Fatigue risk management in a short-haul airline: improving the extent to which conventional safety data collection tools consider fatigue

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1. Background

Fatigue Risk Management Systems (FRMS).

In June 2006 easyJet became the first major airline to implement a multi-layered FRMS (Stewart et al., 2006). An FRMS is an evidence-based safety management system (SMS) for the control of fatigue risk to as low as reasonably practicable. In line with recommendations (Booth-Bourdeau et al., 2005; Dawson and McCulloch, 2005; Gander and Yates, 2005), easyJet manages fatigue risk similar to any other risk and the FRMS has been adopted as an integral part of the organisation's broader SMS. The key components of the FRMS are listed below (in no particular order):

- Tools for the measurement of fatigue risk eg. roster metrics, flight data monitoring (FDM);
- A formal statement of the company's fatigue risk management policy;
- A competency-based Fatigue Awareness and Countermeasures Training (FACT) programme;
- Management processes supporting the monitoring, reporting and investigation of fatigue risk;
- A chain of responsibility statement and the inclusion of the FRMS within the company and Civil Aviation Authority (CAA) audit schedules.

2. Improving the extent to which conventional safety data collection tools consider fatigue

The easyJet FRMS has been developed in line Dawson and McCulloch's (2005) conceptual framework for managing fatigue risk that is based on Reason's 'error trajectory' (Reason, 1997). The error trajectory considers a fatigue-related incident to be the endpoint in a chain of events and advocates the identification and management of precursors, before they lead to an incident. According to this approach, a FRMS should manage fatigue risk at the following 5 levels:

1) Is there adequate opportunity for sleep?

2) Have employees actually obtained adequate sleep?

3) Is there evidence of fatigue-related behaviours?

4) Have there been fatigue-related errors?

5) Have there been fatigue-related incidents?

Limitations of existing (level 1 and 2) methods

The majority of fatigue risk management activity that takes place in aviation focuses on level 1 and is concerned with the management of crew's sleep opportunity. The control strategy that is most commonly utilised at this level is compliance with flight and duty time limitations (FTL). easyJet uses both FTL and a software tool (FAID^{TM}) that models the estimated fatigue associated with rostered hours. FTL provide clear work parameters for employers and employees but have been criticised on the basis that they are not scientifically defensible and because there is significant variability between prescriptive rule sets offered by National Aviation Authorities (Fatigue Expert Group, 2001; Cabon et al., 2002). The complementary use of a science-based fatigue model provides enhanced level 1 protection.

The second level of the fatigue risk trajectory considers the actual amount of sleep obtained by employees and is notoriously difficult to manage. In easyJet crew sleep is assessed in biannual sleep recordings (using actigraphy) of a sample of the pilot population. The sleep studies provide valuable information, but as they are a snapshot taken at a discrete point in time, individual differences within the population and the variable nature of rostering means that the results cannot be assumed to be broadly representative.

Another method for assessing actual sleep duration is to provide employees with rules or a 'sleep contract' that they can utilise for assessing and reporting their own sleep (Dawson and McCulloch, 2005; Holmes et al., 2006). An important drawback of this approach is that because the relationship between sleep duration and fatigue risk is not well understood, it is not possible to confidently advise crew on the amount of sleep (especially in the long-term) they need to obtain to ensure safe performance.

Managing fatigue risk at the level of fatigue-related behaviours, error and incidents

In order to implement a multi-layered FRMS easyJet focused on addressing the subsequent three levels of the trajectory. There is no known practical guidance on how to consider fatigue-related behaviours, errors and incidents within an airline, but we felt that these variables could be captured relatively easily by capitalising on the company's strong existing safety reporting culture and systems for performance monitoring.

Performance is already objectively recorded via Flight Data Monitoring (FDM) and there is an accepted procedure for reporting and managing safety events using an Air Safety Report (ASR) form (Civil Aviation Authority, CAP 712). To improve the information relating to fatigue recorded for serious FDM events a formal report form is being developed for the flight crew liaison officers (FCLO) that interview crew regarding these events. To enhance the level of information the ASR collects on fatigue an additional page has been added to the form that asks crew to rate the contribution that a range of factors, including fatigue, experience and team factors, made to the event.

