Some Perspectives on Fatigue Risk Management Systems

EUROCONTROL

Table of contents

1. Introduction

Shift workers who work at night, late evenings or early mornings will experience some degree of sleep deprivation leading to a fall in alertness during the duty period. For night workers, this is exacerbated by naturally falling performance that is driven by the circadian rhythm.

With the exception of night workers on oil rigs, there is unlikely to be any improvement due to adaptation. The degree of sleep deprivation varies with the individual and becomes more pronounced with aging. Although counter measures such as napping before and during duty can help, it is likely that some adverse effects will persist.

The consequence of a fall in alertness leads to slowed reaction times and reduced vigilance, poor decision making and lack of communication. In extreme cases this may contribute to incidents and accidents as evidenced by Exxon Valdiz and the Challenger space mission disaster.

Unless individuals actually fall asleep, the incident or accident is normally a combination of faulty decision making within a critical situation. In the case of the Challenger disaster, there was a technical fault in some fuel line components that caused the failure but the managers making the decision to proceed were chronically sleep deprived and failed to take into account the state of the faulty components voiced by NASA engineers. Indeed, Professor David Dinges at University of Pennsylvania states that fatigue contributes between 30 and 90% of all serious incidents across industries.

Working hours are controlled by a variety of prescriptive schemes in most countries in the world. The European Union introduced their working time directive to guide all workers apart from military personnel and aircrew; the latter having had customised schemes in place for decades, In addition, a number of unions have negotiated terms to restrict duty times to cover specific industries and occupations. All of these are based on prescriptive rules that have little or no flexibility and treat on-call duties as work duties. This creates a capacity issue as being on call is counted as duty time thereby reducing the real duty time available. Health workers are particularly affected by this approach, as medical staff can no longer use on call duties to increase their availability for work, leading to a shortage of doctors at night and during the weekends. A recent report claimed that deaths in UK hospitals increase by 10% at weekends due to the lack of sufficient doctors to cover these periods

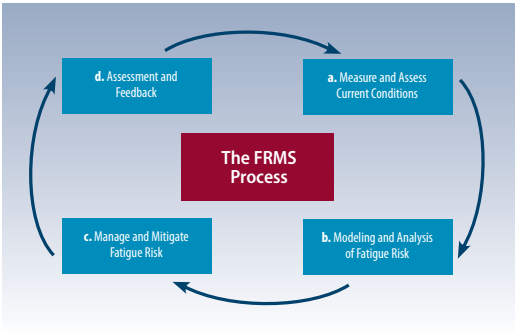
In any prescriptive rules set, there may be anomalies and in the aviation industry there are examples where less fatiguing schedules fall outside the rules yet more fatiguing alternatives are permitted.

Accordingly, there are good safety and business benefits that flow from managing employee alertness in a less prescriptive manner.

2. Fatigue Risk Management Systems (FRMS)

What they are

FRMS is an alternative to the use of prescriptive rules when managing risks that are a consequence of a reduction in employee alertness when on duty. The International Civil Aviation Organisation (ICAO) has a definition of 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.

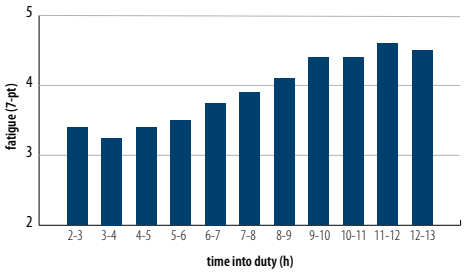
This definition can be easily adapted to reflect any appropriate occupation.

ICAO recognises that fatigue is a major human factors hazard because it affects most aspects of a crewmember's ability to do their job safely. It therefore has implications for safety. ICAO defines a Fatigue Risk Management System (FRMS) as:

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.

The key statements here are "data driven", "scientific principles" and "operational experience".

An important part of management is making sound decisions. These can only be made if the base data for them is available and of course is both appropriate and reliable. Data that is not based on scientific principles is worthless and if the decisions on good data do not take into account the operational context, then risks are run that the decisions may not be appropriate or simply won't fit. All three must be present as a precursor to getting a sound decision.

