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A critical approach to fatigue risk factors in cockpit and cabin crew for the flight safety in aviation industry

Engin Ozel [(a)*] *Umit Hacioglu* [(b)]

[(a)] *Master of Science in Air Transport Management, School of Graduate Studies, Ibn Haldun University, Istanbul, Turkey*
[(b)] *Professor, School of Management, Ibn Haldun University, Istanbul, Turkey*

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ABSTRACT

This paper aims to develop a critical approach to flight safety by assessing theoretical and empirical studies on fatigue risk factors in cockpit and cabin crew. This paper also builds a fundamental basis for managing fatigue risk factors in aviation industry. The main contribution of the paper demonstrates the fact that primary and secondary fatigue risk factors in cockpit and cabin crew affect the level of job satisfaction, operational efficiency and flight security.

Introduction

Crafting effective business strategies in aviation industry requires the dedication of well-motivated and qualified employees with high job satisfaction. As in all businesses, it is always expected that the employees are well-educated, professionally experienced, skilled, idealistic and dynamic people who care about the quality in their work, in the success of an airline business. Combination of both speed and comfort for passengers in aviation industry has become also an important key parameter for overall business performance and attracts new passengers as well.

The law that introduced liberalization in the airline transportation sector in the United States in 1978 also affected Europe and Turkey, causing new airline companies to enter the sector, and the number of flight frequencies and networks to increase; therefore, it has created an intense competitive environment. In the meantime, technological innovations that make communication between people easier, faster and more comfortable have increased and continue to increase service quality expectations by increasing the interaction of passengers who prefer airline in their travels (Dawson et al., 2011).

The air transport sector, where there is fierce competition on both domestic and international lines, is a service-oriented sector by its very nature. The most important duty of airline companies should be the successful and healthy management of human resources, which is the most fundamental factor that can ensure the desired quality and sustainability of service delivery. During the flight operation, the cabin crew on board plays the most effective role on passengers in evaluating the service quality and therefore the company's success. Employees at the frontline do the delivery of the final service to the customer face to face. Unfortunately, these employees often encounter situations that are stressful and require special effort in the service sector. For example, while dealing with customers who are constantly waiting to be served, they may encounter customers who verbally taunt them to an insulting

* *Corresponding author. ORCID ID: 0000-0003-2840-7120*

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degree, and yet are expected not to compromise on politeness. In addition, they must be able to communicate with customers and constantly smile while providing services. A profession that requires full control of their emotions and managing them well, cabin crewing is a profession that combines long flights that cause mental and physical fatigue and low duty initiative, and can easily lead to emotional exhaustion(Phillips et al., 2017). This emotional exhaustion situation may cause the personnel turnover rate to be very high due to the fact that this job is at irregular hours and its unique characteristics, although there are many applications to become a flight attendant. In Turkey, although it is not possible to reach clear and precise information due to the airline companies' refusal to provide information about their personnel, the results of the research conducted on personnel in other foreign airlines around the world support this. When flight attendants working in airline companies with scheduled and intense flight activity, they may stay away from regular social relations both in their workplace and in their private lives when they work in companies that operate non-scheduled (charter) flights. This situation can cause them to feel detached from life, and when combined with mental and physical fatigue, they become extremely sensitive and stressed.

It cannot be denied that flight safety, which is a must at every stage of air transportation activity, offers a sustainable competitive advantage and has positive effect on investors' perception in capital markets for their investments (Dincer & Hacioglu, 2013; Dincer, et al., 2016; Dincer et al., 2018). To compete with the rival firms in aviation industry, there should be a strategic fit between long term firm specific characters including dedicated and satisfied employees, organizational structure and business culture as well (Hacioglu, 2019; Hacioglu & Sevgilioglu, 2019; Hacioglu, 2020). However, one of the elements that airline companies cannot give up in order to achieve this goal is the quality of service provided to passengers (Dincer et al, 2017). For this reason, the mental, psychological and physical health of the personnel serving the passengers face to face is the most important factor that determines the quality of the service to be provided to the passengers.

Cabin and cockpit crews make an effort to please passengers with different cultures, personalities, religions, languages and other demographic variables by providing them with good service every day. Apart from these duties, important responsibilities such as preparing, calming, directing, reminding the passengers of their movement, and applying safe evacuation procedures, when necessary, increase their workload. However, cockpit and cabin crew, where human relations are particularly significant in the quality-of-service delivery (Dincer et al., 2018), is a profession that brings well-organized and cost-effective results (Hacioglu and Aksoy, 2021) to the company only if high job satisfaction and sufficient motivation are provided to its employees. This extraordinary and self-sacrificing job can lead to physiological and psychological fatigue, mental wear, depression and, in more advanced stages, burnout in cabin crews over time.

Some flight attendants who are exposed to fatigue prefer to leave their jobs, but most of them continue to stay in this job due to the reasons mentioned above, however, they cannot show sufficient and quality service delivery performance. In recent years, with the increase in the number and frequency of flights, and the effect of long-term and night flights, the working conditions of cabin and cockpit crews have become more difficult. The high quality and quantity of requests and expectations of the company management from cabin crews negatively affect the perceived workload and stress level. This situation can lead to physical and emotional fatigue, which leads to emotional exhaustion, which is at the core of burnout. Therefore, the body's defense mechanism can push cabin and cockpit crews to insensitivity.

Cabin and cockpit crews may need longer than other employees to recover from the effects of time differences and fatigue caused by jet lag. As a result, this situation may cause the personnel qualified in the airline industry to experience burnout and leave their jobs. Studies indicate that job satisfaction plays a key role in increasing the performance of cabin crews and decreasing personnel turnover rates(Castro et al., 2015). The decrease or exhaustion of the dignity, earnings, status and social support elements that are very important for the employees creates stress(Dorrian et al., 2012). Cabin crews, whose dedication and good service are expected, can easily lose the mentioned factors with their stressful workload and tend to quit the job due to emotional exhaustion and then job dissatisfaction(Efthymiou et al., 2021). Although the topic is crucial, the causes and consequences of job satisfaction in the airline industry have been little addressed. Emotional work in the service sector can be stressful and push the person to burnout. Burnout affects the attitudes and behaviors of cabin crews and therefore their choice of the same airline again depending on the satisfaction of the passengers. Plieger and colleagues showed that being aware of burnout can positively contribute to a person's health and well-being (Plieger et al., 2015).

There has been very limited number of studies on stress, burnout and fatigue syndrome in cabin crews, who have a high-risk level due to their nature, operate on a 24-hour basis, require great responsibilities especially in emergencies and perform a stressful job in close contact with people. Nonetheless, in a recent study, Hacioglu and Ozer (2021) examined the relationship between burnout and job satisfaction of flight crew with an elaborate analysis on the critical fatigue risk factors in the aviation industry. Their study employed a factor analysis with a target population of 254 international flight crew using Minnesota Job Satisfaction Survey and Maslach Burnout Questionnaire. They clearly demonstrated that cockpit and cabin crews' job satisfaction and performance have been affected by stress and fatigue risk factors. Moreover, psychological depression, anxiety and personal problems of the flight crew were highlighted as the main causes of emotional fatigue which may lead to flight safety risks (Hacioglu & Ozer, 2021).

This study therefore aims to develop a precarious approach to fatigue risk factors for cabin crews in the aviation industry with a critical review of related literature.

This paper organizes as follows: Theoretical and conceptual background of fatigue and related risk factors in aviation industry have been assessed in the literature review part. In the following part, Fatigue Risk Management Systems (FRMS) has been explained. Finally, this paper concludes with final remarks, limitations and future research directions.

