MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF AIR NAVIGATION, ELECTRONICS, AND TELECOMMUNICATIONS
DEPARTMENT OF AVIONICS

APPROVED
Head of department
________S.V. Pavlova
'___'___________2022

GRADUATION WORK

(EXPLANATORY NOTES)

FOR THE DEGREE OF BACHELOR
SPECIALTY 173 'AVIONICS'

Theme: 'Warning and recommendation system in case of avionics failure for aircrew during flight'

Done by: __________ T.O. Pinchuk
(signature)

Supervisor: __________ Y.V. Hryshchenko
(signature)

Standard controller: __________ V.V. Levkivskyi
(signature)

Kyiv 2022

МІНІСТЕРСТВО ОСВІТИ І АУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ АЕРОНАВІГАЦІЇ, ЕЛЕКТРОНІКИ ТА ТЕЛЕКОМУНІКАЦІЙ
КАФЕДРА АВІОНІКИ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
_________С.В. Павлова
«___»___________2022

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ
БАКАЛАВР ЗА СПЕЦІАЛЬНІСТЮ 173
«АВІОНІКА»

Тема: «Система оповіщення та рекомендацій екіпажу при збоях авіоніки в польоті»

Виконавець: __________ Т.О. Пінчук
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(підпис)

Київ 2022

NATIONAL AVIATION UNIVERSITY

Faculty of Air Navigation, Electronics and Telecommunications

Department of avionics

Specialty 173 ‘Avionics’

APPROVED

Head of department

_________S.V. Pavlova

‘___’___________2022

TASK for execution graduation work

T.O. Pinchuk

1. Theme: ‘Warning and recommendation system in case of avionics failure for aircrew during flight’, approved by order №352/ст of the Rector of the National Aviation University of 04 April 2022.
2. Duration of which is from 16.05.2022 to 16.06.2022.
3. Input data of graduation work: Boeing 737 flight crew training manual, data on the peculiarities of the principle of operation of warning devices for failures in aircraft systems
4. Content of explanatory notes: analytical review of literature sources on the topic of the thesis; review of the main warning systems in the aircraft; analysis of air crash statistics; study of the main sources of aircraft failures; study of the impact of aircraft failures during flights on the psychological state of the pilot; study of methods for assessing the quality of piloting techniques; providing recommendations for further development of warning and recommendation system in case of avionics failure for aircrew during flight.
5. The list of mandatory graphic material: figures, graphs, tables.

5. Planned schedule

№	Task	Duration	Signature of supervisor
1.	Validate the rationale of graduation work theme	16.05-18.05	
2.	Carry out a literature review	19.05-22.05	
3.	Develop the first chapter of diploma	25.05-29.05	
4.	Develop the second chapter of diploma	23.05-27.06	
5.	Develop the third chapter of diploma	28.05-01.06	
6.	Presentation development and review preparation	02.06-04.06	
7.	Tested for anti-plagiarism and obtaining a review of the diploma	09.06-16.06	

6. Date of assignment: ‘16’ May 2022

Supervisor ________________
(signature) (surname, name, patronymic)

The task took to perform ________________
(signature) (surname, name, patronymic)

ABSTRACT

The explanatory notes to the graduate work ‘Violations and their eliminations during aircraft maintenance’ contained 41 pages, 13 figures, 4 tables, 13 reference books.

Keywords: AIRCRAFT, HUMAN FACTORS, ERROR, PILOT, STRESS PILOTING, FLIGHT SAFETY, WARNING SYSTEM, PSYCHOPHYSIOLOGICAL PRESSURE

The purpose of the graduate work is to investigate the warning and recommendation system in case of avionics failure for aircrew during flight to avoid the negative consequences of failures.

The object of the research is the process of investigation of warning and recommendation system in case of avionics failure for aircrew during flight.

The subject of the research is warning and recommendation system in case of avionics failure for aircrew during flight.

Research Method – comparative analysis, processing of literature sources, statistical data processing.

CONTENT

INTRODUCTION

Relevance of the topic. The human factor problem is one of the head causes of the most aviation accidents and incidents. If we analyze the statistics of aviation accidents in recent years, we can see the growth dynamics of such cases precisely because of the human factor. The establishment of processes between man and machine is the basis for optimizing their interaction.

The development of the particular warning system and recommendations for avionics failures during flight could reduce the impact of aircraft system malfunction on the pilot's psychophysiological stress and reduce the likelihood of errors due to the emotional state of the crew. This system would help the pilot improve his work and increase the effectiveness of his decision-making. Thus, the greater the number of failures in aircraft systems during flight, the greater the likelihood of making a mistake.

My initial point would be that, I want to offer options to reduce the impact of the human factor on the quality of piloting and increase the efficiency of decision-making by the pilot in an emergency with the particular warning system. This step is principal because the system will help the pilot overcome stress and focus on overcoming errors in the operation of avionics systems. That is why my topic is relevant and important for further research.

The purpose of the graduate work is to investigate the warning and recommendation system in case of avionics failure for aircrew during flight to avoid the negative consequences of failures.

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CHAPTER 1. GENERAL PRINCIPLES OF INTERACTION BETWEEN HUMAN AND AIRCRAFT IN AN EMERGENCY SITUATION

1.1 The human factors in aviation

Over the last few decades, the problem of human factors has increasingly proved the importance of a detailed study of this area. However, a large number of studies and analyzes show that the human factors are the primary cause of 80% of aviation accidents and catastrophes. Human error is the most common error that occurs during a flight, and the consequences of aviation personnel error can cost hundreds of lives. For this reason, further study of the human factors is principal.

Human is the main one in the process of flying an aircraft because an aircraft cannot function without a human. Even if we think about installing autopilot on board modern aircraft, most of the process is still controlled by man. In particular, take-off and landing - the most difficult stages of flight, must take place under the strict control of humans, and cannot be carried out without his participation in these processes. [1]

The human factors are the process of human interaction as a social being with its activities. In the case of aviation, the human factors are a study that shows the relationship between aviation personnel and technical equipment; learning technology to better understand how people can interact more effectively and securely with technology.

The main goal of the analysis and study of the human factors is to determine the human abilities and limitations. In the future, these elements help to understand how to avoid aviation accidents caused by human weaknesses and strengthen the skills of the pilot through his abilities and capabilities. At the same time, human factors analysis is performed in order to create comfortable, safe, efficient and effective human work under different flight conditions. In this way, we can learn more about the sources of human error and create artificial ways to eliminate it. The study of the causes of errors and fatalistic situations in the work of the pilot encourages researchers to draw conclusions and influence the improvement of the processes of interaction between the aircraft and the pilot.

No one is safe from mistakes. Both the person and the system can make mistakes during their work. But such dominant qualities as flexibility, the ability to adapt, and to make non-standard decisions belong to man, not the machine. That is why human presence during the flight is important and indispensable.

1.2 Analysis of statistics of aviation incidents and accidents

Error analysis is an extremely chief step to improve the effectiveness of future experiences. Aviation incidents and accidents continue to occur, despite the improvement of security systems in modern aircraft. It is unlikely that the world will ever be able to completely get rid of the fatalistic cases in the field of aviation. On the other hand, I am confident that we can reduce the percentage of such occasions to a minimum.

Let's look at the information provided on the ICAO website. I propose to review the total number of aviation incidents and accidents from 2008 to 2020. [2]

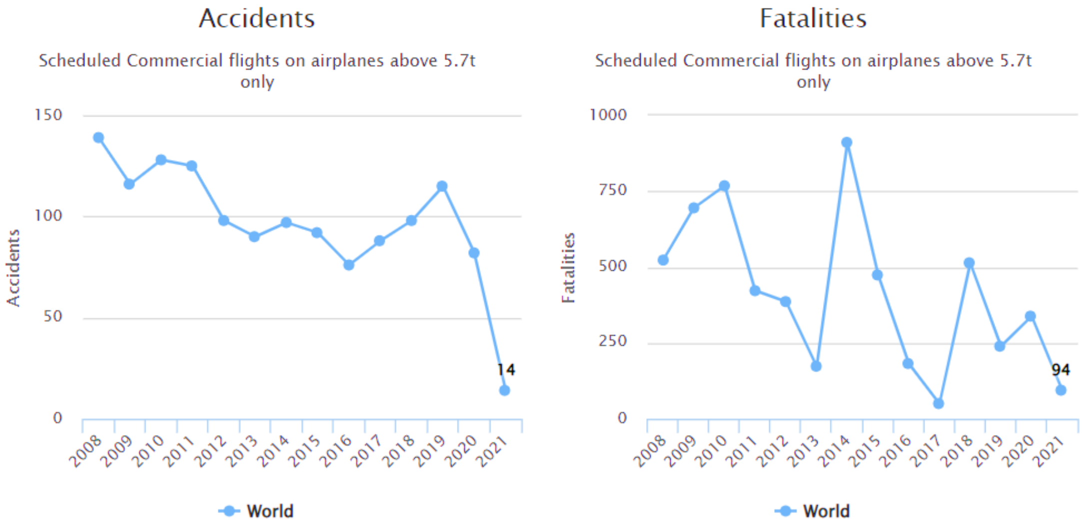
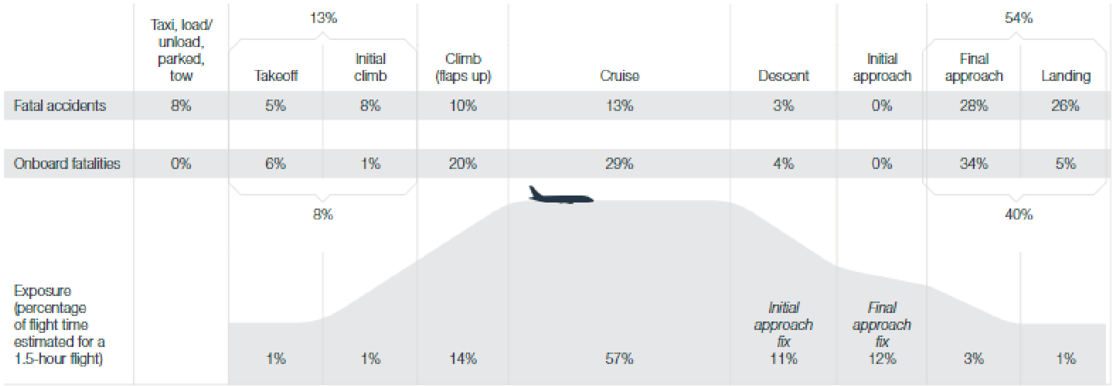


Fig. 1.1 Number of annual fatalities due to air crashes in period 2008-2021

As we can see from the graphs above, the total number of aviation accidents decreases every year. It reduces the number of casualties. After analyzing such information, it is possible to conclude improving the training of aviation personnel and directing forces to better the safety of air transport.

