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# Human factors in aviation: Fatigue management in ramp workers

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**Abstract:** Although over the years, technical systems (equipment) have been evolving, most of the occurrences in the aviation industry, namely in the ground-handling area, are related to human error, constituting a neglected topic in aviation safety. Since one works 24 h a day and 7 days a week in the aviation industry, the shift work system is the most viable and (only) option to solve this problem, making fatigue an important and quite significant safety issue. Currently, the performance and alertness of ramp workers continue to be negatively affected by fatigue, increasing the risk of accidents/incidents. In this sense, the overall objective of this study was to establish and propose a first attempt to develop a Fatigue Management System, designed to prevent ramp workers from performing their tasks when fatigued and to take appropriate mitigation actions to minimize the consequences of fatigue caused by shift work. Despite not being exhaustive, this approach may also provide good guidance for future research in this field since fatigue is not associated with sleep disorders only.

**Keywords:** human factors, fatigue, ramp workers, shift work, Fatigue Management System, flight safety

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## 1 Introduction

Over the years, aviation services have been growing, despite external shocks such as increase in fuel prices and rise in taxes associated with aircraft operation [1,2]. This growth has caused increased congestion at airports, and consequently increased concerns about the safety of ground operations (ground handling, GH).

Fatigue is a known risk factor in all aspects of transportation safety, especially in aviation. For aviation to be safe, fatigue must be managed throughout the entire aviation system, from aircraft crew members, to air traffic controllers, to ramp workers [3].

It is known that the Federal Aviation Administration (FAA) has implemented new rules to manage pilot fatigue; however, there are no federal or industry standards for ramp operations [3]. It can be stated that ramp workers are a neglected sector of the safety circle in the aviation industry. The lack of complete data, concerning accidents/incidents that have occurred on the ground, hampers the effort to improve safety in airport ramp areas [4]. Airport ramps, or aprons, are busy and dangerous places; they are confined areas in which aircraft, vehicles, and people are in constant motion. To make matters worse, employee turnover is high due to shift work, training provided may be irregular, and standard operating procedures may be non-existent or ignored.

Through the analysis of the information included in the IATA (International Air Transport Association) Safety Reports [5–9] about accidents and ground damage occurring between 2016 and 2020, it was found that ramp accidents account for about 10% of all accidents. In turn, through a search conducted in the ASRS (Aviation Safety Reporting System) database [10], 35 cases of ground events caused by fatigue, reported between 2016 and 2021, were obtained.

In this sense, the general objective of this work is to understand how to prevent and manage the negative impact that fatigue has on the performance of ramp workers.

Over the years and with the evolution of technology, it has been found that the majority (about 80%) of accidents/incidents come from human errors and only 20% are caused by technical failures [11].

These numbers are alarming, so any progress in this field can have a significant impact on improving flight safety. In the aviation industry, operations can cause a considerable number of errors as it involves human activity and therefore a large proportion of human factors (HF) [12]. The human component is the most flexible and adaptable part of the aviation system, yet it is the most vulnerable to influences that can negatively affect its performance [13].

The study of HF involves the application of scientific knowledge about the body and mind to better understand human capabilities and limitations, and to achieve the best possible fit between people and the systems in which they operate [14].

HF cover all external factors that can be associated with human limitations and that can later lead to human error [14]. In this sense, HF can provide answers to the "why" of the inevitable human error in aviation, to be able to prevent or mitigate it [12].

According to International Civil Aviation Organization (ICAO), fatigue can be defined as a physiological state of reduced mental or physical performance capacity resulting from loss of sleep, prolonged wakefulness, circadian phase, and/or workload (mental and/or physical activity) that may impair alertness and a person's ability to perform safety-related operational tasks [15].

