Fatigue Risk in Helicopter Operations

A CALL TO ACTION FOR THE IMPLEMENTATION OF A FATIGUE RISK MANAGEMENT PROGRAM

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Background

Fatigue risk impacts all aspects of rotorcraft operations, including air crew, ground crew, and support personnel whose mission-critical activities ensure safe and effective operations. The US Helicopter Safety Team (USHST) Fatigue Working Group was established to evaluate the sources of fatigue risk in helicopter operations, develop a framework for fatigue risk management, and provide practical resources to support fatigue risk management program implementation. The USHST is a 501(C)3 volunteer team of US government and industry stakeholders formed to improve the safety of civil helicopter operations. The USHST is a partner of the Vertical Aviation Safety Team (VAST).

Objective

Develop a call for action for the helicopter industry to view fatigue risk as a major causal or contributing factor to safety incidents in the industry and solicit active engagement from helicopter operators in the future development and improvement of Fatigue Risk Management Programs (FRMPs) as part of the Safety Management System.

Introduction

Across the rotorcraft industry, fatigue risk management improvements are needed. This need for fatigue risk management improvements is evidenced in National Transportation Safety Board (NTSB) investigations and scientific literature. In a 2008 Safety Recommendation, NTSB stated that recent aviation accidents have underscored the risks of human fatigue, the importance of addressing both company policies and crew responsibilities, and the ongoing need to revise flight and duty time regulations to enhance safety.

In spite of the fact that these regulations were made nearly two decades ago, a review of helicopter-specific regulatory and industry guidance reveals the absence of a comprehensive fatigue risk management approach that adequately addresses the extant evidence of fatigue risk in helicopter operations. Accordingly, Federal rulemaking has issued a compliance deadline of 2027 for Part 135 operators, in addition to operators that hold a § 91.147 LOA, to comply with Safety Management System (SMS) regulations. Moreover, SMS regulations require organizations to surveil for hazards, quantify the risk associated with the identified hazards, then make an informed decision as to whether to mitigate or to accept the risk. Given the abundance of operational data demonstrating that fatigue is a ubiquitous, significant hazard in helicopter operations, it follows that operators need to be able to monitor for and mitigate fatigue risk within their SMS program to be compliant within the regulations. It is therefore highly recommended that all operators implement a comprehensive FRMP as an integrated part of the SMS ahead of this deadline.

This paper serves as a call-to-action for the US helicopter industry to work in concert to address the pervasive safety risk that fatigue poses; it presents specific instances where fatigue resulted in catastrophic events, a summary of the existing regulatory and industry guidance, and a review of the scientific literature pertinent to fatigue risk in helicopter operations. This demonstrates the need for a complete and comprehensive framework for fatigue risk management—one that encompasses all sources of operational fatigue risk, including individual factors, and is suitable for adoption by helicopter operators to further advance safety across the industry. To assist operators in developing an FRMP ahead of the deadline, the community must work together, and this paper aims to serve as a starting point for discussion. Below, three examples of rotorcraft accidents where fatigue was cited as a contributing factor are described.

"Are you alright up there?"

"Uhhh, think so. Good enough to get us home at least."

On April 26th, 2018, around 22:50 local time, a pilot and two emergency medical services crewmembers were fatally injured when their helicopter was destroyed upon terrain impact near Hazelhurst, WI. Prior to the accident, the pilot and crewmembers were discussing their desires to go to sleep, and yawning could be heard. One crewmember asked the pilot if he was alright, and the pilot responded, "Uhhh, think so. Good enough to get us home at least." The pilot could be seen stretching and was last heard speaking around 22:29. As the helicopter began to roll to the right, the crewmembers shouted the pilot's name and received no response from the pilot, who had slumped to the left. The helicopter became inverted before colliding with terrain. The evidence suggests that the pilot fell asleep at the controls.