Literature Review

Theoretical and Conceptual Background

Fatigue

The concept of fatigue has been attracted the attention of various science from the times of World War I to the present day. First initial researches on fatigue were in the industrial field and the effects of fatigue on productivity are discussed. George Poore developed a framework for fatigue, separating between general/local and chronic/acute fatigue in 1881(Noy et al., 2011). Afterwards researches of fatigue investigated physiological and anatomical pathways. Various authors have been described fatigue as a moral and physical problem which results a breakdown of a mind and body causing to a complete exhaustion. Fatigue researches were especially performed on war pilots during World War II. These studies are focused on determining pilot's fatigue. The research has continued for many years (Maslach et al., 2001). American Neurologist Beard identified fatigue with the word of "neurasthenia" in the late 19th century. The word 'neurasthenia' is a disease refers to many physical and psychological complaints. This disease appears in the literature in various ways. While it is used chronic fatigue syndrome as neurasthenia in American medical literature it is used as Asthenia in Europe (Brezonakova, 2017). The words exhaustion and weakness are often used to mean fatigue. Cella and friends have identified fatigue as weakness, lack of energy and exhaustion (Torres-Harding & Jason, 2018). Fatigue is a reality of the life cycle in normal life or it is a reaction that occurs as a result of activities or effort. Exhaustion is extreme fatigue. Olson suggested as a meaning that "fatigue is an unadaptable response to exhaustion. Ream and Richardson defined exhaustion as a temporary decrease in strength and energy (Englebienne & DeMeirleir, 2002). However, it is thought to be fatigue is chronic and relentless. Weakness has been described as a neurological disorder which prevents individuals from performing their duties. People can do their activities on their own when they are tired, but they cannot do if they are weak (Maslach et al., 1996).

Fatigue is an experience of physical or mental weariness that results in reduced alertness. For most people, the major cause of fatigue is having insufficient rest and recovery from previous activities. In a simple term, fatigue mainly results from insufficient quantity or quality of sleep because both factors mean equal importance to recover from fatigue and to maintain normal alertness and performance(Nelson, 1997; Ozer & Hacioglu, 2021). An insufficient quantity or quality sleep series of nights causes a sleep debt which results as increased fatigue. As can be seen from the analysis made, the word of exhaustion and weakness have different characteristics and should not be used as a substitute for fatigue. There are some differences and similar points between these two subjects. There are several up-to-date studies on fatigue listed below.

Table 1: Summary of related studies

Author	Subject	Contribution
Van Drongelen et al., 2017	Risk factors for fatigue among airline pilots	The aim of this study is to determine fatigue risk factors for pilots in aviation
Reis et al., 2016	Sleep complaints and fatigue of airline pilots	The aim of this study is to determine sleep complaints prevalence and evaluate the influence of sociodemographic parameters variables on sleep complaints and fatigue
Phillips et al., 2017	Fatigue in transport: a review of exposure, risks, checks and controls	The aim of this study is to review fatigue-related risk, exposure factors and control measures for transportation operators
Honn et al., 2016	Fatiguing effect of multiple take-offs and landings in regional airline operations	The aim of this study is to establish scientifically a connection between circadian rhyme and the number of flight sectors effect to fatigue
Australian Civil Aviation Safety Authority, 2012	Fatigue Management Strategies for Aviation Workers: A Training & Development Workbook	The aim of this study is to improve aviation safety through the management of Fatigue-related risks in aviation industry
Kandera et al., 2019	Consequences of flight crew fatigue on the safety of civil aviation	The aim of this study is to find an objective way to measure fatigue through sleep which is a component of fatigue
ICAO, 2016	Doc 9966. Manual for the Oversight of Fatigue Management Approaches	This manual is one in a suite of manuals which related to fatigue management.

Source: Ozel,. E (2021).

As a result of the developments and needs in the 21st century, the necessity of continuing the transportation sector activities on a 24/7 basis has emerged worldwide. This necessity has affected the aviation industry as well as in other branches of the sector and fatigue has emerged as one of the most important factors. Fatigue has been recorded as an important factor in many cases in the civil

aviation industry. The literature review of cockpit and cabin crew fatigue factors includes information from experimental studies, scientific publications, articles, manuals and survey reports. Unfortunately, we should accept that flight crew fatigue literature has certain limits. Most experimental studies were not conducted with cockpit and cabin crew or conducted only with cockpit crew. Several studies have proved that fatigue can significantly impair people's ability to perform duties and tasks that requires manual dexterity, high concentration and complex thinking. Fatigue is not only an uncomfortable sensation to be suffered because fatigue reduces peoples' performance (Ozer & Hacioglu, 2021).

Fatigue is a nonspecific symptom because it can be an indicator of many illnesses or diseases, medical conditions and physiological disorders. For example; sleep deprivation, autoimmune illnesses, anxiety and major depression(Greenberg, 2002). Also consuming excessive caffeine and alcohol, psychosocial stressors and frequent sleep disorder may cause fatigue. Health identified by the 'World Health Organization' (WHO) as; purely physical, mental and social well-being and the absence of illness or weakness. The factors that negatively affect the health of people are medical and disease states. Medical conditions and illness condition causes fatigue. The effects are don't only depend on for medical conditions or the nature of the disease, but on the type of work performed(Hartley, 1998). For example, a person with a problem of Anemia constantly complains of tiredness. This condition shows that Anemia disease increases the fatigue of people and decrease work performance of people. Some unnoticed psychological problems, chronic hormonal disorders such as fatigue syndrome, vitamin deficiencies, hypothyroidism, viral upper respiratory tract infections, anemias and some rheumatologic diseases can increase stress or cause work stress. The common cold flu, which is a small disease, delays the response time and effects your coordination. The common cold flu also effects people's performance efficiency.

Adverse working conditions while causing weaken the person's performance and periodic fatigue; bad health status of people causes long-term fatigue. Long-term fatigue of the person concerned with cognitive performance and health. Health has an impact on people's performance(Hartzler, 2014). Health problems cause performance decreases, motivation decreases and their concentration deterioration. Other factors that affect fatigue are the age of the person and the fit of his body. Changes depending on the age of the person; less sleep than need, high blood pressure, poor visual perception, worsening of physical condition, medication increases in usage cause decrease in performance of people.

Fatigue is a common problem at all transportation sectors including aviation. It is a known fact that fatigue is the most important factor which causes accidents. For this reason, it's important to conduct researches on the causes and occurrence rates of fatigue. The reasons for the occurrence of plane crashes are based on many reasons, however it was determined that fatigue is one of the most important factors which causes plane crashes(FAA, 2010a). There is no accepted universal definition of fatigue. Fatigue; is a complex and subjective concept which is extreme energy loss as a result of physical exertion or lack of sleep. The definition of fatigue is defined in the Medical Dictionary in three different ways. First fatigue in definition; exhaustion after strenuous physical activity. In another definition, fatigue; it is a situation where the responsiveness of tissues ready to give is reduced. (Like a muscle contraction in response to a motor neuron). Another definition of fatigue; it is an emotional state, manifested by exposure to excessive and prolonged psychological pressure. Fatigue accepted as a nursing diagnosis by the North American Diagnosis Association (NANDA) in 1988. NANDA describes fatigue as; continuous fatigue that doesn't go away with rest, reduces physical and mental work capacity (Plieger et al., 2015).

According to the FAA, fatigue can be defined as a condition which is usually accompanied by tiredness and a feeling of weariness, characterized by lessened capacity for work and increased discomfort (FAA, 2007). According to the ICAO, fatigue impairs crew members' ability to maintain their ability to safe fly an aircraft or to perform safety-related duties (ICAO, 2016). Fatigue causes to a physiological condition due to biological sleep clock patterns or workload and causes a decrease in mental or physical performance ability.

Fatigue has been classified in various ways. But among them the most common classification is between acute and chronic fatigue. Although acute fatigue is seen as temporary fatigue, it occurs as a result of physical or mental exertion. Acute fatigue limit varies from person to person and when enough rest is achieved, fatigue disappears. Chronic fatigue is not about straining oneself. It is a type of fatigue that continuing for more than 6 months and usually accompanied by a chronic disease (Englebienne & DeMeirleir, 2002). It is obvious that a variety of sources can develop fatigue. The main issue is the negative impact of fatigue on a person's task performing ability. Daily long mental concentration such as getting prepared for an exam or writing an important report can be as fatiguing as manual labor(Australian Civil Aviation Safety Authority, 2012). Studies about fatigue proved that fatigue may significantly impair a person's ability to perform tasks which require high concentration, complex thinking, and even manual dexterity. Fatigue may become in a short time after some significant heavy and long physical or mental activity. As an alternative, fatigue may happen after several days or weeks(IATA, 2014). The recent situation typically happens when someone does not get sufficient sleep over a prolonged period for reasons such as having a baby at home, frequent long travels, sleep disorders such as insomnia or sleep apnea, and shift work. Ongoing physical / mental effort with insufficient rest may often involve by personal demands or workload(Dai et al., 2020).