In other words, fatigue may be described as a complex state characterized by lack of alertness and reduced mental and physical performance, often accompanied by drowsiness, and can be observed in changes in performance, including increased reaction time, attention lapses, reduced speed of cognitive tasks, reduced situational awareness, and decreased motivation. Self-perceived levels of fatigue are often lower than observed decreases in performance [16,17].

There are two main types of fatigue: physical and mental. Physical fatigue is related to the inability to exert force with the muscles at the level that would be expected. It can be a general (whole body) fatigue or be confined to specific muscle groups. It usually arises because of physical exercise or sleep loss and can often cause mental/cognitive fatigue [18]. Mental fatigue, which may include drowsiness, concerns a general decrease in attention and the ability to perform complex or even quite simple tasks with usual efficiency. It usually results from the loss or interruption of the normal sleep pattern and is therefore a major concern for ramp workers, who are often required to work early in the morning or late at night (shift work) [18].

The causes, symptoms, and effects/consequences of fatigue can be summarized in the following diagram (Figure 1).

GH company employees (ramp workers) are on the front line when it comes to the safety of flight operations. They are the first to intervene in the aircraft when it arrives at an airport, prepare it for its flight, and are the last to observe it from the outside before takeoff, i.e., they are placed at the first and last observation point for flight safety [22].

Therefore, they must have the proper reflexes, the necessary knowledge, and an appropriate attitude. While some of these characteristics are acquired with experience, others are obtained mainly through communication, training, and awareness of safety and accident/incident prevention [23].

The work performed by ramp operators requires some energy, in that it requires physical strength, while lifting and moving baggage and cargo of different weights, shapes, and sizes [24].

During the transfer of baggage between vehicles and aircraft compartments, these workers are subject to frequent lifting and working in awkward body postures [25], i.e., pushing and moving loaded trailers, and stowing baggage and cargo, often in inappropriate positions in limited spaces [26].

In addition to these factors, because the work is outdoors most of the time, the ramp workers are also exposed to weather (temperature variations, wind, and visibility) and occupational noise [24]. Physical factors related to the execution of the required tasks, such as strength, height, reach, vision, and hearing, are significant and affect individual performance and can contribute to fatigue, creating the necessary conditions for operational errors to occur [23].

In addition to physical fatigue, this work also burdens workers mentally. Unpredictable schedules (caused by changes in flight schedules), stress (caused by the need for attention to multiple activities simultaneously), shift work, and cognitive ergonomic problems significantly influence the health and safety of ramp operators [27]. In this sense, in the workplace, human physical differences should be considered, as well as individual tolerances for variations in temperature, pressure, light, noise, and time of day [23].

GH operations are characterized by the need to ensure continuity of service, and ramp workers and other airside workers are faced with irregular schedules that interfere with the normal sleep/wake cycles that allow for nighttime sleep and daytime work [28].

Individuals may suffer, to a greater or lesser degree, from a range of symptoms caused by shift work,

