EFFECTS OF FATIGUE ON AERONAUTICAL PERFORMANCE

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Abstract: *Events occurring in aviation affect the entire activity of a company. The contribution to the occurrence of an event is both routine and fatigue that can have negative preponderant effects. Identifying the factors favoring the occurrence of an event brings a progress in the development of programs to maximize flight safety. The study of routine and fatigue factors raises the level of importance and awareness on aviation events. Each member of the company must actively participate in the compliance of working procedures to increase the degree of safety at work. This level can only be reached when we establish and maintain strict rules, eliminate chaos and stress, minimize the pressure of tasks to create an environment proper to development.*

The study addresses all aeronautical personnel to increase the understanding of the effects of fatigue and how they contribute to the rate of occurrence of events.

Keywords: *routine, aviation event, safety, chaos, procedures*

1. INTRODUCTION

The purpose and necessity of this study is to identify, minimize and correct how aerospace activity is affected by fatigue and routine.

A study published by EASA[1] (European Union Aviation Safety Agency) shows that in 2020 a number of 323 people died in air accidents, compared to 1972, when 2365 people died (Fig. 1).

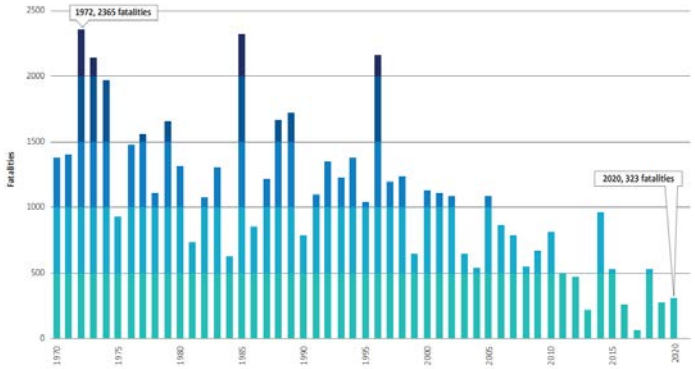
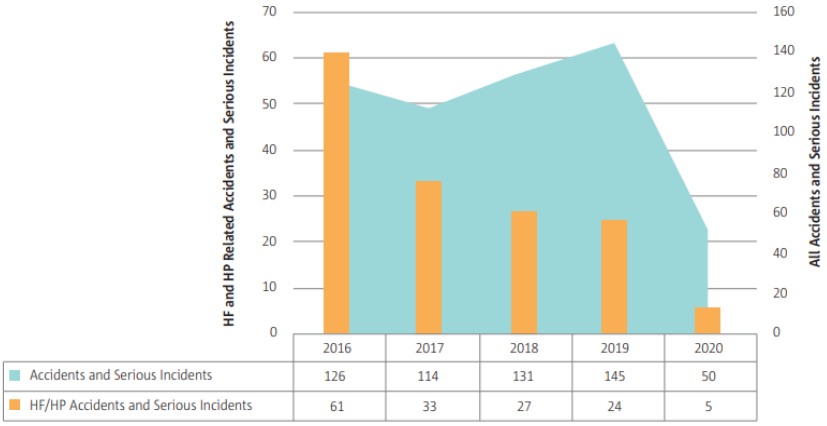


FIG.1 EASA report on the number of deceased persons between 1970 and 2020

The death rate from airborne causes is steadily decreasing due to the increase in the level of aeronautical safety. This level is reached if education on the line of safety reaches the first places in any company. A company without a developed safety system attracts accidents, lack of trust and sanctions from the authorities but also from users.



	2016	2017	2018	2019	2020
Accidents and Serious Incidents	126	114	131	145	50
HF/HP Accidents and Serious Incidents	61	33	27	24	5

FIG 2 The rate of occurrence of the human factor in aeronautical events

Another EASA report (EASA_asR_2021), Annual Safety Review 2021 (p. 47) on performance and the human factor shows that a quarter of commercial transport aviation accidents identify as the cause the human factor or links to the human factor.

The graph is made over a period of 5 years and a very high occurrence rate is observed in 2016 decreasing towards 2020, with the mention that all the data were analyzed only after the publication of the final report, therefore in 2020 the occurrence rate is very low.