A distinction needs to be made between chronic fatigue and acute fatigue(Johnston et al., 2019). Acute fatigue is time-limited, usually with a good rest or adequate sleep fatigue is reduced. Chronic fatigue does not decrease with rest or sleep. Chronic fatigue is an unpleasant situation, the person can't get rid of feeling excessive tiredness and exhaustion for a long time. While acute fatigue takes on protective function, chronic fatigue creates a feeling of running away and inadequacy (Maslach et al., 2001). Chronic fatigue

leaves profound negative effects on their abilities to perform the activities and roles of patients that add value and meaning to their lives. (Opal Arilla Mclnnis, 2011) studied with a hundred twenty-two subjects about the connection between chronic fatigue syndrome and fibromyalgia. Author found that; subjects living with chronic fatigue syndrome and fibromyalgia impact their well-being by high level of depression. In a study, human error-based accidents are reported due to fatigue as an important factor in the occurrence of aircraft accidents in the aviation industry. Fatigue and the effects of fatigue are inevitable if preventive measures are not taken (Goode, 2003).

When trying to determine why fatigue has occurred, there is often a focus on the sleep quality and quantity because, sleep quality is very important to recover from fatigue and to maintain stable alertness and performance. Lack of sleep over a continuous series of nights causes a "sleep debt," and it results as increased fatigue which can sometimes be bad than a single night of lack of sleep. Shift works, especially night shifts, may limit the opportunity for sleep and recovery in each 24-hour period. Shift work usually reduces the amount of sleep which a person normally gets by between one and three hours per day. According to(Dawson & McCulloch, 2005), there are four identifiable segments which common to all fatigue-related incidents. These segments are related to appropriate utilization of a sleep period and the provision of an adequate opportunity to sleep. The level of mental fatigue is linked to the duration of sleep. Some theoretical models of circadian rhythms and sleep which aimed to predict to fatigue examined by (Dawson et al., 2011). They also determined how current fatigue models being applied by companies and regulators. They discussed about these models and made recommendations on the most applicable ways to use and improvement ways of these current fatigue models. According to(Drury et al., 2012), it is significant that cabin and cockpit crews with restricted sleep, they display emotional responses. They investigated whether sleep patterns influence the strength of Heightened Emotional Activity (HEA) as a response to threats and the relationship between restricted sleep and (HEA). The findings indicate that reduced sleep causing to increased occurrences of confusion and frustration in response to threats.

(Darwent et al., 2012) used software-based bio mathematical models of alertness which means to estimate fatigue-related risks in a work schedule. The purpose of the analyses is to evaluate the predictive validity of a sleep predictor model which is designed to predict sleep probability of the long-haul pilots. The model validated on 225 samples who collected sleep/wake and work/rest data during two weeks. Observed and predicted sleep periods robusted 85%. (Roach et al., 2012) examined the impact of layover length on the pilots' sleep. They determined the effects of layover length on the amount of sleep that pilots obtained during the trip and subjective fatigue levels and capacity to sustain attention. Results showed that pilots had higher fatigue level at the end of the flight, obtained more sleep during layover days than they obtained on days off at home. (Ferguson et al., 2012) examined the independent contributions of sleep, sleep debt and circadian phase to fatigue ratings. They used a sophisticated laboratory protocol. In the study subjective fatigue ratings were recorded to determine the sleep dose and effects of circadian times. Pre-sleep fatigue related to only circadian time but post-sleep fatigue related to sleep dose and circadian time. Results showed that, with higher levels of sleep restriction post-sleep fatigue ratings are higher. (Matthews et al., 2012) determined the independent effects of time of day and prior wake on driving performance with sleep restrictions. They used circadian phase, prior wake and sleep debt as fatigue factors. Results showed that, circadian influence and its combined effects with other factors of fatigue have been detected. Also, prior wake influence achieved. Reduced sleep combined with these two factors and conditions identified as high fatigue risk. (Åkerstedt et al., 2014) studied about sleepiness levels on factory workers in a chemical factory who works at night shift. Sleepiness level was low during the day but it was rising in the evening on the first day. Next three days workers involved wakefulness after a 5 hours' sleep. It has been seen that there was no adjustment.

Mental Fatigue, Motivation and Performance

Demanding cognitive activity which is characterized by lack of energy and tiredness causes a psychobiological state described as mental fatigue(Lee & Kim, 2018). There is a significant relationship between fatigue and motivation. It can be measured as a reducing ability when performing mental tasks. Fatigue may be considered a deficiency of motivation or drive to perform. In recent years, researchers have compared the effects of alcohol and fatigue on performance. While most people understand that alcohol intoxication can be a significant risk on the roads, the effects of fatigue may not be as readily understood or acknowledged. Studies using particular performance tests have indicated that(Australian Civil Aviation Safety Authority, 2012):

i. The performance of a person who wakes at 7 a.m. and stays awake for 17 hours until midnight is, by that stage, likely to be as impaired by fatigue as someone with a blood-alcohol concentration (BAC) of 0.05% -- the legal driving limit in many countries

ii. A person who wakes at 7:30 a.m. and stays awake for 23 hours until 6:30 a.m. the following day will have a level of general performance impairment similar to someone with a BAC of 0.10% - which is twice the legal limit for fully licensed drivers

Honn and colleagues studied with twenty-four airline pilots about early beginning and long duty times' effect on fatigue with multiple take-off and landings during two days(Honn et al., 2016). Study showed that work load which associated with multiple take-offs and landings increased fatigue over the duty day. Cockpit crew's performance indicated greater fatigue in the five duty day than in a single duty day on the PVT. (Brezonakova, 2017) examined European Aviation Safety Agencies' new Flight Time Limitations within the legal framework. Author found some threats caused by unmanageable and extensive job demands which increased pilot burnout. Frequently time zone changes, early beginning duty planning's and long duty hours leave the cockpit and cabin crew members

fatigued without enough time to recover from fatigue. Aviation has a safety sensitive environment and fatigue with burnout symptoms will cause to lack of performance for critical tasks by longer reaction times.

According to (NASA, 2015) coordination is the most important factor for effective team performance and stress significantly reduces teammates' performance. They analyzed some accidents for errors and found 212 errors. Thirty of the errors involved insufficient and improper communication. Thirty-six errors involved to lack of management of competing task demands. Another thirty-six errors involved to inadvertent omission of required tasks and actions. After these analyses some critical points of skilled performance of pilots are vulnerable to disruption emergency and other serious situations. (Boksem et al., 2006) examined the effects of mental fatigue on behavior. Subjects performed a task during continuously two hours that required a high concentrated action monitoring. Subjects offered a cash reward if they can perform very well as a motivation. They stressed the instructions accuracy and speed. Subjects choose to focus on to improve their performance only on their speed or accuracy. For the concept of mental fatigue these results have important implications. When fatigued subjects motivated, subjects monitored their actions adequately by sacrificing their speed of response. These results showed that there is a significant motivational component involved in the process related to mental fatigue. On the other hand, subjects couldn't improve their performance in both ways. This explains that fatigue is more than a reward/effort imbalance and need adaptive strategies at an acceptable level under adverse conditions to keep performance.