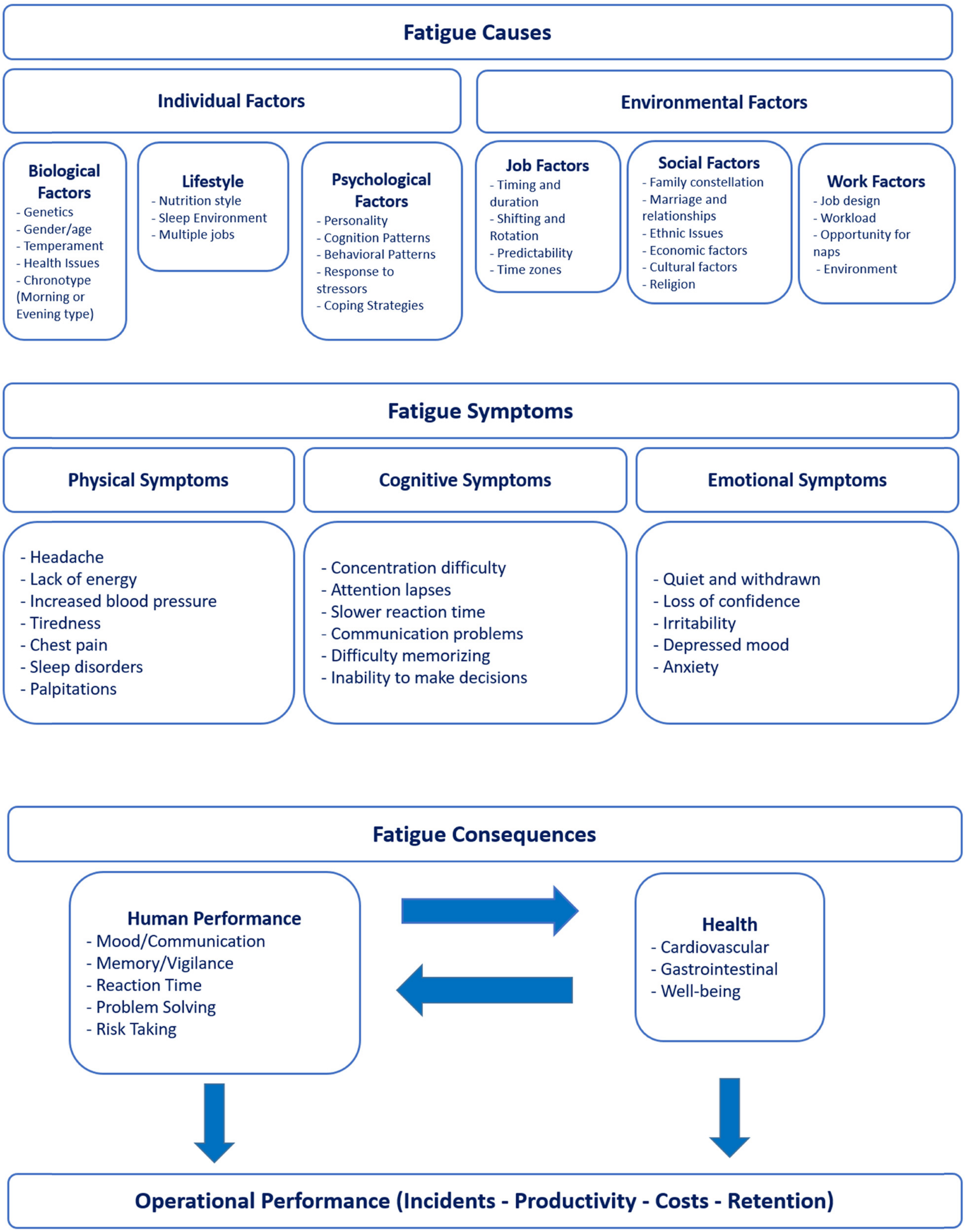


**Figure 1:** Causes, symptoms, and effects of fatigue. Source: own elaboration based on previous studies [19–21].

characterized by feelings of fatigue, sleepiness, insomnia, and reduced attention span and performance, with sleep being the main altered function (decreased in both quantity and quality) [29]. In the case of night shifts, daytime sleep is disturbed due to the difficulty in falling asleep during the rising phase of body temperature and unfavorable environmental conditions (light and noise), and is therefore more fragmented and disturbed losing some of its restorative properties. Such long-term conditions can not only give rise to permanent sleep disturbances but also cause chronic fatigue [30].

The health problems associated with this type of worker also include heart problems, gastrointestinal problems, and metabolic changes. Therefore, shift work must be seen as one of many risk factors favoring the development of health problems, which are likely to become visible after long-term exposure [30]. In this sense, any organization whose employees work in a shift system, i.e., in a constant alteration of the sleep/wake cycle due to changing schedules, should pay special attention to fatigue in the workplace in order to try to prevent the occurrence of accidents/incidents [31].

