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НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ АЕРОНАВІГАЦІЇ, ЕЛЕКТРОНІКИ ТА ТЕЛЕКОМУНІКАЦІЙ
Кафедра авіоніки

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
_____________С.В. Павлова
“_____”___________2020 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬО-КВАЛІФІКАЦІЙНОГО РІВНЯ “МАГІСТР”

Тема: “Методика формування дій екіпажу при відмовах в системах авіоніки”

Виконавець: _______________Кравець І.В.

Керівник: _______________Грищенко Ю.В.

Консультанти з окремих розділів пояснювальної записки:

Охорона праці: _______________Коновалова О.В.

Охорона навколишнього середовища: _______________Фролов В.Ф.

Нормоконтролер: _______________Левківський В.В.

КИЇВ 2020

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL AVIATION UNIVERSITY

FACULTY OF AIR NAVIGATION, ELECTRONICS

AND TELECOMMUNICATION

Department of avionics

APROVED FOR DEFENCE

Head of the Department

_____________ S.V. Pavlova

“_____”____________2020

GRADUATE WORK

(EXPLANATORY NOTE)

GRADUATE OF AN EDUCATIONAL DEGREE
"MASTER"

Theme: “The method of forming crew actions in case of failures in avionics systems”

Done by: __________I.V. Kravets

Supervisor: __________Y.V. Hryshchenko

Consultants on individual sections of the explanatory note:

Occupational Safety: __________O.V. Konovalova

Environmental Protection: __________V.F. Frolov

Standart controller: __________V.V. Levkivskyi

Kyiv 2020

Faculty of Aeronavigation, Electronics and Telecommunications

Department of Avionics

APPROVED

Head of the Department

________S.V. Pavlova

“_____”____________2020

TASK

for execution graduate work

Student’s name: Iryna Kravets

1. Theme of master work: “The method of forming crew actions in case of failures in avionics systems”, approved by the Rector’s order of “09” September 2020 № 1435/ст.

2. Duration of which: «05» October 2020 – «15» December 2020.

3. Background to the work: to develop methodical recommendations to the pilots when avionics systems signal about errors.

4. Contents of the explanatory notes: regarding of various human factors in aviation, of alarming methods in systems, analyses of flight simulator training, calculation of functions, implementation of method algorithms of crew try to prevent failures in avionics systems.

5. The list of mandatory graphic material: categories of unsafe acts committed by aircrews, categories of preconditions of unsafe acts, relationship between probability and severity of failure conditions, schematic of possible divergence between actual system state and crew mental model, novel model of divergence between crew mental model and actual system state, the events and contributing factors, scheme of signaling in case of failure of indicator, oscillogram of factor linings when landing with idle engine number 4.

6. Timetable

№	Task	Duration	Evaluation of the perfor-mance
1.	Selection of literature for performing of master's graduation diploma work	05.10.20-10.10.20	
2.	Introduction	11.10.20-19.10.20	
3.	Overview about human factor in aviation	20.10.20-31.10.20	
4.	Investigation of crew training on flight simulator and performing alarming method for pilots	01.11.20-13.11.20	
5.	Find out information concerning occupational safety and environment protection	10.11.20-19.11.20	
6.	Regarding graphics and making calculation	20.11.20-04.12.20	
7.	Conclusions	05.12.20-09.12.20	
8.	Making an explanatory notes	10.12.20-15.12.20	

7. Consultants on individual sections

Chapter	Consultant (position, Name)	Date, signature	
		Task issued	Task accepted
Occupational safety	O.V. Konovalova		
Environmental protection	V.F. Frolov		

8. Date of assignment: "_____" ____________2020

9. Supervisor ___________Y.V. Hryshchenko

The task took to perform ___________I.V. Kravets

ABSTRACT

Explanatory note to graduation work “THE METHOD OF FORMING CREW ACTIONS IN CASE OF FAILURE IN AVIONICS SYSTEMS”: 102 pages, 10 figues, 3 tables, 12 references.