(Arsintescu et al., 2020) examined the relationship between cockpit crew workload, sleep duration, performance, subjective fatigue and flight duty time. The subjectives were ninety pilots and they wanted from pilots to complete a NASA Task Load Index, a Samn-Perelli fatigue scale and Psychomotor Vigilance Task on top-of-descent of each flight. At the end of the study, they found significant correlations between workload and other factors. When fatigue increased cockpit crews reported higher workload and objective performance was worst. (Flindall, 2015) researched to improve mental fatigue related errors without pharmacological use. Author explored cognitive cues which can be used to improve cognitive recall and medical documentation in the acute mental fatigue state with a medicine. The research has demonstrated that non-sleep deprived subjects have improved recall if cognitively fatigue. Author suggest that it is possible to improve fatigue related errors without pharmacological use.

Fatigue, Stress and Job Satisfaction

Fatigue and Stress

Stress has become a part of every stage of daily life and has become an indispensable element. With each passing day, a period of rapid change is experienced and innovations are rapidly entering the lives of people. It is noteworthy that the majority of the studies in this area have been carried out in the last 30-40 years(Pourabdian et al., 2020). Among the reasons for this; Factors such as rapid change in all aspects, the transition from the industrial era to the information age, the change in competition and production conditions, the emergence of differences in human needs, metropolization and the need for qualified human resources can be shown. It is also not expected that the intensity of work in this area will decrease. In particular, it is expected that companies that want to increase their workforce efficiency sufficiently in business life will actively continue their stress research. Stress affects people at many stages of life. This effect often shows itself negatively and it is stated that it reduces the productivity of human resources and the quality of production and service in the organization. Threatening the organism and thus disrupting its balance causes an alarm response aimed at preserving vitality(Kelly, 2017). In order to restore the deteriorated balance, it is necessary to adapt to the new situation. For this reason, the stress response is also known as the "General Symptom of Adaptation".

The General Adaptation Symptom developed by Selye on stress describes the body's reaction process when faced with stress. The first stage, the Alarm Reaction (A) stage, is the process in which the body encounters stress and gives the first reaction. In this process, the resistance of the body that experiences a shock in the first-place decreases, and the organism tries to struggle or avoid to cope with this situation. If an adaptation can be achieved in response to the stress encountered in the second stage, the Resistance Period (B), the resistance of the body rises and rises above normal. If this stage is successfully overcome, the body returns to normal. In the third and last stage, the Exhaustion Period (C), the resistance of the body decreases significantly since the effect of the stressful event is very serious and long-lasting(Sallinen et al., 2017). At this stage, the symptoms of the Alarm Reaction stage are seen, the balance is disrupted and the harmony energy is exhausted. During this period, signs of burnout begin and may leave deep scars in the organism.

The concepts of stress and fatigue, which are often confused with each other in the literature, do not express the same thing. Stress can have both positive and negative effects, but it is not possible to say the same for fatigue. When the stress is continuous, anxiety / anxiety, depression increase and fatigue occurs(Price et al., 1992).

Fatigue and Job Satisfaction

The concept of job satisfaction means that a person feels competent in his / her job, produces creatively, thinks that he / she receives material and spiritual reward for what he / she produces, and that he / she is happy in his / her job. When job satisfaction is examined conceptually, the concepts of motivation, personality traits, interests, attitudes, values, needs, and subordinate relations come before us. When we look at the results of job dissatisfaction, it is seen that besides the decrease in work efficiency, the psychological and physical health of the person is negatively affected(ERSO, 2018). Therefore, it is understood that job satisfaction affects the person and the life he / she lives in addition to his / her job. When occupational fatigue is examined, it seems conceptually different from

job satisfaction, but when its causes and effects are examined, it is seen that they are similar to each other. Occupational fatigue causes are personal characteristics, stress, needs, conflict, psychological harassment (mobbing), excessive workload, subordinate relations. Although the results are similar to job dissatisfaction, it can be thought that it has more negative results than job satisfaction. The consequences of fatigue may be alienation, burnout and stress symptoms, negative affect, and occupational suicide. While it is thought that job dissatisfaction is at a more normal level and can be reduced more easily with measures and regulations, occupational fatigue can be seen as an occupational depression and it may be thought that it is more difficult to alleviate the feelings of occupational fatigue(van Drongelen et al., 2017). Studies have found supportive findings that there is a significant and inverse relationship between fatigue and job satisfaction. Based on these results, the higher the job satisfaction of individuals, the less likely they are to experience fatigue.

Fatigue and Organizational Success Relationship

Fatigue Syndrome is a condition that individuals and organizations should take seriously due to its negative consequences affecting physical and mental health, social relations and business life. While fatigue affects customers who are exposed to low quality service and inhumane attitudes; It also affects organizations whose employees have to deal with problems such as low performance and high turnover rate. The negative consequences of fatigue on the individual can lead to undesirable conflicts and relationships in family life. The fact that fatigue affects not only the individual himself, but also the people around him and the organization he works for, and therefore the economy, social and cultural life of the country, is the most basic feature that needs to be taken seriously. The individual symptoms of burnout also appear as the consequences of fatigue on the individual(Zaslona et al., 2018). Therefore, the organizational consequences of fatigue are emphasized in this section. As mentioned before, the concept of fatigue is perceived as an individual problem by institutions and workplaces. However, a depleted employee can have a negative effect on the work at the workplace, on the workflow or on other employees. In fact, many of those who suffer from fatigue are really good and careful workers. Considering that every person has a backup, and a reserve that can be run even cheaper, causes really talented people to waste. Among the consequences of fatigue affecting the organization(Dorrian et al., 2012),

i. Neglecting or slowing things down,
ii. Increasing reports and permissions,
iii. Carelessness towards customers or people receiving services,
iv. Increasing customer dissatisfaction,
v. Increasing tension in relationships at work,
vi. Increase in error rates,
vii. Losing good employees,
viii. Decrease in work efficiency,
ix. Loss of qualified workforce,
x. Systemic problems due to the deterioration of work disciplines in institutions,
xi. The consequences of disruptions at work can be counted.

An organization with fatigued employees cannot easily make changes in its structure and processes in order to adapt to changes in the environment. Fatigue prevents creativity and decreases the capacity of the individual to work efficiently with customers and colleagues (Maslach, Leiter, 1997). Employees who experience fatigue gradually decrease their job satisfaction and their commitment to the organization. The retirement of people caught with fatigue syndrome, despite being able to work productively for many years, is a significant loss for the organization.

Causes, Symptoms and Risk Factors of Fatigue

Fatigue is complex and multi-factorial. We understand some things reasonably well such as sleep and circadian rhythm. But there are multiple factors such as; inadequate sleep, circadian rhythms, high workload, extended duty periods, psychosocial factors, environmental factors, and others(Tiesinga et al., 1996). There is also considerable individual variability. It's important to emphasize that there is no simple, universal solution to the problem.

Fatigue is a physiological condition that occurs when three main factors come together(Holmes et al., 2012). These are;

i. Environmental factors
ii. Personal factors
iii. Workload

Fatigue can have serious consequences in both business and daily life. Insomnia, sleep debt, chronic insomnia, and staying awake for a long time are the main causes of fatigue. Some factors that can cause insomnia(Greenberg, 2002);

i. Working or staying awake at hours that can disturb the circadian rhythm
ii. Time difference
iii. Factors that can affect sleep quality, such as caffeine and alcohol consumption and light
iv. Personal factors such as stress, irregular lifestyle

When people report fatigue, they are not fully aware of the effects of fatigue. The person experiencing fatigue may show symptoms such as forgetfulness, poor decision making, slow reaction time and apathy(Goode, 2003). Adequate quality sleep is required to combat this triple threat. Sleep is an antidote to fatigue and is essential for being fit. When people do not get enough sleep, fatigue affects people negatively.

There are several factors that can cause fatigue, and primary factors are directly considered to be causes of fatigue (ICAO, 2016);

Sleep Time: On average, it refers to the time spent asleep in a night. Night sleep is more effective in relieving fatigue than daytime sleep

Wakefulness time: Refers to the total time elapsed since waking up

Circadian rhythm disruption: It refers to the cycle of sleep and wake in the biological clock pattern of our body. Generally, this rhythm is at its lowest hour intervals between 02: 00-05: 59 and 15: 00-17: 00. During these hours, the body tends to sleep due to its natural structure. In particular, staying awake between 02:00 and 05:59 in the adapted home base time frame counteracts the body's natural tendency to sleep and affects the circadian rhythm.