The performance of GH activities is an important part of the civil aviation flight cycle. In this regard, the proper functioning of an organization's safety management is critical, which depends on the safety culture and plays a decisive role in minimizing the risk of small-scale (e.g., minor damage to aircraft, equipment, and baggage) and large-scale accidents/incidents [32]. It is believed that the success of an organization's safety management depends largely on the existing safety culture.

Safety culture is a set of values, behaviors, and attitudes concerning safety issues, shared by all members and at all levels of the organization [33]. In a good safety culture, the effects of HF, namely fatigue, on GH operations are recognized and training is provided to manage it in order to prevent it from arising during the execution of a task and that the risks that may occur are mitigated as much as possible [34].

## 2 Fatigue Management System (FMS) for ramp workers

The risk of fatigue is inherent in any work schedule regime that involves shift work, long working hours, irregular schedules, and work that is physically or mentally demanding, repetitive, or requires high vigilance [35]. It can be said that the risk factor to be addressed in this article is shift work (night work, insufficient rest breaks, altered sleep/wake cycle, irregular schedules) and the risk is the occurrence of fatigue.

There is no single approach to fatigue management and no single strategy will eliminate the threat of fatigue in the workplace. The main challenge associated with fatigue management is to recognize that these management interventions have technical, social, and cultural implications. Managing these consequences in accordance with regulatory, organizational, and individual requirements is imperative to the success of any Fatigue Risk Management System (FRMS) [17].

According to ICAO, fatigue management refers to the methods by which aviation service providers and operational staff address the safety implications of fatigue on the organization [36], consisting of planning and controlling the work environment to minimize, as far as reasonably practicable, the adverse effects of fatigue on alertness and individual performance. It also includes strategies to reduce the likelihood of individuals being fatigued in the workplace [37], through the process of identifying and assessing fatigue risks, determining what they are and how to mitigate them [38].

In this process, it is essential that organizations ensure that any individuals, especially those performing safety-related tasks, are sufficiently alert. Managing fatigue is everyone's responsibility; both individuals and organizations have an obligation to take steps to prevent, manage, and mitigate the effects of fatigue so that it does not result in a safety hazard [39].

The best approach to fatigue management is the FRMS approach as it represents an opportunity to use advances in scientific knowledge to improve safety, use resources more efficiently, and increase operational flexibility. There is increasing doubt about the effectiveness of rigid prescriptive regulations to mitigate fatigue as they usually do not consider its complexity.

FRMS is defined by ICAO as being "*a data-driven means of continuous oversight and management of fatigue-related safety risks, based on scientific principles and knowledge as well as operational experience that aims to ensure that relevant personnel perform at appropriate levels of alertness*" [15, p. 47].

An FRMS consists of organizational methods and procedures to control the risk of fatigue in aviation operations. It is part of a repetitive process of performance improvement, promoting continuous improvement in safety by identifying and addressing fatigue factors over time and changing physiological and operational circumstances. It also combines scheduled assessment, operational data collection, continuous and systematic analysis, and mitigation of both proactive and reactive fatigue through information provided by scientific fatigue studies [16].

The goal of FRMS is to manage, supervise, and mitigate the effects of fatigue to improve workers' alertness and reduce errors caused by its presence [16], i.e., it aims to decrease the adverse consequences of fatigue on health, safety, and individual performance [3].

FRMSs go beyond simply managing the fatigue levels of transport operators; they also seek to address the safety risk that fatigued workers pose to themselves and others in the workplace. They provide a flexible and proactive approach to risk management adapted to the specific operational context rather than the prescriptive approach of forcing all operations into a single regulatory framework [37]. By measuring the actual risk of fatigue and developing adapted mitigation measures within an organized safety system, an FMS can identify a wide range of fatigue causes and provide multiple defenses to combat it [40]. The following will present some advantages and disadvantages associated with FMSs.