Despite the benefits of the amended FDM and ASR processes we felt that in isolation they did not provide adequate information for the management of fatigue risk at levels three to five of the trajectory. The FDM and ASR processes are designed to be relevant for all types of safety events, ranging from air traffic control incidents to disruptive passengers, and can not be extended to collect detailed information on fatigue. Moreover, as FDM records incidents and the majority ASRs are lodged after an incident, these processes do not encourage the reporting of fatigue precursors i.e. behaviours and errors. To overcome these limitations a form for crew to report fatigue-related behaviours, errors and incidents, and any concern relating to fatigue has been developed. This paper reports on the design of the fatigue report form (FRF1) and provides examples of some of the preliminary data that that has been collected from the network.

3. Objectives of FRF1

The FRF1 was developed with the following objectives:

a. Provide a formal method for capturing data on fatigue
FRF1 should enable crew to report fatigue-related incidents and errors and should also capture information on precursors including fatigue-related behaviours, instances of fatigue and any concerns relating to fatigue. In essence, the form should capture information on fatigue that would otherwise be lost, for example in informal crew discussions regarding feelings of tiredness or roster difficulties. It is important that the form considers fatigue experienced at work and also outside work, for example at home and on the road.

b. Enable an additional layer of fatigue risk management

FRF1 must be supported by a system for managing and responding to reports if it is to enhance the degree to which the company is protected from fatigue risk.

c. Enable data mining and trend analysis
The form should collect information on contextual factors that contribute to fatigue, for example workload. All data should be entered into a central database which can then be mined to reveal trends: over time, between bases, between ranks etc., thereby enabling the company to determine where company safety resources should be directed.

d. Provide a forum for employees to suggest corrective actions
The input and local knowledge of operational staff are widely recognised as being essential for the development of effective controls. Consequently, the fatigue reporting process should include space for crew to suggest corrective actions.

e. The form should be user friendly
To encourage utilisation of the form it should be no more than one page long, easily accessible and incorporate both 'tick boxes' and a space for free narrative.

4. Design of FRF1

In order to meet the objectives listed above, a one page FRF1 was designed and made available in crew rooms and on the company intra-net. FRF1 includes structured (fixed contextual) and unstructured (free narrative) data fields. The selection of contextual fields was informed by in-house workshops and research on fatigue risk factors in short-haul airlines (CAA 2005/04, Nguyen et al., 2003).

As a result of piloting the first version of FRF1 and feedback from crew a number of improvements were made. The FRF1 is still being monitored and developed, but the latest version collects data in the following fields:

- Personal eg. rank, base, age, commute details
- Reason for submitting FRF1: fatigue-related ASR, FDM, non-reported safety event or general concern
- Details of event (if applicable)
- Duty details eg. rostered and actual start and end time, duty duration
- Factors that contributed to the event/general concern eg. hotel, insufficient time off
- Physical signs of fatigue observed in 2 hours leading up to the event eg. yawning
- Cognitive signs of fatigue observed in 2 hours leading up to the event eg. delayed response
- Subjective rating of alertness (Samn and Perelli, 1982).

For every form that is submitted the company the Fatigue Risk Safety Officer (FRSO) collects additional information from the network on the primary variables listed in Table 1. Depending on the circumstances of the particular case, secondary variables may also be researched.

Table 1
Network variables during the fatigue investigation process

Primary Variables	Secondary Variables
Estimation of work-related fatigue (FAID);	Crew ASR history
Discretionary use	Crew FDM history
Roster legality and stability	A/C technical status
Duty hours, duty timing, cumulative days off	Interview with Base Captain/Base Crew Cabin Manager
Crew sickness	Crew Training records

5. FRF1 investigation and management

FRF1 is supported by the reporting, investigation and management processes that apply to the ASR and crew that submit a FRF1 are covered by the confidentiality/non-jeopardy arrangement with the pilot union that applies to FDM. These processes are managed by the FRSO who keeps crew informed of the progress of FRF1 investigations and any controls that have been implemented.

