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FATIGUE AS A HAZARDOUS FACTOR FOR FLIGHT SAFETY

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The main priority of any air company activity and the main condition for its development is the achievement of the highest flight safety level. Significant positive results in this area have been recently achieved, hence, the relative stagnation of indexes, reflecting the flight safety as a condition of air transport system, has been revealed. It has become evident that the present accident prevention philosophy seems to be exhausted, and at the current stage of development it doesn't allow to make a breakthrough in the solution of all the problems, which air companies face in this respect. In the perspective to find new ways to solve the existing tasks, in 2011, International Civil Aviation Organization Council adopted fatigue risk management international standards as an alternative for the traditional approach to managing crewmember fatigue by prescribing limits on maximum daily, monthly and yearly flight and duty hours. It's a well-known fact that state of fatigue has a special place among the functional states, which are professionally significant for airmen work and which are the key link in "man-aircraft-environment" system.

In this article, fatigue is considered to be a risk factor that contributes to the formation and development of crew violations and errors in the process of piloting the aircraft. We have analyzed the characteristics and reasons leading to in-flight fatigue and estimated its influence on crew performance, considering the interrelation between them. The article specifies the methods and techniques to measure pilots fatigue; besides it has been substantiated the necessity of fatigue risk management system development in airlines to effectively ensure the flight safety.

Key words: flight safety, crew resource management, pilot's error, risk factor, fatigue, fatigue risk management system (FRMS).

INTRODUCTION

Aviation equipment is constantly improving and becoming more expensive, the airlines are dominated by the large passenger capacity aircraft, increasing the total intensity of flights. All this inevitably leads to an increase in the "cost" of each accident and, especially, disaster, which consequently resulted in a closer attention to flight safety.

Most of the aviation accidents and incidents result from human actions which are considered to be less than optimum; according to different authors, the human factor is the main reason in 75–80% of the total number of events.

The human factor is one of the main concepts used in addressing the problem of flight safety, and accidents and disasters have identified a practical necessity to study the actions reliability of a person operating the aircraft (AC), as most aviation accidents are the result of functional errors committed by healthy and qualified individuals.

The profession of a pilot is characterized by high psycho-emotional load, so it is accompanied by a significant reduction in its functional reliability because of the use of the body resources. Frequent pilots errors significantly depend on the current functional state and are complex arguments functions describing the impact of flight conditions and living environment on the crew.

In civil aviation the most unfavorable factor of the functional state of flight crew members is the fatigue, since it directly affects the safety of flight operations and is the most common for the profession of a pilot.

Important factors influencing the accumulation of fatigue are the geographic and climatic conditions of the area: flying in mountainous terrain, in the Arctic or over the sea has a different impact on the performance of flight crews. The flight time and time of departure (at night or during the daytime) also have a great influence. Herewith psychological and physiological abilities of a human being are

far from perfect; therefore, because of their biological nature the pilots are carriers of psychophysiological risk factors that can be the direct cause of erroneous actions.

VIEW OF THE TOPIC

Among accidents factors there is a group "Crew members' violations", which includes:

a) violations (omissions) in compliance with the established order and rules of the flight assignment;

b) Captain's violations (errors) in piloting technique;

c) crew members' violations (errors) in aircraft operation;

d) crew members' carelessness in their personal preflight preparation;

e) insufficient training of crew members;

f) violations (omissions) in CRM;

g) crew members' violations (errors) due to performance impairment.

A characteristic feature of these categories is a manifestation of behavior and limits of psychophysiological capacities of a human being in providing a flight safety, as it was noticed that in the same flight conditions, in similar situations, accidents happen not with all the pilots. Regardless of the root causes or triggers of a dangerous situation, it remains with the crew to fix it, and, if it is a crew member, who makes a mistake, it is only the crew, who can fix it [1].

Affecting most aspects of pilots' ability to perform their duties, fatigue represents one of the adverse conditions related to the human factor. In the process of piloting the aircraft it is natural that consumption of body resources occurs, as well as the functional reliability is reduced due to fatigue. It is often the fatigue that leads to conflict situations and carelessness, difficulties in focusing on problem solving and in the perception of the colleagues' opinions. In a state of fatigue, pilots are less active and accurate in response to changes of the situation, pilot-controller communications and flight instruments setup. As a result their decisions are not always adequate to the situation. Aircraft incidents and accidents are associated with a reduction in functional reliability of the pilot. More often this hazardous factor becomes the cause of incorrect actions that leads to incidents. There has been stated an increase in the number of messages that indicate fatigue as a factor exacerbating the situation development in flight [2].