Some of the human factors that contribute to the occurrence of an event are: lack of communication (example: a simple quarrel between crew members), complacency, lack of knowledge (many accidents occurred due to lack of knowledge of the procedures), distraction, lack of teamwork, fatigue, stress but also the pressure of executing the mission (a mission canceled for reasons of undue fatigue creates great problems for some pilots).

The basic idea is to highlight how aeronautical personnel are affected by their activity depending on their level of fatigue and routine. Although sometimes routine is a positive factor because repetition increases safety, in combination with fatigue it can become a triggering factor for a catastrophe.

2. THE MASK OF FATIGUE AND ROUTINE

Many times, we say that we can do one thing because we have done it 100 times. This is the trap of routine. Many times, we say that we can drive another 10 km that we have a little more to go home after driving 700 km and then an accident happens. This is the mask of fatigue. But what happens when we combine the 2. Often the results are not positive. But what happens when these 2 elements appear in the aeronautical environment? We are still looking at it from the point of view of aviation safety.

Aeronautical safety is the state in which the risk of injury to people or damage to material property is reduced and maintained at an acceptable level through a continuous process of hazard identification and risk management.

The concept of safety starts from the beginning of the last century when technical and technological deficiencies were identified in civil aviation and aimed at investigating, improving and education on safety.

At the beginning of the 7th decade, aeronautical safety was directed towards the human factor, especially the human-machine relationship, considering that the car fully complies with the rules imposed by man, so the problem is in the way of conceiving i.e., the human factor.

Since the 90s, the concept of safety has been viewed as a combination of several factors such as organizational, human and technical[2].

3. CIRCADIAN RHYTHM

Fatigue is not felt only in the military or aeronautical environment. The analysis begins with the study of circadian rhythm[3] and its effects on the human body. We will analyze the effects of insufficient sleep, acute or chronic sleep deprivation, willful or forced, and the appearance of a change in the cyclicality of the rhythm caused by the crossing of several time zones. Unfortunately, many people who work in this environment resort to illegal methods such as medicines or alcohol to combat the effects of disrupting this cycle.

Within a period of 24 hours, the human body goes through several states. The route of these states (sleep, fatigue, alert) is known as the circadian cycle and follows a set of constant parameters such as body temperature, endocrine functions or hormones. Evolving over time, this cycle has remained constant on mammals, so including humans, and is quite resistant to change. Most people have adapted to a 24-hour cycle[4], that is, the human body feels when it needs sleep, food or rest even if it were locked in a darkroom. Scientists tried to understand what sleep represents, but no one has come up with a clear conclusion of what it represents. The recovery or sleep period is 8 hours in a cycle of 24 to maintain active cognitive functions.

Newborns need a lot of sleep, especially in short periods, but by the age of one year they begin to develop a continuous sleep especially at night. From one year to 10 years, children need, in addition to nightly sleep, a half of light sleep during the day. Adolescents and young adults give up daytime sleep but recover at night with 1-1.5 hours of extra sleep. The constant lack of this hour causes the imbalance of the circadian cycle, which leads to fatigue. The triggering factor for sleep is melatonin. This substance is naturally produced by the body at the time of preparing the body for rest. Many times, due to multiple tasks or exhaustion we resort to artificial solutions for resting the body such as melatonin pills. They have a positive effect in the short term because the human body will fall asleep ordered and not through a natural secretion of melatonin and in the medium and long term negative effects due to the fact that the body no longer produces the same amount of melatonin in its natural state.

4. EFFECTS OF INSUFFICIENT SLEEP

In the case of a prolonged flight through several time zones, prolonged shifts or chronic fatigue[5], they contribute to insufficient or uneasy sleep. Unfortunately, these elements begin to become frequent in aeronautical activities where tasks are continuous and difficult. In case, instead of rest, we spend a long time on social networks, we have 2 affected organs (eyes and brain) that are subject to prolonged stress. In other words, instead of giving the body a state of rest we bring it an extra fatigue. Over a long period

of time, a disorder of the circadian cycle and the out of synchronization of the organism regarding the state of natural rest occurs.

