# If You Don't Snooze, You Lose

**There's more to fighting on-the-job fatigue than simply limiting the number of hours worked.**

BY LINDA WERFELMAN



Traditional methods of managing fatigue in the aviation workplace by limiting work hours are inadequate and should be replaced by comprehensive fatigue risk management systems (FRMSs) that help detect fatigue-related behavior and thereby prevent fatigue-related accidents, sleep researchers say.

"The traditional prescriptive HOS [hours of service] approach most likely derives from earlier regulatory models for managing physical, rather than mental, fatigue," Drew Dawson and Kirsty McCulloch of the University of South Australia Centre for Sleep Research said in remarks prepared for delivery at a worldwide aviation safety seminar in October in Paris.[1]

"While the application of prescriptive duty limitations may have been an appropriate control for physical fatigue, the same cannot be assumed for mental fatigue. … Regulatory models based only on shift duration are unlikely to produce congruence between what is safe and what is permitted and what is unsafe and not permitted."

Dawson and McCulloch's comments were included in one of four fatigue-related presentations that were part of a fatigue risk management session held during the joint meeting of the Flight Safety Foundation 59th annual International Air Safety Seminar (IASS), the International Federation of Airworthiness 36th annual International Conference and the International Air Transport Association.

Dawson and McCulloch said that recent research and policy initiatives in Australia, Canada, New Zealand and the United States have examined the "defenses-in-depth" method of fatigue management often used in the



military. This method, which includes fatigue management within the framework of a safety management system (SMS), provides a "more defensible conceptual and scientific basis for managing fatigue-related risk as well as the potential for greater operational flexibility," they said.

They said that within an SMS framework, five levels should be considered in managing fatigue risk: "sleep opportunity, or average sleep obtained across the organization, actual sleep obtained by individual employees, presence of fatigue-related behavior, occurrence of fatigue-related errors and occurrence of a fatigue-related accident and/or incident [Figure 1]."

In this context, a fatigue-related incident (FRI) is "merely the end point of a causal chain of events or error trajectory and is always preceded by a common sequence of event classifications that lead to the actual incident," Dawson and McCulloch said. "Thus, [an] FRI is always preceded by a fatigue-related error (FRE). Each FRE, in turn, will be associated with an individual in a fatigued state exhibiting fatigue-related symptomology or behaviors. The fatigued state in the individual will, in turn, be preceded by insufficient recovery sleep or excessive wakefulness, [which] will be caused by either insufficient recovery sleep during an adequate break ... or by an inadequate break."

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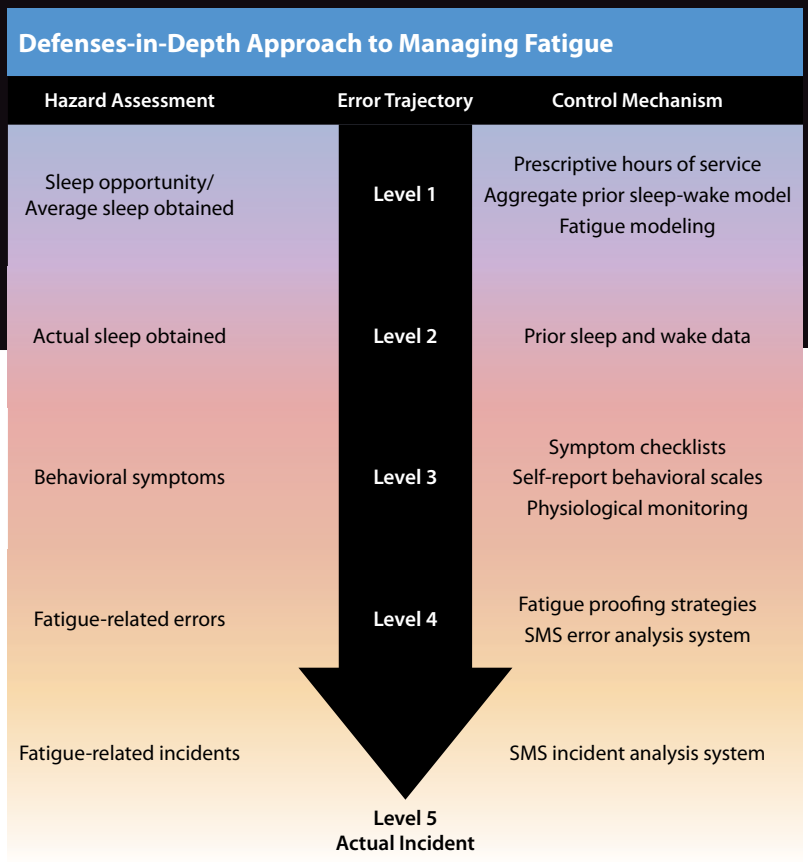
An FRMS can be effective only if it addresses each of the five levels with organized defense systems, they said.