**Advantages** [40,41]:

- *Greater awareness and understanding of fatigue*: workers are better able to understand the importance of fatigue and what countermeasures can be used to combat it, resulting in a perceptible increase in safety;
- *Operational flexibility*: the workload can differ from the prescriptive limits, as long as it is appropriate to the job and the individual's capabilities;
- *Increased productivity*: better use of the workers' skills, leading to increased productivity and efficiency of operations, and consequently the viability of the organization;
- *Less complex*: easier to use relative to prescriptive limits;
- *Clearer sharing of responsibility for fatigue*: concerns associated with fatigue are clearly defined and are inherent throughout the organization;
- *Scientific basis for fatigue management*: fatigue modeling software enables a strong scientific background;
- *Improved fatigue management skills*: individuals have an easier time detecting fatigue symptoms, in themselves and in others, resulting in a significant evolution of performance and judgment, promoting better fatigue management.

**Disadvantages** [38,40]:

- *Poor understanding and low employee engagement*: due to the time-consuming nature of continuing education;
- *Difficulties with the fatigue modeling software*: doubts about its viability and reliability;
- *Increased administrative workload*: increased workload in setting up and maintaining the FMS, particularly in terms of policy development;
- *Increased legal exposure*.
- *Lack of understanding of the costs and resources required*: both the regulator and the organization may not fully understand how to develop, implement, and operate an FMS in order for it to be effective;
- *Difficulty of acceptance*: the transition from a prescriptive approach to a results-based culture can be difficult, as it requires substantial changes in an organization's attitude and policy.

Overall, the benefits of an FMS far outweigh the costs of implementation and administration. A strong FMS, based on best practices, has significant advantages for the organization, employees, stakeholders, and regulators [33].

Any FMS must address the unique needs of the operation in which it is to be implemented. It must be integrated into normal operations, and it must encourage the active participation of all stakeholders. It is therefore necessary to develop a culture in the organization where everyone accepts that fatigue is a barrier to excellence in safe production and well-being, and that everyone needs to work together to overcome this obstacle. In this regard, it is important that a comprehensive approach is taken to expose the issue of fatigue on airport apron boards [35].

This FMS proposal for ramp workers is based on the application of several levels of defense, based on an analysis of the factors that promote fatigue and the application of practical mitigation alternatives, in order to prevent fatigue and fatigue-induced errors from progressing to a degree that allows accidents/incidents [37], which are summarized in the map in Figure 2.

Once mitigation strategies have been implemented, they should be supervised and reviewed to ensure that they continue to effectively manage and control fatigue. Consideration should be given for implementing trial periods for any new work schedules and encouraging workers to provide feedback on their effectiveness. To determine how often this process occurs, the level of risk (as described in the fatigue risk management map, Figure 2) should be considered, with high-risk hazards requiring more frequent assessments [42].

As with any management system, an FMS requires periodic audit to evaluate its effectiveness and to achieve continuous improvement. An FMS is usually audited annually or according to the existing audit schedule for other safety management systems. The objective is to

**Step 1: Hazard Identification**

Identify the potential hazards and risks in the workplace. The following are some factors that contribute to fatigue. Consider these factors in the context of your specific workplace or industry.

**Step 2: Risk assessment**

For a better comprehension of risk assessment, a general level of risk is indicated for each hazard along arrow guides. When assessing risk, it is important to consider the interaction between risk factors that may influence the level of risk. Also take into account the specific workplace/industry circumstances that may influence it.