On the following page figure 1 summarises the processes by which data on fatigue (including via the FRF1) is collected, analysed and reported. On a monthly basis a summary of FRF1s that have been submitted and the controls that have been implemented based on these reports is provided to the fatigue safety action group (FSAG). In turn, the FSAG report to the safety action group (SAG), company board and the CAA. In the long term, the enhanced information on fatigue provided by FRF1 can contribute to enabling evidence-based strategic development at the board level.

6. Preliminary results and discussion

The FRF1 was introduced in June 2006 and at the time of writing 25 unique FRF1s had been received. Crew have commented that they appreciate having an auditable forum for recording instances of fatigue and see the reporting system as evidence of the company's commitment to managing fatigue risk. While it is premature to undertake data mining and trend analysis it is worthwhile looking at the initial results to see whether the objectives that the form was designed to meet (introduced in section 3) are being attended to. The objectives of the FRF1 that are relevant to this process are listed below. Note: The reported results are from an earlier version of the FRF1, which did not request information on physical and cognitive signs of fatigue.

a. Provide a formal system for capturing data on fatigue
b. Enable an additional layer of fatigue risk management
c. Enable data mining and trend analysis
d. Provide a forum for employees to suggest corrective actions

a. Provide a formal method for capturing data on fatigue

Reason for submitting the FRF1 Of the 25 FRF1s submitted to date, 17 were submitted by flight crew, 8 by cabin crew. Sixteen FRF1s (64%) reported a general concern regarding fatigue; 5 (20%) detailed a non-reported safety event; and 4 were associated with a lodged ASR. To date no forms have been received in relation to FDM events.