Another dominant element of the analysis of aviation incidents is their grouping by category according to the stage of flight. We can consider in Fig. 1.1 disaster statistics divided by flight stages and see what percentage of them at one stage or another.



Note: Percentages may not sum to 100% because of numerical rounding.

Fig. 1.2 Percentage of fatal accidents and onboard fatalities from 2011 to 2020 according to the phase of flight

In Fig. 1.2, according to a Boeing study, from 2011 to 2020, the most fatal accidents occur during flight. More specifically, 13% of tragic incidents occur during the cruise (optimal) flight altitude, 54% each occurs during landing and final approach, and 3% during descent. At the beginning of the flight, according to statistics, during take-off and initial climb 13% of the airplane crash occurs, and 10% during the rise, and another 8% occur on the ground during towing, runway, etc.

According to the figure above, most aviation incidents occur during the final approach and landing. Although the aircraft spends most of its time cruising, only 13% of accidents occur at this stage. For these reasons, takeoff and landing are considered crucial processes, and researchers are constantly working to improve this phase of flight.

During landing, the pilot is most exposed to psychophysiological pressure because he must be involved in a large amount of work. It includes constant changes in aircraft configuration, communication with the air traffic controller, and the need to pay attention to flight parameters. Such a large amount of information and actions increases the likelihood of unforeseen situations.

In table 1.2 shown statistics of aviation fatalities from 2012 to 2021, according to the statistics presented by the resource center for aircraft accidents and civil aviation safety issues - Aviation Safety Network, we follow the trend of reducing aviation accidents in recent years.

Table. 1.1

Statistics of aviation fatalities from 2012 to 2021

Year	Airliner Accidents	Airliner Fatalities
2012	23	476
2013	28	232
2014	20	692
2015	14	186
2016	17	258
2017	14	59
2018	18	561
2019	23	289
2020	8	137
2021	20	176

If we take the statistics for the last and previous five years, in the period from 2012 to 2016, there were - 102 incidents that killed 1,844 people. In the next five years, their total number decreased. In the period from 2017 to 2021, 83 incidents were recorded, which resulted in the death of 1,022 people.

According to information from the electronic online encyclopedia Wikipedia, we can consider the general statistics of the causes of plane crashes:

- Pilot errors - 50%:
- errors of pilots are unprovoked - 29%,
- pilot errors caused by difficult weather conditions - 16%,
- errors of pilots caused by equipment failures - 5%.
- Failures of aircraft - 22%.
- Meteorological conditions - 12%.

- Terrorism - 9%.
- Errors of ground staff (air traffic controllers, aircraft maintenance technicians, etc.) - 7%.
- Other reasons - 1%

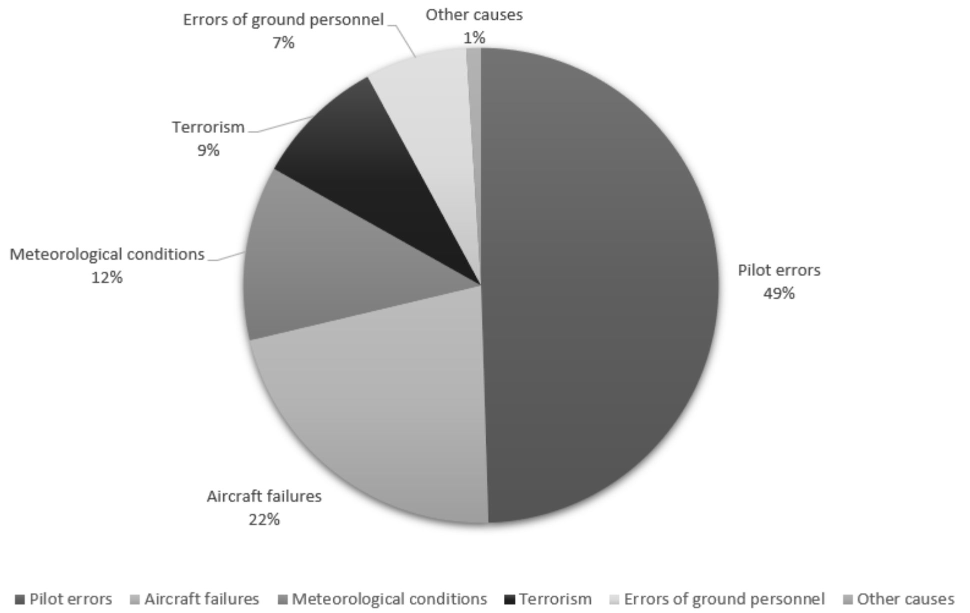


Fig. 1.3 The main causes of aviation accidents

Such statistics show us that the most common cause of aviation accidents is human error, not a technological error in the operation of the aircraft. Pilot error is the most common of all human errors. Moreover, in addition to pilots, there are other people involved in the operation of the aircraft, such as the air traffic controller, crew members, and personnel involved in aircraft maintenance. That is why I believe that the true percentage of failures caused by the human factors is even higher than indicated in these statistics.

1.3 Examples of aviation accidents due to human factors

Table. 1.2

Examples of aviation accidents caused by the human factors

№	Aviation accident	Date	Reason	Consequences
1	Boeing 737 near Bishkek	24.08.2008	Loss of flight altitude control by the crew during the maneuver for	Collision of the plane with the ground

1	2	3	4	5
			re-approach (landing which was due to incorrect assessment of the position of the aircraft relative to the estimated trajectory of descent); non-compliance by the crew with the rules of visual approach to landing, maintaining constant visual contact with the air landing strip	
2	An-24 near Varandey	16.03.2005	Prolonged maneuver of descent with slipping and loss of speed, with insufficient engine operation and lack of speed control. There may be errors in the readings of the devices: speed indicators, angle of attack	The drop-in sliding speed led to the aircraft entering the supercritical angles of attack and its stall
3	Boeing 737 in Phuket	31.08.1987	Incorrect measurement of the distance between two aircraft by the air traffic controller. The pilots slowed down because they feared a collision and went beyond the minimum altitude.	The plane crashed into the Andaman Sea 15 kilometers east of Phuket Airport and went underwater to a depth of 20 meters.

1	2	3	4	5
4	Tu-154 in Smolensk	10.04.2010	The decision to land and ignore the departure for the second round, lowering below the minimum height, psychological pressure on the crew, and the ignoring by aircrew of the signals of the traffic collision avoidance system.	The plane collided with trees in a fog and overturned.
5	Boeing 737 in Mangalore	22.05.2010	The mistake of the pilot. He continued the landing and tried to go to the second lap after landing. The captain's behaviour was caused by the fact that for 90 minutes of the flight he slept. After waking up he could not quickly understand the unusual situation.	The plane rolled off the runway and fell into a ravine.
6	An-148 in the Moscow region	11.02.2018	Incorrect aircraft speed readings due to icing of Pitot tube. The captain tried to increase the readings by introducing the aircraft into the dive, while the co-pilot pointed out the inadmissibility of such actions.	There was a violation of the instructions: the angle of attack was exceeded, due to which the pilot failed to control. The aircraft crashed 6 minutes after takeoff.

1	2	3	4	5
7	Airbus A330 took off from Rio de Janeiro and crashed in the Atlantic Ocean	01.06.2009	Inaccurate speed readings, the signal was turned off during stall and then turned on again several times during stall.	The pilots decided that all the readings of the devices were incorrect. The co-pilot began to climb, holding the nose of the aircraft without notifying the captain of the aircraft. Limit angles of attack and marginal height were reached.
8	Boeing 737 Sulawesi, Indonesia	01.01.2007	The pilots were distracted by troubleshooting the navigation system and accidentally turned off the autopilot	The heading-correction maneuver led to a jerk with a set of speeds to a level close to the speed of sound
9	Tu-154 Donetsk region, Ukraine	22.08.2006	Trying to stay at the height of the flight level, critical angles of attack.	Falling into a flat spin

End of table 1.2

1.4 The main types of human errors

The profession of a pilot involves a great deal of responsibility, as the lives of the entire crew and passengers depend on his actions. For this reason, future commanders of the aircraft undergo extensive training, where they learn to deal with unforeseen situations. Their model of behavior is developed by long training, supported by practice, and approved by the main provisions of aviation documents.