This duty period was the pilot's first following a week-long vacation, during which his circadian rhythm would have aligned with sleeping at the time of the accident. Further, he may have been awake for 15.5 hours when the accident occurred. According to NTSB, the pilot "likely fell asleep during the flight as a result of the time of day, his time since awakening, and the fatigue-inducing effect of the 1.5-hour flight." NTSB determined the probable cause of the accident to be "the pilot's loss of helicopter control as a result of fatigue during cruise flight at night."

"I'm not going to spend a lot of time or we're going to have two search and rescues."

On June 9th, 2009, a Search and Rescue (SAR) helicopter operated by New Mexico State Police (NMSP) collided with a mountainside, fatally injuring the pilot and rescued hiker and seriously injuring the patrol officer. Prior to the accident flight, the pilot was at home after working a full shift earlier that day. Around 18:00, the pilot received a call from the dispatcher—who was his wife—asking if he would be able to come in to conduct a SAR flight for a missing hiker. After initially declining, the pilot called back to accept the mission after learning the other pilot was unavailable.

Despite fatigue and limited sleep, he prioritized the mission over rest. The maximum rest time available to the pilot prior to the accident flight was 4 hours. He was regularly called in to work when he was off duty, even though he was not on call, resulting in very few days free from work-related duties. His wife noted he would avoid flights due to the weather but not fatigue. Colleagues described him as heroic and willing to take risks to save others.

During the rescue, the helicopter landed near the hiker's location in deteriorating weather conditions and darkness. The pilot told the dispatcher, “I’m not going to spend a lot of time or we’re going to have two search and rescues” before leaving the helicopter to retrieve the hiker on foot. He spent nearly an hour locating her. Upon returning, he attempted to take off despite an operating environment of poor visibility and rugged terrain. Shortly after liftoff, at 21:35 local time, the helicopter struck the terrain twice and crashed, fatally ejecting both the pilot and hiker.

According to NTSB, “Contributing to the accident were an organizational culture that prioritized mission execution over aviation safety and the pilot's fatigue, self-imposed pressure to conduct the flight, and situational stress. Also contributing to the accident were deficiencies in the NMSP aviation section's safety-related policies, including lack of a requirement for a risk assessment at any point during the mission; inadequate pilot staffing; [and] lack of an effective fatigue management program for pilots.”

“The fatal accident was due to errors made by maintenance personnel as the result of fatigue.”

Fatigue risk can pose a hazard to any safety-critical role in helicopter operations, including aircraft maintenance personnel.

On December 7th, 2011, outside of Las Vegas, NV, one pilot and 4 passengers were fatally injured during a “twilight tour” sightseeing trip after the helicopter impacted mountainous terrain. During the flight, the helicopter became uncontrollable when the servo control input rod separated from

the main rotor fore/aft servo. The hardware holding them together was not properly secured during maintenance conducted the previous day.

The investigation determined that the fatal accident was due to errors made by maintenance personnel as the result of fatigue. Both the mechanic and inspector were called in on an off-duty day and had insufficient time to adjust to working an earlier shift than normal. The mechanic had an inadequate amount of sleep, and the inspector had a long duty day. According to NTSB, a major contributor to the maintenance personnel's fatigue could have been mitigated if their work shifts had been more consistent.

Safety-Sensitive Employees

The table below lists common safety-sensitive roles in helicopter operations.

Employee Group	Employee Role
Air Crew	Pilots
	Flight Attendants
	Hoist Operators
Ground Support	Mechanics
	Ground Crew
Support	Clinicians
	Communications Specialists
	Logistics / Dispatch

Note: this list is not comprehensive and will vary by organization.

Each role can have different levels of exposure to fatigue risk based on operational factors related to that role, and each employee can have different levels of exposure to fatigue risk based on individual factors. Furthermore, consideration should be given to the individual fatigue risk of any worker commuting to/from work irrespective of whether they perform safety sensitive tasks while on duty.

This paper identifies the need for a comprehensive fatigue risk management framework that addresses all sources of fatigue risk for all personnel and establishes a common language and set of factors to improve safety throughout the rotorcraft industry.