Performance capability, functional state and fatigue are related concepts. The level of efficiency is determined by the absence or presence of fatigue, and in the latter case, by the degree of development and the severity of the condition. On the other hand, the speed and intensity of fatigue development in the course of professional activities depend on the initial degree of performance capability and the initial functional state of a pilot.

It has become evident that the standard rules of flight and duty time setting is a simplified approach to providing the flight safety that focuses on tolerance of an average pilot (that doesn't exist) and on flights performed in average conditions, without taking into account the particularity of some aircraft operation, their current technical condition, conditions of current and preceding flights. While meeting the requirements of certain flight types rationing forms an approach that doesn't take into consideration the individual characteristics of crew members. In this regard, in 2003, the ICAO experts formed «Subgroup on flight duty time limitations for the study of factors related to flight and duty time limitations in order to better control the fatigue of the crew». The result of their work was submitted in June, 2011, when the ICAO Council adopted Doc. 9966 – fatigue risk management system manual (FRMS), as an alternative to the regulatory flight and duty time restrictions with the consideration of crew fatigue. This fact, regarding flight and duty time and rest time of the pilots, proves the world community's recognition of the growing complexity of crew fatigue problem.

ICAO defines fatigue of crew members as: a physiological state of reduced mental or physical performance resulted from insomnia or extended wakefulness, circadian phase or workload (mental and/or physical activity) that can impair performance and ability of crew members to safely fly an aircraft or to perform their duties [3]. Fatigue may be also considered as a condition reflecting inappro-

priate rest. It is a consequence of a natural physiological process, which being protective, prevents the full depletion of the energy reserves in the organism by introducing the braking process in the Central nervous system and starting recovery mechanism [4].

There is physical, mental and emotional fatigue. The profession of pilot is characterized by the predominance of the latter two forms, especially for operations in difficult conditions, while the effects of fatigue tend to lower the reaction rate and decision-making time, contribute to the loss or decrease of short-term memory accuracy, cause errors when performing calculations and create a tendency of following simplified operational standards, that, of course, is a risk factor for flight operations. Thus, it is necessary to pay special attention to the organization of flight operations and increase the efficiency of management decisions making [5].

Within the concept of FRMS a multilevel strategy is used for aviation safety, allowing managing fatigue risks, irrespective of their sources. Continuous adaptive process based on the actual data analysis allows to develop, implement methods of these risks mitigating, and to evaluate their effectiveness.

In the Russian Federation the regulation of working and rest periods of crew members with a valid certificate authorizing their flight operation on board the aircraft as a member of the crew, including flight school cadets and trainees, is established on the basis of the Order of the Ministry of Transport of the Russian Federation No. 139 of November, 21, 2005 "On the approval of the regulation of the Russian Federation civil aircraft crew members working and rest period" [6]. This regulation, complying with requirements of certain flight types, however, does not address the peculiarities of operation or the individual characteristics of crew members. The FRMS concept allows the operators to identify flight and duty time limitations, to bring them in line with their needs, making them much more flexible in the sense that they can be adapted to the change of the operations nature.

When implementing FRMS in order to manage fatigue risk, the Operator, at least:

a) creates FRMS based on scientific principles and knowledge;

b) consistently identifies fatigue risk factors and the resulting risks;

c) ensures immediate corrective action necessary for the effective fatigue risk factors mitigation;

g) provides continuous monitoring and regular evaluation of fatigue risk factors mitigation achieved by such actions;

d) supports the continuous improvement of the overall FRMS functioning [7].

When identifying hazards associated with fatigue, the operator shall develop and implement three fundamental and documented processes:

1. Predictive:

The predictive hazard identification process focuses on establishing crew schedules and tracking the specified conditions that affect sleep, fatigue and performance.

2. Proactive:

In the framework of the proactive process, fatigue risk factors are monitored during operation.

3. Reactive:

In an FRMS, reactive processes are designed to identify the contribution of crewmembers fatigue to safety reports and events. The aim is to identify how the effects of fatigue could have been mitigated, and to reduce the likelihood of similar occurrences in the future.

