PROBLEMS OF CREW FATIGUE MANAGEMENT IN AIRLINE OPERATIONS

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Abstract: Crew fatigue is increasingly recognised as a major threat to air traffic safety. Although there is plenty of research in risks related to human fatigue in different industries, more research is needed to precisely establish the correlation of crew fatigue and risk in airline operations. Current practice of fatigue risk management through appliance of flight time limitations has proven inadequate. On the other hand, the emerging methods of systematic fatigue risk management are heavily dependant on organisation’s safety culture. Our work outlines the basic principles of risk management, observed problems of flight time limitations scheme, anticipated problems of fatigue risk management system and proposed solutions.

Key words: air traffic, fatigue, flight time limitations, fatigue risk management system, safety culture

1. Introduction

15-20% of fatal accidents related to human errors have pilot fatigue as a contributing factor. 160 people died in 2010 in an accident in India and 52 people in 2009 in an accident in the USA. Fatigue played a decisive role in both cases. Fatigue is a reality in Europe’s cockpits today. 50-54% of pilots recently surveyed in several EU countries said they had already fallen asleep in the cockpit (Pilot fatigue).

Current practice of fatigue risk management through appliance of flight time limitations has proven inadequate, but the emerging methods can also fail, if the possible problems are not addressed in time.

2. Fundamentals of Sleep Science

There is plenty of knowledge in risks related to human fatigue, but the format of this paper does not allow us to address it in detail. However, some fundamentals (Caldwell and Caldwell, 2003) have to be mentioned before progressing to applications in aviation.

Fatigue is a function of three basic interconnected parameters:
- Sleep inertia – a short-term feelings of grogginess and disorientation, occurring when someone is woken up suddenly;
- Circadian parameter – a present position of peson’s “body clock”;
- Homeostatic sleep pressure – the body’s need for slow-wave sleep, a function of time passed since last sleep.

All three of these parameters are further modulated with personal differences.

3. The Relationship between Fatigue and Fatigue Risk in Aviation

Throughout history, technology has outpaced human ability to adapt. Operating an aircraft produces fatigue, sleep loss and inurement of circadian cycle, initiating (Cabon, 2011):
- Microsleep (Eurocontrol, 2005) – short periods (several seconds or less) of total perceptual disengagement. Microsleeps are possible during critical flight phases, such as take off or landing.
- Prolonged reaction time.
- Instable cognitive ability (greater performance variations)
- Divergent processing (creative, inventive problem solving) – under greater influence than convergent processing (rule-based and check-list based problem solving).

Environmental factors, such as limited space, reduced airflow, background noise and vibrations in aircraft cockpit, are also contributing to fatigue. Besides, the increased cockpit automation has fundamentally changed the tasks pilots face. Manual handling has been substituted with systems monitoring, a low-effort task which throught extended time bears boredom. This implies the automation increases the symptoms of fatigue and sleep loss.

Different operational environment brings different operational demands, performed in different regulatory frameworks and by different populace. Therefore, every operational environment represents specific psychological challenges to people involved.

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The most notable examples of different operational environments:

- **Short haul flights** are specific for high number of sequential short flights, often with long duty days, short-spaced high-intensity workloads (take-offs and landings) with high proportion of time in the dense terminal zones. Additionally, these duties usually start very early or end late in the night. Long flight duties combined with periods of circadian low can result in degraded human performance. On the other hand, short haul flights require almost constant cognitive processing. Fatigue related risks in short haul operations are degraded cognitive and psycho-motorical abilities, which represent a partial pilot incapacitation. Full incapacitation (sleep) is not likely to occur.

- **Long haul flights** are characterised by long flight duties with long period of low workload. These duties are usually accompanied by a change in time zones, often during local nighttime. Fatigue related risks in long haul operations are mainly related to probability of one or both pilots falling asleep.

**Jet lag** syndrome is a continuous problem for long haul pilots. Crewmembers do not spend enough time in one zone to be able to adapt. A routine change of time zones produces a chronic jet leg, compromising the ability to stay awake and alert. Additionally, a cockpit environment restricts body movement while low light and high automation demotivate alertness.

The other problem associated with circadian rhythm disruption is **work in shifts** and at night. Non-standard and variable work schedules require awareness during normal sleeping hours and sleep during normal hours of activity. This is called Shift Lag. Although the symptoms with Shift Lag are similar to Jet Lag, the problems last longer because the local time cues are opposed to one’s circadian rhythm. Circadian rhythm disruption in shift work is present in:

- night shifts
- early-morning shifts
- change of shifts.