"Each of the four steps in the general error trajectory for [an] FRI provides the opportunity to identify potential incidents and, more importantly, the presence (or absence) of appropriate defenses in the system," they said. If such defenses are not developed, the overall system probably will not be protected against fatigue-related incidents, they said.

For example, limits on a crewmember's hours of service would be — according to Figure 1 — a Level 1 defense designed as an attempt to ensure that the crewmember had an opportunity for sufficient sleep. If the crewmember did not receive adequate sleep, the error trajectory would continue beyond Level 1; "thus, a system with little or no hazard controls at Level 2 or beyond may be quite poorly defended against FREs," the presentation said.

Dawson and McCulloch suggested that a determination could be made of the likely extent of a crewmember's fatigue by calculating the amount of sleep received during the 48-hour period immediately prior to beginning work and the length of time from the last wake-up until the end of the shift. If the time awake, as of the end of the shift, exceeds the amount of sleep obtained in the 48 hours before beginning work, there is "a significant increase in the likelihood of a fatigue-related error, and the organization should implement appropriate hazard-control procedures for the individual," the presentation said.




SMS = Safety management system

Source: Dawson, Drew; McCulloch, Kirsty. "Managing Fatigue: Defenses in Depth." In *Enhancing Safety Worldwide: Proceedings of the 59th Annual International Air Safety Seminar.* Alexandria, Virginia, U.S.: Flight Safety Foundation, 2006.

**Figure 1**

## Diminishing Fatigue's Impact

In recent years, Transport Canada has examined similar fatigue issues in the Canadian aviation industry, where — as in most countries — flight and duty time limits apply to flight crewmembers but not to aviation maintenance personnel, Transport Canada officials said in a presentation prepared for the IASS (see "Maintenance Concerns Yield Plan to Fight On-the-Job Fatigue," page 16).[2]

"The main drive to address the fatigue issue in Canadian aviation came initially from the aircraft maintenance side of civil aviation," the Transport Canada presentation said. After a study found that "fatigue and excessive periods of work may be present in the work force," Transport Canada developed an FRMS toolbox, designed to aid in implementation of an FRMS — in both flight operations and maintenance — as a mandatory component of an operator's SMS. The next step will be a 12- to 18-month FRMS implementation trial involving flight and maintenance personnel at a medium-size Canadian airline.

"Transport Canada believes that the implementation of an FRMS as an integral part of [an] SMS will provide the various operators with a flexible and company-specific approach to managing workplace fatigue," the presentation said. "In the long term, it is expected that well-implemented FRMSs will diminish the impact of fatigue problems and therefore contribute to reducing the number of fatigue-related incidents and accidents, as well as improving productivity and work-related satisfaction."

## Scheduling Changes

An FRMS already is in place at easyJet, which in April 2005 received an "alleviation" from U.K. Civil Aviation Authority (CAA) flight time limitations, representatives of the airline said in a presentation prepared for delivery at the IASS.[3]

The alleviation followed a six-month trial at two easyJet bases, which eliminated a

## Maintenance Concerns Yield Plan to Fight On-the-Job Fatigue

Concern about fatigue among aviation maintenance personnel — whose duty time often has been unregulated — was a primary impetus behind the search for measures to address fatigue in the Canadian aviation industry, Transport Canada (TC) officials say.[1]

In a presentation prepared for delivery at the joint meeting of the Flight Safety Foundation 59th annual International Air Safety Seminar (IASS), the International Federation of Airworthiness 36th annual International Conference and the International Air Transport Association, the TC officials cited past research that found that "maintenance tasks involving planning, documenting, communicating, supervising, troubleshooting and inspecting can be severely affected by fatigue."

One of the officials who produced the presentation said, in earlier writings on fatigue, that the association of fatigue and maintenance error has never been as clear as the association of fatigue and pilot error.

"This is in spite of the fact that the physiological challenges are still the same: shift work, night work and long working periods," said Jacqueline Booth-Bourdeau, chief of technical and national programs of the Aircraft Maintenance and Manufacturing Branch of the TC Civil Aviation Directorate.[2] "The link between fatigue and performance impairment is somehow perceived as less critical because the maintainer is not seen as being on the 'front line.'

"The fact remains, however, that many maintenance tasks are performed in the middle of the night when the propensity for human performance error is at its greatest."

— LW

**Notes**

1. Marcil, Isabelle; Booth-Bourdeau, Jacqueline; Laurence, Mark; Dawson, Drew. "Fatigue Risk Management in the Canadian Aviation Industry." In *Enhancing Safety Worldwide: Proceedings of the 59th* Annual International Air Safety Seminar. Alexandria, Virginia, U.S.: Flight Safety Foundation, 2006.

2. Booth-Bourdeau, Jacqueline. "Fatigue and Performance Degradation." *Aircraft Maintenance Technology*, March 2001.

"6/3" work roster (three days with early duties, three days with late duties and three days off) and replaced it with a "5/2/5/4" work roster (five days with early duties, two days off, five days with late duties and four days off).

"The 5/2/5/4 roster was predicted to reduce fatigue by decreasing the number of days worked consecutively and increasing the amount of time off provided for the changeover from early to late duties," the presentation said.

