

Analysis of stress effects on pilot workload

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Abstract

Since human errors are one of the major causes of flight accidents, understanding the pilot workload is the basis for human errors prevention. More than 70% of aviation accidents can be attributed to human factors, which are recognized as one of the key determinants for managing and improving flight safety. Aviation is closely related to stress, and the pilot workload can be classified as the most stressful. The goal of this paper is to understand the impact that stress could affect pilots and the measures for coping stress in cockpit. In order to understand the human factor importance on piloting, the effects of stress on a pilot performances and limitations are analyzed in the paper. Due to the constant growth of air traffic, stress among flight crew is becoming an increasing problem. Therefore, the research was conducted on 46 pilots from different airlines and nationalities (Bosnia and Herzegovina, Croatia, Montenegro and Serbia). Those pilots were surveyed with the aim of discovering the impact of stress on pilot performance during the flight. The age of the respondents ranges from 20 to 65 years. The provided research could improve the human factor understanding regarding on human performance and limitations during the piloting.

Keywords: Aviation, Pilot, Workload, Stress, Survey

1. Introduction

In aviation, the pilot's job is very complex due to variety of tasks and duties, and therefore it can be easily concluded that the occurrence of stress affects the aviation safety during the flight. According to nowadays science achievements, levels and sources of stress could be briefly assessed and managed. However, stress combined with other factors can lead to safety violations and therefore great attention is paid to the notion of stress in aviation.

Stress could lead to errors in aviation. However, despite keeping a record of and monitoring global safety issues, many studies define a human factor as the cause of at least 2/3 accidents in commercial aviation [1], [2], [3].

The motivation for the research and analysis presented in this paper stems from the significant impact of stress on human performance and limitations when piloting an aircraft, as well as from the severity of the consequences that stress leads to.

The paper presents the results of a survey that was conducted on the sample of pilots from different countries. The research confirmed that stress is a phenomenon that is common and hazardous in aviation, and that it mostly disrupts the pilots on duty by increasing their workload.

Table 1. Causes of Fatal Accidents per Decade (%)

Cause	1950	1960	1970	1980	1990	2000	Average
Pilot Error	40	32	24	25	27	26	29
Pilot Error (Weather Conditions)	11	18	14	17	21	17	16
Pilot Error (Mechanical Failure)	7	5	4	2	4	3	4
Total Pilot Errors	58	55	42	44	52	46	50
Other Human Errors (ATM Controllers, Inadequate Aircraft Loading, Inadequate Maintenance, etc.)	0	8	9	6	8	8	7
Weather Conditions	16	10	13	15	9	9	12
Mechanical Failure	21	20	23	21	21	28	22
Sabotage (Explosive, Unlawful Interference, Terrorist Attacks, etc.)	5	5	11	13	10	9	9
Other Causes	0	2	2	1	0	1	1

More than 70% of aviation accidents can be attributed to human factors, which are recognized as one of the key determinants for managing and improving flight safety [1], [4], [5], [6].

Table 1 shows the distribution of the main causes of accidents by decades, where the human error has the predominant role.

2. Stress management in aviation

Stress is a condition, or feeling, experienced when a person perceives that demands exceed the personal and social resources the individual is able to mobilize. Stress is a bodily response to a stimulus that disturbs or interferes with the “normal” physiological equilibrium of a person and, in the context of aviation, refers to a state of physical, mental or emotional strain due to some external or internal stimulus.

Understanding the factors that lead to stress, as well as how to cope with stressful situations, can greatly improve a individual's performance. Also, understanding that colleagues may react differently to the same stressor is important and can help you control a situation that can quickly get out of hand if an individual is having a negative reaction [7].

In order to manage stress, it is essential to be aware of the problem. One who recognizes the fact that he suffers from stress is at the beginning of a long journey towards identifying the source and overcoming the problem. There is great variation in how stress is perceived among

different populations. Generally, individuals suppress knowledge of problems and thus fail to perceive them or require coping strategies. On the other hand, those who are highly sensitive to problems and anticipate difficulties that others do not notice and use coping strategies to avoid experiencing stress. Coping strategies can be classified into three categories: action coping, cognitive coping, and coping with stressors.