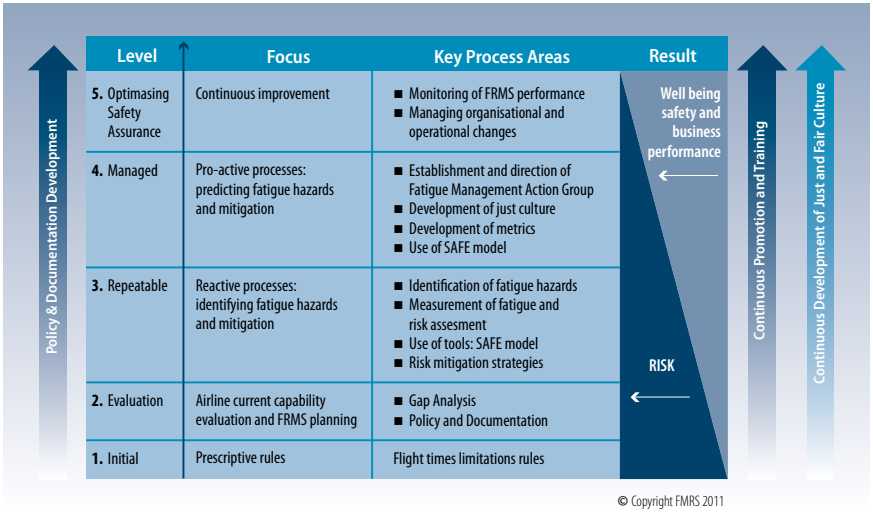


A further pillar of FRMS is the adoption of a so called Just Culture that empowers employees to make safety related decisions that impact operational performance sensibly, responsibly and without fear of retribution. An example would be if a pilot with a young family is kept

awake all night tending to a sick child, then the pilot ought to be able to responsibly alert his manager that he is unfit for duty without fear of retribution. It is clearly in all stakeholders' interests to ensure that the pilot on duty is properly rested and fit to fly.

An FRMS Model

Managing occupational alertness uses a similar approach to managing any risk. Data should be collected, compared to a preset standard and analysed within an operational context to monitor activity and highlight risks of objectives being compromised. With the right kind of data analysis by subject matter experts, an experienced decision making body can assess the risks and decide what actions are or are not necessary to return the activity under scrutiny back on track.



FRMS Maturity Model

There is a five level maturity model that can be used to demonstrate the steps required to develop an FRMS. The processes mature as each level is attained.

Throughout the FRMS maturity process, the benefits of FRMS and the progress of the project must be promoted and all stakeholders should be educated in the causes of fatigue and countermeasures. Moreover the process should be integrate into the Safety Management System and Occupational Health and Safety processes

Similarly, the organisational environment must be capable of supporting a culture where pilots are encouraged to responsibly report fatigue issues without fear of repercussions. Such Just and Fair Cultures often need to be carefully developed as the FRMS process matures else it will self

limit at a low level. All stakeholders have to act responsibly and with care to develop mutually trusting relationships that focus on the goal of creating an organisation that effectively manages its fatigue risk. It's a collective responsibility: no one stakeholder group can succeed alone.

The initial level is where every organisation starts. The organisation is relying on prescriptive regulations such as the European Working Times Directive or CAP371 in UK for aircrew for their guidance. This is already in place and the organisation reacts to these rules.

Level 2 is achieved when the employing organisation makes a choice to move outside of the prescriptive rules to manage alertness. A Policy will be written to describe how alertness will be managed; a gap analysis against industry standards or Best Practise will be completed to find areas where measures are already in place and where action is needed.

Level 3 is still a reactive level but by now the organisation is collecting data to identify the hazards and investing resources to design mitigation strategies. Part of the data gathering and analysis may include the use of a predictive bio-mathematical tool that identifies problematic duty periods for further investigation. Models are a very useful method of assessing risk quickly but are not a solution by themselves. This paper will discuss models in more depth in later chapters. Reactive metrics will be used to track performance.

At Level 4, the organisation is starting to be proactive by managing the alertness issues when they form their Fatigue Action Safety Group (FSAG). The FSAG should be equipped with Terms of Reference so they have authority to take action within a boundary, to manage fatigue. Some of their decisions may include commissioning a fatigue study to explore areas of concern. Proactive metrics will be introduced and used.