Monitoring of crew performance found that 1.8 percent of duties on the 6/3 roster were associated with a fatigue risk described as "high or very high," compared with 0.7 percent on the 5/2/5/4 roster. In addition, line operations safety audit (LOSA) observers found a mean error rate of 5.2 per sector on the 6/3 roster, compared with 2.6 per sector on the 5/2/5/4 roster.

The presentation said that these and other data supported the April 2005 switch to a 5/2/5/4 roster at all 14 easyJet bases. In the months following adoption of the new roster, flight data monitoring found that serious events, such as 500-foot altitude deviations, decreased to about one-third the rate that had been reported one year earlier; however, at the same time, crewmembers' complaints of fatigue increased.

The airline responded with crew workshops designed to produce a better understanding of the sources of fatigue and their effects on performance, and the work schedule subsequently shifted to a 5/3/5/4 pattern, with an additional day off "as a risk-mitigation step between early and late sequence duties," the presentation said.

"The experience of developing a safety case to work outside [flight time limitations] ... has enabled the company to develop a sophisticated FRMS," the presentation said.

The FRMS has been included within a broader risk-management system, which is intended to evaluate overall system risk and implement measures to mitigate those risks, the presentation said.

## Degraded Crew Performance

A separate study of international long-haul flight crews found that fatigue was associated with degraded crew performance, especially in areas of increased mismanagement of operational threats, increased rates of error occurrence and increased mismanagement of errors that were detected by the crew, researchers from the Centre for Sleep Research at the University of South Australia said in a presentation prepared for delivery to the IASS.[4] A reduction in sleep during the 24 hours preceding flight was the fatigue-related variable most consistently associated with changes in crew performance, they said.

"Crews take longer to make decisions if they have obtained a small opportunity to sleep, based on recent duty history; have obtained a small amount of sleep in the prior 24 hours; are experiencing high levels of subjective fatigue; and/or have slow response times," the presentation said. "Taking longer to make decisions may have negative implications for operational safety, as this could lead to greater time pressures, which may enhance the risk of errors during the later stages of flight."

The study also found several areas, such as improved cross-checking, in which fatigue was associated with improved performance, perhaps because fatigued crews anticipated errors and "devoted more cognitive resources and targeted behavioral strategies towards the detection of fatigue-related error."

Nevertheless, the researchers said that their study "reinforced the conventional wisdom that fatigue is a real issue within commercial flight operations, with significant implications for the operational performance of flight crew and the overall safety of flight operations." ●

### Notes

1. Dawson, Drew; McCulloch, Kirsty. "Managing Fatigue: Defenses in Depth." In *Enhancing Safety Worldwide: Proceedings of the 59th Annual International Air Safety Seminar (IASS)*. Alexandria, Virginia, U.S.: Flight Safety Foundation, 2006.
2. Marcil, Isabelle; Booth-Bourdeau, Jacqueline; Laurence, Mark; Dawson, Drew. "Fatigue Risk Management in the Canadian Aviation Industry." In *Enhancing Safety Worldwide: Proceedings of the 59th Annual IASS*. Alexandria, Virginia, U.S.: Flight Safety Foundation, 2006.
3. Stewart, Simon; Holmes, Alexandra; Jackson, Paul; Abboud, Rafeef. "An Integrated System for Managing Fatigue Risk Within a Low-Cost Carrier." In *Enhancing Safety Worldwide: Proceedings of the 59th Annual IASS*. Alexandria, Virginia, U.S.: Flight Safety Foundation, 2006.
4. Thomas, Matthew J.W.; Petrilli, Renée M.; Lamond, Nicole; Dawson, Drew; Roach, Gregory D. "Australian Long Haul Fatigue Study." In *Enhancing Safety Worldwide: Proceedings of the 59th Annual IASS*. Alexandria, Virginia, U.S.: Flight Safety Foundation, 2006.

### Further Reading From FSF Publications

FSF Editorial Staff. "Fatigue Evaluation Indicates Most Aviation Maintenance Personnel Obtain Insufficient Sleep." *Aviation Mechanics Bulletin* Volume 49 (November–December 2001).

Hobbs, Alan; Williamson, Ann. "Survey Assesses Safety Attitudes of Aviation Maintenance Personnel in Australia." *Aviation Mechanics Bulletin* Volume 48 (November–December 2000).

Caldwell, J. Lynn. "Managing Sleep for Night Shifts Requires Personal Strategies." *Human Factors & Aviation Medicine* Volume 46 (March–April 1999).

FSF Editorial Staff. "Overcoming Effects of Stress Offers Greatest Opportunity to Sleep Well." *Human Factors & Aviation Medicine* Volume 45 (July–August 1998).

Flight Safety Foundation Fatigue Countermeasures Task Force. "Principles and Guidelines for Duty and Rest Scheduling in Corporate and Business Aviation." *Flight Safety Digest* Volume 16 (February 1997).

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