AVIATION ERGONOMICS, ALARMING DEVICE, FLIGHT SAFETY, FLIGHT SIMULATOR, PILOTING QUALITY EQUIPMENT, HUMAN FACTOR IN AVIATION, ACCIDENTS, EXERCISE MACHINE, FLIGHT ANALYSIS, PROCESS, PHENOMENA, FACTOR LOADING, CORRELATION FUNCTIONS, DYNAMIC STEREOTYPE, PHENOMENON OF AMPLIFICATION OF A DYNAMIC STEREOTYPE, TRAINING, DEVELOPMENT.

Object of study – display of avionics failures on the control panel and their impact on the pilot during the flight operation of the aircraft.

The purpose of the graduation work – implementation of the methodological recommendation for pilots in case of systems failures.

Method of research – the mark of the presence of phenomenon of amplification of dynamic stereotype, analysis of the law of distribution.

Established, that necessary to determine the amplitude of change of angle of attack; analyzed oscillograms of real flights, construct a histogram of the distribution of the roll angle flight without failures after the 3rd turn.

Thesis materials are recommended for using alarming system in case of training of pilots’ anti-stress program on simulators.

Foreseeable assumptions about the development of the research object: increasing the quality of the flight operation, reliability and aviation safety in general, by training pilots on simulators to withstand the stress that arises in emergencies.

CONTENT

LIST OF ABBREVIATIONS

AC – aircraft;

ASN – Aviation Safety Network;

DS – dynamic stereotype;

EFIS – Electronic flight instrument system;

FAA – Federal Aviation Administration;

FL – factor loading;

FS – Flight Simulator;

FSTD – Flight Simulator Training Device;

LOFT – Line-oriented flight training;

PADS – phenomenon of amplification of dynamic stereotype;

INTRODUCTION

The effectiveness of the use of aviation technology is inextricably linked to the question of flight safety. The successful solution of which problem largely determines the development prospects of both civil and military aviation. Complexity of solving the problem of ensuring flight safety is continuously increasing due to the increasing intensity of the use of aircraft and the expansion of the range of its functional tasks. Associated complication of the on-board equipment not only increases the probability of equipment failures, but also complicates the crew’s activities and causes additional piloting errors.

This leads to an increase in the role of on-board means of automated control, diagnostics and control of on-board equipment, unloading and information support of the crew. One's ensuring the safety of the elements of the on-board ergatic complex "Crew - On-board Equipment - Aircraft" in the contour of the steering and automatic control of the aircraft. There are special on-board instrumentation support tools which ensure flight safety in possible emergency situations on the aircraft, in particular on airplanes. They are used by the crew: critical mode warning systems, failure monitoring and alarm systems, electronic display systems and other monitoring systems.

Ones observe increase in the number of functional systems, units and other objects of on-board equipment of modern aviation technology. An increase in the number of critical flight parameters affect the level of piloting safety. Necessitate further automation of processes controlling the current state of the aircraft, on-board equipment and crew actions, diagnosing failures, and forming control impacts and operational decisions at all stages from ground handling and preflight to preparation before landing under the general control of the crew.

Modern passenger aircraft are largely automated, and this makes it easier pilot work, especially in difficult weather conditions and night. However, automation has a negative the side. In case of its refusal or the impossibility of using a ground, system providing the flight of the aircraft along the required trajectory for the landing approach has to be flown manually.

And having got used to fly in automatic mode, the pilots lose their skills manual piloting, especially in difficult weather conditions.

At all times the existence of aviation one of the main dangers for aircraft was stalling it in a corkscrew because loss of speed. So usually said before, but more correctly due to the increase in the angle of attack above its critical value. At such an angle of attack, smoothness is disturbed. Flow past the wing that is there is a stall on the top surface of the wing. At the same time sharply reduced lift. Because full symmetry of the flow usually does not happen then a breakdown occurs on any one wing. Therefore, the plane falls onto the wing on the one on which the failure occurred and turns into a spin.

The angle of attack may increase to a critical value or when lost speed, or when increasing overload during maneuvering, and also when flying at high altitude near the ceiling of the aircraft, especially above thunder clouds. Where in at high altitude due to low instrument speed (i.e., small velocity head) it is also possible manifestation of instability aircraft angle of attack - a tendency to its spontaneous increase.