Level 5 is where the management of the FRMS process is established and the organisation is looking ahead to where hazards may emerge. Audits will be made to ensure the processes are being used effectively and appropriately and of course the processes developed to reflect the operating environment and needs of the employee and organisation.

Throughout the FRMS maturity process, there is a need for FRMS promotion, communication and education to ensure all stakeholders are aware of the subject matter, goals, progress, lessons learned and successes of the programme. More, the policy and documentation will also change as the processes mature.

In many ways, FRMS is just another management system, which focuses on alertness. It can be and should be integrated into an organisation's Safety Management Process or Occupational Health and Safety process. The management process is not complicated and reflects common, good business practise irrespective of the group being managed.

Advantages for stakeholders

There are many advantages for implementing an FRMS for all stakeholders. These include:

- Risk Reduction
  - An organisation using FRMS will be identifying hazards and reducing risk to all stakeholders.
- Educates all stakeholders to the risk and behaviours of fatigued people
  - Those at risk can be educated and take steps to mitigate the effects of fatigue whilst on duty
  - Those who engage with fatigued people will be educated in recognising the signs of fatigue and have the opportunity to change their normal approach to accommodate fatigue driven behaviours in order to be more effective in their direction, communication and management.
- Increase labour productivity, employee satisfaction and customer service levels
  - FRMS can increase labour availability and promote more employee engagement leading to a happier workforce and higher output per employee
  - Mistakes cost money to correct and are disruptive. Fewer mistakes lead to a more productive workforce that have a higher sense of achievement and pride in their work by getting things right first time; reducing QA engagement and discord with management. More, the direct and consequential costs for correction are avoided completely and customer service levels increase.
- FRMS data collection and analysis can bring issues to the surface for resolution before annual pay award negotiations thereby making the employee group - management interaction more cordial.
- Managing sick leave
  - FRMS focuses on fatigue related sick leave data, which should reveal issues with particular shift and highlight sleep disorders. Management action can then be brought to bear to resolve such issues.

- Increase flexibility
  - What happens on the day is different to what is planned. FRMS will give the personnel or scheduling department the tools to adjust duty periods or if appropriate by choosing stand by staff according to least level of fatigue. The availability of statistics and information will assist with managing the events on the day thereby increasing flexibility of an operation.

Some Myths

- FRMS is costly to implement
  - If an organisation wishes to work outside of the prescriptive rules, the risk has to be managed. Any FRMS that is installed must be appropriate for the risk. Evidence so far shows that once installed, an FRMS can offer a good Return on Investment. One low cost airline employs five people in its FRMS group that have identified significantly more savings than their cost.
- FRMS will give more power to unions or will give more power to organisations to make employees work harder
  - Transparent data means that both sides will have firm evidence to make their decisions and agreements. The issue is not about working less or harder compared with current regulations; it is more about ensuring that the correct capacity for the planned duties exists within an acceptable envelope of safety.

- An FRMS can be considered as simply buying a model and believing its predictions
  - There is more about models later in this paper but a model can only apply to the average outcome of any operation and do not always apply to the performance of an individual. Models are an excellent way of rapidly identifying problematic areas and assessing likely fatigue related scenarios. However, by themselves, they only provide one aspect of hazard identification and **certainly are not an FRMS**.

3. History of FRMS

The first study of the effect of sleep deprivation in humans was published in 1896. It was not until the first use of the electroencephalogram by Berger in 1928 that the differences between brain activity when subjects were asleep or awake was first recognised. Later in the 1930's scientists at Harvard University first reported the major elements of the Electroencephalographic measures of sleep. But it was not until the 1950's that Kletitman and his colleagues discovered Rapid Eye Movement (REM) sleep.

Shortly after the discovery of REM sleep, the cyclical nature of sleep was recognised with REM and non-REM sleep alternating in intervals around 90 minutes. During the 1960's there was a focus on research on sleep disorders with discoveries of narcolepsy and sleep apnoea.

The discovery and use of benzodiazepines and their use in the treatment of insomnia also began in the 1960's. The other important development was the recognition of the intrinsic nature of circadian rhythms in humans with isolation studies in the 1960's establishing the existence of free running rhythms in man even when isolated from time cues.