Regulations and Guidance Related to Fatigue Risk Management

Regulators, industry organizations, operators, and crewmembers all have a role to play in addressing fatigue risk in helicopter operations. Regulations and guidance materials from the following were reviewed:

Representative regulatory organizations:

- Civil Aviation Safety Authority (CASA); Australia
- European Union Aviation Safety Agency (EASA); Europe
- Federal Aviation Administration (FAA); United States
- International Civil Aviation Organization (ICAO)
- International Business Aviation Council (IBAC) – International Standard for Business Aircraft Operations (IS-BAO)
- Transport Canada (TC); Canada
- Transport Malta; Malta
- United Arab Emirates General Civil Aviation Authority (GCAA); United Arab Emirates

Representative industry organizations:

- Air Charter Safety Foundation (ACSF)
- Airborne Public Safety Accreditation Commission (APSAC)
- Commission on Accreditation of Medical Transport Systems (CAMTS)
- Flight Safety Foundation (FSF)

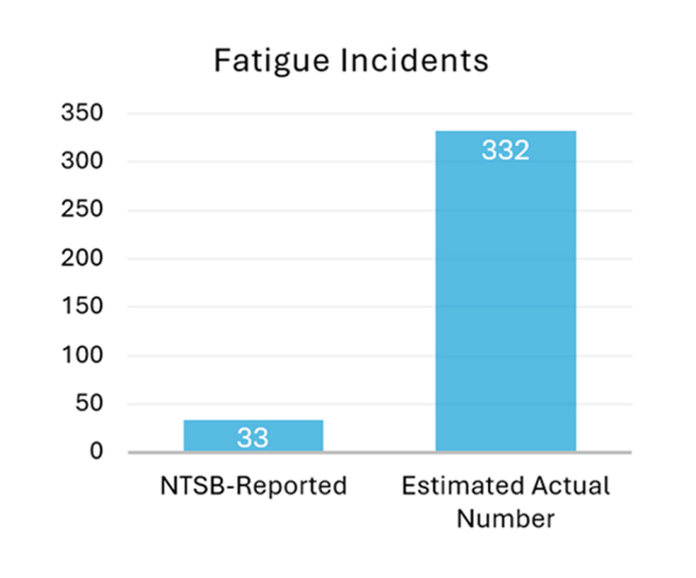
The tables below summarize the contents of these materials relative to key fatigue risk management areas detailed in a later section.

Tables 1-2: Summary of regulations and guidance across key fatigue risk management categories.

Regulatory Organization	Policies	Training	Scheduling	Fitness for duty
CASA	✓	✓	✓	✓
EASA	✓	✓	✓	✓
FAA	✓	✓	✓	✓
ICAO	✓	✓	✓	✓
IS-BAO	✓	✓	✓	
TC	✓	✓	✓	✓
Malta	✓		✓	
GCAA	✓	✓	✓	✓

Industry Organization	Policies	Training	Scheduling	Fitness for duty
ACFS	✓		✓	
APSAC	✓	✓	✓	
CAMTS	✓	✓	✓	✓
FSF	✓	✓	✓	✓

Fatigue Incidence and Risk



Since 1990, the National Transportation Safety Board (NTSB) has conducted 6561 helicopter accident investigations. Of these investigations, 33 have cited fatigue or lack of adequate sleep as a contributing factor, which have resulted in 32 fatalities and 19 injuries. Of these, human factors were a contributing factor in 1661 incidents. Fatigue is often under-cited in NTSB helicopter investigations because of a lack of available objective information related to fatigue. Based on benchmarks from other industries, fatigue is a factor in at least one in five safety incidents, or 20%.[1-5] Applying this rate to the helicopter industry, we arrive at an estimate of 332 incidents over this time period with fatigue as a contributing factor. This is more than ten times higher than the 33 fatigue-related incidents reported by NTSB.