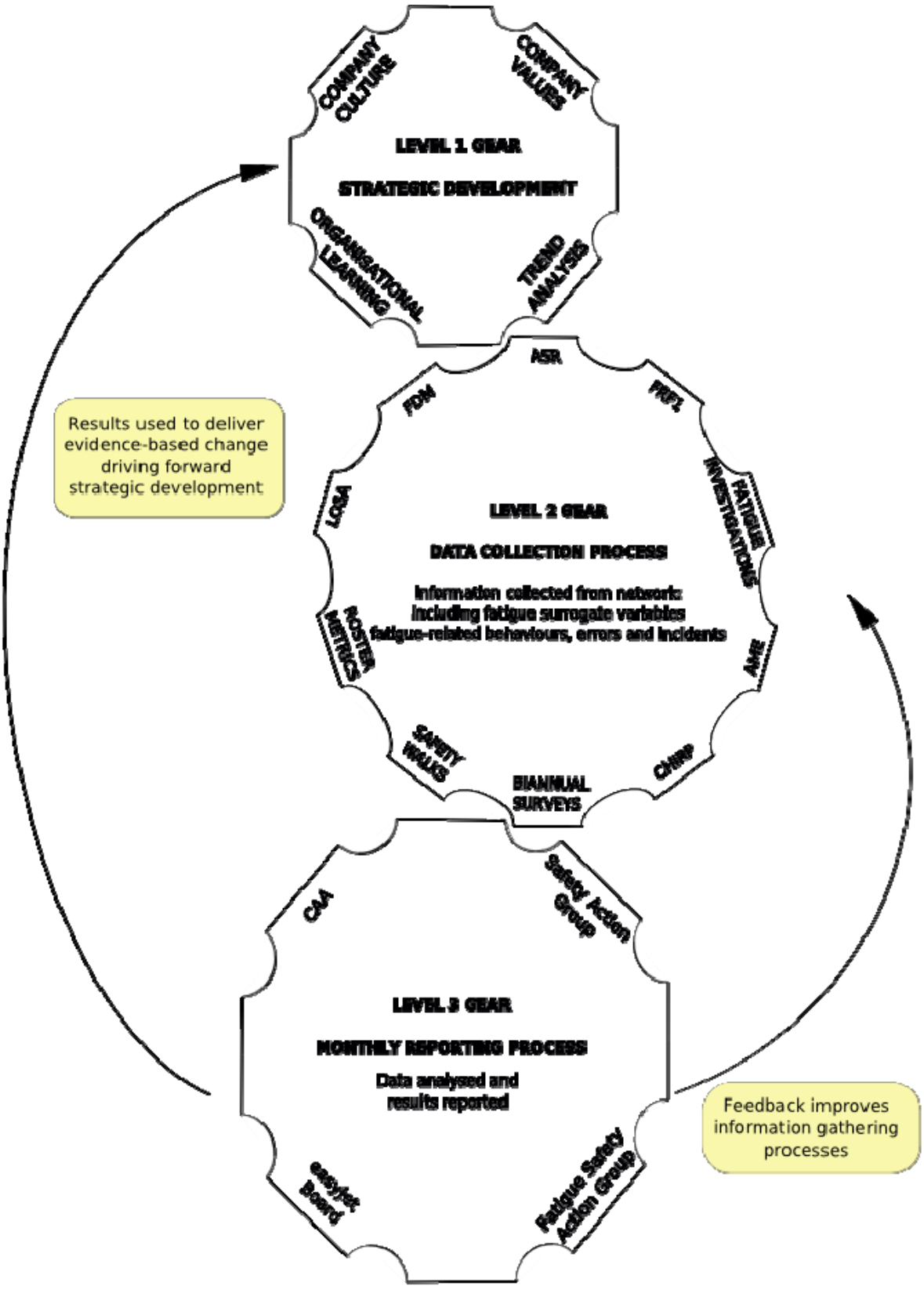

Figure 1: Summary of the easyJet / Clockwork fatigue data collection, analysis and reporting system (© Holmes, Stewart and Jackson, 2006)

The fact that the majority of forms reported general concerns regarding fatigue and non-reported safety events suggests that the FRF1 is enabling the collection of information on fatigue precursors that would otherwise not have been recorded by existing reporting systems. The FRF1s in which an error or incident has been reported are valuable in that they can assist the company is better understanding the relationship between fatigue and safety and where fatigue risk boundaries should be drawn.

Activity at time of fatigue Of the 23 FRF1s in which respondents recorded the activity they were performing at the time they experienced fatigue, 10 (43%) were in flight and 10 were driving (to, from, or during work; Table 2). The high frequency with which driver fatigue has been reported is perhaps not surprising as crew tend to be on the road at times when the circadian rhythm in alertness is relatively low. For example, early duties commence around the early morning minimum in alertness and finish mid-afternoon during the post-lunch dip in alertness. The value of the FRF1 is that it provides an evidence-based rationale for managing fatigue risk on the road.

Table 2

Activity at time of fatigue

In flight	Driving to work	Driving home	Driving as part of work	Other
10	2	6	2	3

b. Provide an additional layer of fatigue risk management

By collecting information on precursors for fatigue-related incidents the FRF1 facilitates a pro-active layer of fatigue risk management. The following case study provides a summary of an investigation that followed on from a FRF1 and has lead to evidence-based change and enhanced fatigue risk protection.

Case study

A Training Captain lodged an FRF1 reporting a ‘general fatigue concern’ relating to the rostering of simulator duties. The captain reported feeling ‘exhausted’ as the result of working one early duty that started at 05:25, followed by two consecutive night time simulator duties both starting at 03:05. He was rostered to fly the line the next day, starting at 10:20. Local FTL limitations (CAP 371) do not take account of simulator duties and these duties can legally be sandwiched between flying duties.

A subsequent investigation by the Operations Safety Team included a review of all training captain rosters that incorporated night simulator duties, interviews with training captains, training department management and the consideration of other safety data, for example other FRF1s.

The investigation identified the risk factors listed below and these were presented to the Fatigue Safety Action Group (FSAG).

- The simulator is in operation 24 hours a day and duties can start and finish at any time. Simulator duties, particularly those that include work in the early hours of the morning, have the potential to lead to a high level of fatigue.
- Although simulator duties pose a low risk (in the short term), fatigue associated with a night simulator duty can be carried over to subsequent line duties, which has the potential to pose a significant fatigue risk.
- The crew member operated an early duty on duty 1, preventing him from achieving a full local night’s rest prior to operating the two consecutive night simulator duties.