The trigger for the involvement of the correctional process can be, at least, any of the following:

– fatigue reporting system,

– confidential reports,

– audit reports,

– incidents investigation reports,

– Flight Data Analysis events [8].

An effective fatigue reporting system requires an effective reporting culture.

Crew fatigue surveys are of two basic types:

1. Retrospective surveys that ask crewmembers about their sleep and fatigue in the past. These can be relatively long and are usually completed only once, or at long time intervals (for example, once a year); and

2. Prospective surveys that ask crewmembers about their sleep and fatigue right now. These are typically short and are often completed multiple times to monitor fatigue across a duty period, trip, or roster. They usually include measures such as sleepiness, fatigue, and mood ratings. The reporting form should also have some intentionally blank page for crew to comment on fatigue reasons and corresponding consequences.

Fatigue reports provide extremely important feedback with individual crew members to identify place and time of fatigue risk factors during flight operation of the aircraft. Thus, it is possible to identify, for example, the most problematic routes and phases of flight, to analyze pilot performance capability at the beginning of the shiftwork, to develop effective preventive measures in relation to a particular individual.

Expert studies carried out by the leading Russian airlines, confirmed the sleep of crew members during long-haul flights. FRMS identifies controlled flight deck napping as an effective mitigation strategy to be used as needed in response to fatigue experiences during flight operations. Sleep on board the aircraft is less deep and more fragmented than on the ground. Anyway, there is compelling evidence that sleep on board the aircraft enhances the subsequent activity and the rate of crew reaction. Controlled short sleep may temporarily weaken its deficiency symptoms, it contains a minor component of deep slow sleep, so upon waking, the effect of carotid inertia is much less likely. Controlled flight deck napping investigation provided by the National Aeronautic and Space Administration (NASA) has identified enhanced crew attention at the end of long-haul flights (8–9 hours), if the crews were given the opportunity of 40 minutes sleep at the workplace in the pilot's seat [2].

One way to reduce the complexity of perception of this material is to develop specific guidelines for the implementation of good sleep habits techniques and implement crew members usage of personal compensation techniques to reduce the fatigue risk during flight operations.

Fatigue can result from a broad range of factors concerning crew members' life and work: intensive flights, long-haul flights, night flights, illnesses, work out of hubs with layovers in hotels. In particular, inappropriate rest between flights leads to crew fatigue even before departure. More sophisticated recreation and accommodation of crews, optimized crew transportation (especially in big cities with heavy traffic) and well-developed system of on-board meals are considered to be preventive measures in FRMS.

FATIGUE RISK MANAGEMENT SYSTEM

One of the main items to be checked during the operator's audit is paragraph 5.23 of FAR-128 "Civil aviation flights operation and planning in the Russian Federation":

The Operations Manual contains regulations established by the Operator for flight time, flight duty period, and rest time limitations authorizing the Operator to use a Fatigue Risk Management System (FRMS) to manage fatigue, FRMS regulations and meet the requirements of Civil Aviation regulations [9]. However, there is no clear understanding of the fatigue problem; the audit process is limited to the calculation of flight time and rest time. Herein findings concerning, for example, leave provision, also do not reflect the real picture of the functional state of a pilot. The implementation of FRMS would better reflect the situation in the airlines.

In recent years the interest for flight crew fatigue has significantly increased at the state level. For example, in June 2015, Federal Air Transport Agency on the basis of the Aviation training center of the Institute of transport and technical service of Baltic Federal University named after Kant held an annual research and training conference "Current issues of flights medical support in civil aviation". Presentations were made by the Chairman and members of the central medical-flight expert commis-

sion of civil aviation, experts of Federal State-Funded Institution "Central clinical hospital of civil aviation", airline doctors.

The agenda of the extended meeting of the Flight Guidance Council of the Federal Air Transport Agency on issues of flight safety in civil aviation and the most current issues of preparation for the autumn – winter period of 2016–2017 operation contained the report on "Fatigue risk management".

FRMS is developed by the aircraft operators on the basis of safety management system (SMS). According to the conceptual framework of the SMS, the key types of processes FRMS are: management of risks associated with safety, and the assurance of compliance for safety standarts [10].

The FRMS includes some of the elements (components) of SMS, it is based on:

– effective reporting on safety issues;

– senior management commitment;

– a continuous process of monitoring;

– the process of investigation (research) developments in the area of safety, aimed at detecting problems, rather than find the perpetrators;

– exchange of information and the most effective methods;

– comprehensive training of staff;

– effective use of standard operating procedures;

– commitment to continuous improvement of the system [11, 12].

