**FRMS has not yet made major inroads in aviation maintenance.**

# Finding a Foothold

BY LINDA WERFELMAN

Aviation maintenance organizations have been slow to implement formal fatigue risk management systems (FRMS), despite their unique opportunities to employ some of the most effective types of fatigue countermeasures, according to a report by the U.S. Federal Aviation Administration (FAA) Civil Aerospace Medical Institute.[1]

Aviation maintenance personnel work in conditions that are conducive to fatigue, often at night and with unregulated duty hours, the report said.

Rudy Quevedo, Flight Safety Foundation deputy director of technical programs and a member of the FAA Maintenance Fatigue Working Group, said airline mergers and general economic upheaval have resulted in increased stress, longer work hours and fewer opportunities for sleep for many maintenance technicians, some of whom have taken second jobs.

Quevedo, who began his career as a mechanic for Eastern Airlines, said that at times, his shift extended for 24 hours or longer, and that, when necessary, he and his colleagues took short naps, although the company had no official napping policy.

The FAA report noted that many maintenance tasks — "especially those involving intense visual attention, communication or a heavy reliance on memory" — are especially susceptible to fatigue's effects.

FRMS usually addresses the threat of falling asleep during a "continuous-control task" such as piloting an aircraft. However, falling asleep is

not the primary hazard facing aviation maintenance personnel, the report said. Instead, the greatest threat involves fatigue-impaired mental functioning and the possibility that it will lead to maintenance errors.

"This distinction, while seemingly trivial, has important implications for fatigue risk management in aviation maintenance," the report said, adding that it follows that the methods and goals of a maintenance-oriented FRMS will differ from those of a flight crew FRMS.

For example, because maintenance tasks typically are "self-paced rather than externally paced," a maintenance technician who recognizes that he or she is fatigued "may be able to pause a task, trade speed for accuracy or repeat a step, as necessary," the report said.

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Maintenance personnel also may, in some cases, have opportunities to modify task performance, perhaps by introducing the use of task cards or operational/functional checks or performing demanding tasks at times of day when fatigue is less likely, the report said.

In addition, the report said, maintenance personnel usually do not travel across time zones and therefore do not experience jet lag and travel-related disruption of their circadian rhythms — two problems that often plague pilots and flight attendants.

As a result, the report added, maintenance organizations may be able to employ a greater number of solutions to their fatigue problems.

The report cited three objectives of fatigue risk management: reducing fatigue, reducing the number of fatigue-related errors or identifying the errors and correcting them, and limiting the harm caused by errors.

Flexibility is crucial, Quevedo said, adding that an absolute limit on the number of hours worked might not be the best option for either an employer that has extra maintenance work that must be completed on time or employees who understand how to adjust their task performance to compensate for fatigue.

"Eventually, there'll have to be FRMS," he said, adding that it would be especially useful "when it's not business as usual."

## '52 Days Straight'

Methods of reducing fatigue include limiting an employee's hours of service (HOS). U.S. Federal Aviation Regulations say only that maintenance technicians working on Part 121 air carrier aircraft must be off duty for "at least 24 consecutive hours during any seven consecutive days, or the equivalent thereof, within any one calendar month."

"In effect," the report said, "a person could work up to 52 days straight, in a period of two consecutive months, and still be in compliance with the regulation."

Only a few countries apply specific limits, the report said. For example:

- The New Zealand Civil Aviation Authority says that maintenance personnel must have had at least eight hours off duty before performing work and at least four 24-hour periods off in the preceding month.
- The Civil Aviation Administration of China says maintenance personnel may work no more than eight hours a day and 40 hours a week. Under special circumstances, they may work as long as 11 hours a day, but monthly overtime may not exceed 36 hours.

The Civil Aviation Safety Authority of Australia, under regulations that took effect in June, does not limit work hours but instead "makes it an offense for a maintenance organization to permit a maintainer who is significantly impaired by fatigue or a psychoactive substance to carry out maintenance on an airline aircraft," the report said.

Best practices guidelines developed for the U.K. Civil Aviation Authority (U.K. CAA) — which does not itself prescribe work limits — call for 12-hour shifts that, with overtime, should be extended to no longer than a total of 13 hours, with a work break every four hours. Technicians should have at least 11 hours off between shifts, and they should be informed of their work schedules a month in advance.[2]

While not incorporated into U.K. CAA regulations, the guidelines were included in an agency advisory document for Part 145

operators and in guidance issued by the International Civil Aviation Organization.

## Scientific Scheduling

Another method of reducing fatigue is scientific scheduling, which incorporates a software modeling system to estimate the level of fatigue likely to result from a specific scheduling pattern.

"Software models … can take into account circadian variations in alertness and sleep obtained, to produce an estimate of the fatigue level that may result from a particular shift pattern," the report said. "When used as scheduling tools, software models have the advantage of offering greater flexibility than HOS limits."

The report cited the Fatigue Audit InterDyne (FAID) model as an example, noting that it considers employee work and break times for a seven-day period and assigns a fatigue score of between zero and 140. Typically, employees who score less than 80 are "generally safe" to perform their jobs, the report said, but scores of more than 80 may indicate an "unsafe condition."

The report added, however, that research by the U.S. Federal Railroad Administration has indicated that scores as low as 60 may indicate fatigue-related risks.

Fatigue models generally have been used in flight crew scheduling, but one airline, which the report did not name, also has used FAID to evaluate maintenance work schedules and to help in schedule design.

The report also cited planned naps of 20 to 40 minutes as a key mitigation for fighting fatigue but acknowledged that "napping as a fatigue countermeasure in maintenance may face resistance from airlines and regulators."