After considering the information the FSAG made the following changes to rostering policy:

Mixed duty rosters involving 2 consecutive night simulator duties followed by a flight duty will provide a local night off prior to the simulator duties. The simulator duties will be followed by a standard period of days off or at least one local night off must be provided prior to the next flight duty.

c. Enable data mining and trend analysis

The FRF1 lists 14 possible contributory factors, and provides additional space for the reporter to identify other factors that they felt contributed to the event or their general concern. To date, the 3 most frequently cited fatigue contributory factors (see figure 3) are all roster-related.

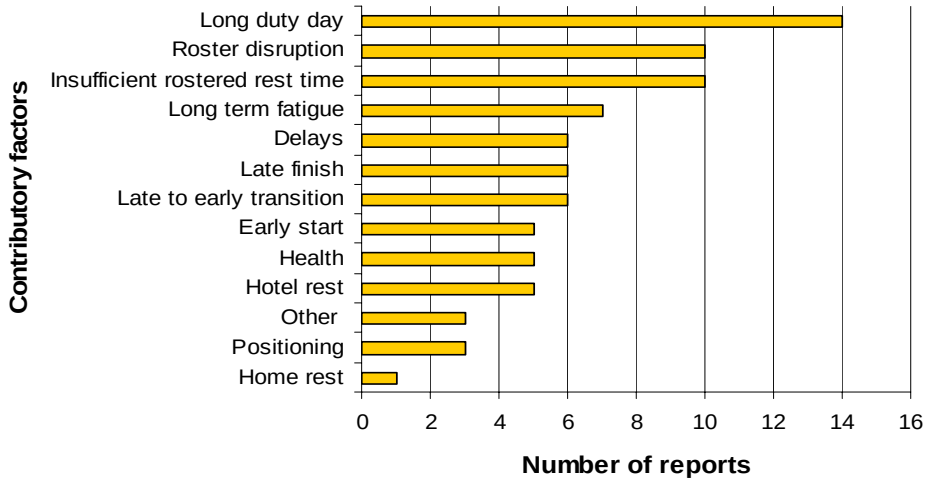

Figure 3 Factors that contributed to the event/the general concern

d. A forum for employees to suggest corrective actions

The final section of the FRF1 asks the reporter to suggest corrective actions for the fatigue they have reported and to prevent a similar scenario re-occurring. The following lists some of the corrective actions proposed by employees to date.

Table 4

Corrective actions suggested in FRF1s

ROSTERING
Don't roster late-early duty transition with 18-30 hours rest
Do not roster 4 sector days for line check flights, Training Captain duty hours are already high
A more stable roster would allow rest to be better planned to minimise fatigue
Don't put us on long / late flights if we have only had minimum rest
HOTELS
Arrange for an "aircrew section" of the hotel for aircrew use only
Hotels should be selected that are aircrew friendly and conducive to sleep during the day
When positioning consider the impact that long delays have rest
OTHER
Arrange a "packed breakfast" for those on early duty so that they can get some nourishment.
Aircraft base training is a variable quantity and shouldn't be shoehorned in between demanding days.
Be aware of the unnecessary fatigue that can arise from delays due to positioning
Allow people to choose 2x5 duty blocks per month to suit whether they are a Morning or Evening Type

7. Conclusion

This paper extends the literature available on fatigue risk management by introducing tools, notably a crew fatigue report form (FRF1) that has been developed to enable crew to report any concern relating to fatigue to the company. By identifying sources of fatigue and where fatigue

has influenced performance, the tools provide the opportunity to pro-actively manage fatigue risk before it is evident in incidents. By monitoring the incidence of contributory factors for fatigue the company can identify where safety resources can most effectively be applied.

Preliminary evidence indicates that the FRF1 has been a valuable addition to the FRMS. Most importantly, the form has already instigated immediate evidence-based change (eg. night duties are now followed by a day off). The reporting process also appears to be facilitating the commitment and involvement of senior management to tackling fatigue, widely recognised as being essential to the success of a FRMS. Before the FRF1 was introduced it was difficult to convince busy senior management to form a fatigue steering committee (FSAG). The lodgement of multiple FRF1s lead to the formation of the FSAG , which now meets on a monthly basis.

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