However, even long-term training and practice cannot provide a complete guarantee that a person will not have a negative experience in the future. I propose to consider the most common sources of errors in the work of the pilot.

James Reason conducted one of the most important researches of human error and described it in his book "Human Error". Let's consider the comparative classification of errors offered by scientists. Thus, the scientist divides human errors into two categories: variable and constant. [3]

Variable errors are accidental errors. Its occurrence is unpredictable. This type of error can have serious consequences.

Constant errors are systemic errors that recur from time to time. Such kinds of errors can be predicted, making them much easier to correct.

Reason also presented three levels of human productivity and presented the mistakes of employees of the organization in each of these three levels. Classification of levels is based on experience, knowledge, and rules.

- Skill-based level

This level of productivity is based on skills that have been mastered over a large number of practices. It consists of the internal patterns of man, according to which he gets used to acting, and motor programs. At this level of productivity, a human act according to the behavior model to which he is get used. Human actions may be unconscious, but well-learned on the physical and psychological levels.

A person can make a mistake in this mode if an unusual situation arises, and the person will be distracted. In such cases, unfamiliar activities will be connection with already familiar situations. For example, a pilot flew on one type of aircraft for a long time. Later he began to control another model of aircraft. In the new model of aircraft, the location of some indicators changed. As usual, the pilot tries to find a desired indicator in the same place as the indicator on the aircraft he had controlled before.

- Rule-based level

A level is based upon the known rules for solving familiar problems. At this level of productivity, a person is guided by some rules that he already knows. That rules should help him in solving a problem.

- Knowledge-based level

This level requires the professional to determine the necessary procedure for solving the problem based on previous knowledge. To do this, a person needs to assess the situation, review the information received, and then use their knowledge to determine specific actions to resolve the problem.

At this level, errors based on other factors are possible. The scientist considers the stress resistance of the individual, his ability to process information, set priorities, and the ability not to succumb to psychophysiological stress. This type of error is the most difficult to eliminate because it requires a person to be able to cope with their own emotions and make the right decision based on their knowledge.

Some professionals find it extremely difficult to behave appropriately in unfamiliar situations and under high stress. Against the background of emotional stress, a lot of important details can be missed. Human use only available information. Also, a person may be overconfident in their actions without checking their appropriateness. Another aspect can be the problem when the individual is overly obsessed with one aspect and does not notice anything else. For example, when some aircraft system fails and both pilots are overly obsessed with solving this problem. They do not pay attention to other indicators: angle of attack, altitude, etc., which can lead to even more serious consequences.

1.5 Error models and theories

1.5.1 SHELL model

The SHELL model is one of the most common behavioral models in the human factors, it was created by Edwards (1988) and later modernized by Hawkins (1993). The letters mean “S” – software “H” – hardware, “E” – environment, and “L” – liveware.

This conceptual model is designed to study the relationships between its elements. The model covers only human factors interfaces. It shows us that human errors or accidents occur when one of the model's connections is broken. Consider in more detail each component of the proposed model:

• Liveware is a person, a component that is placed in the middle and is the most important. Human actions are sometimes difficult to predict, and humans are very susceptible to internal and external changes, therefore an important step is to study their interaction with other elements.

• Software is aviation documents, rules, procedures that are part of standard operating procedures, and the usual way to perform tasks.

• Hardware is aircraft systems, controls, functional systems, and elements.

• Environment is the situation in which this system works together with other components.

Fig. 1.4 Schematic image of SHELL model

The SHELL model helps to clearly present the interaction between different parts of the aviation system:

- Liveware - Liveware

In the context of aviation, this is about how a pilot interacts with another pilot, air traffic controller, maintenance engineer, and so on. This model is used in the management of crew resources or the training of future pilots. This interface covers aspects such as teamwork, leadership, cooperation, interpersonal relationships, and the relationship between team and leader.

- Liveware - Software

For the smooth operation of these two components, it is necessary to be confident in the possibility of implementing software into operation. The interface must be user-friendly, clear, accurate, and relevant.

- Liveware - Hardware

When these two components interact, human contact with the physical interface of the system must be as simple and accessible as possible. Thus, the design of the seats should consider the characteristics of the human body, when creating and placing interfaces and displays, developers should make sure that they are easy to use, do not overload the eyes of pilots, and controls move properly.

- Liveware - Environment

This aspect of interaction concerns the internal and external environment in which a person is. The domestic environment is physical parameters such as temperature, noise level, lighting, vibration, and air quality. For pilots, the external environment is visibility, terrain, and turbulence. [4]

So, although the SHELL model was designed decades ago, its relevance has not disappeared, as the main element in the functioning of the aircraft continues to be a man. For a successful and safe flight, it is essential to monitor human interaction with each part of the system.

1.5.2 James Reason Human Factors Model

Professor Reason has developed a model that, in the context of the human factors, shows that most errors in an organization that lead to unpredictable consequences are due to a group of errors that were made at different stages by different people, not one individual. Quite often in the investigation of aviation incidents, it turns out that more than one mistake is made, which was made by more than one person. The situation may be such that only with a certain combination of errors and violation of their protection, security is violated.

In this model, failures are illustrated in the form of pieces of cheese with holes. Holes in slices are weak points. They can change their position and shape. In that case, if the holes in all the slices are levelled for a moment, it creates an "accident trajectory", which is a real danger and can be the basis for a large-scale failure or even a fatal accident.

Reason suggests that accidents can be prevented by tracking errors at several levels:

1) organizational influences;

2) unsafe supervision;

3) preconditions for unsafe acts;

4) unsafe acts.

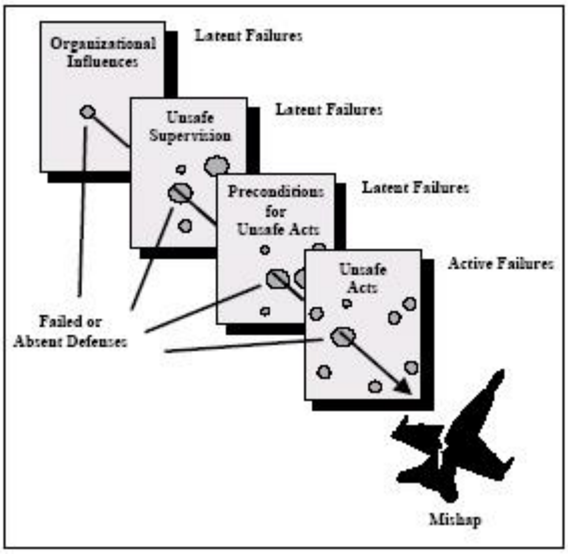


Fig. 1.5 The “Swiss cheese” model of human error (adapted from Reason, 1990)

In the figure above, we can see two groups of errors: active and latent errors.

Active errors are errors that are the main cause of an accident. This category usually includes pilot actions that lead to an accident.

Latent errors are errors that occurred long before the flight. Mistakes of this type are the result of questionable or incorrect decisions of the leaders of the organization, they can occur due to fatigue, low motivation, stress, anxiety, and lack of time.

In a system that is well protected, these two groups of failures interact with each other and do not often lead to security breaches. If protective measures work, the interaction of covert and active failures leads to an incident, and if not - to an aviation event. [5]

One example that springs to mind are when a plane crashes, we usually blame the pilot for it because he could not make the right decision that would allow him to finish the flight safely. But when analyzing Reason's model, it can be concluded that the aviation incident is preceded by certain failures or "latent errors" that were created at different stages of preparation of the aircraft for flight, and the pilot's mistake was just the last hole to create an "accident trajectory". Many of these failures are difficult to track and detect immediately, as their effects only show up over some time.

1.5.2.1 Human Factors Analysis and Classification System (HFACS)

This model of human behavior is a “modernized” version of “Swiss Cheese” model, was developed by Drs. Wiegmann and Shappell (2001). Wiegmann and Shappell proposed their development for the use of accident investigation and analysis. Using the HFACS system, accident researchers can identify the main causative factors that led to an accident.

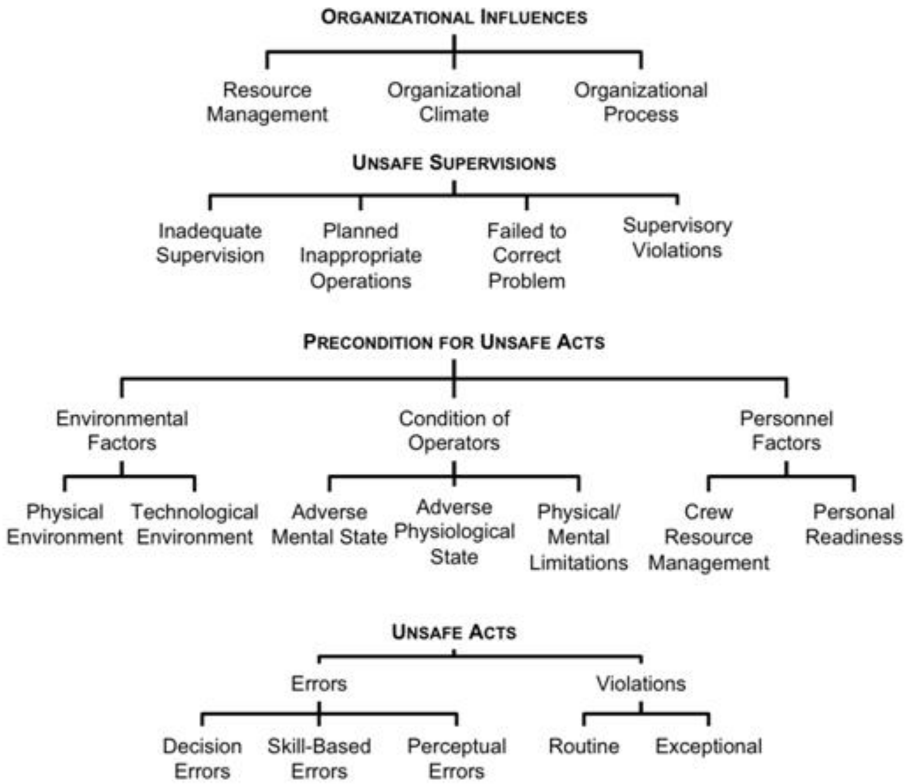


Fig. 1.6 The HFACS framework

This extended model is based on four levels of error, which correspond to one of the layers of Reason's model. These levels include organizational influences, unsafe supervisions, preconditions for unsafe acts, unsafe acts. [3] In the HFACS system, researchers have identified 19 causal categories in these four levels of human failure that define active and latent failures. All categories of this framework are illustrated in figure above. The purpose of using this system is to understand the main factors that lead to aviation crashes. [6]

At the first level, we consider unsafe acts. This level is divided into two categories: errors and violations, which in turn are divided into additional subcategories. Errors are unintentional behavior, and violations are intentional disregard for rules. Errors can be related to skills, decision making and perception errors. Violations can be routine or exceptional.