4. Methods of Fatigue Control in Aviation

4.1. Flight Time Limitations

Crewmembers' work hours are regulated by flight time limitations (FTL). These limitations prescribe in detail maximum amount of time on duty, cumulative time on duty, flight hours and minimum rest periods. For example, European FTL rules (EC, 2006) prescribe maximum flight duty time as 13 hours, reduced if encompassing a window of circadian low (0200-0559 LT), and further reduced by 30 minutes for each additional sector after the third. The rest period before start of flying duty must be minimum 12 hours or the length of previous duty, whichever is greater.

Therefore, the main aim of the FTL concept is to ensure the control of fatigue risk by providing equal rules for all. However, it is applied on one-size-fits-all principle. Significant differences between different kinds of operation (long or short range; mainline, charter or general aviation) are disregarded. Also, the concept assumes a linear relationship between working hours and fatigue.

In its application, another major disadvantage emerges: these rules are crew planning target, not guidelines. They represent a legal line dividing what is safe (a flight duty time lasting 13:00 hours) from what is unsafe (a flight duty time lasting 13:01 hours). Can it be concluded that fatigue risk is acceptable for 13:00 and unacceptable for 13:01. Of course not.

Flight time limitations do not take into account (Stewart, 2009):

- Sleep opportunity and quality linked to crew traits and lifestyle;
- Fatigue risk associated with flexible shift patterns where it is more difficult to obtain sleep;
- The ability to perform complex tasks safely when sleep deprived;
- Risk associated with the flight before roster generation e.g. weather, ATC, route complexity, crew experience; aircraft serviceability;
- Workload on the day (task demand and number of block/duty hours programmed) and operational hassle factors (delays, aircraft AOG, complex and congested airspace) 4;
- That the protection of being “legal” does not necessarily equate to being safe.

To conclude, due to described deficiencies every operator and/or authority must determine if a specific rotation (combination of flights within single flight duty) is safe, even if it fits into FTL scheme. Again, a rotation legal under FTL is not necessarily safe.

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4 Operational hassle factors also include the availability of equipment on ground and weather. Ground equipment (e.g. ILS) defines the possibility of automation. Weather factors not only present risk in itself but significantly contribute to fatigue accumulation (e.g. prolonged turbulence).
4.2. Fatigue Risk Management System

Science and experience have clearly shown the fatigue risk in aviation must be managed better. Shortfalls in current regulatory practice must be corrected and guidelines to operators must be established how to set a safe system.

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.

FRMS is an integral part of Safety management system (SMS) and it also shares the building blocks of SMS.

The Fatigue Management SARPs (Annex 6, Part I and Appendix 8) prescribe components that must be in an FRMS, and the ICAO guidance material provides further information on how an FRMS should function. Annex 6 prescribes state regulations for fatigue risk management. This implies primarily to FTL, but also leaves provision for implementation of FRMS:

4.10.2 The State of the Operator shall require that the operator, in compliance with 4.10.1 and for the purposes of managing its fatigue-related safety risks, establish either

a) flight time, flight duty period, duty period and rest period limitation that are within the prescriptive fatigue management regulations established by the State of the Operator; or

b) a Fatigue Risk Management System (FRMS) in compliance with 4.10.6 for all operations; or

c) an FRMS in compliance with 4.10.6 for part of its operations and the requirements of 4.10.2 a) for the remainder of its operations.

Therefore, the implementation of FRMS is not mandatory if an operator chooses to conduct its operations within prescribed flight time limitations. It is however recommended. The reason why most operators choose not to run an FRMS is simple – extra costs. Although, the benefits are hard to measure before the system is implemented, this comes down to a safety classic of productive versus protective functions of an organisation (Reason, 1997). The main advantages of FRMS implementation are (Stewart, 2009):

- avoiding pitfalls of FTL (as described above, but also);
- FRMS gives you measures of fatigue risk exposure;
- Safety links to commercial interest via brand protection;
- Facilitates increased rostering flexibility and workload balancing;
- Better packaging of work time and time off;
- Company insurance premiums are linked to risk signature;
- Reduction in frequency of medium and high risk events;
- Reduction in oversight from the regulating authority;
- Reduction in attrition (...);
- Reduction in fatigue lost duty days and sickness incidence due fatigue related factors.