In the case of military missions, the degree of fatigue tends to increase compared to the civilian environment and the reason is that combat missions have priority. The military is not only confronted with the hostile external environment, but they must also face the internal environment that becomes hostile due to fatigue, stress, panic attacks, fear or fear that can become dangerous.

After a 10-hour transport mission, a civilian pilot has enough time to rest and recover in a beneficial environment (hotel, recovery center) but an operational military pilot often recovers in a hostile, difficult or stressful environment for a longer period.

Let's look at the actuality of the war in Ukraine (fig 3). How can soldiers rest after a mission in enemy territory under the conditions in which they can be attacked at any time.

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FIG. 3 AzovStal soldiers

The soldiers of the Azov Battalion (Azovstal platform, Mariopol, Ukraine) were in a continuous struggle both externally and internally. Acute stress, hunger, insufficient rest were at very high levels. Their circadian cycle has been disrupted and the recovery period will be long. The level of stress resistance of a military man depends on his level of preparedness. A well-trained military man will cope with stress more easily compared to a civilian caught in a fight.

The AZOV battalion had between 3000 and 5000 soldiers trained for the special operations forces, but their role was complicated because they were surrounded by the Russians and among them were civilians, members of the families

4.1 Fatigue

Fatigue poses a huge challenge to the military environment and degrades crew performance[6]. The effects of fatigue are proportionally related to the body's response capacity so the probability of an error increases.

The effects of fatigue are visible in: decision-making capacity, communication skills, memory loss, accuracy of movements, the ability of logical analysis, oxygenation of the body.

According to Skybrary (2015) when a person is tired, the chances of errors appearing increase especially if they fly in difficult conditions such as flying, instrumental flight or use in combat.

Fatigue leads to the occurrence of late response for crew members or traffic controllers, and the occurrence of a special situation amplifies the error in making the decision.

According to Brandon (2000) the crash of the KAL aircraft (Korean Airline) on August 6, 1997 was the result of a series of errors committed by the crew, in particular the lack of attention due to fatigue.

4.2 Flight time limitation analysis

An EASA (European Union Aviation Safety Agency) report – provides an analysis of the effects of fatigue and recommendations on how to combat them. The report includes the impact of fatigue on the crew for certain periods of work:

a) Working time more than 13 hours mainly during the day;
b) Working time of more than 11 hours in little-known climate, both day and night;
c) Working time in different areas (sectors), more than 6;
d) Unspecified program.

The research was based on 3 sources:

- 15 000 online questionnaires to aircrew;
- Analysis on 260 000 flight hours;
- 381 crew members from 24 different airlines.

From the online questionnaires it emerged that tasks longer than 10 hours and the unspecified schedule have the highest weight in increasing fatigue. All 381 crew members volunteered to participate in the study. The information collected and analyzed refers to fatigue, drowsiness and mental exertion over a period of 14 consecutive days. Objective metrics were recorded in a rest log using an online app.

The study on flight hours showed an increase in the level of fatigue measured on the KSS' scale (Karolina Sleepiness Scale) at the time of transition from cruise flight to the descent phase (when the aircraft starts the landing procedure) at night, with no significant results for periods of less than or greater than 10 hours.

Consequently, in order to reduce the level of fatigue[8][9], airlines have considered limiting shifts below 10 hours at night, especially for pilots, in order to grant recovery time.

5. BOWTIE MODEL ANALYSIS OF THE AVIATION CATASTROPHE OF JANUARY 26, 2020

On January 26, 2020, at 9:45 a.m. PST (Pacific Standard Time), a Sikorsky SK76B helicopter crashed on a field in Calabasas, California. The NTSB (National Transportation Safety Board) states that the probable cause of the crash in which 9 people died (the pilot, Kobe Bryant, his daughter and 6 other people) was the pilot's decision to continue flying in severe weather conditions, favoring the appearance of disorientation and loss of control.

A human factor that contributed to the catastrophe was the self-induced pressure to continue flying to take the VIP to its destination. The pilot, Ara Zoboyan was forbidden by the controllers to enter the cloud formation, he reported that he was climbing over the ceiling but crashed on a hill.