At the second level, we are presented with the preconditions for unsafe acts. They are divided into three categories: environmental factors, condition of operators and personnel factors. These three categories are divided into additional subcategories. Environmental factors are physical and technological factors that affect human actions; the condition of the operators are situations related to unfavorable mental and emotional state, and physical or psychological limitations of the individual; personnel factors are factors of crew resource management. Each of these categories can lead to human error or an unpredictable situation.

The third level includes unsafe supervisions. This level of error consists of four categories such as inadequate supervision, planned inappropriate operations, failed to correct problem, and supervisory violation. The third level of error is directly related to the supervision of the aircraft. This level includes neglect of training, instructions on supervision by supervisors, and disregard for existing rules and regulations.

The fourth level of error is organizational influences. This level includes three groups of errors: resource management, organizational climate and operational process. All three types relate to the governing bodies of the organization and their decisions regarding the maintenance of organizational assets, attitudes toward their employees, decisions and rules that govern the day-to-day activities of the organization.

The use of the HFACS framework is important because a detailed analysis of historical accidents and safety data can be used to prevent similar errors in the future of aviation. HFACS can be used to identify weaknesses in an organization and implement measures to reduce accidents or incidents. [7]

1.6 The problem of pilot stress

Stress is the highest level of emotional pressure associated with psychological or physical overload. When a person's demands exceed the level of his resources, stress arises. Stress can also be caused by a person's awareness that he cannot perform the tasks because he does not have the necessary experience or knowledge to solve them.

Stress is an integral part of our lives. We are always under a certain level of stress. Sometimes a state of stress can be beneficial to an individual, because in a state of stress we become more productive, doing what we seemed unable to do earlier. The impact of a small amount of stress can even have a positive effect and lead us to a state of excitement, while too much stress will have the opposite effect on our consciousness and body.

The pilot is the main part of the mechanism of operation of the aircraft. During the flight, he processes a large amount of information and makes many decisions of greater or lesser complexity. Although the future captains of aircraft need to undergo extensive training and a wide range of tests and health checks before taking their first flight for the first time, no one is safe from stress and its effects on the body and mind. In the table 1.5 shows the main effects of stress on the human body. [5]

Table. 1.3

Effects of fatigue on performance

Performance category	**Effects**
Attention: Reduced	Leave out steps in tasks.
	Preoccupation with single tasks or steps.
	Tunnel vision, less likely to notice the unexpected.
	Less aware or poor performance.
	Concentration requires more effort.
Memory: Diminished	Poor memory for tasks completed or underway.

1	2
	Forget to perform task steps.
	Revert to “old habits”.
	More likely to forget to return to interrupted tasks.
Mood: Withdrawn	Reduced communication.
	More irritable, frustrated by minor difficulties.
	Temptation to shortcut tasks.
Reaction Time: Increased	Slower to notice problems
	Less smooth control of equipment or vehicles.

End of table 1.3

As we can see, the impact of stress on the human body slows down many psychological and physical processes. Stress hurts the mental component of the individual.

In order to be prepared for the stress and be able to get out of panic and anxiety, you need to be prepared for the fact that an emergency may occur. The best method for this is anti-stress training of pilots on the simulator. When modelling failures on the flight simulator, it will be important to use those that are most common in the analysis of recent aviation incidents on the model of HFACS. Training and frequent repetition of unforeseen situations in the future will make the pilot more confident. In the future, under stressful circumstances, he will be able to assess the reality of the situation and be able to cope with his emotions, not allowing panic and stress to take over his body. By understanding the mechanisms of stress, the captain of the aircraft will be able to control the negative emotions caused by stress and try to solve the problem in the most logical and safe way.

CHAPTER 2. THE PROBLEM OF PILOT DECISION-MAKING IN AN EMERGENCY SITUATION

2.1 Influence of information phenomena on aircrew work

An essential step for the reliable operation of the aircraft and an element of decision-making is the processing of information by the aviation operator. The airline operator processes a large amount of basic and ancillary information, the amount of which can vary depending on the complexity of the task.

Complicated unforeseen circumstances and situations in the activities of pilots are the cause of the threat of erroneous actions that can lead to real aviation incidents and accidents.

During the operation of aircraft, there are cases when it may seem that a significant element of the situation is correct and not even in doubt. Sometime later, it turns out that this element was wrong, and time to correct the circumstance may not remain. In this case, the aviation operator falls into the information trap.

The most common cause of erroneous actions in the activities of the pilot is a violation of interaction in the system "man-machine". The reasons for the violation of this link may be the emergence of psychophysiological pressure on the pilot, stress in the workplace or the action of factors of complexity and responsibility.

Information traps can be detected:

- with an ambiguous interpretation of the reasons for the operation of emergency warning systems;
- if you do not understand the reasons for the development of the emergency situation;
- due to mutual misunderstanding of each other's crew members, communication problems;
- in case of chaotic actions, due to psychophysiological stress of aviation operators;
- due to the action of a large number of different factors, a large amount of information makes it difficult to identify the main ones and the decision-making stage to eliminate them.

The study of information processes and mechanisms of their formation is the basis for the development of mechanisms to reduce their impact on the human body and will be a prerequisite for further maintaining the level of reliability of the aviation operator.

Given the fact that the phenomena of information traps and information processes remain almost unexplored and unexplored, although they have a significant impact on aviation security, this topic is quite relevant. In modern conditions, the trend of growing new technologies is spreading very fast, and information has a very big impact. [8]

Another essential factor in the emergence of information traps is the phenomenon of accumulation of information. With a large amount of information, the pilot may lose most of it, such a sequence of actions often becomes a prerequisite for a plane crash or even a plane crash. Also, in the event of information traps, the operator may lose the ability to perceive new information.

2.2 The problem of decision-making for the aircrew in case of an emergency

As discussed above, during his practice the pilot occasionally faces risks and unforeseen situations. In such circumstances, it is especially important to make the right decisions and resolve the problem positively.

Getting rid of risks completely is quite complicated. Most risks are part of our daily lives, but we need to be prepared for the fact that they can manifest themselves in life from time to time. The first step to overcoming a risk is to define its degree of threat. Risks can be objective and subjective, which means external and internal risks respectively. After assessing the risk, it is necessary to weigh all the alternatives to overcome it, make a balanced conclusion and act.

There is no single best way to act in abnormal situations. Pilots with extensive experience have repeatedly encountered similar situations during their practice. In such cases, the decisions do not require too much time and effort. The pilot repeats actions that have been effective in the past. However, when an aviation operator first encounters a difficult situation in which he had no previous experience, he needs time and cognitive effort to determine the course of action.

Effective decision-making consists of the pilot's mental qualities and skills. These categories include the ability to recognize stress and overcome it, the ability to assess the degree of risk, and the desire for continuous self-improvement. For most people, these qualities are not natural and are acquired only during personal training.

The process of processing information by the human brain illustrated in the Fig. 2.1. There are five main stages.

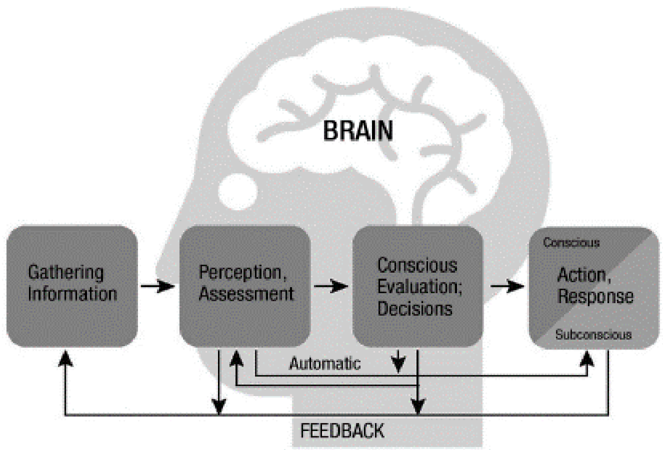


Fig. 2.1 The stages of information processing

1) Gathering information

During the first stage of decision-making, the main task of the human operator is to gather all available information that is relevant to the situation to be resolved. Information is collected through our senses: sight, hearing, touch or smell. During this phase, the pilot can use sensor readings, visual and auditory signals, and so on.