In coping action, the individual tries to reduce stress by taking some action. It reduces the level of demands by eliminating the problem or changing the situation so that it becomes less demanding. For example, a pilot asked to fly in hazardous weather conditions might refuse to remove an immediate stressor. However, this action can lead to another stressor - loss of employment.

This requirement, however, could be changed by delaying the take-off by a few hours when the weather is forecast to improve. An individual may also delegate some tasks, either to other crew members or to air traffic control by asking, for example, for navigational assistance. Also, an individual can distance himself from a stressful situation by changing jobs or, in the case of personal stress, by getting a divorce. These methods can, however, only substitute one source of stress for another. It is clear that in many cases it is impossible to undertake such a solution.

As some situations cannot be changed through action coping, cognitive coping involves reducing the impact of stress on the individual. Our brain can use "defense mechanisms" that operate outside of our awareness (the suppression or denial system) to prevent the brain from becoming aware of the stressor. Other strategies include rationalization or segmentation that can change the perceived magnitude of the problem. If an individual has responded to certain requests in the recent past, it will enable the problem to be perceived through a solution.

Some of the symptoms of stress can be alleviated by the use of certain substances. In this context, substances can be relatively simple, such as the caffeine contained in coffee or tea. Other cases may be relieved by the use of alcohol or tobacco. It must be emphasized that this form of coping appears to alleviate the symptoms of stress. It represents an apparent solution, can cause serious addiction and certainly does not remove stressors, but only worsens the stressful situation [8].

2.1. Coping stress in cockpit

Coping is a process in which an individual adapts to a perceived demanding situation or changes the situation itself. Some changes in coping are carried out completely unconsciously. Only if changes are unsuccessful do individuals consciously consider the stressor. Reducing the effects of flight stress involves mainly psychological mechanisms and involves learnable behavioral patterns.

Each individual must learn and gain experience in order to develop the automatic responses they require [8]:

- A completely professional approach to training will increase the range of available responses and reduce the opportunities for dealing with unfamiliar situations. By practicing on flight simulators, certain emergency situations are practiced in advance.
- One should learn from the past, including the experiences of others.
- Detailed flight briefing and preparation will enable the individual to anticipate critical events during the flight.

Some stressors that pilots face during flight cannot be avoided. The best way to deal with such stressors, which cause acute and chronic stress, involves a combination of preparations (before the flight) and corrective actions during the flight [9]: preparation, forecasting, planning, communication, resources allocation, crew resource management and time management.

Despite all the actions taken, it is possible for pilots to face a completely unexpected stressful situation. In that cases, it is crucial for the crew to recognize the symptoms, remain calm and provide as much time as possible to make decisions. By understanding the mechanisms of stress, negative emotions resulting from stress such as irritation, nervousness and anxiety can be controlled, and problem solving can be attempted in the most logical and safe way possible.

2.2. Crew Resource Management (CRM)

Crew Resource Management (CRM) is the efficient use of all available resources for aviation crew to ensure safe operation, reducing errors, avoiding stress and increasing efficiency.

CRM is actually a type of technique that divides and assigns tasks while preventing any one individual from being overloaded, while emphasizing the effective use of all crew members' knowledge to increase the range of possible responses. Improving crew performance should improve situational awareness, collaborative efforts and enable the generation of new ideas. A good atmosphere in the cockpit is a great help in a stressful situation, even humor can be effective in relieving stress. There are five main guidelines for preventing stress that affects safety [8]:

- Keep it simple - don't make complications,
- Acceptance of the situation - facts and danger should never be hidden,
- Use of all crew resources (group support),
- The captain should make decisions and control the situation,
- Never give up: there is always an appropriate answer.

