# Developing a fatigue risk management took for military personnel

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### Introduction

Fatigue is defined as 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 (ICAO).

**Fatigue in a military context.** Military personnel are required to undertake safety critical, high risk tasks that require high levels of concentration, problem solving and effective decision making. Personnel can be tasked at short notice, during unsociable hours and are expected to perform error free. Therefore, sleep is essential to aid optimal human performance.

Identifying high risk activities and implementing mitigations to lower the risk is paramount in maintaining high safety standards. Errors relating to fatigue risk can compromise high safety standards, increasing the risk of damage to assets and injuring personnel.

**Use of the operational risk matrix.** Military personnel currently use a risk management tool called an Operational Risk Matrix (ORM) to identify high risk elements of a task, this could be a flying or air traffic control task. The ORM was used by US Air Force and was adapted for UK personnel. One element of risk was identifying fatigue management. Fatigue risk was determined by asking questions on a range of topics such as quality of sleep, number of hours sleep within the last 3 days, number of consecutive shifts and other questions. Each question is scored and the total score has different action levels, (dependent on which personnel or unit are using the ORM). Discussions with military personnel highlighted that no scientific basis of the ORM was known and each unit/ squadron (Sqn) adapted the matrix for their own needs, therefore it was not standardised.

**Measuring fatigue.** According to ICAO, fatigue occurs due to sleep loss or extended wakefulness, circadian phase, or workload (physical or mental).

A number of methods to measure fatigue were available. Sleep diaries alone have been shown to be ineffective because humans are unable to accurately recall the number of hours spent sleeping during a night, often over-estimating sleep. Wrist worn actigraphy devices use an accelerometer to record sleep and wakefulness and have been shown to accurately record sleep and awake periods when compared with polysomnography. The actigraphy derived sleep data was fed into a biomathematical fatigue model. The Fatigue Avoidance Scheduling Tool (FAST) model was chosen because of its ability to predict an objective measure of fatigue. The model calculates an effectiveness score that is represented as a percentage: high numbers signify high performance (and low fatigue), and vice versa. Physical and mental performance at 70% has been shown to have equivalence to performance at a Blood Alcohol Concentration of 0.08. **Aim of the research.** The purpose of the research was to develop an evidence basis for a fatigue risk management tool for military personnel.

#### Method

There were 3 elements of the research;

1. Desktop review of current ORMs being used.

A desktop review was undertaken of ORMs that were used by flying sqns and air traffic control units across the Royal Air Force (RAF). The review included identifying what questions were asked, the science behind the scoring system and what happens following the completion of the ORM.

The desktop review included discussions with a number of personnel on how the matrix was utilised and its effectiveness.

2. Review of literature to identify which questions that could identify fatigue risk.

A literature review was undertaken in 2017 to identify research that used questionnaires, sleep diaries and wearables to highlight factors that identified fatigue risk.

3. Assess usability of actigraphy to provide evidence for a fatigue risk management tool.

Typhoon pilots participated in the research whilst out on exercise in Las Vegas. 17 out of 18 pilots participated in the study for a 3-week period to assess the performance of the ORM in identification of fatigue risk pre-flight. Daily sleep diaries and actigraphy was utilised to measure performance effectiveness. Individual pilots completed an ORM prior to each flight, the responses were compared against effectiveness using ANOVA to identify whether each question was able to identify fatigue risk. The null hypothesis was that there was no difference in the measured mean effectiveness between ORM question responses.

### Ethics

Ethical approval was granted by Ministry of Defence Research ethics Committee (MoDREC)

Fatigue safety was considered as part of the proposal and it was agreed that no exception to extant policy were to be recommended by the investigators. Whilst this study measured fatigue, it was not possible to provide a real time analysis of fatigue.

Whilst taking part in the research, participants were required to adhere to current fatigue policy. AP8000 in Directive 8213(3) and the Acceptable Means of Compliance state that aircrew should take all reasonable measures to manage their own personal fatigue and that they should make appropriate use of rest periods to obtain good quality sleep. Aircrew are directed to inform the chain of command if they have any doubt about their capability to accomplish their duties; this would include fatigue.

### Results

There was no standardised ORM used across the RAF and each ORM used had a different scoring basis, with no scientific backing.

Previous research indicated that factors such as sleep quality, number of hours worked, number of consecutive shifts work, number of consecutive night shifts and the amount of sleep prior to a working shift were able to indicate fatigue risk.

Participation for the actigraphy research was extremely high, with 17 out of 18 pilots taking part for the entire 3-week Exercise. A total of 140 flying tasks were undertaken. Mean effectiveness at ORM completion was  $83.9 \pm 15.8$ ; effectiveness was normally distributed. Only 5 sorties were undertaken with effectiveness less than 70.

There was no difference in measured effectiveness for number of consecutive previous duties (p=0.91), reported sleep quality (p=0.57), reported time to adjust to current time zone (p=0.54) or anticipated duty length (p=0.15). There were significant differences in measured effectiveness for duty start time (p<0.001), number of prior consecutive night duties (p<0.001), sleep immediately prior to flight (p<0.001), hours of rest since previous duty (p=0.001), sleep in the previous 3 days (p=0.001) and number of reported wakeful hours at the end of duty (p=0.01).

## Discussion

Current RAF ORMs being used had no scientific basis for identifying fatigue risk. Personnel highlighted that ORMs were useful in highlighting risk management of tasks and a useful decision aid for senior personnel.

The actigraphy research indicated that quality of sleep and number of consecutive previous duties were not good indicators of fatigue risk. However, it highlighted that the duty start time and wakefulness may indicate fatigue risk. Shift patterns could also indicate fatigue levels in personnel, consecutive night shifts may increase risk of fatigue. Ensuring personnel have adequate levels of sleep/rest were also good indicators. The results highlighted that sleep immediately prior to flying, hours of rest since previous duty and sleep in the previous 3 days, could determine fatigue risk.

Therefore, the ORM may be a useful decision aid to identify fatigue risk pre-flight; further work should be undertaken to refine question sets and whether the ORM could be applied to other units across military personnel. Whilst question sets may generate discussion for flight authorisers, future work should try to develop a scientifically valid scoring system, that could potentially be applied to all ORMs in the future. Additionally, further work will be required in how the ORM could effectively be integrated for military personnel.

## References

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