In the 1970's there was an explosion of research into sleep performance and fatigue. In the early 1980's there were congressional Hearings on Biological Clocks and Shift work scheduling. The first International Shift work symposium was held in 1979 in San Diego. The recognition of the effects of fatigue on safety can be seen from the number of Federal Investigations of fatigue related accidents in transportation and other industries since 1984. Since drink driving laws have been enacted fatigue related accidents are recognised to be the largest preventable cause of accidents on the road.

In order to minimise the risk of fatigue of shift work and airline schedules most countries introduced various prescriptive rules to govern hours of work. However in the 1980's in Australia there was a move away from a prescriptive approach and the regulator became responsible for driving and enforcing the process and not for the solution. This was essentially the birth of The Fatigue Risk Management process.

In 2002 the New South Wales Rail Safety Act adopted Fatigue Management processes as a regulation. This incorporates Fatigue as a workplace hazard to be controlled, Duty of Care for managers and employees and Medical pre-placement requirements all within OH&S legislation. Duty of care is within a shared responsibility model.

4. The FRMS Forum

In 2009 staff at QinetiQ realised that despite best efforts from a number of individuals in aviation, the concept of FRMS was not gaining much traction. The Regulators were speaking about creating guidelines but few airlines were doing more than waiting and watching to see if regulations would be enacted to encourage organisations to consider this approach.

It was clear that a major blockage to even the exploration of what FRMS entailed was cost. Airlines simply did not see the advantages to them and with the daily pressures of operations most airlines did not prioritise let alone budget for any formal or informal exploration of the subject.

A very few airlines had already started implementing FRMS at that time so QinetiQ approached easyJet, Virgin Atlantic, Air New Zealand, Delta Airways and UK Civil Aviation Authority with the idea of a Forum to offer very low cost access to basic information and guidance on implementing FRMS.

The objective was to deliver a low cost method whereby those with some experience could share their knowledge with those who wanted to explore the subject to understand the benefits, costs and processes in order to evaluate whether FRMS would be beneficial and gather enough information to write a business case for investment to take exploration further.

In May 2009, an initial meeting was held at QinetiQ where 52 of the 83 registrants heard presentations on the subject from European Aviation Safety Agency (EASA), easyJet, QinetiQ, Civil Aviation Safety Authority (Australia), Air New Zealand and Flight Global. This was designed to demonstrate the information and experience that was already available to share. The audience agreed to create the Forum with a set of Guiding Principles and a budget primarily to fund a website. A management committee was elected.

Membership was open to any organisation who is genuinely interested in contributing towards the, development, implementation and promotion of best practise in FRMS. Typical members would be airlines, rail companies, Employee groups, Independent FRMS consultants, rostering software suppliers, fatigue scientists and regulators.

Since then a number of meetings have been held to assist members to understand what FRMS entails, how to start exploring what to do and what benefit any organisation will derive from adopting this approach. These networking events are very valuable and free of charge to attend for any delegate from any member organisation.

The Forum[1] is an inexpensive way to explore the subject, learn about how some organisations are approaching the implementation of FRMS and sharing lessons learned. This organisation is free of commercial interest and is apolitical.

[1] You can learn more and join on line at www.frmsforum.org

5. Status of FRMS in Aviation

Status in Regulators

ICAO formed a task force comprising airline operations, aviation medicine and sleep science to create guidelines[2] for airline operators and the regulatory community. They announced their guidelines on 30th and 31st August 2011 and released them for adoption by member states on 15th December 2011

EASA plan to follow the ICAO guidelines and enact these regulations into European Law during the second quarter of 2012. It is likely that EASA will permit the introduction of FRMS as an alternative to new prescriptive rules that are about to be introduced. They will however, insist that if FRMS is chosen then a full FRMS must be adopted and audited.

This precedent having been set by EASA, it is highly likely that other industries may be allowed to propose an FRMS alternative to the European Working Time Directive. Indeed, the UK Rail industry is well advanced in considering this approach.

The Federal Aviation Authority (FAA) announced their new rules on 21st December 2011 after publishing their draft proposal on 6th December 2010. That proposal was a mixed bag: work hours would be shortened for pilots who fly at night, while some pilots who fly during the day could be required to spend more time on duty. Pilots would be required to have a minimum of nine hours off to rest between work shifts, one hour more than under present rules.