By virtue of the individual characteristics of the organism is almost impossible to define a single way of eliminating fatigue even after establishing the cause [3]. To minimize the inevitable development of fatigue in pilots is first necessary to select the optimum mode of operation based on objective regularities of development of fatigue as a function of time, intensity and complexity of action. Important variations of the functional state of the pilot, due to progressive fatigue of the night as a result of bad adaptability of man to changing circadian rhythms "sleep-Wake" and the circadian biorhythms that have a circadian period of 20–28 hours, with a reduction in the reserve capacity of the organism to the twelfth hour of professional activity [13].

CONCLUSION

Every airline has its own regulations, which based on FAR (Oder) № 139 end establish flight duty and rest time. There are recommendations of the Ministry of Health and the Federal Air Transport Agency, but they can be interpreted differently. For example, some air companies don’t include a pre-flight briefing in flight-duty time. It is possible to legislatively consolidate the process of identifying and eliminating fatigue hazardous factors, which have not yet manifested, but in the future can cause incidents, accidents and disasters. States have to establish minimum rest periods after flights taking into consideration their complexity, after 7-day roster and longer rest periods to relieve the accumulated fatigue in their national regulatory documents. While ICAO does not offer all States the common standards, since the insufficiency of scientific data to establish strictly grounded unique quantification.

In 2009, ICAO adopted the 33rd amendment to the Annex 6, one of the important requirements of which is that any changes relating to the flight crew work should only take place on a scientific basis and not just at the request of the employer [10]. Accordingly, the state sets:

a) rules for the regulation of flight time, flight duty time and rest time;

b) rules regarding FRMS, if the aircraft operator is permitted to use it.

However in the Russian legislation, this amendment is still not reflected, despite its being lobbied by aviation trade unions. In general, the changes in the Order of Ministry of Transport of the Russian Federation dated 21 November 2005 No. 139 "On approval of the regulation of the civil aviation crew members flight duty and rest time in the Russian Federation" were previously made only in 2010.

FRMS Implementation will enable the Operators to gain a competitive advantage in their internal and external business operations (within the operational safety), and comply with International Standards and Recommended practices. Herewith the first, but sure step towards the adoption and implementation of FRMS is the recognition of fatigue problem existence. Indeed a tired human on board is an indicator of flight operations safety management system failure.

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УТОМЛЕНИЕ КАК ФАКТОР ОПАСНОСТИ ДЛЯ БЕЗОПАСНОСТИ ПОЛЕТОВ

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Важнейшим приоритетом деятельности любой авиакомпании и необходимым условием ее движения вперед является достижение максимально высокого уровня безопасности полетов. За последние несколько лет в данной области удалось добиться значительных положительных результатов, однако обнаружилась относительная стагнация показателей, отражающих безопасность полетов как состояние авиационной транспортной системы. Стало очевидным, что существующая идеология предотвращения авиационных событий себя исчерпала и на современном этапе развития гражданской авиации не позволяет совершить прорыв в решении всего объема задач, стоящих перед авиакомпаниями по данному направлению. С целью поиска новых подходов для решения имеющихся задач Совет Международной организации гражданской авиации в июне 2011 года принял международные стандарты по системам управления рисками, связанными с утомляемостью, в качестве альтернативы нормативным ограничениям полетного и рабочего времени с учетом утомления экипажей. Ведь не секрет, что среди функциональных состояний, профессионально значимых для деятельности авиационных специалистов, являющихся ключевым звеном в системе «человек – воздушное судно – среда», особое место занимает состояние утомления.

В предложенной статье утомление рассматривается как фактор опасности, обуславливающий формирование и развитие нарушений и ошибок экипажа в процессе пилотирования воздушного судна. Проведены анализ признаков и причин возникновения и развития утомления в полете и оценка его влияния на работоспособность экипажа, рассмотрена их взаимосвязь. Представлены методы и методики определения утомления пилотов, обоснована необходимость разработки системы управления рисками, связанными с утомляемостью, в авиакомпаниях с целью эффективного обеспечения безопасности полетов.

Ключевые слова: безопасность полетов, человеческий фактор, ошибка пилота, фактор опасности, утомляемость, система управления рисками, связанными с утомляемостью (СУРУ).

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