2) Perception or assessment

At this stage, we need to provide an appropriate assessment of the information we have already received. We need to understand the importance of the information we already have and how we can use it. Are we familiar with this situation? Have we seen this information before? There is a kind of analysis of the data. Our brain decides what to do next and what to do with the information provided. If the situation was already familiar to us, the information is sent by an automatic program of action. If the information is unfamiliar and new to us, then the brain directs its solution through conscious evaluation.

3) Conscious evaluation, decisions

The decision-making stage is one of the main stages. After analyzing and evaluating the situation, against the background of the fact that the brain has already concluded whether we are familiar with this situation, or we are faced with such a situation for the first time, we decide exactly how we will act. On the one hand, if in the phase of assessing the situation, we have attributed it to the already familiar, the decision-making stage is automatic and does not require heavy effort and excessive attention. For the most part, this happens automatically. On the other hand, if the situation is difficult and unfamiliar, we need a high level of concentration and consciousness. Quite often it can reduce our ability to do other things or completely deprive us of this ability.

4) Action

At this stage, depending on whether the circumstance is familiar to us or not, we act consciously or subconsciously. If the action is performed consciously, then this process takes place with our full attention. If the process is subconscious, then we act on the "machine", especially without thinking about how to make this action correct. But even in this case, we still have to be careful and monitor the process, because our brain is limited to being able to process only one case at a time.

5) Feedback

The last step in the information processing process is to get feedback. At this stage, we understand whether we managed to get what we wanted and expected or not.

Aviation operators must have a basic understanding of how a person processes information. It helps him better understand herself, her mistakes and other people. Large amounts of workload and information that need to be processed in the allotted time can cause information overload, which can cause additional stress and negatively affect performance, increasing the likelihood of error. That is why the creation of a system that could stop and help the pilot is an extremely important step for the development of aviation security. [5]

There are a large number of decision-making models that encourage the pilot to remember the best course of action to avoid exacerbating a difficult flight situation. But in an emergency, it is sometimes quite difficult to unambiguously apply analytical models to every decision made. The pilot chooses the path to act automatically and compares the situation with his experience. In general, a person does not spend time choosing the best option possible but chooses the first workable option. This type of decision making can be called automatic. This type of decision is based on knowledge and practice and is used in cases where there is not enough time to make analytical decisions. [8]

However, an essential part of making an effective and informed decision is the application of external and internal resources inside and outside the cockpit. If the pilot can properly manage their resources and cockpit resources, this skill makes him more productive and encourages better decision-making. The use of resources has a significant impact on flight safety.

For perfect pilot interaction, it is essential to understand how aircraft systems and equipment work. The absence of this knowledge can lead to excessively negative consequences. Checklists are another significant internal resource of the cab. Their role is a major because they are a pilot's tool that provides additional information about the serviceability of aircraft instruments and systems and helps solve problems related to these systems.

External resources include communication with air traffic controllers. Specialists provide the pilot with information about traffic around airports and along flight routes, and they can assist in emergencies. This category of resources also includes flight service stations. However, the most valuable resource is the pilot himself and his ability to manage the workload.

Thus, we can conclude that there is no single correct model of effective decision-making, which will give a one hundred per cent guarantee that the decision will be correct. This solution includes a combination of experience, efficient use of resources, mastery of their psycho-emotional state and the ability to distribute the workload.

2.3 Features of designing warning systems in the aircraft

The aircraft system, as in any other system, may periodically malfunction. It is impossible to predict all the current situations that may arise during the flight. To be able to get out of dangerous situations, you need to know the source of this problem. For that reason, the cockpit has appropriate systems that inform the pilot where exactly the crash occurred.

Centralized warning systems have been modelled for a simplified version of the transmission of critical messages related to a large number of aircraft systems and indicators. Quite often the detector panels are placed on the instrument panel. They can look different and be placed in different cabin locations, depending on the type of aircraft and its model.

There are the following types of warnings:

- Visual

- Voice.

Visual warnings include light signals that are turned on when an event occurs that requires attention and vigilance.

Visual signals are divided into three levels:

- Level A: Warnings alerts require immediate crew action
- Level B: Cautions require immediate crew alertness and possible future action
- Level C: Advisories alerts require crew alertness.

There are three leading colors used in the cockpit to announce visual messages. The crew needs to know what each of these colors means, as the values of these colors quickly provide the pilot with additional information. For example, green is a color that indicates a satisfactory condition. Yellow is used to prevent a serious condition and requires further monitoring. Red is an unsatisfactory color, and messages of this color require the pilot to take immediate action to resolve the issue. Blue is applied for warning, it indicates the transition state of the component by bright lighting, and when the desired configuration of indicators is achieved, the color becomes dull blue.

When triggered, visual warnings draw the crew's attention to a critical situation. Upon receipt of such notification, the pilot may deactivate the main warning, but the special lamp concerning the system or component through which the threat arose shall remain on until the situation has been rectified.

Aircraft audible warning systems inform the crew of a critical situation with an audible signal. A variety of phrases can be used in a voice alert, and the tone may vary depending on the component in which the fault occurred. Audible signals can warn of the following: abnormal takeoff, landing, pressure, reaching a critical angle of attack, engine fire, and recommendations to avoid a collision. [10]

Table. 2.1

Aircraft aural warnings

Examples of Aircraft Aural Warnings				
Stage of Operation	Warning System	Warning Signal	Cause of Warning Signal Activation	Corrective action
Takeoff	Flight control	Intermittent horn	Throttles are advanced and any of the following conditions exist: 1. Speed brakes are not down 2. Flaps are not in takeoff range 3. Auxiliary power exhaust door is open 4. Stabilizer is not in the takeoff setting	Correct the aircraft to proper takeoff conditions
In flight	Mach warning	Clacker	Equivalent airspeed or mach number exceeds limits	Decrease aircraft speed
In flight	Pressurization	Intermittent horn	If cabin pressure becomes equal to atmospheric pressure at the specific altitude (altitude at time of occurrence)	Correct the condition
Landing	Landing gear	Continuous horn	Landing gear is not down and locked when flaps are less than full up and throttle is retarded to idle	Raise flaps; advance throttle
Any stage	Fire warning	Continuous bell	Any overheat condition or fire in any engine or nacelle, or main wheel or nose wheel well, APU engine, or any compartment having fire warning system installed Whenever the fire warning system is tested	1. Lower the heat in the the area where in the F/W was activated 2. Signal may be silenced pushing the F/W bell cutout switch or the APU cutout switch
Any stage	Communications	High chime	Any time captain's call button is pressed at external power panel forward or rearward cabin attendant's panel	Release button; if button remains locked in, pull button out

In Boeing 737, an aural warning for airspeed limits is given by a clacker, takeoff configuration and cabin altitude by an intermittent horn, the autopilot disconnect by a warning tone, and landing gear positions by a steady horn. The fire warning by a fire warning bell. Ground proximity warnings and alerts, and windshear warnings and alerts are given by voice warnings.

Typically, the audible alert automatically turns off as fast as the problem with its built-in is solved.

When designing a system, it is necessary to adhere to particular requirements so that this system is comfortable and can be used in the event of real critical situations during the flight. [9]

The main requirements for audio notifications are the following:

- discrete sound notifications were used in the development of the best situations, and their maximum number did not exceed 4;

- Intensive automatic adjustment of the intensity of notifications should be provided, as far as noise reduction conditions are concerned.

- it is forbidden to turn off the voice signal in a situation of the first level of threat without its correction, but can reduce the intensity of the signal after reaching the initial recognition;

- the signal must be heard against the background of noise or other sound sources;

- alarm signals must be different from other sound signals;

- signals should attract awareness, but not interfere with employees' work function;

- the message must be transmitted by an identifier whose pilot is more than sensitive.

The requirements for modeling visual notifications are as follows:

- visual notices should be readable and conveniently located for each pilot;

- first-level warning devices must be located within 15 degrees of the pilot's central line of sight

- second-level warning devices must be located within 30 degrees of the pilot's central line of sight

- warning devices with green and blue lights may be located anywhere in the cab, but the indicators must be visible to the crew;

- the brightness level should be automatically adjusted depending on the outdoor lighting conditions;

- use flashing indicators only for warnings with the highest priority.

2.4 Examples of existing warning systems in aircrafts

The topic of flight safety is very significant to this day. Although the number of aviation accidents is decreasing every year, it is pretty difficult to get rid of them completely. The design of modern aircraft is becoming increasingly complex. The latest airliners are very sophisticated machines. The availability of warning and warning systems is an essential aspect of the further development of flight safety. Consider how warning systems work on the example of two warning systems for Boeing 737 aircraft.

2.4.1 Engine Indicating and Crew Alerting System (EICAS)

One of the largest displays related to warning systems in Boeing aircraft is the engine indication and aircraft warning system. This system performs the function of monitoring engine parameters and warns the crew about a malfunction in the system if any. The system widely demonstrates the parameters of the aircraft engine, which helps the pilot to quickly detect any damage or breakage. EICAS may also display additional information on other aircraft systems, depending on their model and manufacturer. These can be the following parameters: oil pressure, temperature values, speed, amount of fuel, surface control, and electrical and hydraulic systems. [11]

The system uses visual notification methods. The system uses a 6-color code to display alerts. The system uses the following colors: red, orange, green, white, blue, magenta. Each of these colors is important for providing information about the operation of the system. The meaning of the colors is the same as already described in the guidelines for the design of alarm systems. Red indicates failure and requires immediate action, yellow informs the crew, green indicates that the system is operating in a coordinated manner, white means names, blue - to determine the necessary actions, magenta is used for equipment messages or directly related to the situation.