Literature Review

It is well known that fatigue-related deficits accumulate relative to factors such as long days, sleep debt, and night work. But how much fatigue is too much? Most rotorcraft operators have policies that enable crewmembers to “raise their hand” to take themselves out of duty if they feel too fatigued to safely perform their duties. While such policies are essential, they are insufficient to achieve a reliable standard of safety because they suffer from one or more of the following limitations: (1) rely on self-perception of individual fatigue; (2) impacted by individual subjectivity relative to the threshold for what is a safe operating limit. The scientific literature provides evidence that workers are biased towards underestimating the degree of their own fatigue-related impairment, especially in the case of chronic sleep debt.[6] This is especially problematic given that sleep debt, often a result of insufficient sleep opportunities between shifts, is also common in helicopter operations.[7, 8]

Evidence indicates that personnel are reluctant to take themselves out of service either because they think the degree of their impairment is within an acceptable limit based on their own personal standard or because of concerns about a punitive response from their employer. One study found that 65% of Helicopter Emergency Medical Service (HEMS) pilots reported experiencing excessive daytime sleepiness, 39% reported nodding off in flight, and 65% indicated that they should have refused to fly due to fatigue (with only 45% of those actually refusing to fly).[9] Another study found that the correlation of pilot fatigue and prior accidents and incidents may be caused by the pressure to fly despite knowing safety is threatened.[10] Two studies of Norwegian HEMS and Search and Rescue (SAR) personnel revealed that more than half of on-call HEMS and SAR physicians reported being influenced by fatigue at least sometimes, and 41% of SAR helicopter personnel experienced excessive daytime sleepiness.[11, 12]

The literature further indicates that fatigue-related factors can negatively affect the performance of Emergency Medical Service (EMS) personnel. One study found that, for fatigued personnel, the rate of medical errors was 1.9x greater and the rate of incidents of safety-compromising behavior was 3.6x greater than for non-fatigued personnel.[13] The non-technical performance of HEMS clinicians has also been found to degrade with fatigue.[14] Among air medical transport operations, a disproportionate amount (72.4%) of fatalities occur on helicopters, and nighttime-related factors may have contributed to 38.9% of the fatalities.[15]

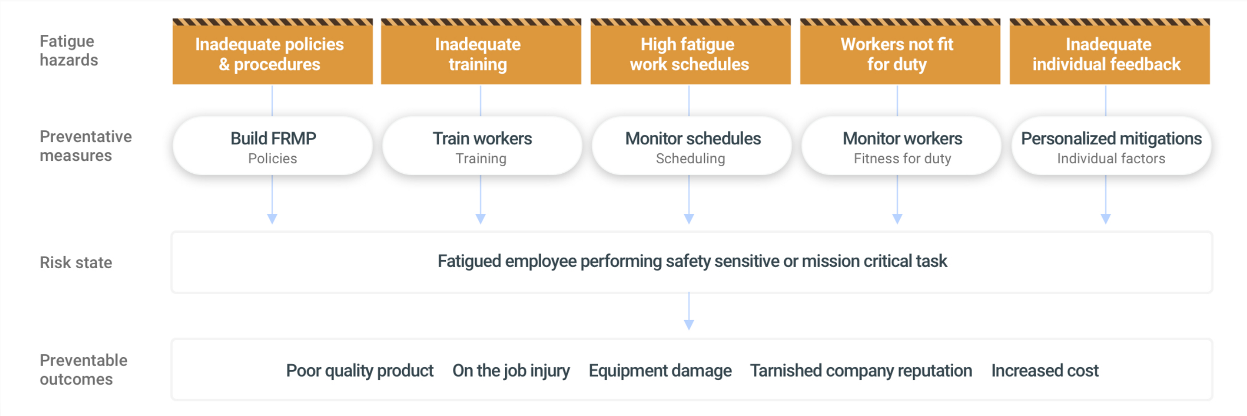
Unsurprisingly, many studies on helicopter personnel have identified the need for policy change, Fatigue Risk Management Program adoption, and fatigue training across the industry.[16-25]

Problem Statement

Evidence presented in scientific literature demonstrates the need for a comprehensive approach to fatigue risk management that:

- Covers all sources of fatigue risk
- Includes quantitative and objective measures
- Has clear thresholds to identify elevated fatigue risk conditions
- Has pre-defined workflows to mitigate fatigue risk
- Tracks the effectiveness of the whole fatigue risk management process