In order to solve this problem, in this paper, recommendations for pilots in decision-making in unusual situations are considered. In the global situation it is proposed to carry out anti-stress training of pilots on training simulators with this method of focusing attention. This is required in order to gain additional insights in the event of collision and to cover the instantaneous instructions of this device.

CHAPTER 1
CONSIDERATIONS FOR A HUMAN FACTORS ANALYSIS

1.1. Introduction to human factor

Human factor is a scientific field that is based on the interaction between people, technologies and organizations. It focuses on safe and effective goods or services production. Human factor embraces many different disciplines such as psychology, technology and engineering science, sociology, organizational theory and management. The human factor can cover everything from fundamental ergonomic issues around the design of systems and methods, to complex associations between managers expressing their goals and how this affects the day-to-day work of an organization.

The purpose of human factors research is to try to understand why it makes sense for people to do what they did. As the background is taken their physical and psychological work medium. In a result of human factors analysis, the data about people behavior have been received. But the main problem in it that it did never allows to entirely close the gap to why they did it. The data cannot give a full explanation of a human factor analysis. Human factor can often be seen as vague, speculative, or as merely a matter of opinion, and not in great need of the same level of expertise as a technical part of an investigation.

The better way for the human factors analysis of the accident investigation is to find as many as possible details and insights, the eventual reasons for why the pilots did what they did. The understanding of causes holds an important key to the accident reasons solving and it moves to improve recommendations for a flight crew. The performance of pilots in extreme situation is evidently critical for the recoverability of such a situation.

The results of a human factors analysis may remain infinitely negotiable and never entirely certain. In other words, other people can always draw different conclusions about a person's capabilities based on the proposed data. This does not mean that some explanations are no more plausible than others. Some explanations take into account more data, or account for data better and with a greater level of detail, or make better use of the theoretical, methodological and research foundations of modern human factor work.

1.2. The human factor analysis and classification system (HFACS)

In order to work on correcting and improving human factors problems, it is necessary to delve into the true root causes of events. For this, the basis was taken Reason’s (1990) concept of latent and active failures. HFACS describes four levels of failure: 1) Unsafe Acts, 2) Preconditions for Unsafe Acts, 3) Unsafe Supervision, and 4) Organizational Influences. A brief description of the major components and causal categories follows, beginning with the level most closely tied to the accident, i.e., unsafe acts.

1.2.1. The concept of Unsafe Acts

Unsafe actions of the crew can be roughly divided into two categories: errors and violations. In general, errors are mental or physical activities of people who cannot achieve the desired result. Unsurprisingly, given the fact that humans make errors by their very nature, these unsafe practices dominate most accident databases. On the other hand, violations refer to the willful disregard of rules and regulations governing flight safety. Unfortunately, predicting and preventing these terrible and totally “preventable” unsafe practices continues to elude policymakers and researchers. Distinguishing between errors and violations does not provide the level of detail required for most aircraft accident investigations. Therefore, the categories of errors and violations were expanded on Figure 1, and include three basic error types (skill-based, decision, and perceptual) and two forms of violations (routine and exceptional). [1]