CRM was developed in response to new knowledge about the causes of aircraft accidents which suggested that many accidents were not the result of a technical failure of the aircraft or its systems, or a failure of aircraft handling skills or lack of technical knowledge of the crew; instead the causes indicated the inability/inability of the crew to respond adequately to the situation in which they found themselves. For example, inadequate communication between crew members and/or air traffic controllers can lead to a loss of situational awareness, problems with in-flight teamwork and, ultimately, a wrong decision or series of decisions resulting in a serious accident or fatal accident.

Crew performance improvement can also be defined as a management system that optimally utilizes all available resources (equipment, procedures and people) to improve safety and improve the efficiency of flight operations. CRM does not deal entirely with the technical knowledge and skills required to fly and operate an aircraft, but rather with the cognitive and interpersonal skills required to operate a flight within an organized aviation system.

3. Analysis of the impact of stress on pilot workload – survey

Due to the constant increase in air traffic, stress among flight crews in recent years has become a growing problem in aviation. Therefore, the paper provides the survey which was conducted among the group of pilots, regarding to determine the impact of stress on pilots' workload.

The sample of respondents in this survey consisted of 46 pilots from the Republic of Serbia, Bosnia and Herzegovina, Montenegro and Croatia who are employed by different airlines around the world. The age of the participants ranges from 20 to 65 years, and the stress test was carried out with the help of pilots who have active pilot licenses. For the purpose of evaluating the impact of stress on the pilot's workload, sociodemographic characteristics such as the age of the pilot, gender and seniority were taken into account.

The study was predominantly male (96%). Table 2 shows a summary of the age of the respondents, while Table 3 refers to the years of service.

Table 2. Age of the pilots

<25	25-35	36-45	46-55	56-65	>65
6.5%	17.4%	4.3%	17.4%	50%	4.3%

Table 3. Years of service (or within the company)

<2	2-5	6-10	11-15	16-20	21-25	26-30	>30
13	0	15,2					47,8
%	%	%	2.2%	0%	13%	8.7%	%

Over 95% of the pilots surveyed confirmed the presence of stress in certain situations during aircraft operation, while only two respondents who have been working as pilots for less than two years responded negatively. It is clearly understand that the occurrence of stress in aviation flight operations does not diminish the experience. Pilots with a higher number of years of service encounter far more diverse situations than pilots who are at the beginning of their careers.

More than half of the respondents confirmed that stress has an impact on the ability to perform tasks during flight operations and all 26 subjects were under the stress while making mistakes. Those who denied the impact of stress on the

ability to fly also denied that they had made mistakes under the influence of stress.

Figure 1 presents answers related to self-assessment of mental health. Based on the results, it can be concluded that the respondents are on average very good mental health and are self-conscious, and that the mental health assessment does not depend on the pilot's age or years of service.

Some of the factors that influence pilot stress is shown in Figure 2. It is clearly concluded that in most pilots stress causes fatigue and workload, are the most common stressors, as well as internal physiological stressors and organizational ones. Most of the pilots who indicated that stress is driven by relationships in the company, confirmed the presence of stress due to their private lives.

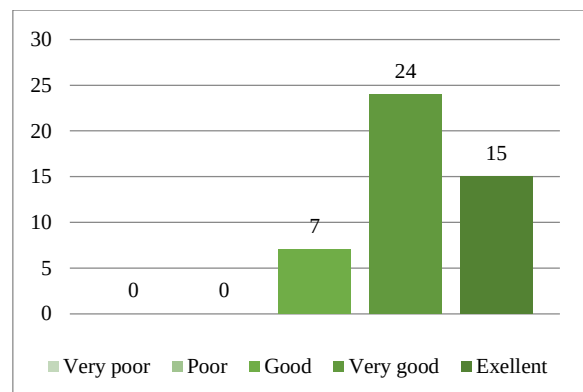


Fig. 1. Self-assessment of pilot mental health

According to this, it is confirmed that stress experienced at home is transferred to work and vice versa. Also, based on the respondents' answers, it is pointed out that the nature of the pilot job is not common and that external physiological factors such as temperature and noise can cause stress. One respondent noted past experience as the main source of stress and pointed out that the main stressor in his situation was the war action.