5. Important Aspects of FRMS

5.1. FRMS Education and Trust

FRMS is focused on human performance and limitations. Therefore, the two most important FRMS building blocks are:

- Training and information sharing – a continuous training of all relevant stakeholders: crewmembers, crew schedulers, dispatchers, operational decision-makers, all members of Fatigue Action Safety Group (ICAO, IATA, IFALPA, 2011); and personnel involved in overall operational risk assessment and resource allocation. It also includes senior management, in particular the executive accountable for the FRMS and senior leadership in any department managing operations within the FRMS (ICAO, IATA, IFALPA, 2011).
- Effective safety reporting based on generative safety culture. There must be adequate trust and respect among all relevant stakeholders. Management must trust their crewmembers to responsibly utilise their rest opportunity and not to abuse the reporting system for industrial reasons. Crewmembers must trust their management to use FRMS primarily to enhance safety, not profit. Authority must trust the operator to run the system in safe, generative manner.

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1 Fatigue Safety Action Group (FSAG) – A group comprised of representatives of all stakeholder groups (management, scheduling, crew representatives) together with specialist scientific, data analysis, and medical expertise as required), that is responsible for coordinating all fatigue management activities in the organisation.
One example of training is a changed perspective on in-flight naps (UK CAA, 2003), or “controlled rest on the flight deck”, as ICAO, IATA and IFALPA prefer to call it. Controlled rest on the flight deck is an effective fatigue mitigation for flight crews (ICAO, IATA, IFALPA, 2011), keeping or restoring attention, performance and emotional state. If fatigue is experienced during flight operations, as little as 15 minutes of napping can significantly help. While historically viewed as a sign of laziness, in-flight napping is today recognised as a very powerful tool for fatigue control.

The example of enhanced understanding of fatigue science in crew planning is a consideration of “sleep gates” - periods when it is easier to fall and stay asleep and periods when this is very hard (forbidden zone).

![Schematic representation of time periods favoring sleep onset](source: Cabon, 2011)

Most of the training is actually a promotion of the system: building trust and reporting culture. This is a joint part of FRMS and SMS. Continuous education and awareness retention of management is at least as important as the education of operational personnel. If the management sees FRMS primarily as a productivity enhancement tool, the system will have a negative impact on safety. Not only will fatigue risk be sustained or even worsened, but the safety culture will be eroded, which will have a secondary impact on the entire SMS.

This leads us to the component that crucially determines FRMS utilisation and success: trust.

### 5.2. Measuring Fatigue

Fatigue is operationally defined …

- Subjectively by self-report, e.g., “I am tired.”
  - Karolinska Sleepiness Scale (KSS)
  - Samn-Perelli Fatigue Scale
- Objectively by degraded performance, for instance
  - Psychomotor Vigilance Task (PVT)
  - FOQA-derived metric

FRMS is actually mostly based on subjective fatigue reports, which is why reporting culture is crucial to its success. Besides fatigue reports, there are various computer applications for duty schedule analyses (e.g. FAID) utilised to analyse certain flight rotations or monthly schedules.

Since FRMS is data-based, more research is needed to develop standardised fatigue risk indicators. More operational feedback from the operators would create a collective experience database.

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Not usable on short-haul flights
6. Some problems with FRMS

Finally, a question must be asked if FRMS can provide an “equivalent or greater level of safety”. There are several problems associated with its successful implementation or with the concept as a whole. Some of them are:

1. The prerequisite for safe FRMS is a well developed safety culture, which itself is unregulated.
2. FRMS will always shift the system from protective to productive. Otherwise it will not be implemented.
3. FRMS is a form of self-regulation, which can inherently be unsafe.
4. The core process of FRMS is safety assessment, objectivity of which is questionable.
5. Any form of fatigue self-assessment is of questionable value.

6.1. The Prerequisite of Safety Culture

It is undoubtedly agreed that “both SMS and FRMS rely on the concept of an ‘effective safety reporting culture (ICAO, 2009; IATA, 2009), where personnel have been trained and are constantly encouraged to report hazards whenever observed in the operating environment’” *(ICAO, IATA, IFALPA, 2011).