2.4.2 Stall Warning Systems

Another type of warning system is the Stall Warning System. This system provides the pilot with an early warning of approaching a critical angle of attack, which could lead to a crash. [12]

Types of warnings may differ in different types and models of aircraft. Warnings can be issued due to the aerodynamic performance of the aircraft.

Consider some of the most common warning systems about falling:

The warning of a stall can be in the form of an audible signal, which occurs with the help of a special mechanical or electronic device. A warning beep is the simplest version of this type of device. A beep sounds when airflow through it occurs at a certain angle. Warning devices with pressure sensors or a moveable metal tab can also be used for an audible warning.

Sometimes the warning system can only operate with aerodynamic shaking. If the aircraft approaches the stall phase, the airflow through the upper surface of the wing will stop flowing smoothly. Under such circumstances, air turbulence is formed, which flows through the horizontal stabilizer and shakes.

Stick Shaker. - The stick shaker is another device to warn of the start of dumping. Usually, this type of device is installed on aircraft, where the types of rudders are prone to supercritical angles of attack. As a result of the supercritical angle of attack, there may be an exacerbation, after which the situation may become irreparable. The stick pusher helps the pilot avoid a critical situation and prevent the aircraft from entering the dump.

The angle of attack data is an important part of some stall warning systems. With a pre-configured configuration of the angle of attack, the sensor of the angle of attack helps to turn on the warning sound or activate the automatic shaking of the steering wheel. If the angle of attack indicator is included in the pilot's dashboard, it will visually show the approach of the aircraft to the critical angle of attack.

CHAPTER 3. WARNING AND RECOMMENDATION SYSTEM IN CASE OF AVIONICS FAILURE FOR AIRCREW DURING FLIGHT

3.1 Stress pilots training

During the flight on the aircraft, the pilot is affected by significant number different factors. As mentioned above, the aviation operator works with large amounts of information, which can sometimes slow down the data reduction process. Also, excessive amounts of data can cause stress, negatively affect mental processes. A large volume of information are not the only source of stress and psychophysiological pressure. Because the human body is quite complex, the psyche and reactions of the human can be unpredictable, especially when the pilot is exposed to stress. In order to be ready to cope with the emotional overload of the pilot, it is necessary to be ready for him and understand how it affects him.

The importance of stress training is proven fact by many studies. When something goes wrong, but you have been familiar with a similar situation before - it is much easier to deal with stress and solve the trouble. It is quite difficult to reproduce all possible circumstances of systems on the simulator. However, when you have already encountered imperfect circumstances and know that they can be corrected, it becomes much easier to master yourself and your emotional state. The leading purpose of anti-stress training is to prepare a person for a stress. A person must be able to note the stress in his body, understand how it manifests itself, what it leads to and know how to stop it.

Note the effectiveness of stress training on the example of a study conducted in 2011 in California, four researchers McClernon, C.K., McCauley, M.E., O'Connor, P. & Warm. [13]

This study aimed to discover whether stress training on the simulator is really important and whether it helps increase productivity if the stressor occurs in actual flight.

The study involved 30 participants. All members were US servicemen and had no previous experience in flying an aircraft. Participants were randomly divided into two groups of 15 people each. One group underwent pilot training with the addition of stress training, while the other group was the control group and underwent regular flight training without stress.

During the training on the simulator, a cold pressor, which acted as a stressor, was attached to the left leg of the group members who were learning flight skills with the addition of a stress factor. In the next flight task, the stressor was flying in simulated instrumental meteorological conditions.

The group's training with the stressor was based on the three-phase method of teaching Friedland and Keinan (1992). First, there was a familiarization phase, where participants were introduced to verbal descriptions and videos about the work of primary flight display and a 10-minute exercise session. In the second stage, participants were asked to immerse their left foot in cold press and read instructions to relieve stress. In the third stage, the interaction of the previous two stages took place. A flight was performed on the simulator with the addition of the stress factor described above. After that, the participants were transferred to a real plane, where the inspection of controls and tools was closed so that they could use only the technique of piloting instruments. During the flight, the experimenter offered participants 10 tasks.

The results of the experiment were shown in the form of variance to estimate each of the participants transferred from the telemetry measurement of the aircraft.

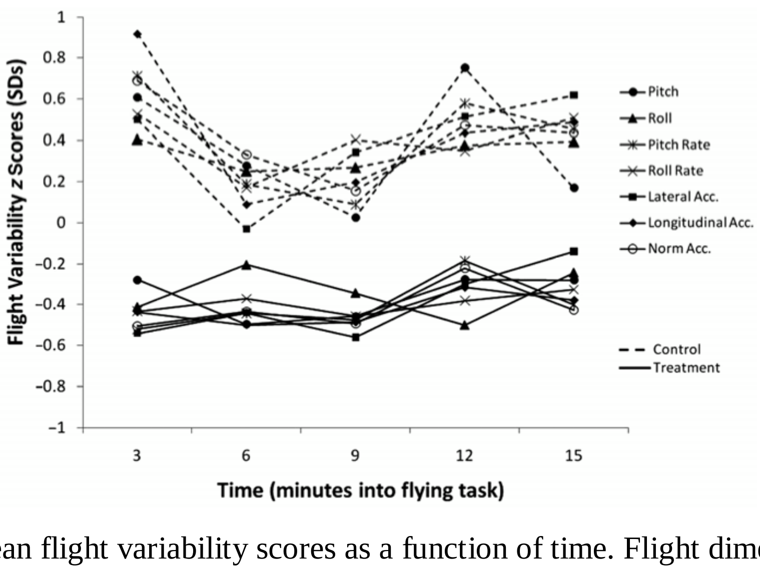


Fig. 3.1 Mean flight variability scores as a function of time. Flight dimensions and experimental groups are the parameters.

The variance is one of the indicators that describes the effectiveness of flight control and shows the smoothness of the aircraft in the air.

The figure shows the average variability of the seven flight parameters for the two groups as a function of 3-minute intervals. The higher the variance, the lower the flight performance. Therefore, given the graph of the function obtained as a result of the experiment. It can be concluded that the group in the preparation of which was used stress training coped with the task better. The variance for this group is below. [14]

This experiment proves once again that anti-stress training plays a significant role in the face of actual stressors during the flight, as it increases the effectiveness of the pilot. The results of the study show that the pilot benefits from anti-stress training even if the context is different.

3.2 Special warning and recommendation system in case of avionics failure for aircrew during flight

Warning and recommendation system in case of avionics failure for aircrew during flight consists not just of visual warnings of failures. The goal of system is to reduce the harmful effects of the human factors in an emergency, to detect and reduce stress. Therefore, in the event of a failure, the system will not only demonstrate where the failure occurred. The system also guide the pilot on a specific path to resolve the issue. To help calm the pilot and return him to normal. Such characteristics of the system are necessary because in order to make an effective decision a person needs to be at rest and be able to think rationally.

The essential problem with the occurrence of psychophysiological pressure in the pilot's body is the fact that the captain of the aircraft often does not notice that he is exposed to stress. As a result, his movements can become accelerated and uncontrollable. Stress can cause an increase in the amplitude of aircraft flight parameters. If you do not stop the action of psychophysiological stress in time and allow the pilot to increase stress, it can lead to reaching supercritical angles of attack and stall of aircraft.

You can determine the quality of piloting techniques using the autocorrelation function. The increase in the amplitudes of the aircraft parameters is directly related to the change in the psychophysiological state of the pilot. A comprehensive analysis of the function, where the flight parameters are presented, can help determine the psychophysiological state of the pilot and show his level of training.

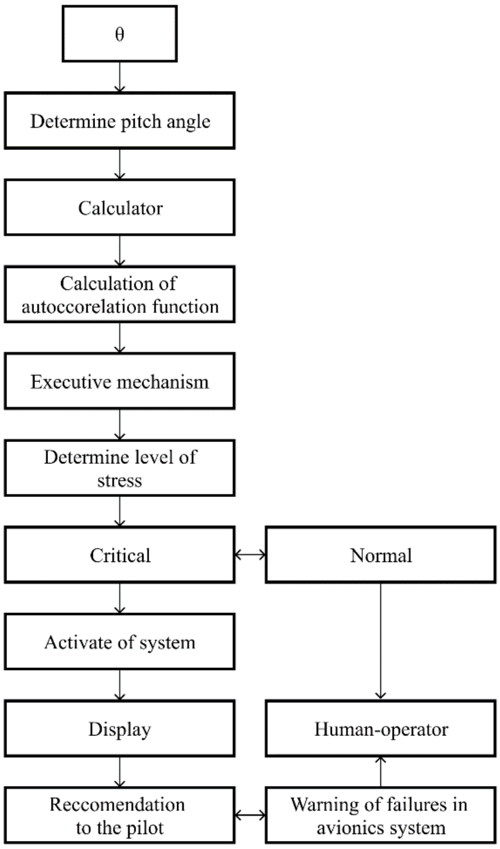


Fig. 3.2 Scheme of signaling in case of determine psychophysiological pressure of the pilot

The first step in the operation of the system is to determine the pitch angle of the aircraft, the amplitude of changes in its parameters using telemetry data of the aircraft. These indicators directly characterize how smoothly the aircraft moves. To calculate the autocorrelation function, we collect the input data of the flight amplitude. In our case it is the parameters of the pitch angle. As a result of calculating the function, we have graphs that show us in what condition the pilot is.