Fig. 2. Causes of stress during piloting

When analyzing the types of stress (weather conditions) experienced during the flight operations, all respondents, regardless of age and work experience, responded that they experienced acute stress. From Table 3, it is concluded that only 9 pilots with the presence of acute stress experienced chronic one. Fortunately, acute stress can also be positive, which is confirmed by the fact that 30 respondents, who were exposed to acute stress, agreed with the statement of positive experience.

Table 4. Number of pilots who experienced different types of stress

Type of stress regarding to weather conditions	Number of respondents
Acute stress	37
Chronic stress	0
Acute and chronic stress	9

During the observation of the symptoms of stress manifested during the flight operations, it was found that one of the most noticeable is nervousness. According to individuals live style, nervousness is very present and is accompanied by worry, high heartbeat, anger and pain. A Low group of respondents point out problems in relationships, forgetting, indecision, tremors, cigarette use and depression as symptoms of stress.

Thus, the symptoms of stress (Figure 3) that occur in pilots duties are different and relate to emotional, physical, cognitive and behavioral symptoms with the most common symptoms being precisely emotional and cognitive. It is very

important to emphasize that the factor of relationships within the flight crew is classified as the least source of stress. This kind of stress is significant because aircraft management is a dual task and any form of disruption of relationships can endanger safety.

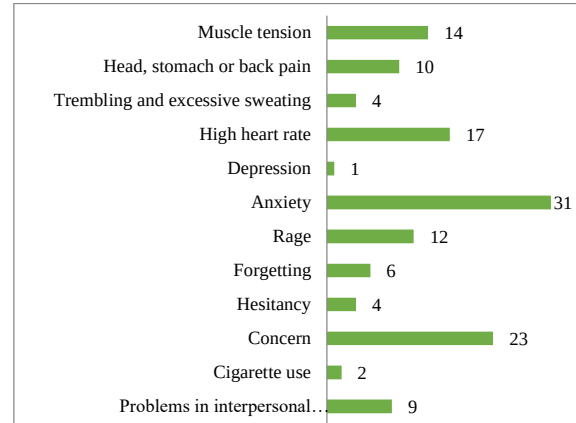


Fig. 3. Symptoms of stress experienced by pilots

Table 5. The relationship between the age of the pilots and the impact of stress

<25	Working memory	Decision-making	Cockpit relationships
Affects	1	2	0
No Affects	2	1	0
25-35	Working memory	Decision-making	Cockpit relationships
Affects	3	4	3
No Affects	5	4	5
36-45	Working memory	Decision-making	Cockpit relationships
Affects	0	0	0
No Affects	2	2	2
46-55	Working memory	Decision-making	Cockpit relationships
Affects	5	5	6
No Affects	3	3	2
56-65	Working memory	Decision-making	Cockpit relationships
Affects	9	10	10
No Affects	14	13	13
>65	Working memory	Decision-making	Cockpit relationships
Affects	1	1	0
No Affects	1	1	0

Given the fact that human error is the dominant risk factor in aviation, it is very important to underline the importance of the error reporting system. Therefore, there is a list that contains common error reporting principles that help prevent errors from going unreported. For example, error reporting involves a non-criminal approach, after analyzing the error, feedback is available and the reporting mechanism itself is simple and easily accessible [6].

Stress is a daily occurrence in aviation and is often one of the casual factors of incidents or accidents. Therefore it is of fundamental importance to report stressful situations, in order to prevent certain events in the future (proactive approach). Figure 4 shows the reasons given by the surveyed pilots for not reporting the presence of on-duty stress. 34 (of 46) pilots answered that they would not submit a report: 40% of pilots answered that they did not want to exaggerate the situation, and 34% did not see the benefit of submitting a report on the presence of stress.