Secondary factors indirectly affect fatigue(FAA, 2005);

Sleeping disorders: It can reduce the sleep quality of the person by affecting the sleep cycle. People are often unaware that they have a sleep disorder, and this condition can be treated if diagnosed.

Accommodation in different time zones: Traveling in different time zones can lead to fatigue. Because the incompatibility between the body's biological clock and environmental factors can affect the day / night sleep balance from time to time and making it difficult to sleep.

Stress and illness: Chronic illnesses and stress can lead to sleep loss. Stress and anxiety can often prevent people from falling asleep even when they feel very exhausted. Doctor control is important for treatment.

Flight Scheduling/ Rostering: The body's biological clock working differently from the normal sleep pattern often results in too little or poor-quality sleep. Like overwork, low workload also causes fatigue.

Lifestyle: Healthy eating, regular exercise and water consumption are important factors in combating fatigue.

For physiological reasons, people live actively throughout the day and have to sleep at certain times at night. Fatigue emerges as an important risk in the aviation industry due to physiological needs and the operation structure that continues 24/7. Being awake, especially during the time to sleep, causes unwanted cognitive effects and consequences by creating sleep debt. Errors and omissions, decreased situational awareness, inability to perform routine tasks or make mistakes, inattention and forgetfulness, difficulty in making decisions are common effects of fatigue on human performance(Tiesinga et al., 1996). Human biorhythm involves cyclical activities that occur in the body within 24 hours.

Hormones, blood circulation, digestive system and neurological systems increase or decrease their activities depending on certain time intervals of the day. This cycle is controlled by the central nervous system and creates the circadian rhythm, also called the biological clock. When the inconsistency in day and night time perception affects the circadian rhythm, for example during the sleep time in different time zones, the brain tries to cognitively adapt itself to this situation and the body and central nervous system work hard to compensate for the difference between the biological clock. All of these will increase fatigue(Caldwell, 2005).

Another symptom is; people cannot continue to their routine works. People's routine work need extra energy to realize, physically making complaints, emotionally unstable and restless, having trouble concentrating or focusing on a topic, the loss of joy and the mood of indifferent to the environment, sexually strong reduction and increased susceptibility to accidents are also signs of fatigue(Göker, 2018). Also, people have difficulty remembering, difficulty concentrating, dizziness, nausea, unexplained weight loss can also be seen. Healthy, successful, intellectual and strong individuals can quickly get into a bed-bound and unable to work mood. Fatigue can be a symptom of many diseases, but more than 50% patients with fatigue complaints had no significant disease. This result has led to the recommendation of emotional and psychiatric etiologies for fatigue(National Road Transport Commission, 2001).

Catherbas (1992) compared patients who were and were not tired in his study and determined that tired patients have a higher diagnosis of depression and anxiety. It is comparable that phobia, panic disease, overstrain and timidity rates for both groups. Patients with fatigue complaints, although they have stated that they have more personal stress in the last 3 months were no significant differences in their stressful life stories. It has been seen that patients with and without fatigue symptoms; there is not much difference between their current illnesses and the severity of their past illnesses(Englebienne & DeMeirleir, 2002). Working constantly under heavy workload causes fatigue. Workload; the burden of a person working long hours or considered to performing tasks which is physically demanding, mentally stressful. Lack of rest periods during long working hours causes fatigue. Working time in the air, although working conditions are intense often around 12 hours a day, 7 days a week. It is not always possible to realize uninterrupted and long-term sleep period to relieve fatigue for supporting the performance of the flight crew. Excessive working hours and fatigue cause the following adverse situations:

i. Increase in accident and death rates
ii. Increase in tobacco, alcohol and drug addiction
iii. Poor quality and interrupted sleep
iv. Frequency of cardiovascular, respiratory and digestive disorders
v. Increased risk of infection
vi. Loss of appetite

Sleep is an active process and when people sleep, their state of consciousness is actually changing. Not all sleep is the same quality and it doesn't provide the same healing benefit. Effective sleep must have four features to meet the needs of the human body(Holmes et al., 2012). These features are duration, continuity, time of day and the quality of sleep. Although everyone's sleep needs are different, the recommended sleeping time is about 7-8 hours of sleep per day. The people need enough sleep to feel refreshed. Vigilance and performance are directly related to sleep(Castro et al., 2015). Excessive insomnia for several days in a row adversely affects people's condition. Only sleep maintains and renews people's performance levels. Nights with overlapping short sleep periods negatively affect the depth of sleep. This situation reduces people's energy levels as they start their day and strengthens the effects of fatigue accumulated throughout(Australian Civil Aviation Safety Authority, 2012). Even a one-day insomnia situation causes a decrease in cases of occurrence. In such a situation, the probability of an accident occurring is very high. People who work from the night hours until the early hours of the morning feel the same effects. Regarding symptoms of fatigue factors specific to flight crew in aviation industry have been recognized for a long time(Gregory et al., 2010). At the same time, it has been noticed that such symptoms may be an important factor hindering the performance and reliability of the person. Specific symptoms or disorders arises as a result in individuals.

Sleep State and Fatigue

Sleep is an active process and when people sleep, their state of consciousness is actually changing. Not all sleep is the same quality and it doesn't provide the same healing benefit. Effective sleep must have four features to meet the needs of the human body. These features are duration, continuity, time of day and the quality of sleep(Ferguson et al., 2012). Although everyone's sleep needs are different, the recommended sleeping time is about 7-8 hours of sleep per day. The people need enough sleep to feel refreshed. Vigilance and performance are directly related to sleep(Van den Berg et al., 2020). Excessive insomnia for several days in a row adversely affects people's condition. Only sleep maintains and renews people's performance levels(Greenberg, 2002).

Nights with overlapping short sleep periods negatively affect the depth of sleep. This situation reduces people's energy levels as they start their day and strengthens the effects of fatigue accumulated throughout(Coombes et al., 2020). Even a one-day insomnia situation causes a decrease in cases of occurrence. In such a situation, the probability of an accident occurring is very high. People who work from the night hours until the early hours of the morning feel the same effects(Pellegrino & Marqueze, 2019). The person must have at least 8 hours of sleep. Sleep must be uninterrupted. When people are sleeping, different levels of sleep fluctuations are experienced. These levels are known as sleep stages, and this stage offers different functions for the person's body. Sleep structure is called a cyclic model of light sleep, deep sleep and REM (Rapid Eye Movement) sleep. The cycle normally takes place within 90 minutes and there are 4 to 5 cycles in the period of 8 hours of sleep. Each cycle has a distinct role about refreshing. Sleep must be uninterrupted during 3 to 5 cycles while doing its refreshing task(Eurocontrol, 2018). When people's sleep is interrupted due to external factors, this situation tends to keep sleep quality in mild sleep stages. So, it becomes difficult to pass form of deep sleep and the third, fourth and the fifth phase.