If the calculation of the autocorrelation function results in negative values on the graph, it indicates that the pilot feels tension and his stress level may increase depending on the number and magnitude of negative values. The system defines this indicator as evidence that the pilot-in-command is under psychophysiological tension. In this case, the system works and displays recommendations for reducing stress and directs the pilot's attention to the information that will help him return the aircraft to a safe position.

Blue indicators are used on the system indicators, as the system is of a recommendatory nature. The alert level of the warning system refers to the alert level C, as it requires the attention and vigilance of the operator.

3.3 Determination of the psychophysiological pressure of the pilot using autocorrelation analysis of pitch angle parameters

During the flight, to determine whether the pilot is under stress, we use the analysis of flight parameters, namely the analysis of the amplitude of changes in pitch angle during the flight of the aircraft.

With the help of the autocorrelation function, we determine whether the pilot is in a state of stress. If the avionics system fails, our warning and warning system displays a message on display about what is best to pay attention to the pilot to correct the situation. The system tells the pilot exactly what information he needs to solve the problem.

Flight analysis using the autocorrelation function significantly expands the possibility of obtaining flight statistics data.

Calculations of autocorrelation functions were performed in the Mathcad environment. Using the determined data of the amplitude of the pitch angle change and the formulas for determining the normalized and unnormalized function. I plotted two graphs of normalized and unnormalized autocorrelation functions before each flight. With the help of autocorrelation functions, we can learn about the psychophysiological state of the pilot and whether the pilot was exposed to stress during the flight.

The calculations show flights taken from actual flights on a Boeing 737 NG. To calculate the autocorrelation function, we first determined the amplitude of the change in the pitch angle during four flights. Then with the help of formulas, the normalized autocorrelation function is calculated:

$$K(t) = \frac{1}{\sigma N} \sum_{i=0}^{N-t-1} [(\theta_i - m)(\theta_{t+1} - m)], \qquad (3.1)$$

where N – the number of observations in the time series t, θ_i – pitch amplitude, i = 1, 2, 3; m – mathematical expectation, σ – standard deviation.

The unnormalized autocorrelation function was calculated:

$$\psi(t) = \frac{1}{N-t+1} \sum_{i=0}^{N-t-1} [(\theta_i - m)(\theta_{t+i} - m)] \qquad (3.2)$$

where N – the number of observations in the time series t, θ_i – pitch amplitude, i = 1, 2, 3; m – mathematical expectation, σ – standard deviation.

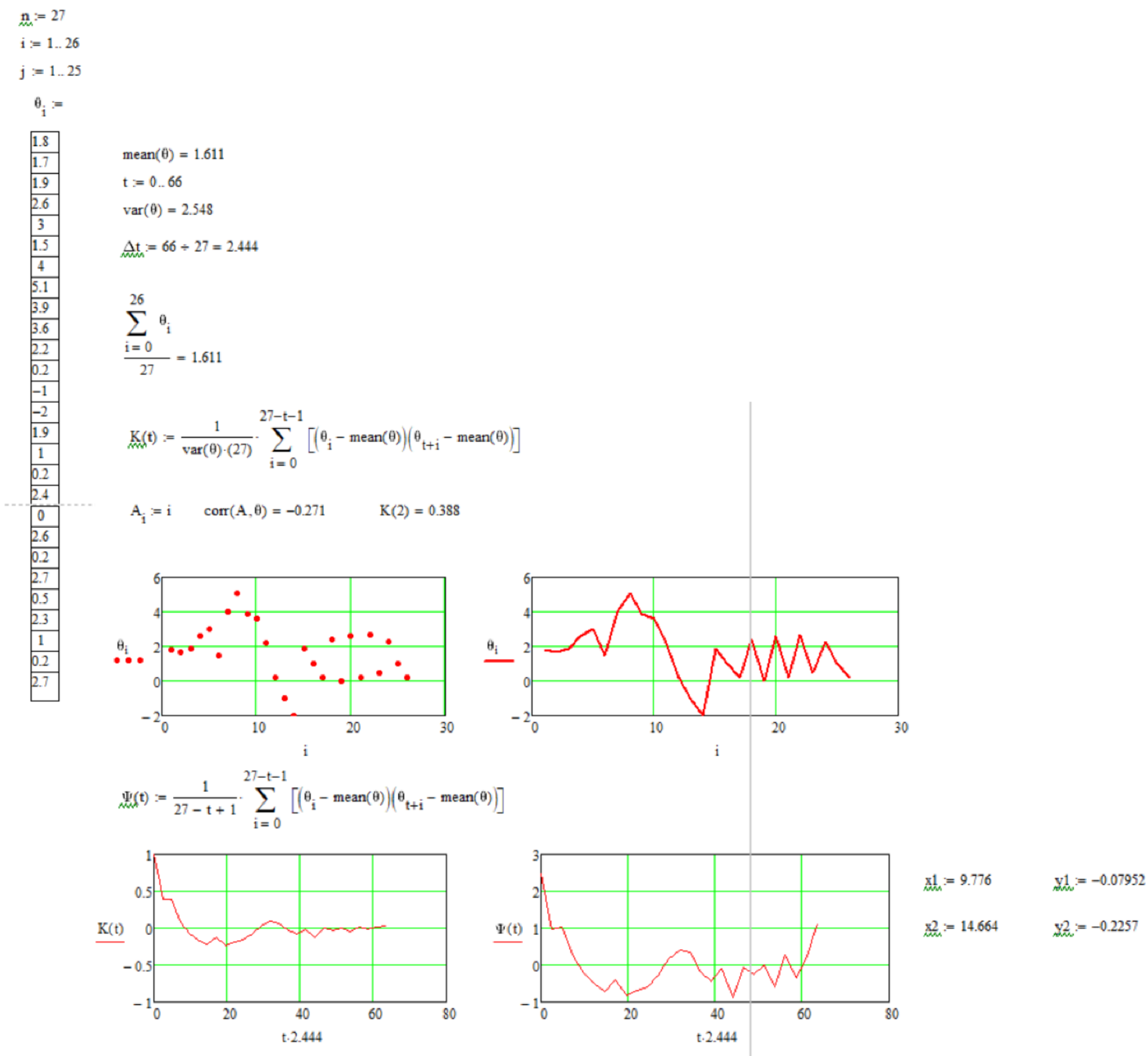


Fig. 3.3 Listing of calculation of autocorrelation functions of pitch angle, flight 1

$n := 26$

$i := 1..25$

$j := 1..24$

$\theta_i :=$

2
5
4
3
4
−3
0.5
2
1.5
2
0.4
−0.1
−0.3
1
0.7
1
1.7
1.2
1.8
1.5
1
2
−0.1
2.2
1.9

$\mathrm{mean}(\theta) = 1.374$

$t := 0..90$

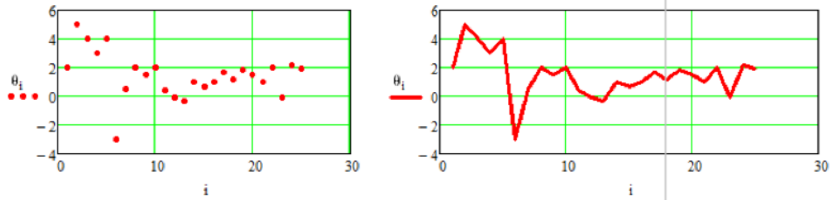
$\mathrm{var}(\theta) = 2.392$

$\Delta t := 90 \div 26 = 3.462$

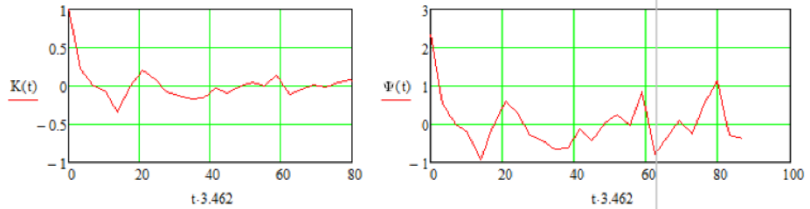
$$\frac{\sum_{i=0}^{25} \theta_i}{26} = 1.419$$

$$K(t) := \frac{1}{\mathrm{var}(\theta)\cdot(26)} \cdot \sum_{i=0}^{26-t-1} \left[\left(\theta_i - \mathrm{mean}(\theta)\right)\left(\theta_{t+i} - \mathrm{mean}(\theta)\right)\right]$$

$A_i := i \qquad \mathrm{corr}(A, \theta) = -0.211 \qquad K(2) = 2.719 \times 10^{-3}$



$$\Psi(t) := \frac{1}{26 - t + 1} \cdot \sum_{i=0}^{26-t-1} \left[\left(\theta_i - \mathrm{mean}(\theta)\right)\left(\theta_{t+i} - \mathrm{mean}(\theta)\right)\right]$$



$x1 := 10.386 \qquad y1 := -0.084342$

$x2 := 13.848 \qquad y2 := -0.34099$

Fig. 3.4 Listing of calculation of autocorrelation functions of pitch angle, flight 2

