should not be relied upon as the sole or primary means of assessing fatigue risks. There is a tendency for some users of the tool to over rely on the tool's output and/or over rely on thresholds that have been proposed but not sufficiently validated. Therefore, users do not always take account of the following caveats in their use and interpretation of the FRI:

- The FRI is a general indication of likely average fatigue and cannot take into account the many individual factors which can make an individual more or less fatigued;
- The tool assumes that staff get sufficient, quality sleep during off-duty periods and does not take into account that staff may not have been able (or in some cases willing) to get the "assumed" amount of quality sleep;
- The FRI is for decision support rather than a way of imposing a new schedule /working pattern;
- The tool must not be used in isolation to make decisions about working hours. Information about the tasks to be undertaken and assessment of an individual's risk factors (such as previous sleep, health and wellbeing and personal circumstances) should also be considered.
- Potential biases in the tool: More recently, there has been increasing attention on the particular risk that that first night shifts represent, because they need a change in sleeping patterns, and this is not considered in the FRI (Hesketh, 2016).

The RSSB research results show that, in general, the main bio-mathematical models tend to correlate, but no one model stands out as being best or worst; the choice of method depends on intended use and operational requirements. This in itself lends further support to the advice that predictive fatigue risk assessment, as determined by bio-mathematical models, should form only one part of the FRMS. The authors propose that the FRI is used by those deemed competent in its use as a decision support tool only to help anticipate fatigue risks (i.e. predictive method) and/or inform those managing shift patterns about the impact of changes to the design of shift schedules.

Self-report measures - proactive measures

In an attempt to understand day-to-day variance in fatigue, self-report measures of fatigue and daily fitness for duty checks seem a logical approach; however, as RSSB has highlighted, it can be very difficult for a person or their supervisor to predict what their physiological and psychological state will be throughout their shift. There is a risk that safety critical workers may underestimate their risk of becoming tired, and the effect that this might have on their performance.

A useful proactive method is the Alertness Consideration Tool (Energy Institute, 2014). Originally designed for the aviation industry, the use of this tool provides a risk rating depending on the answers to questions relating to alertness, sleep, actual shift times and the risks expected during the shift. This risk rating when linked with organisation-specific mitigation measures can be a powerful way to proactively manage fatigue. Whilst customisation of this tool is not without challenge, informed and motivated stakeholders that adopt a pragmatic approach through open and honest discussion of day-to-day work demands on staff and safety critical tasks can prove beneficial. Such discussions need to consider numerous aspects including: the broader questions of thresholds for working time limits that trigger use of the tool; who is deemed competent to use it; the practicalities of whether the tool can be completed face-to-face; and how to ensure there is a user-friendly system for logging and self-checking working hours. The success of such proactive measures is particularly dependent on the prevailing safety culture and the development of trust and understanding that the management of fatigue is a shared responsibility between employer and employee.

Fatigue Investigation Tools - reactive measures

Fatigue is recognised as a contributing factor for accidents, injuries and deaths in a wide range of settings (Williamson, *et al* 2011). Published literature supports a positive association between long work hours, risk of attentional errors, accidents and/or injury occurrence, sleepiness and fatigue (e.g. Di Milia *et al*, 2011). While fatigue is acknowledged as a contributing factor for accidents, the evidence for a causal link is more complex, particularly in sectors such as aviation where individual fatigue can be partially compensated for by crew cooperation and automation (Cabon, *et al* 2012). Since fatigue is not a directly observable or objectively measurable occurrence, the role that it may play in an accident is often underestimated or potentially ignored especially when other, more obvious contributory factors are evident. As part of an FRMS, organisations need to commit to ensuring that fatigue is considered in incident investigations.

Recognising the difficulties associated with investigating whether fatigue contributed to an accident, the National Transportation Safety Board (NTSB) has developed a relatively simple methodology for investigating operator fatigue focused on four fatigue factors 1) sleep (acute loss and cumulative debt), 2) continuous hours of wakefulness, 3) circadian rhythms (time-of-day), and 4) sleep disorders (Strauch, 2015). Similarly, the International Civil Aviation Organization (ICAO) has developed a question set to help investigators explore the potential for fatigue as a factor in accidents (ICAO, 2016b). These questions are extensive and require expert knowledge to interpret, but, like the NTSB approach, they help an investigator to think about the issues that might point to a fatigue risk. Using these question sets and other good practice guidance, the authors have been able to provide bespoke questions that can be used as part of a company's existing investigation procedure to identify if fatigue might be have been an issue.

CONCLUSIONS

Whilst critics have expressed concerns that Fatigue Risk Management Systems can be overly complex, the authors have found that organisations can use them to make significant steps in fatigue management. Cultural and organisational buy-in challenges can be addressed by gaining an understanding of fatigue risk, involving the right people early in the fatigue risk management plan to inform the development of tools, foster learning around working hours and good practice and help manage expectations regarding cultural change.

It is beneficial to have an initial focus on some key FRMS elements and ensure tools/methods are used competently and with awareness of the limitations and complexities of fatigue. There are several limitations to bio-mathematical fatigue models. Whilst it is unlikely that any that any of the current fatigue models can be used in isolation to predict or manage fatigue-related risk, they can play a key supporting role. It appears it would be useful for industry if further research included improvements to available methods e.g. investigation into the benchmarks/thresholds that could be applied to models, how to improve the incorporation of factors such as quality of sleep, type of task, commuting time and breaks in existing models.

Whilst there are limitations to current available methods and gaps in the scientific literature, companies can be doing something now, because the available information is good enough to help companies predict, be proactive and react appropriately to manage their fatigue risk.

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