People need deep sleep. A comfortable sleep environment is required for people to reach deep sleep levels. Many factors cause sleep interruptions on the plane. Some of these factors are under our control and some are not. Factors beyond our control are(Van den Berg et al., 2020);

i. Environmental factors (severe aircraft movement, weather conditions, intense vibration, sound, bad condition of the crew rest)
ii. Food and consumed chemicals (not fresh food, alcohol, caffeine and taking medication)
iii. Psychological factors (stress, anxiety and longing for family, hierarchical problems, task responsibilities)
iv. Sleep disorders, Sleep apnea

Every person has a biological clock, and this biological clock regulates the body's circadian rhythm. We need to understand circadian rhythm functions. Various physical processes occur such as sleep/wake, body temperature, hormone level in the time period of 24 hours in our body in the cycle of the circadian rhythm. Our biological watch regulates our circadian rhythm. The biological clock perfectly synchronizes the state of wakefulness and sleep at night(Atkinson et al., 2014). Biological clock makes the person sleepy or awake whether the person works on a regular schedule or not. Under normal conditions, the sleep-wake cycle follows a 24- hour rhythm. However, this cycle is not the same for everyone. As a result of the researches, the majority of human-induced accidents at night occurs between 01:00 and 03:00. However occurrence of accidents between 13:00 and 15:00 hours ranks second(Castro et al., 2015). Many flight crew's working hours are contrary to their biological clock. Irregular work schedules disturb the synchronization of the circadian rhythm as a result of the changing working hours cycle and time zone change(FAA, 2010b). In addition, the person's biological clock is adjusted in one or two hours every day. Sometimes, depending on the new work schedule, the adjustment may take days. As a result, the biological clock keeps the people awake when they want to sleep or it takes them sleep when they want to

wake up(Roach et al., 2012). Circadian rhythm synchronizes perfectly to staying awake during daylight hours and sleeping during night hours. The biggest problem of the shift work program that; the shifts are not adapting to the working rhythm of the body(Dawson & McCulloch, 2005). When Person's circadian rhythm adjusts itself between one to two hours a day, it cannot adapt eight or twelve hours change immediately which required by many schedules on board. It takes a few days to adapt to a new schedule and synchronize with the world around us(Abeer A. Al Saedi, Eman A. Al Shafei & Shah, 2019). Flight crews who have to sleep during the day, they sleep shorter and are more likely to experience frequent awakenings. The 3rd and 4th phases of sleep, which are the refreshing feature of sleep, are experienced for a shorter period of time during daytime sleep. Therefore, because of the short stages of 3rd and 4th phases of sleep, it causes people to feel tired after a sleep for 6-8 hours. When people sleep for 6 to 8 hours, they think they will get up rested and revitalized(Castro et al., 2015).

If the way of working in shifts is not in order and the person cannot adjust himself to continue on the same program for a long time, as a result people cannot synchronize their bodies to the way they work. A person flying at night for 8 hours can't adjust his body's biological clock because when he is not working on off days, his body goes back to his daily schedule(IATA, 2014). The body adjusts the program change, but it takes time. The time required to achieve is approximately a few days. But when there is a slip or a sudden change in the program, problems can arise.

Fatigue Risk Factors in Aviation

There is a significant relationship between cockpit/cabin crew member's fatigue and flight safety. A fatigued crew member cannot have enough awakeners and alertness when a safety issue occurs. The effects of fatigue are evidenced by the numerous studies and fatigue-related mishaps. These studies showed that most cockpit crews suffer a deterio-ration in cognitive performance with increased stress during a flight(Patterson et al., 2019). It must be accepted that flight crews have been sentenced to work in a closed environment. Firstly, working conditions varies from flight to flight with unpredictable environmental factors (changing weather conditions, etc.), working hours and duration of layover stays which is away from home. Secondly, there is no clear distinction between the working area and the recreational area while working in aircraft environment. Thirdly, today's crews are from a wide variety of countries and origins and they come together to live together over a long period of time(Patterson et al., 2019). When it compared to standard industries, operational aspects related to aviation is more complicated such as; aircraft types, model and length of the voyage plan, time to return to the airport and turn over duration at the airport. All these aspects are the unique potential constitute combination of reasons of fatigue.

Cockpit and Cabin Crew's Personal Characteristic

As a human-being crew member's age, experience and life styles are naturally personal characteristics which is a fatigue factor. Individual characteristics are also effective to sensitivity to fatigue and relief from fatigue. People's knowledge, education and experience affect the performance of people. In addition, people's health conditions, age, athletic and fit body, drinking, characteristics of bad habits such as consumption alcohol creates individual characteristics. To raise awareness by various organizations, numerous researches, created guidelines and rules created for both crew and the aviation industry. The information in these documents is not for information only, also it is used to train flight crews and airline enterprises to reduce the effects of fatigue.

Lack of knowledge in the flight crew occurs low self-confidence, head confusion and improper actions. Knowledge of the aircraft's equipment, systems, procedures and the environment are important. Education is about improving people's knowledge, skills and attitudes. Insufficient, irrelevant and practicable education effects people's performance negatively. There is an inverse relationship between education and fatigue, fatigue increases while training decreases(Englebienne & DeMeirleir, 2002). Experience includes the personal experience, knowledge and education of the people related to the subject. Experienced flight crew's confidence will increase and it will cause less work stress. Based on the fatigue-increasing effect of work stress, the fatigue level of the experienced flight crew is known to be less than the fatigue level of the inexperienced flight crew.

Consumption of alcohol, caffeine and some narcotic drugs can negatively affect sleep. This situation causes fatigue. Alcohol causes poor perception of visual and auditory stimuli. Also, alcohol has effects in memory, decision-making, judgment, and coordination providing. While alcohol slows people's reaction times, it increases the wiliness of risk. Fatigue and alcohol go hand in hand in many ways. According to the estimates made by insurance company experts, 50% of the 'fatigue accidents' are caused by alcohol consumption(Flindall, 2015). Consumption of drugs with narcotic effects can cause drowsiness and dizziness. While consumption of such drugs may affect the mood and coordination of individuals, it also causes decrease in mental functions and sensory perceptions. Caffeine consumption can also cause side effects such as high blood pressure, headache, mood swings, and anxiety.

Operational Conditions

To avoid fatigue may be impossible for cockpit and cabin crew members due to early morning duty beginnings, frequent changes in daily duty schedule, extended duty periods and average workload. Both cockpit and cabin crew members must be fully high concentrated and must be alerted for any abnormal and emergency condition during every take-off and landing. According to (FAA, 2009b) most aircraft accidents happened between within three minutes after take-off and within eight minutes before landing. Because of this reason take-off and landing period and count in a duty period influences cockpit and cabin crew fatigue. Also, airport performance is another fatigue factor for cockpit crews. Runway length, number of runways, runway floor performance, airport taxi

way scheme, notams, airport performance category (CAT I, CAT II, CAT III), airport's geographical location, weather and wind conditions and airport's aircraft congestion on the taxi-ways and parking gates. Cockpit crew must examine these airport performance criteria due to the weather conditions and need to create a safety and emergency alternative plan against to any unpredicted abnormal and emergency situation before landing via performing a landing briefing in cockpit. Air Traffic Control (ATC) communication is another operational fatigue factor for cockpit crews. ATC and cockpit crew begin to communicate from push-back to parking. Also, there are a lot of documents and reports to fill and sign as a paper work during a flight duty that some of them have no option to forget. Aviation's international language is English but especially spoken English and pronunciation differences in different countries are enforcing cockpit crew to multiple read-backs, multiple corrections and communication failures which causes mental fatigue. As we discussed above; one by one all four reason like a piece of chain and challenging factors for cockpit crew to deal for flight safety in a duty period.

Technical/Maintenance Conditions

Technical and maintenance conditions of an aircraft is another factor which causes fatigue. As the aircraft gets bigger; its control, observation of its system monitors and performance efficiency requires more effort. Aircraft configuration is getting more importance on flights which is longer more than 5 hours. Because resting availability is the key point to fight against fatigue during long flights. Repeating technical failures and emergency landings due to technical and maintenance failures are some factors that causing fatigue on both cockpit and crew members.