The new rules allow pilots to have 8 hours rest excluding travel time and include accommodation of a request to be excluded from night freight operators. Cargo operators may opt in if they wish to. Airlines have two years to make arrangements to comply with these rules

UK Civil Aviation Authority (CAA) is already at the forefront of FRMS implementation and was part of the ICAO task force. They have already aligned their processes with ICAO and EASA guidelines and are ready to receive FRMS applications from airlines

Other European National Aviation Authorities are less prepared and most are either at the start of understanding the guidelines or at best, working with local airlines.

Chile is the most advanced regulator in South America with Argentina and Brazil not too far behind whilst in South East Asia, Malaysia and particularly Singapore have made strong progress ahead of the other countries

[2] These publications can be found though a link on the www.frmsc.com website. Click on the "Guidelines on Fatigue" button at the foot of the page.

Status of FRMS in the Airline Industry

In general there are a few early adopters in the airline industry who have embraced FRMS with others starting to move in this direction. The most experienced practitioners kindly offered their help to set up the FRMS Forum and serve on the management committee. Since then, others have taken their first steps in this direction and the move to adopting FRMS is slowly becoming a reality.

The main adopters are either large airlines or low cost carriers. They see the need to adopt FRMS to improve safety but more, their drivers are either to avoid corporate risk by becoming compliant to the regulations to or to use FRMS as a way of getting a higher productivity leading to an improvement in business performance.

Airlines wish to use FRMS as a way to improve safety whilst improving their business. In this very competitive business, there are few competitive levers at an operator's disposal. The management of occupational alertness is one of the few that delivers both safety and business improvement together.

Airlines may point out that prescriptive flight times regulations puts everyone on the same level playing field but each airline has a different approach to building their business. By demonstrating their knowledge of the fatigue risk and their robust management of it, airlines can apply for derogation from their National Aviation Authority and take a productivity advantage from this increase in flexibility.

The early adopters who have taken this step include Air New Zealand and easyJet.

easyJet required derogation to open up a new market: taking businessmen across Europe in time for the start of the working day and returning them after the day's business was completed. For the pilot, this translates into late finishes followed by early starts – a combination that interfered with obtaining sufficient sleep.

Following a series of studies directed by their safety manager, Captain Simon Stewart, derogation was approved and easyJet is now one of the most advanced practitioners of

FRMS in the world. They have invested a considerable amount in their small FRMS team that comfortably makes a positive return to both airline safety and the bottom line for the low cost carrier.

Similarly, Air New Zealand introduced a Fatigue Safety Action Group in the early 1990s as a response to a series of persistent complaints about certain schedules. They invite independent fatigue scientists to sit on this panel. They were an early collaborator with DERA in allowing their data to be used to validate the SAFE model which they use extensively. They have developed a particularly powerful dataset from top of descent studies and have significantly decreased the reported incidences of fatigue.

Cargo airlines are most interested in the FRMS concept given their normal night operations though the American carriers are in discussions with FAA to make amendments to the FAA NPRM proposal. DHL has already implemented FRMS and FEDEX too is making progress. In Europe, Cargolux has been a strong follower of the subject and is engaged in data collection.

There seems to be little exposure to FRMS in the corporate jet sector though Net Jets have been closely following the subject for at least four years and gave a presentation on their progress at the FRMS Forum meeting in Montreal in 2011. Their presentation is on the Forum website[3].

Around the world some of the largest or more competitive airlines are exploring and adopting FRMS into their operations. There is a huge interest and most airlines are at least considering what to do and making plans to do it but a few such as Delta, Continental-United, US Air, Malaysia, Qantas. Emirates, GOL (Brazil), LAN (Chile and Argentina), Etihad and DHL have actually started the implementation process whilst some such as Air New Zealand, DHL, Germanwings and easyJet are very advanced.

As expected, it is the larger airlines that are investing in FRMS on almost every continent. Clearly, there is a regulatory driver at work but as the experience grows, airlines are becoming aware that there is a very good safety and business reason to invest in a process that also improves business performance.

Managing occupational awareness makes good business sense.