It would therefore be logical to expect the legal requirement for a ‘effective safety reporting culture’. There is none. In fact, there is not even an industry standard, no widely accepted measuring method (Steiner et al., 2009). With approval to switch from FTL to FRMS, an authority provides guarantee to travelling public that the system is safe. But, how can it guarantee a specific operator's FRMS is safe if it cannot guarantee it has a ‘effective safety reporting culture’?

6.2. The Balance between Productivity and Safety

Under current provision, an operator gets to choose whether to stay with FTL or switch to FRMS, with possibility of just switching a part of its operations. While the justification of extra costs was stipulated in chapter 4.2, it is worth addressing this issue from the perspective of historical safety management.

With resources always limited, management must always balance between production and protection (Reason, 1997). With results direct and immediately visible, there is a tendency for an organisation to drift to more production and less protection. Experience had therefore always shown (not just in aviation but in every conceivable industry) that an invention, even if it is a purely safety device, always ends up enhancing production, while safety remains on the previous level – better protection simply allows an organisation to exploit areas previously deemed to risky.

There is no reason FRMS would behave differently. It will ultimately evolve into production enhancing tool.

6.3. The Deregulation Controversy

Switching from prescriptive (FTL) to performance-based (FRMS) regulation is a form of deregulation, also known as self-regulation. It is a current trend in many industries and promoted by aviation authorities not just in fatigue control but in other areas of risk control. While it is still early to know what effect will self-regulation impose on aviation safety, it is possible to compare to other industries, where self-regulation concept had a longer chance to prove itself. The most current example of self-regulation is deregulation of financial sector and the resulting financial crisis. What had brought the world financial banking system on the brink of collapse were: complex products, lack of adequate and sufficient oversight (partly due to lack of expertise), deregulation and wrong incentives (where bonuses are calculated based on short term profits even if it means risking the company on the longer term) (Lewis, 2011; Stiglitz, 2010).

There is a large literature in economics and political science describing how regulators often get “captured” by those they are supposed to regulate. In the case of self-regulation, capture is obvious (Stiglitz, 2010).

There are many other examples in other industries (Deepwater Horison oil spill, Three Mile Island disaster, Ford Pinto etc...) that show self-regulation does not work. Sometimes, the financial companies (and other corporations) say that it is not up to them to make decisions about what is right and wrong. It is up to government. So long as the government hasn’t banned the activity, a bank has every obligation to its shareholders to provide funds so long as its profitable to do so (Stiglitz, 2010). The government (by responsible agency) has obligation to its citizens to adequately regulate every industry. FRMS must not become self-regulation.

6.4. The Objectivity of Safety Assurance

The core operational activities of the FRMS are the FRM processes and the FRMS safety assurance processes (ICAO, IATA, IFALPA, 2011). The core activity of FRM is assignment of a certain risk level within probability/severity matrix. The risk is then proclaimed acceptable or not. No matter how the matrix is defined, its categories are not numerical, but rather fuzzy: for example, probability is frequent to extremely improbable, severity is catastrophic to negligible. This brings risk assessment down to “educated guessing”.

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While there is nothing fundamentally wrong with “educated guessing”, it is crucial who does it. It was already mentioned the management would be production-oriented, while crewmembers would incline to less work and more safety. The risk assignment would be biased accordingly. Therefore, there should be a representative(s) of crewmembers among the risk assessment group.

6.5. The Objectivity of Self-Assessment

One of crucial inputs for FRMS safety assurance process comes from crewmembers questionnaires, reports and surveys, self-assessing the level of fatigue. This information is inevitably subjective, and therefore its reliability is open to question. Reliability is a particular issue when crewmembers are asked to accurately recall details of past events, feelings, or sleep patterns. This is not to question crewmembers’ integrity – inaccurate recall of past events is a common and complex human problem. Concerns about whether some crewmembers might exaggerate in their responses, for personal or industrial reasons, should be minimal in a just reporting culture as is required for FRMS. But, who is to judge if the culture is just or not? Once again, this proves the requirement for crewmembers’ representative to be involved in the establishment of FRMS from the beginning.

7. Conclusion

Crew fatigue is increasingly recognized as a major threat to air traffic safety. Both prescriptive (Flight Time Limitations) and performance-based concepts of fatigue risk control have their advantages and disadvantages. In order to achieve “equal or greater level of safety” various problems associated with FRMS must be addressed in advance. If this is not the case, FRMS could increase risk not only through increased crew fatigue, but secondary through decreased level of safety culture and negative impact on overall SMS.

8. References