In analyzing this case we will use the Bowtie method[10] from the Safety System Management. Although it is not used internationally, about 10% of small aircraft operators consider this model to be the best for auditing an aviation event.

The model is based on going through 5 stages, each analyzing a part of the event and how to implement the solutions.

Step 1: Initial causes

The causes of an aviation event can be due to pilot distraction, malfunction of an airport service, bad weather conditions or human error.

In the analyzed case we can consider the main cause of the event spatial disorientation and loss of awareness of the situation, hence the human factor. Spatial disorientation occurs due to several factors such as fatigue or stress, combined with the fact that the pilot was not ready for the IFR flight and asked for an SVFR authorization to continue the mission.

Stage 2: Previous Events

In the case of the Bowtie analysis, these are the causative actions that occurred just before the event, such as: the pilot did not hear the approval of the takeoff or did not see the stop signal.

In our case, the previous event was the controller's request to board and the pilot's confirmation that he was in a boarding flight even though the aircraft was in a descent flight.

Step 3: Determine the direct consequences after impact

In the analyzed case, the main consequence is the loss of human life, after which the destruction of the aircraft and other goods.

Step 4: Overall impact on the disaster

In addition to the loss of human life in any aviation event, there are other consequences such as the reputation of the firm, the loss of trust implicitly the loss of money. In many cases, after a major event, aeronautical firms go into insolvency due to accumulated debts. The quality of services also has a direct impact on passengers.

Step 5: Implementation

After identifying the causes, we can implement methods to minimize the risks. In the analyzed case, the main event was spatial disorientation, so we can force the air operators to train the personnel in order to combat disorientation.

Another cause is the lack of weather radar or education on the priority of a mission: safe landing or VIP transport. The pressure on the pilot to execute the mission was very high because there was a very important person on board the helicopter.

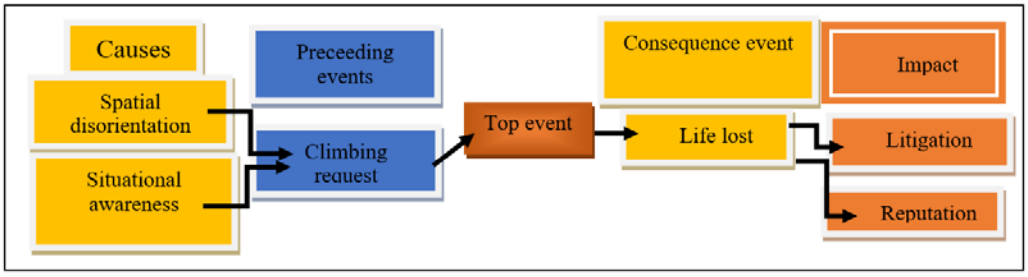

FIG. 4 Bowtie model in the analysis of the aviation catastrophe of January 26, 2020

6. RECOMMENDATIONS, CONCLUSIONS AND IMPLEMENTATION

1. Although companies avoid stating in the safety recommendations, a sleep break of a few minutes, before the descent procedure decreases the level of fatigue;
2. It is recommended to introduce night shifts in shifts. This would help operators devise effective measures to combat fatigue;
3. Informing operational staff of the possibility of fatigue and errors;
4. Increasing the level of attention for air traffic operators when starting the landing phase;

5. Changing the descent strategy especially during night shifts that start earlier than 1:59 and end after 6:00, at which point the state of fatigue is at its highest level.

Ensuring that crew members have sufficient rest time is the responsibility of the operator and crew. Current regulations describe the need for operators to provide opportunities for rest and recovery. As this is essential for the effective management of this risk, EASA will work with national civil aviation authorities as well as industry stakeholders to actively promote the provision and use of rest facilities at or near airports to facilitate the start of the service at night and minimize fatigue.

All indications of analysis lead to the recommendation of "controlled rest", that is, a period "outside of pregnancy" during which the body can relax. Research has shown that short, controlled rest is the most effective strategy to alleviate fatigue during flight.

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