In addition, the report suggested that providing employees with educational material about fatigue and acceptable countermeasures is one of only a few methods by which an organization can influence employees to reduce fatigue that results from lifestyle choices.

The European Aviation Safety Agency includes fatigue among the topics that should be covered in maintenance human factors training, and some civil aviation authorities, including Transport Canada, the U.K. CAA and the FAA, have published educational material on fatigue — some of it aimed not only at maintenance personnel but also at their supervisors, non-maintenance co-workers, and family members.

Some FRMS guidelines call for workers to take "fatigue leave" if they believe they are too fatigued to perform their duties, but the report conceded that the concept may not be readily accepted.

"Organizations need to weigh the potential disruption caused by an unplanned absence with the potential harm that could result when an employee reports for duty impaired," the report said.

## A 'Second Line of Defense'

Because fatigue cannot be eliminated, the report recommended "a second line of defense, with the objective of reducing the probability of error among fatigued workers."

First, workers are taught to monitor their level of fatigue, overcoming the inherent inaccuracy of self-perception by using a fatigue rating scale (Table 1) or psychomotor performance tests that can be installed on hand-held devices or smartphones. The report noted that various alertness monitoring devices now being used in the trucking industry may eventually be incorporated into an FRMS.

To reduce levels of fatigue, work breaks — especially those that include a brief walk — can provide temporary relief, as can exposure to fresh air or cool, dry air, the report said, citing

**Karolinska Sleepiness Scale**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Very alert | | Alert, normal level | | Neither alert or sleepy | | Sleepy, but no effort to keep awake | | Very sleepy, great effort to keep awake |

**Source**: Akerstedt, T.; Gillberg, M. "Subjective and Objective Sleepiness in the Active Individual." *International Journal of Neuroscience*, Volume 52 (1990): 29–37.

**Table 1**

several earlier studies. Bright light also can reduce fatigue and fatigue-related errors, and caffeine, if used according to a precise schedule, can reduce fatigue for about two hours, studies have shown.

## Task-Based Action

Other efforts to reduce fatigue-related errors emphasize changing some aspect of the assigned task — an area that has received relatively little attention.

"Task-based approaches are based on the idea that maintenance tasks vary along a continuum, from tasks that are highly susceptible to fatigue to those that are less susceptible," the report said. "Task-based approaches … can involve two complementary strategies: changing *when* the task is performed and changing *how* it is performed."

Research has identified the types of tasks most prone to fatigue-related errors, including tasks that are monotonous or very familiar. Others that are highly susceptible are inspection tasks, tasks that require "intense, continuous concentration," those performed in a darkened environment and those in which "incorrect performance is not immediately obvious," the report said.

Most maintenance organizations do not consider the fatigue-susceptibility of a task when they develop work schedules, but individual maintenance technicians sometimes have "informal norms concerning the time of day at which tasks are performed," the report said, noting that their procedures may involve performing the most challenging tasks at the beginning of a work shift.

"In most large organizations, [maintenance personnel] have limited control over the timing of tasks throughout their shift, yet crew leads, foremen or planning personnel may have some influence on the time of day at which certain tasks are performed," the report said. "It is critical, therefore, that such personnel have an awareness of the effects of fatigue on human performance."

Some tasks can be "fatigue-proofed," or modified to reduce the likelihood of fatigue-related errors or to increase the likelihood that such an error will be detected," the report said, noting that Transport Canada has recommended that the following fatigue-proofing strategies be used when performing tasks that are susceptible to fatigue:

- Work under close supervision;
- Work in pairs or teams;
- Rotate tasks;
- Use checklists;
- Use experienced personnel to provide support for new personnel; and,
- Conduct briefings when shifts turn over.

Recommendations from other sources call for formalized self-checks, operational or functional checks, or independent inspections for tasks that are especially susceptible to fatigue or those that have been performed incorrectly in the past because of fatigue. Other research calls for rested personnel to check work that has been performed during the window of circadian low — between 0300 and 0600 local time.

## Minimizing the Harm

Recognizing that fatigue-related errors occur despite efforts to prevent them, the report said that a "final line of defense" should limit the damage that results from these errors.

"Harm minimization differs from the interventions described in the preceding sections, as the focus is on the severity of the error's consequences, rather than the probability of error," the report said. "Harm minimization in the context of maintenance fatigue involves keeping the most safety-critical tasks out of the hands of the most fatigued people."

The report said that, for example, work on flight control systems would not be assigned to maintenance personnel during their circadian low point, but they would instead be given other, less critical tasks. "This approach does not prevent maintainers from making a fatigue-related error on whatever task they are assigned but reduces the likely consequences of that error."

The report said that although, in many cases, HOS limits and scientific software scheduling models have been used separately and viewed as competing methods of addressing workplace fatigue, they can be incorporated into a single program. HOS limits can establish the "outer bounds" of duty times while scientific scheduling models form the basis of specific schedules within the bounds.

"In addition to HOS limits, an FRMS for maintenance will include a range of interventions addressing the task, the work environment and the fitness for duty of personnel," the report said. "Whatever approach to fatigue risk management is applied, commitment from all levels of the organization is essential. Upper management has a responsibility to state a clear policy on fatigue, including how fatigue-related incidents will be dealt with under a just culture."

### Notes

1. Hobbs, Alan; Avers, Katrina Bedell; Hiles, John J. *Fatigue Risk Management in Aviation Maintenance: Current Best Practices and Potential Future Countermeasures*. DOT/FAA/AM-11/10. June 2011.
2. Folkard, Simon. U.K. CAA Paper 2002/06, *Work Hours of Aircraft Maintenance Personnel*. West Sussex, U.K.: Research Management Department, Safety Regulation Group. 2003.