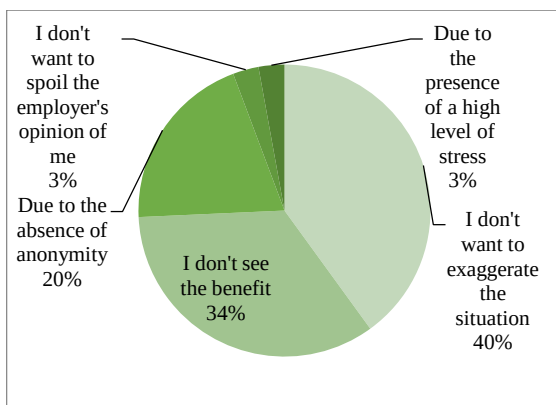


Fig. 4. The reasons given by the surveyed pilots for not reporting the presence of on-duty stress

A presentation of some of the methods of facing the stress can be found in Figure 5. All the respondents mentioned rest as the most important category that helps in stressful situations. 46 pilots indicated regular daily rest as the main strategy in coping stress. On the other hand, they recorded training, which is accessed by 36 respondents, usually several times a week. The younger population (under 35) stated training on a daily basis.

One of the most important observations when is that the pilots are mostly helped by the advice of family and friends. As many as 35 pilots point out that by talking to close people they manage to

overcome stressful situations. They state that they conduct conversations on a daily or weekly basis.

In addition to rest, training and advice from friends and family, the surveyed pilots point out that advice from colleagues as well as CRM training are excellent ways to mitigate and control stress. It is recorded that younger pilots (20) generally looking for advice from their older and more experienced colleagues several times a week, while a couple of pilots over 56 (7) seek advice from colleagues who are either younger or of the same age, several times a year.

Just the few pilots (16) indicated that professional help by psychologists is important by coping with stress. They claim that professional help is useful once or more during the year, while only 7 pilots have regularly helps by professionals during the month. According to the respondents answers it could be concluded that this strategy is more acceptable by those older than 46 years.

This phenomenon can be explained by the experience gained during the career. Pilots who have been working longer have encountered many more situations than their younger colleagues. Also, by the age, the human body changes and weakens, which further results in a more difficult coping with the stress, and that is one of the reasons why older pilots turn to professionals.

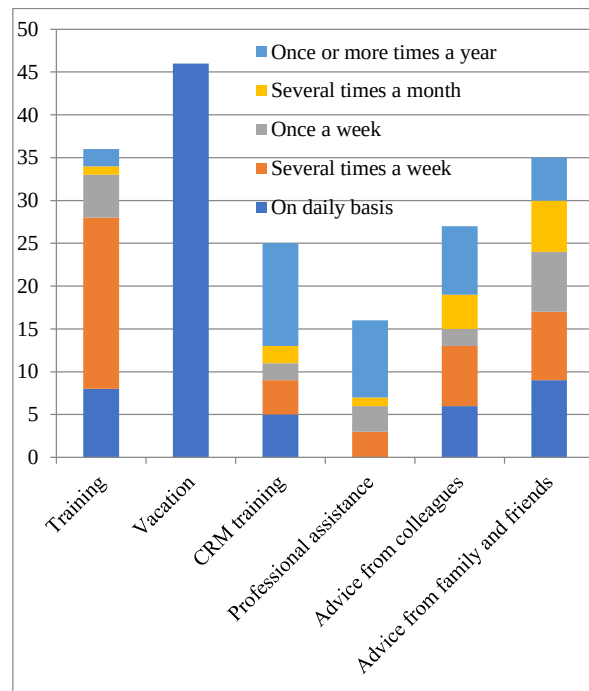


Fig. 5. The frequency of approaching certain strategies against the pilot's stress

The results indicating the relationship between the age of the respondents and the impact of stress on working memory, decision-making and relationships in the cockpit are shown in Table 4. Respondents who are less than 25 or more than 65 years old did not notice a change in the relations in the cockpit due to stress, whilst pilots between 36 and 45 years of age deny the influence of stress on all the mentioned parameters. Moreover, in other age groups it can be observed that stress equally affects working memory, decision making and interpersonal relationships.