Components of a Comprehensive Fatigue Risk Management Program



A comprehensive Fatigue Risk Management Program (FRMP) should cover all potential sources of fatigue risk, including:

1. **Policies** – Policies and procedures that directly or indirectly impact operational fatigue risk.
2. **Training** – Fatigue risk management training delivered to employees involved in safety-sensitive positions.
3. **Scheduling** – Practices that ensure fatigue risk is considered during the scheduling process.
4. **Fitness for duty** – Processes to identify employees with fatigue-related alertness deficits and steps to take to mitigate the operational risk.
5. **Individual factors** – Methods an individual employee can utilize to ensure their fitness-for-duty.

Policies

A common source of fatigue risk emerges when organizations do not have clear policies about how to monitor or mitigate all sources of fatigue risk. Another type of policy-related fatigue risk occurs when existent policies are not enforced during operations. It is the responsibility of senior leadership to set a mandate to address fatigue risk, facilitate the development of clear policies, and allocate resources and continued management support to implement and sustain the Fatigue Risk Management Program.

Training

Effective fatigue risk management requires a partnership between the organization and individual employees. Organizations must provide work schedules that provide adequate rest opportunity.

Employees in turn have a personal responsibility to manage their time off duty and get the rest they need to be fit for duty.

An effective fatigue risk management training program considers factors such as whether personnel's schedules include shift work and/or long hours and whether they perform safety-sensitive tasks. The training content should be matched to the requirements associated with individual roles. For example, managers and schedulers/dispatchers should receive role-specific training on the fatigue risk evaluation and mitigation process.

Fatigue risk management training content should be developed or reviewed by a subject matter expert (SME) to ensure that the content is complete and up to date, as the scientific understanding of fatigue and performance is constantly developing.

Because information is best retained when it is received repeatedly, the training should occur on a regular basis (e.g., annually). Further, quiz-based assessments should be used to confirm that the objectives of the training have been achieved in that the necessary skills have been acquired.

Scheduling

Within a Fatigue Risk Management Program, it is the responsibility of the organization to ensure that fatigue hazards are minimized throughout the scheduling process. Traditionally, flight crewmember fatigue has been managed through prescribed limits on maximum duty and flight hours, based on a historical understanding of fatigue through simple work and rest period relationships. This is known as the prescriptive approach to fatigue risk management, and nearly all of the reviewed regulatory and industry guidance documents cover this approach, including:

- Operator Standards Manual (ACFS)
- Standards for Airborne Law Enforcement, Standards for Aerial Firefighting, and Standards for Airborne Search and Rescue (APSAC)
- Accreditation Standards (CAMTS)
- CAO 48.1 Instrument 2019 (CASA – Australia)
- EU 965/2012 (EASA)
- 14 CFR Part 135 (FAA)
- 14 CFR Part 5 (FAA)
- 14 CFR Part 117 (FAA)
- AC 120-115 (FAA)
- AC 135-14B (FAA)

- Duty/Rest Guidelines for Business Aviation (FSF, NBAA)
- Fatigue Management Guide for Helicopter Operators (FSF, IFALPA, IFHA, ICAO)
- Annex 6 Part III (ICAO)
- An International Standard for Business Aircraft Operations (IBAC)
- SOR/2018-269 (Gazette II) (Transport Canada)
- Operations Advisory Notice 03/23 (Transport Malta)
- State Plan for Aviation Safety in Malta 05/2023 (Transport Malta)
- Civil Aviation Regulations (UAE GCAA)

New knowledge related to the effects of cumulative sleep loss, recovery, and circadian rhythms provides an additional dimension to the management of fatigue risks. It facilitates a performance-based approach that seeks to track fatigue levels throughout the duty period using scientifically validated measures, such as biomathematical models and objective performance data. Many regulatory and industry organizations have begun incorporating performance-based guidance in addition to existing prescriptive guidance, which enables more operational flexibility with reduced fatigue risk.

Within a performance-based framework, any duty schedule that is flagged as having elevated fatigue risk should be rescheduled, mitigated, or receive a case-specific exemption with sign-off from the safety manager.