**Step 3: Risk control**

When a hazard factor is assessed as medium/high risk, consider implementing control measures/mitigation strategies.

| Factors that contribute to Fatigue | Overall risk indicator for factors contributing to fatigue | | | Control Measures / Mitigation Strategies |
|---|---|---|---|---|
| **Work Scheduling** | **Lower Risk** | | **Higher Risk** | **Control measures should be developed for the identified risk factor, including:** |
| **1. Working Hours** | | | | |
| **1.1.** Average weekly hours | 35 – 40 Hours | 48 Hours | 56 Hours | **1.** Reduce the number of safety-critical tasks in the (WOCL) periods between 2am and 6am. |
| **1.2.** Total hours over a three-month period | | 624 Hours | | **2.** Shift structuring, so that work demands are higher in the middle of the shift and lower at the end. |
| **1.3.** Daily working hours | 9 Hours | 12 Hours | | **3.** Use of forward rotation systems (day-evening-night). |
| **1.4.** Daily working hours and work-related travel, including commuting | | 10 Hours | 13 Hours | **4.** Designing the schedule to provide adequate sleep opportunity. |
| **1.5.** Work Scheduling | Regular and predictable | | Unpredictable, irregular and overtime hours | **5.** Checking the actual time worked against the assigned schedule and identifying if excessive hours are being worked. |
| **2. Shift work** | **Lower Risk** | | **Higher Risk** | **Control measures should be developed for the identified risk factor, including:** |
| **2.1.** Shift length | | 10 Hours | 13 Hours | **1.** Consider the opportunity for sleep where workers are required to work on-call after a normal shift or on days off. |
| **2.2.** Shift Time | Day Shift | Afternoon Shift | Night Shift | **2.** Avoid quick shift changes, such as ending at 11 pm and starting again at 7 am. |
| **2.3.** Shift Rotation Type | Forward rotation (morning, afternoon, night) | Backward rotation (night/evening/ morning) | Slower rotation (weekly) | **3.** Use of forward rotation systems (day-evening-night). |
| **2.4.** Variable shifts | | | 13 Hour Period | **4.** Allocate shift and night workers consecutive days off to allow at least two full nights' rest, including some weekends. |
| **3. Night Work** | **Lower Risk** | | **Higher Risk** | **Control measures should be developed for the identified risk factor, including:** |
| **3.1.** End of shift (for those who work 8 hours or more) | | | After 10pm and before 6am | **1.** Plan work schedules, without placing excessive demands on workers. |
| **3.2.** Consecutive night shifts | 9 Hours | 10 Hours | 12 Hours | **2.** Minimize the number of consecutive night shifts. |
| | | 6 or more 8-hour shifts<br>5 or more 10-hour shifts<br>4 or more 12-hour shifts | | **3.** Avoid overtime assignment after night shifts. |

**Figure 2:** Fatigue risk management map for ramp workers. Source: own elaboration, based on previous studies [35,41,42].

| 4. Breaks | Lower Risk | Higher Risk | Control measures should be developed for the identified risk factor, including: |
|---|---|---|---|
| **4.1.** Rest period after a sequence of night shifts | 48 Hours | Less than 48 Hours | **1.** Ensure that workers have and take adequate and regular breaks for rest periods, eating and hydration. |
| **4.2.** Frequency of breaks during work | Adequate and regular breaks | Few or no breaks | **2.** Include rest periods in the work schedule and nap periods if necessary. |
| **4.3.** Recovery time / sleep opportunity between work periods | Adequate time for leisure activities, including sleeping | Inadequate time for leisure activities, including sleeping | **3.** Appropriate design of work schedules to allow good quality sleep and enough recovery time between work days or shifts. |

| Job Demands | Lower Risk | Higher Risk | Control measures should be developed for the identified risk factor, including: |
|---|---|---|---|
| **1.** Repetition (physical and/or mental)<br>**2.** Mental | Variable demand during the work period | Highly repetitive, highly concentrated work that is demanding over an extended period of time | **1.** Ensure that adequate machinery and equipment is installed so that it can be used in the workplace.<br>**2.** Design tasks to reduce or eliminate repetitive or monotonous work, sustained mental or physical effort, or overly complex tasks. |
| **3.** Physical | Minimal physically demanding work | Highly physically demanding work that results in muscle fatigue | **3.** Introduce job rotation to limit the accumulation of mental and physical fatigue. |