[3] http://www.frmsforum.org/meetings_and_conferences/september_2011_conference/index.html

Studies in the aviation domain

The first study of the sleep of an airline pilot was published by Professor Tony Nicholson of the Institute of Aviation Medicine (IAM) in the UK in 1970. He recorded the sleep reported by a single pilot as he flew round the world. In this early study the pilot reported the use of naps on-board when workload was low and the co-pilot was flying the aircraft. Fragmented layover sleep was also observed. It was not until the 1980's that IAM scientists together with colleagues from Germany, Japan and the US made the first EEG recordings of sleep and alertness of aircrew on layover after long haul routes. NASA coordinated these studies.

IAM, supported by the UK CAA, continued to gather data on aircrew sleep and alertness in long haul and short haul operations. The advent of portable EEG recorders allowed the scientists to monitor the sleep of aircrew in bunks on board aircraft during long flights when extra crew allow crews to rest. These recorders also allowed the monitoring of sleep in layover hotels rather than in sleep laboratories. This work continued when the IAM scientists moved to DERA and subsequently to QinetiQ. The aircrew studies were supplemented by a series of laboratory investigations on naps and the effect of noise and light. Later studies used actiwatches (movement monitors) and diaries to record sleep patterns and alertness.

Other groups in Germany and the US that were involved in the early NASA coordinated studies carried out other investigations of aircrew sleep and alertness. Dutch, French and Swedish scientists and later studies in Australia and New Zealand later joined these.

Flight attendants have an important role to play in aviation safety and Finnish, Swedish and UK scientists have monitored their work and rest patterns. Their work not only involves reduced sleep with subsequent effects on alertness but

also physical fatigue associated with their duties.

Another important group for air safety are the aircraft engineers who maintain the aircraft. Some of their work involves night shifts when aircraft are available. Long night shifts of around 12 hours are frequent and Professor Simon Folkard of the UK carried out a study for the CAA and identified some of the problems associated with extended night shifts.

Baggage screeners are responsible for ensuring that dangerous articles do not reach the aircraft and performance, at what is essentially a monotonous task, can be improved by inserting computer generated simulated threats. Time on task is also strictly controlled so that vigilance is controlled. Shift swapping allowing back-to-back shifts is a potential problem for this group.

Air traffic controllers are also required to maintain high vigilance and time on screen is also restricted to ensure that reduced alertness does not lead to diminished performance. Studies by scientists at IAM emphasised the importance of breaks to this group. Some groups of air traffic controllers are allowed to sleep for short periods in order to maintain their performance on the night shift. Recently, in the US this problem has received a large amount of media attention after a controller fell asleep on the night shift and US controllers have been forbidden to take naps. It is not only cognitive performance and vigilance that are important for ATCOs. Sleep deprivation also leads to reduced communication between individuals

This might represent a critical area, as it is suggested by the fact that communicative failures are implied in more than 70% of incidents and accidents in air navigation. In 2001 Corradini and Cacciari investigated the extent to which the structure of controller's communications varied relative to work shifts (morning, afternoon, night) and workload level. In particular, they focused on ambiguity, deviations from standard phraseology and possible misunderstandings.

Communicative patterns and accuracy were significantly different according to shifts and workload: while communicative deviations increased during the nightshift and with a low workload, the best performance was found in the morning shift.

UK Rail Industry

The Rail Safety and Standards Board (RSSB) are working closely with the Office of Rail Regulation in the UK to create guidelines on managing fatigue in the UK Rail industry. Both organisations have created outline guidelines and have submitted them to their respective committees for comment. The RSSB sponsored studies by QinetiQ of the effects of shift patterns in train drivers and trackside workers.

The FRMS Forum approached the UK rail industry to develop a division dedicated to the rail industry. Given that the RSSB has a mandate to deliver similar services, both sides agreed to collaborate closely and share information. RSSB hosts similar guidance and information on their website for the UK rail industry.

6. MODELLING

Biometric models exist that predict likely fatigue within a population. Some are generalist and some more specific in their target audience. Some were based on new research whilst others have used the published research to build their models.