Managerial Conditions

Busy paperwork requirement, flight duty schedule and overtime cause very significant fatigue in flight crew and It increases the mistakes made by the flight crew. Undoubtedly; management style of aviation companies on airplanes has great importance in terms of its effect about fatigue on flight crew. Company management policy sometimes does not give the necessary attention to needs and flight crews. This causes conflicts between staff and increased stress in people. (Bandeira et al., 2018) studied on a model of aircraft accident analysis according to the principal factors as well as organizational, human and environmental factors. The results showed that pilot's performance is being influenced by these factors and indicates how may impact on success or failure of tasks of flight procedures. Cockpit and crew members must be always up-to-date about company procedures and regulations, country civil aviation procedures and regulations and world-wide civil aviation procedures and regulations. Cockpit and crew members are responsible to apply all regulations and procedures 100% effectively and true during their duty for flight safety. Cockpit and crew members refresh their certificates every year via recurrent trainings and simulator trainings. Cabin and cockpit crew members are mobile personnel and management needs to be sure to reach every cockpit and crew member about new announcements, regulation changes, duty changes and sensitive implements about operation via e-mail or mobile applications. This causes to an information and notification bombardment on personnel's mailboxes and mobile applications which will be very hard to follow, compare and understand the new revisions. Also, there are a lot of documents and reports to fill and sign as a paper work during a flight duty that some of them have no option to forget. Management's FRMS policy is another factor. It must be easily accessible from all platforms and must give to personnel a clear expression way without a punishment to express themselves and also effective immediate action must be taken due to fatigue reports. Layover accommodation conditions also another factor for cockpit and crew member's fatigue. There is a significant connection between sleep and fatigue(ICAO, 2016). It is very important to get pre-flight sleep enough and quality for flight safety. Most of the airline companies mark this subject with bold and underlined letters and put it to their operation's manual procedures that cockpit and cabin crew members must get a minimum eight hours of sleep-in horizontal conditions. Instead of commercial concern and cost control worries, accommodation must be chosen according to the best rest and sleep condition availability. Due to the reasons which explained above, managerial issues are another factor of fatigue.

Fatigue Risk Trajectory in Aviation Industry

The importance and need of transportation industry are getting growing every single day in the whole world. This will continue to rise the number of vehicles, drivers and off course hazards. Transportation companies competing about cost efficiencies and expanding their networks globally. This fast-growing industry also competing with time. This competitive condition directs companies to some compulsory targets to achieve success. Because of these conditions' transportation workers in operational side, especially drivers and couriers are facing to work during long duty times. Fatigue is affecting the behavioral and cognitive safety performance of transportation industry operators and linked to safety outcomes(Noy et al., 2011). There are also implications between long-term health disorders and shift work(Bandeira et al., 2018). Fatigue is still a hazard for transportation industry. Staffing cuts, delivery pressures, increasing workload and increasing competition are some of them to recognized (Phillips et al., 2017). Transportation industry fatigue has been managed by rules which describes the upper limits for the spent time on work or operation. According to (Civil Aviation Safety Authority (CASA) Australia, 2014) these rules are failing to detect important causes of transportation industry's fatigue. (Dawson & McCulloch, 2005) studied to describe how transportation industry companies would manage and mitigate fatigue risks as a chain of events. They called this chain of risk subjects as the fatigue-risk trajectory (FRT). This chain of risk error trajectories and events always preceded by an event classification which leads to the accident.

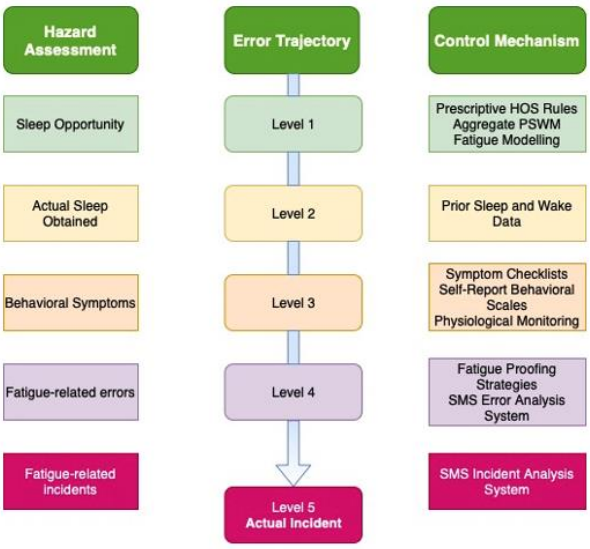

Figure 1: Fatigue Risk Trajectory (Dawson & McCulloch, 2005); *Source:* Dawson & McCulloch, 2005

Fatigue is a problem for transportation industry as well as aviation industry which goes on 24/7 operation conditions. However, the aviation industry has unique aspects that distinguish it from other transportation sectors. Aviation industry workers' alertness, performance and well-being are influenced by the presence of circadian rhythm. Economic factors in the aviation industry decreases the tendency to struggle with the fatigue of flight crews. Below there are the factors that trigger fatigue. These factors are:

i. To reduce the number of people working on the plane for economic gain increases the workload of the flight crew and causes fatigue
ii. Since the institutions do not realize the importance of fatigue sufficiently, they do not take the issue of fatigue very seriously
iii. Safety rules and laws currently in force is not enough to protect against fatigue
iv. Work and recreation programs are not effective enough, and this increases fatigue
v. Loneliness felt due to the working environment while working on the plane and the feeling of isolation triggers the increase in fatigue

Regarding symptoms of fatigue factors specific to flight crew in aviation industry have been recognized for a long time(Ono et al., 1991). At the same time, it has been noticed that such symptoms may be an important factor hindering the performance and reliability of the person. Specific symptoms or disorders arises as a result in individuals. Fatigue has effects on the human body, mind and emotions. Prominent symptoms of fatigue in the aviation industry are;

i. Forgetfulness
ii. Poor decision-making
iii. Slowed reaction time
iv. Sleepiness
v. Poor communication
vi. Impaired mood
vii. Micro-sleep
viii. Apathy and lethargy

Fatigue Risk Management System (FRMS)

The theoretical foundation of this study is based on the Fatigue Risk Management System. The International Civil Aviation Organization (ICAO) published an amendment to Annex 6 Operation of Aircraft, Part 1, Section 4 Flight Operations and Appendix 8 FRMS requirements. A science-based approach to duty and flight time limits (FTL) has been introduced in this amendment. FRMS is a management system for airlines to use in particular operations to lessen the effects of fatigue(Cabon et al., 2012). FRMS is a kind of data-driven system that based on operational knowledge and scientific principles. Aviation companies can monitor and manage safety risks with FRMS. It can help to determine the fatigue-related errors, potential risks associated with fatigue, chronic sources of fatigue(FAA, 2005). The FRMS is a recurring performance improvement process to maintain continuous and effective safety improvements by identifying fatigue factors and changing operational / physiological conditions across time. The aim of the FRMS is to monitor, manage and lessen the effects of fatigue to improve cockpit and cabin crew members' alertness and minimize performance errors. The FRMS should be designed to reach a truthful balance between productivity and safety.

If the company build it on valid scientific principles FRMS will be an effective fatigue mitigation strategy. When an FRMS guided by information which is provided by scientific studies of fatigue it combines continuous and systematic analysis, operational data collection and schedule assessment for reactive and proactive fatigue mitigations(ICAO, 2016). There are four useful tools for an

FRMS to be more effective. These are application of fatigue lessen procedures, fatigue data, management and identification of fatigue elements and fatigue analysis methodology(Goode, 2003). Application of Fatigue lessen procedures is a part of collaborative management process which includes all employees. Fatigue data is difficult to detect because there is no obvious biomarker or plain test for fatigue. A secret volunteer reporting system and no punitive reporting system allows employees to report subjective fatigue(Roach et al., 2012). These subjective reports contain valuable data and this reporting system is necessary as part of overall safety system to encourage the reporting of fatigue-related events. Management and identification of fatigue elements are the factors that aviation companies must manage to minimize risk of fatigue such as crew duty periods, schedule changes and layover timings. Fatigue analysis methodology is to monitor, manage and lessen operational risk by using a science-based fatigue model(FAA, 2005).

FRMS is a living system which gives a visualization to the aviation companies about detecting, adapting and taking specific actions to fatigue impact on their operations. FRMS process is a very sensitive process and it must be handled and evaluated very carefully.