| Environmental Conditions | Lower Risk | Higher Risk | Control measures should be developed for the identified risk factor, including: |
|---|---|---|---|
| **1.** Exposure to noise | Short-term exposure or low noise levels | Long-term exposure or high noise levels | **1.** Install fit-for-purpose (low noise) equipment, for example headphones with a microphone, for better communication.<br>**2.** Install heating systems in cold work environments or provide access to ventilated areas. Provision of appropriate clothing. |
| **2.** Exposure to extreme temperatures | Short period of exposure | Long period of exposure | **3.** Check if it is necessary, different types of equipment for different shifts and tasks, for example, sunglasses during the day and reflectors at night.<br>**4.** Provide and maintain a well-lit, safe and secure workplace. |

| Individual Factors and Lifestyle | Lower Risk | Higher Risk | Control measures should be developed for the identified risk factor, including: |
|---|---|---|---|
| **1.** Quantity and quality of sleep | Night Sleep<br>8 Hours of sleep<br>in 24 hours | Daytime Sleep<br>6 Hours of sleep<br>in 24 hours | **1.** Designing shift schedules that allow workers to meet their work and personal commitments. |
| **2.** Health and well-being | | Poor diet<br>Recent illness<br>Sleep disorders | **2.** Develop a fitness for work policy and consider implementing health and physical and/or mental fitness programs. |
| **3.** Social Life | | Influence of alcohol, illicit substances or amount of sleep | |
| **4.** Family Responsibilities | Adequate time to fulfill responsibilities | Inadequate time to fulfill responsibilities | |
| **5.** Other work commitments (for example, having a second job) | No other work commitments | Additional work commitments (second job) | |

**Figure 2:** (*Continued*)

identify potential changes to the FMS that may be required to reflect organizational developments and to ensure that it still conforms to the latest and best industry practices. An audit seeks to establish whether fatigue risk is being managed effectively and whether the FMS is actually operating successfully [41].

The success of an FMS will depend on management commitment and the allocation of appropriate resources [43]. The development and implementation of an FMS requires a lot of work, commitment, and dedication, but when it is well designed and tailored to address the specific circumstances of a particular industry (in this case, ramp workers), the benefits it can bring to the organization and the workforce can be significant [41].

# 3 Discussion

Considering that fatigue is a subjective, multicausal, multifactorial phenomenon whose genesis and expression involve physical, cognitive, and emotional aspects, measures to decrease its impact on flight operations can be understood between preventive strategies and operational countermeasures.

Although duty-hour restrictions have long been in effect for pilots and flight attendants, there are currently no limitations on the number of hours that ramp workers and other airport ground personnel that operate on the airport airside can work consecutively or in a 24-h period.

As regard to flight crew members, Article 8(1) of Commission Regulation (EU) No. 965/2012 of October 5, 2012 [44] laying down the technical requirements and administrative procedures for air operations, as amended, provides that for commercial air transport operations performed with aircraft, Subpart FTL of its Annex III introduced by Commission Regulation (EU) No. 83/2014 of January 29, 2014, on flight and duty time limitations and rest requirements shall apply.

Very recently, Decree-Law No. 25/2022 of March 15 [45] established the flight and duty-time limitations and rest requirements for mobile civil aviation personnel. This decree-law also establishes the penalty system applicable to violations of the rules in subpart FTL of Annex III of Commission Regulation (EU) No. 965/2012 of October 5, 2012, as amended, which establishes the technical requirements and administrative procedures for air operations.

This regulation, limiting flight time and thus seeking to prevent exposure to fatigue, only to mobile civil aviation personnel, does not guarantee that it can be prevented completely and has no equivalent for ground operations personnel.

Commission Regulation (EU) No. 139/2014 of February 12, 2014, establishes requirements and administrative procedures concerning aerodromes, showing how all tasks should be performed, i.e., requirements applicable to authorities (Aerodromes) – Annex II, organizations (Aerodrome Operators) – Annex III, and operations (Aerodromes) – Annex IV are presented [46].