In the early 1980s The Institute of Aviation Medicine (IAM), (subsequently DERA and QinetiQ) carried out its first series of studies for UK Ministry of Defence simulating the work rest patterns of aircrew involved in continuous and sustained operations. The information from these studies was used to create a three-process alertness model incorporating time since last sleep, sleep inertia and time of day

At a similar time in Switzerland, Professor Alex Borbély was working on his two-process model of sleep regulation covering time of day and time since last sleep. Other scientists in the world learned from the resulting publications and a number of models started to emerge.

During the 1980s the UK CAA funded IAM to carry out a series of studies of aircrew sleep and circadian rhythms in collaboration with NASA, Stanford University, the German aerospace Centre (DLR), University of Tokyo and a number of airlines. Separately, IAM continued these studies for CAA alone in collaboration with a number of worldwide airlines conducting studies that included bunk sleep, round the clock operations, early starts, late finishes and cargo operations.

The UK Civil Aviation Authority approached IAM in the early 1990s to discuss their issue with authorising new routes for airlines and in particular the management of fatigue as they recognised the growing problem in aviation. Recognising that some of the basic science and aircrew studies were already in place, they agreed to fund IAM to continue their work and develop their fundamental model for specific application in the aviation industry.

More studies were completed and the first model, then called System for Aircrew Fatigue Evaluation (SAFE[4]) was used by the UK CAA in 1998. Then version 2.09 was released in 2001 for comment by regulators and airlines worldwide. Since then, a stream of studies of short, long and ultra long haul routes has been conducted to improve the algorithms and usability.

[4] http://www.frmsc.com/the-safe-model-2/the-safe-model-2/

In 2004 Airbus approached QinetiQ to help resolve an operational issue concerning the current Flight Times Limitations rules that would not allow flights of more than 16 hours. They proposed to introduce the A340-500 that was capable of operating for 20 hours. By extrapolating the SAFE model, city pair scenarios were modelled and that suggested such ultra long operations would be no more fatiguing than some existing long haul operations providing that the four aircrew attained good on board sleep.

Subsequently, these results were compared with the results of studies to capture the actual alertness levels and sleep patterns during the first six months of ULR operations between Singapore and Los Angeles and then between Singapore and New York. The findings showed a high correlation between the SAFE predictions and the actual alertness levels

SAFE remains the only model validated for aircrew.

During the early part of the 21st century, QinetiQ developed the base model for another group of users: shift workers and drivers of locomotives. The Fatigue Risk Index was developed with UK Health and Safety Inspectorate support. In these applications there is no need for trans-meridian algorithms so the model is not as complex.

From 2011, SAFE and the Fatigue Risk Index are licensed to Fatigue Risk Management Science Limited (FRMSc Limited[5]) for development and market supply.

During the early 2000s, the Karolinska Institute in Stockholm was developing their own three-process fundamental model. They published the results of their studies in 2004.

Australia has a particular set of fatigue issues related to their transport industry due to long rail and road distances and travelling time to mining operations. In 2004 Gregory Roach and Professor Drew Dawson at University of South Australia announced the development of the FAID model based on their laboratory studies and measures of transport and shift workers, which is marketed by Interdynamics pty. The model is designed for local applications in Australia, which were predominantly for the road transport and mining industries. Since then, the model has been introduced to the airline industry but until recently did not have any time zone transition algorithms to accommodate transmeridian flights. The population it was designed for has different workloads to airline pilots but it was amongst the first to be developed and sold commercially.

[5] www.frmsc.com

In the USA, Institutes for Behaviour Resources (IBRINC) and Circadian Inc have developed similar models. The SAFTE model from IBRINC is based on sleep disturbances and has been validated for shift workers and the rail industry though it has been applied to military aviation within the USA. The Circadian Alertness Simulator is validated in the shift-working context. Both models are offered for use in the aviation domain.

Boeing too has an offer in this space. Their Goteborg located Jeppesen division supplies many airlines with management programmes that include pairing and rostering modules. Jeppesen is working to embed fatigue models in their rostering programmes to optimise for minimum fatigue. They also supply their CFAS service to analyse rosters using the fundamental fatigue model developed by the Karolinska Institute, which they market as the Boeing Alertness Model (BAM).

EUROCONTROL has done some work in creating the FIT model and has published, "When are you too tired to be safe? - Exploring the construction of a fatigue index in ATM" by Nuno Cebola, Lisbon University Institute (ISCTE-IUL); Andrew Kilner, EUROCONTROL. This work uses and refers to the work completed for the Fatigue Risk Index and SAFE by Mick Spencer of QinetiQ.