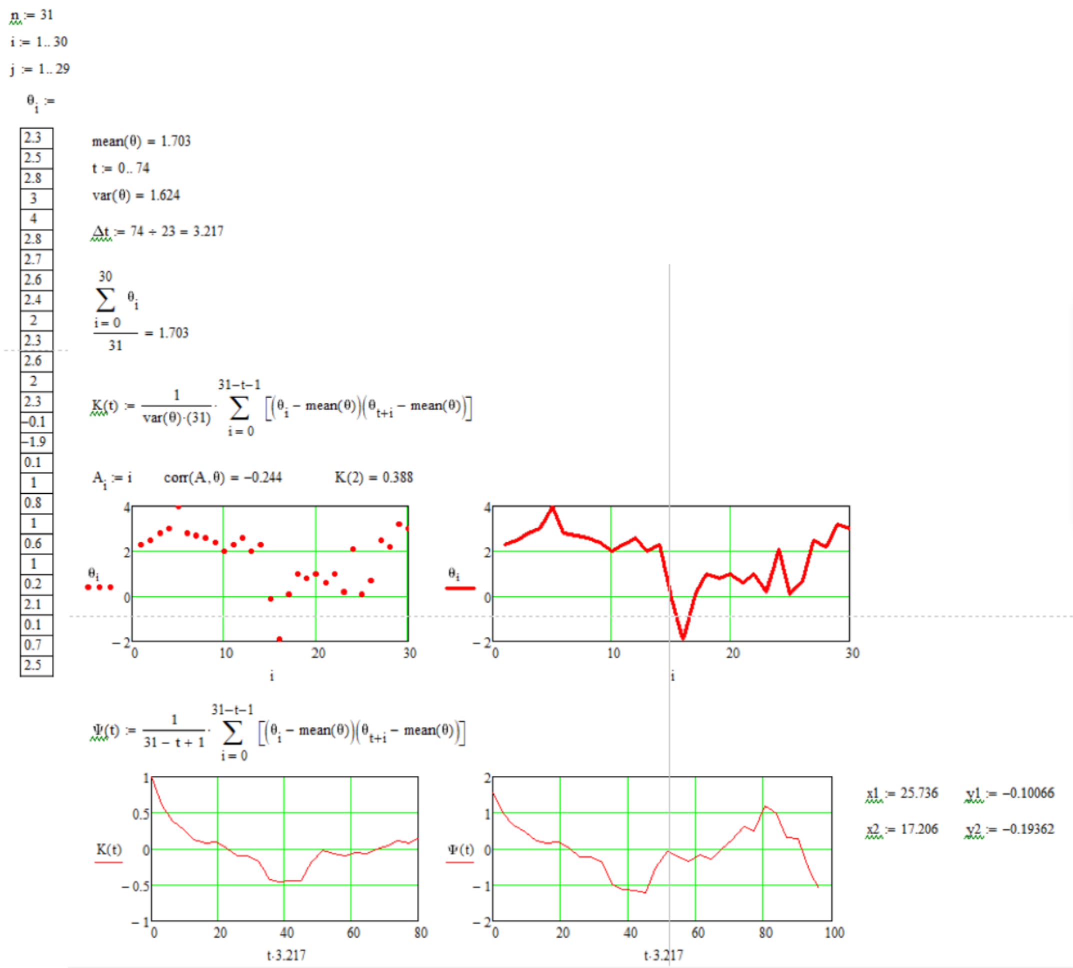


Fig. 3.5 Listing of calculation of autocorrelation functions of pitch angle, flight 3

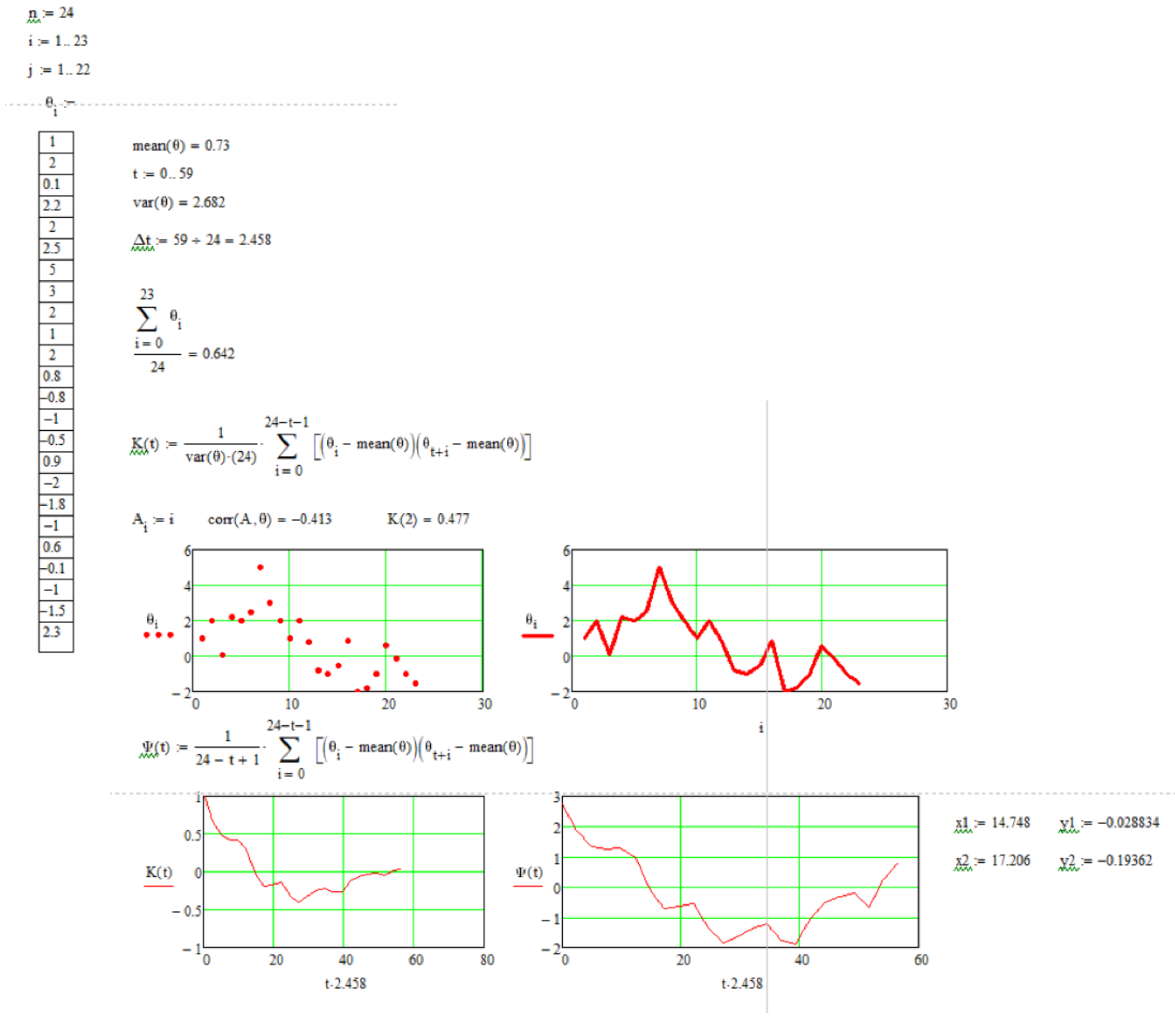


Fig. 3.6 Listing of calculation of autocorrelation functions of pitch angle, flight 4

During the calculations, we obtained the following graphs. The figures show the changes in the amplitude of the pitch angle and the result of the normalized and unnormalized autocorrelation function.

The graphs show in the form of values y_1, y_2 the first negative values of the amplitudes of autocorrelation functions, which are proof that the pilot during the flight was exposed to a certain level of stress.

CONCLUSIONS

It can be concluded that human is an integral part of the mechanism of operation of the aircraft. Analysis of aviation incidents showed that the human factors accounts for more than 50% of negative aviation events. The role of the human factors in aviation is an extremely important area for further study. The human factors consider the concept of human abilities and limitations, the study of these aspects helps to develop the safety of modern aircraft.

Also, for further study of the field of human error and the human factor, it is important to consider those models of human behavior and errors that have already been considered earlier.

By creating a warning and recommendation system in case of avionics failure for aircrew during flight, we can improve pilot performance. Proper cockpit design, adapted to the psychophysical characteristics of man, promotes better interaction between aircraft and pilot.

We analyzed decision-making models, examples of existing systems and the impact of information phenomena on the psychological state of the pilot. Well-designed automation reduces the pilot's workload, helps him focus on the main thing and not distract his attention, gives quick information about the state of aircraft systems, reports errors.

At the same time, automation has its disadvantages because it contributes to the deterioration of flight skills of the pilot. For example, if you fly long enough in automatic control mode, then over time the quality of the approach in the director's mode may be worse. The person begins to get used to automation and feels an auxiliary mechanism in the system, which can be negatively reflected during flight practice in case of system failures.

Warning systems have a significant role in the operation of the aircraft. These systems report critical situations. It helps the pilot to make decisions and reduce psychophysiological pressure. At the same time, recommendation systems reduce the information load on the pilot and help reduce or eliminate stress.

The design of the warning system must meet certain criteria and cannot be installed in the cab without prior checks. A poorly designed system can cause even more workload and increase the likelihood of erroneous actions.

We considered the importance of anti-stress training and its role in preparing pilots for stressful situations. It has been proven that stress training helps to reduce stress and increase productivity in the actual interaction of the pilot with stressors during the flight. For example, in case of failures of aircraft systems or in case of erroneous indicators of aircraft indicators.

The importance and relevance of the warning system and crew recommendations in case of avionics failure in flight is proved. An important argument in confirming the relevance of the system is the fact that it reduces the negative impact of the human factors on the operation of the aircraft. Human factors are the essential cause of most aviation accidents and directly affect flight safety. If the pilot's stress level increases, this system of warning and crew recommendations creates conditions for reassuring the pilot.

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