Annex II sets out the requirements applicable to competent authorities involved in the certification and supervision of aerodromes, aerodrome operators, and apron management service providers.

Annex III sets out the requirements to be followed by aerodrome operators and apron management service providers.

In turn, Annex IV sets out the requirements that must be met during operations at aerodromes.

After reading this regulation it was found that there is no incompatibility with the implementation of an FMS, i.e., if the resources are sufficient and/or acceptable, then the requirements will be met.

Interestingly, in ADR.OPS.B.010 of this Regulation, the acceptable means of compliance and guidance material GM1 ADR.OPS.B.010 (a)(4), approved by Decision 2020/009/R of the Executive Director of the European Union Aviation Safety Agency, in accordance with Regulation (EU) 2018/1139 states that "*rescue and fire-fighting personnel potentially required to act in aviation emergencies must demonstrate that they have the medical fitness to perform their duties satisfactorily, taking into account the type of activity. without evidence of unjustifiable fatigue*."

In this sense, if an FMS is introduced in an organization with the objective of minimizing and preventing the effects caused by fatigue, thus improving health conditions and operational safety, it can be concluded that there is no collision/conformity with the rules and requirements established in Regulation (EU) No. 139/2014.

For program evaluation and output analysis, a combination/comparison between work organization (work schedules) and a fatigue-rating scale is preferable, rather than the analysis of voluntary reports of fatigue alone, so that one has a better understanding of what time of day and at what type of time did workers feel most fatigued mentally and physically.

For this purpose, we recommend the use of an integrative computerized biomathematical model with the *Fatigue Assessment Scale* (FAS) [47] and work schedules. These data can be cross-referenced with accident and incident reports and will also allow identify vulnerable individuals most at risk for adverse health and safety outcomes.

## 4 Conclusion

Aviation is embedded in the high-risk industries and is significantly affected by fatigue, especially regarding operational safety and individual performance. Due to the high competition in the aviation industry, the risk of fatigue-related accidents/incidents is likely to increase in the future, and airlines are likely to increase the working hours of pilots, air traffic controllers, and ramp workers in order to optimize productivity. An effective management strategy to manage fatigue issues is therefore essential. In this sense, it was decided that the main objective of the present work would be to understand how to prevent and manage the negative impact that fatigue, resulting from shift work, exerts on the performance of ramp workers.

It was concluded that for the population under study (ramp workers), the main factor contributing to the increased risk of fatigue is the type of work, from routine aircraft rotation and respective GH to line maintenance interventions, scheduled or unscheduled, which requires problem solving under great time pressure, since the aircraft needs to be prepared as quickly as possible so that it can continue flying as per schedule. All this activity, which must be done 24 h a day, determines a shift work system, and what comes with it, i.e., night work, insufficient rest breaks, altered sleep/wake cycle, and irregular schedules.

The development of the FMS for Ramp Workers was based on the application of various levels of defense and on an analysis of the factors that promote fatigue and the application of alternative mitigation practices, in order to prevent fatigue and the errors induced by it, from progressing to a degree that allows accidents/incidents. These include the provision of education, training and coaching, optimization of sleep opportunities, nap periods, rest breaks, recovery sleep, work organization (shift design guidelines), voluntary fatigue reports, and implementation of an FAS.

It was also found that there is no incompatibility of Regulation (EU) No. 139/2014 with the implementation of an FMS for airport workers.

This type of model has never been applied to airside airport workers, so no comparison can be made. One of the main conclusions that can be drawn from the completion of this work is that although the development and implementation of an FMS requires a lot of work, commitment, and dedication, when it is well designed and adapted to deal with the specific circumstances of a given sector (in this case, ramp workers), the benefits it can bring to the organization and the workforce can be significant.

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