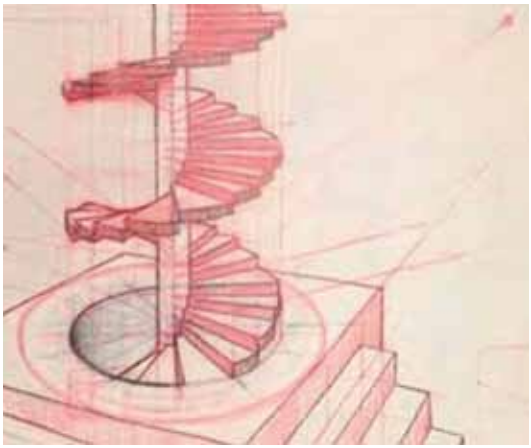
On choosing a model

When choosing a model the usability and features that flow from a requirements specification are normally the main focus. However, the following attributes are particularly important

- Robust science
- Criteria and robustness of validation for use in a given domain
- Interactivity: ability to adjust actual sleep and work pattern values to enable users to explore alternative solutions to discover the best fit for their problem.

7. SUGGESTED INITIAL STEPS WHEN STARTING TO EXPLORE FRMS

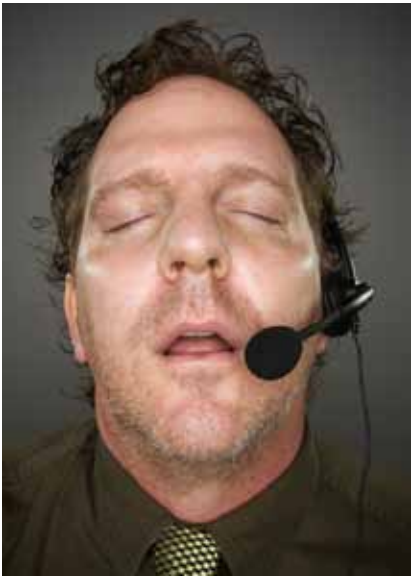
Finding the starting point in exploring FRMS can be daunting. It is recommended that the following actions be considered



- Consider the FRMS Forum as an inexpensive way to get access to a library of papers that will give the background to the subject and some examples of what implementing benefits FRMS will bring to an organisation. View articles, handbooks, and PowerPoint presentations and attend the conferences to network with like-minded individuals. Use the network to discuss how to approach FRMS and swap experiences.
- Analyse rosters. Running a month's worth of rosters through a model will show likely problematic areas and provide the initial evidence of likely alertness issues with employees that can then be supported with other data collected by interview.
- Consider some initial advice from FRMS and airline scheduling consultants to prepare your business case document.
- Obtain basic, introductory and overview training on FRMS systems and methodologies to support additional management decision-making.

8. SUMMARY

Fatigue Risk Management Systems are a proactive alternative to prescriptive rule sets. They place the onus on the organisation to demonstrate that any proposal they may have that takes their operation out of the prescriptive rules, is no less fatiguing than if the operation stayed within the rule set.



This provides organisations a way to become more flexible in their operations and thereby improve their business performance. However, FRMS is not for every organisation. Some will happily continue to remain within the prescriptive rule set. One can imagine that those more competitive organisations that are looking for greater degrees of flexibility with which to create a competitive edge will adopt FRMS. This may oblige others to follow their direction if only to remain competitive so the commercial imperative will deliver greater safety.

Society is moving towards a 24/7 culture and so those who are increasingly required to work outside the normal working day or cross time zones will require a management framework with appropriate tools and processes to assure safety. As things stand, the aviation industry is blazing the trail with FRMS but other industries, notably other transportation, health and nuclear fuel related industries are following the experience of the aviation industry and in turn, will most certainly be followed by the financial services industry.

The aviation industry is in the vanguard of developing tools and processes to create Best Practise in FRMS from a robust scientific base. There is still much research to pursue in this subject but already, great progress has been made, particularly in the last decade.

FRMS is likely to be adopted in one way or another in many industries where safety critical occupations exist as managing occupational alertness makes good business sense.

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