Fitness for Duty

The level of fatigue experienced by a worker at any given time is only partly explained by their duty schedule. Individual factors are a key part of the picture. However, these factors are usually outside the visibility and control of the organization. Assessing the alertness level of a worker is a means to verify that the worker is able to perform their duty/tasks safely and reliably. The alertness assessment approach should include scientifically validated self-reported and objective measures. Alertness assessments should be a part of a process that also includes specific mitigating workflows. These mitigating workflow and applicable risk controls should be specified during the FRMP configuration.

Fatigue reporting by crewmembers is a critical part of the process of reactive fatigue hazard identification. Fatigue reports should be assigned in response to events such as SMS incidents, fatigue calls, or when risk controls are used. Fatigue reports may also be submitted voluntarily. In order to be forthcoming with self-declaring fatigue, crewmembers need to feel comfortable that there will be no reprisal for doing so. A non-punitive reporting policy is important here. By eliminating obstacles to crewmembers reporting feeling fatigued, the organization creates a strong sense of trust and fosters a transparent safety culture.

Individual Factors

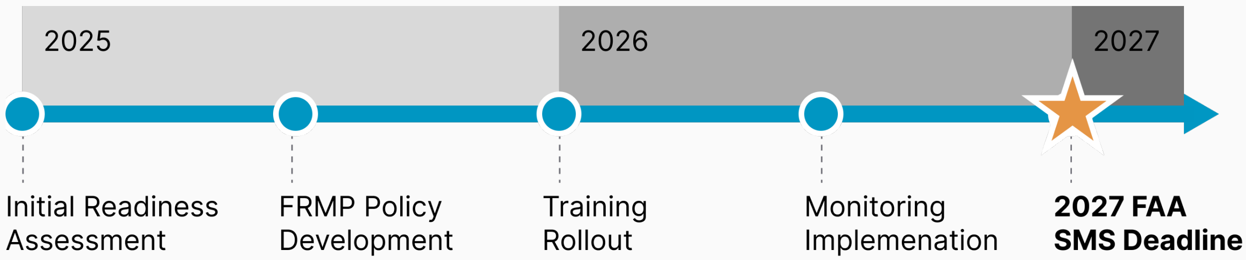
A comprehensive Fatigue Risk Management Program must equip individual employees with the means to ensure their own fitness-for-duty. Employees should be informed about fatigue hazards associated with upcoming duties. Employees should be able to view their duty schedules in a context that highlights fatigue hazards, with the ability to view the fatigue risk level of an upcoming duty period relative to benchmarks. Visibility of fatigue hazards associated with upcoming duty periods empowers employees to take mitigating steps proactively (e.g., prioritizing sleep prior to duty).

Driving is a safety-sensitive activity, and driving while fatigued is dangerous. Certain work patterns—such as extended duty periods—may result in an employee feeling fatigued after clocking out. Driving home in a state of elevated fatigue is unsafe. The risk from commute time is particularly challenging as it is in the boundary between the work space and the life space, and thus outside the control of the organization. Therefore, it needs to be managed by the individual. To support the employee, feedback about fatigue hazards in advance of an upcoming commute as well as recommendations for personal countermeasures should be provided.

Conclusion

Evidence presented in the literature and shown in historical incident data reveals fatigue risk management in helicopter operations can be improved. While regulatory and industry organizations all demonstrate a commitment to managing fatigue risk, to date, they have not considered the impact of individual factors. What is needed is a complete framework for comprehensive fatigue risk management that addresses all sources of operational fatigue risk, including individual factors, that can be adopted by helicopter operators to further improve safety across the industry.

Given the 14 CFR Part 5 2027 SMS regulation deadline, Part 135 operators, in addition to operators that hold a § 91.147 LOA, should proactively implement a comprehensive FRMP. While fatigue is not explicitly called for in the regulations, it follows that, as fatigue is a well-documented and significant hazard in helicopter operations, it must be monitored and mitigated within an SMS to be compliant within the regulations.



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