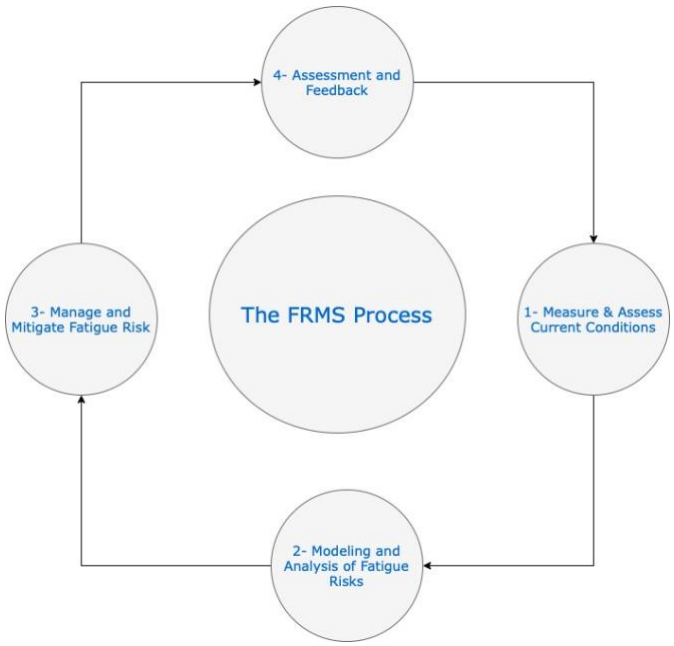

Figure 2: Fatigue Risk Management System Flow Chart (FAA, 2005)

FRMS process divided into four general repeating steps:

Measure and Assess Current Conditions: This is the first step for measuring and assessing the associated level of fatigue risk with current operations and schedules. It is critical for the development of a valid fatigue mitigation plan to collect information from crew reports about fatigue-related incidents and errors.

Modeling and Analysis of Fatigue Risk: This is the second step to understand the root cause of fatigue. Scientific principles are aided by computer modeling to determine significant performance changes due to fatigue.

Manage and Mitigate Fatigue Risk: It requires all the information, measuring and analyses from last two steps to develop solutions to the fatigue-causing factors.

Assessment and Feedback: This step is necessary and important for continuous improvement(ICAO, 2016).

Some changes between new flight time limits and old regulation are shown below.

Table 2: Differences Between Flight Time Limits (FTL) and Operational Regulation of FTL (ORO.FTL)

Regulation	Subpart Q	ORO.FTL	Revision Reason
Max. Flight Duty Period (Daily)	Day: 05:00 – 21:59 = 13 hours. Night: 22:00 – 04:59 = 11:45 hours.	The night time period changed to 17:00 – 04:59 and maximum Flight Duty Period limited to 11h. Day period remained 13h but it will be maximum four sectors in case of consecutive night flights. More than 10h night duties must be applied with FRMS.	According to scientific researches on chronic sleep loss and circadian rhythm and Window of Circadian Low (WOCL) period limits have been set.
Extending Flight Duty Times with in-flight rest	There is not a universal limit. National aviation authorities deciding to the procedures.	Class1, Class 2 and Class 3 rest and duty time limitation types created. Class1: Must be apart from passenger cabin. There must be a bunk or a seat with an 80 degree recline. Class 2: Must be apart from passenger seats with a curtain. It must have 45 degrees recline ability. Class 3: Must be apart from passenger seats with a curtain and it must have 40 degrees recline ability.	It is an important factor for cabin and cockpit crews to rest in-flight especially on over-seas duties which is more than 10 hours. Creating effective crew rest types will fight against on-flight fatigue.
Duty and Flight Time Upper Limits	Consecutive 7 days:60 hours. Consecutive 28 days: 190 hours. Consecutive 12 months: 900 hours.	Consecutive 14 days: 110 hours. Consecutive 12 months 1000 hours.	This regulation limits the maximum duty periods in a short period of time.
Day-off rest periods	Minimum 12 hours at home base or 10 hours at layover destinations or length of proceeding duty.	Local time rest and Local time WOCL definitions added to rules. Day-off and duty beginning time limitations will be calculated on local time zone.	Most of the airlines are used to be schedule and plan crew duties and day-off times according to GMT. For example, Istanbul is GMT+3. Before new FTL, day-off beginning time was GMT 23:59 which means Local 02:59 in Istanbul.
Fatigue Risk Management	No subject	A Fatigue Risk Management must be maintained by aviation operators as a part of Safety Management System.	Due to scientific researches about sleep loss, performance and fatigue effects FRM will assist FTL in a positive way to reduce fatigue and accident risks.

Source: Authors

Cockpit and cabin crew members are frequently facing with long duty times, early beginning duties and nonstandard duty times which includes heavy night duties. Long-haul cockpit and cabin crew members frequently fly over-seas and deal with time differences which cause to circadian disruptions and sleep disorders. (Honn et al., 2016) studied with twenty-four airline pilots about early beginning and long duty times' effect on fatigue with multiple take-off and landings during two days.

Cockpit and Crew Member Responsibilities

Cockpit and cabin crews begin to their duties two hours before the scheduled flight's take-off time. When we add the travelling distance from home to airport and the way to reach to airport, by public transportation or by own car it makes minimum three hours from home to flight's take-off time(Yildiz et al., 2017). Cockpit and crew members are responsible from serious and high concentration required responsibilities from beginning to the end of the flight duty.

Pre-flight Responsibilities

Checking destination airport performance and country regulations, printing and checking flight plan and weather report, checking revisional documentations, attending to pre-flight briefing, checking aircraft maintenance log, checking on-board emergency and operational equipment, checking flight and entertainment systems, performing a security search checklist in the whole cabin,

checking notification to captain documents, checking dangerous goods items and creating an intervention plan to any abnormal condition caused by these items, refueling the aircraft, making take-off briefing, profiling passengers, observing the boarding to make sure passenger seating plan is valid according to company and country regulations especially exit seat procedures and luggage stowage procedures, arming doors and checking door status.

During Flight Responsibilities

Preparing cabin and passengers for take-off and landing, making necessary announcements on time, observing cabin, aircraft and passenger conditions, preparing catering service, observing any abnormal situation sign, applying medical procedures if needed, applying emergency procedures if needed, applying fire procedures if needed, applying decompression procedures if needed, getting ready cabin and passengers for emergency landing or ditching if needed, keeping communication with ATC, observing aircraft technical conditions, observing weather conditions, observing flight plan en-route changes, following and repeating desired checklists during whole flight, making landing briefing and determining turn around and hold point decisions.

Post-Flight Responsibilities

Disarming doors, de-boarding passengers, checking whole cabin and aircraft, filling the flight documentations, filling flight reports.

As we mentioned above cockpit and cabin crews are responsible from a number of physically demanding tasks. Many cabin crew spending most of the flight on their feet and also emotionally challenging by requirements to perform multiple tasks in a short time. On the other hand, cockpit crew spending most of the time to observe flight indicators and a lot of radio conversations with ATC to fly safe in their seats. These responsibilities require high concentration. Crew members always need to be alerted, proactive and must response quickly to any situation. The biggest challenges for crew are to maintain safety and to respond to an unexpected emergency situation. At this point the crew's skill, ability and trainings becoming more important because in an abnormal situation which a crew would expect the other stressors' effects such as fatigue and circadian dysfunction to have the biggest impact.

Conclusions

Cabin and cockpit crews are different from other service workers in terms of the characteristics of the place they work and the work they do as their performance affects the flight safety. In an area with limited mobility, they often have to deal with problematic passengers and at the same time feel the pressure of strict rules of flight safety. They undergo special training to establish healthy emotional interactions with the passengers they serve. In most countries where educational opportunities are unfair and finding a job is getting more and more difficult, the difference in individual abilities restricts the job alternative and thus makes it difficult to transition to different professions, which can force those in this situation to remain as cabin and cockpit crew. This naturally increases social life, future expectations and career plan concerns, thus creating a relationship with burnout syndrome.

The fatigue risk factors and the burnout syndrome in related literature shows causes in low job satisfaction and performance which may lead to an accident during the flight, which must be seriously dealt with.

The fact that the job performance and service quality of cabin attendants is a very important factor contributing to the commercial success of the national air transport sector as well as the company they work for should be well known by the national civil aviation authority. In this context, the aviation authority should take radical decisions and include the job satisfaction and fatigue levels of sector employees as flight safety multipliers among the company evaluation criteria. The main constraint of the study is the lack of related scientific work in the field. Fatigue risks factors should be weighted and ranked also by using hybrid business analytics tools and models to demonstrate the priority and importance for effective FRMS applications.

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