4. Conclusions

The paper shows the process of the effect of stress on the performance of aviation personnel, which includes its causes, the development and response of the humans to a stressful situation, which can escalate to serious health problems. Moreover, the stress of working with additional negative factors can completely undermine the safety of aviation and cause fatal accidents.

When considering the impact of stress on the workload of pilots, it is necessary to emphasize that despite training and regular health check-ups, pilots largely encounter stressful events and that stress accumulates in such working conditions. As the job of a pilot requires certain human abilities, it can be concluded that it does not belong to the group of usual and standard jobs, but for that reason it carries with it great responsibility and dedication. Therefore, awareness is created about the complexity of stress and its effects on flight personnel.

In order to understand the problems faced by pilots as a result of stress, it is necessary to understand the cause of stress and the nature of its occurrence. Therefore, a more effective self-assessment is enabled and a wider knowledge is provided that avoids the mistakes that can lead to risky situations.

Stress in the cockpit could be analyzed within the framework stress related to weather conditions and stress related to specific situation or event. When assessing the presence of stress it should be taken into account how long the stress caused will last and whether it will have positive or negative effects.

Understanding the nature of stressors associated with work, life, internal or external

influences enables understanding the nature of stress, decision-making and relationships. Therefore, it is necessary to provide pilots with adequate training to copy the stress and teach them ways of managing stress in the cockpit.

The stress is always present in one's life. From the early beginnings of aviation, throughout the evolution, pilots, regardless of their years of service, encounter stress daily.

Although certain complex strategies are used to manage stress in cockpit, stress is still present. Therefore, in the future it is necessary to work more on developing methods to copy stress, providing reports on the presence of stress and develop adequate training for pilots. It is necessary to put emphasis on all possible side effects of stress and bring the definition of stress closer to pilots in order to reduce stress in order to minimize effects to flight crew workload.

References

- [1] O. Čokorilo, "Civil Aviation Pilot Education, Coaching and Beyond: Building Capacity in the Cockpit", *International Journal for Traffic and Transport Engineering*, vol. 10, no. 1, pp. 1-14, 2020.
- [2] O. Čokorilo, "Human Factor Modelling for Fast-Time Simulations in Aviation", *Aircraft Engineering and Aerospace Technology*, vol. 85, no. 5, pp. 389-405, 2013.
- [3] O. Čokorilo, G. Dell'Acqua, "Aviation Hazards Identification Using Safety Management System (SMS) Techniques", in *16th International conference on transport science (ICTS 2013)*, May 27th, Portoroz, Slovenia, 2013, pp. 66-73.
- [4] S.A. Shappell, D.A. Wiegmann, „A methodology for assessing safety programs targeting human error in aviation”, *The International Journal of Aviation Psychology*, vol. 19, no. 3, pp. 252-269, 2009.
- [5] S. Steiner, D. Finkleš, T. Gradišar, „Problems of crew fatigue management in airline operations”, in *International Conference on Traffic and Transport Engineering (ICTTE 2012)*, November 29-30, Belgrade, Serbia, 2012, pp. 617-623.
- [6] O. Čokorilo, "The influence of the human factor on safety risks management", in *Aircraft Safety*, 2nd edition, Belgrade, Serbia: University of Belgrade, Faculty of Transport and Traffic Engineering, 2020, 79-110.
- [7] EUROCONTROL, "Stress Sources" in *Human factors module – Stress*, Brussels, Belgium: EUROCONTROL, 1996, pp. 7-13.

[8] R.D. Campbell, M. Bagshaw, “Human Overload and Underload”, in *Human Performance and Limitations*, edition 3rd, London, UK: Blackwell Science, 2002, pp. 157-177.

[9] J. Allsop, R. Gray, “Flying under pressure: Effects of anxiety on attention and gaze behavior in aviation”, *Journal of Applied Research in Memory and Cognition*, vol. 3, no. 2, pp. 63-71, 2014.