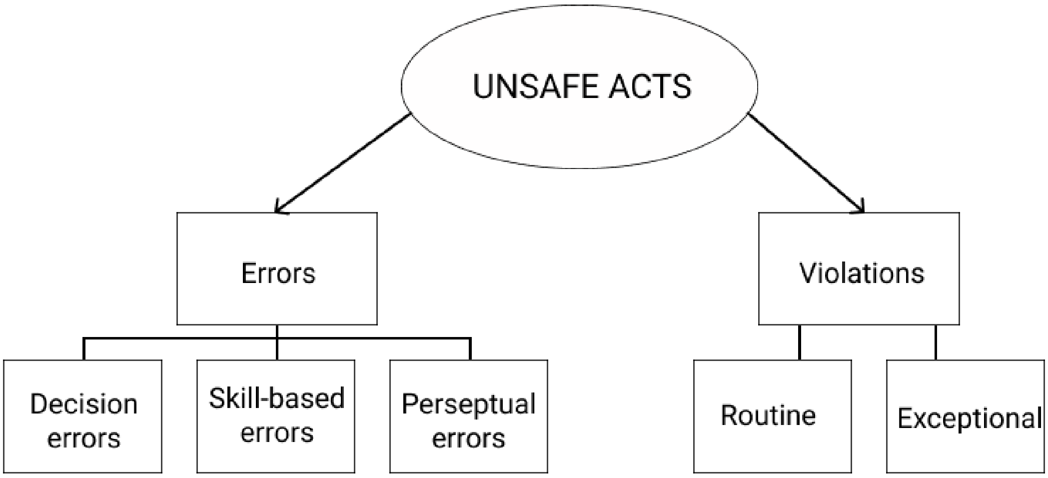


Figure 1. Categories of unsafe acts committed by aircrews

1.2.2. Human error in aviation

Human error has been documented as the leading cause of over 70 percent of commercial aircraft hull damage accidents. Although human factor is usually associated with flight operations, it has also become a major problem in maintenance and air traffic management practices in recent years. Human factors professionals work with engineers, pilots and mechanics to apply the latest knowledge of the interaction between human performance and commercial aircraft to help operators improve the safety and efficiency of their day-to-day operations.

The term "human factor" is becoming more and more popular as the commercial industry realizes that human factors, not mechanical failure, are at the root of most accidents and incidents. Human factors are often considered synonymous with Crew Resource Management (CRM) or Maintenance Resource Management (MRM). However, it is much broader in both its knowledge base and scope. Human factor includes collecting information about human capabilities, limitations and other characteristics and applying it to tools, machines, systems, tasks, workplaces and the environment to ensure safe, comfortable and effective human use. In aviation, the human factor seeks to better understand how people can most safely and effectively integrate with technology.

Despite the rapid development of technology, people have full responsibility for ensuring the success and safety of the aviation industry. They need to remain knowledgeable, flexible, goal-oriented and effective with common sense. In the meantime, the industry continues to invest heavily in training, equipment and systems that have long-term implications. The use of technology continues to advance faster than the ability to predict how people will interact with it. Instead, a solid scientific basis is needed to assess human performance in design, training and procedures, just as developing a new wing requires robust aerodynamic engineering. Improving human performance can help reduce accidents in commercial aviation, with a focus on designing human-aircraft interactions and developing procedures for flight crews and technicians alike. It is necessary to use the capabilities of a person in an aircraft to improve usability, maintainability, reliability and comfort. In addition, human factors specialists are involved in analytical security and the development of methods and techniques to help operators manage human error. These responsibilities require close cooperation from professionals, safety experts, test pilots and training pilots, mechanics and flight attendants to properly integrate the human element into the design of all aircraft. Their area of responsibility includes taking into account the human factor in the design of the flight crew compartment, design of maintainability and support during operation.

1.2.3. Error management

Over the past several decades, safer and more reliable designs have led to significant progress in reducing accidents and improving efficiency. Improvements in engines, systems and designs have contributed to this achievement. In addition, design has always been considered a factor in preventing and mitigating human error. Analytical methods, such as layout or simulator evaluation, are used to assess how well different design solutions meet these requirements. At the heart of these efforts is a human-centered design philosophy backed by millions of flights and decades of experience. This approach allows you to create a project in which the technology best meets the confirmed requirements:

- Customer input.
- Appropriate degree of automation.
- Crew interaction capability.

- Communication, Navigation and Surveillance/Air Traffic Management improvements.

The cockpit should be designed to provide automation to assist, but not replace. The flight crew member responsible for the safe operation of the aircraft. Flight crew errors usually occur when the crew cannot see the problem and cannot correct the error in time to prevent the situation from getting worse. Hence, cockpits include intuitive and easy-to-use systems. These systems support instrument displays with visual and tactile motion cues to minimize potential confusion about which functions are automated. Visual and tactile cues for movement are provided by reverse controls. These controls enhance situational awareness and help keep the flight crew fully informed of changes in aircraft status and flight path during all phases of automatic and manual flight.

1.2.4. Decision errors

Decision errors are deliberate behavior that happens as intended, but the plan is inadequate or inappropriate for the situation. These unsafe actions, often referred to as “honest mistakes,” are actions or inactions of people that they either did not have the appropriate knowledge or were simply wrongly chosen.

Decision errors, perhaps the most studied of all forms of error, can be divided into three main categories: procedural errors, wrong choices, and problem-solving errors represented in Table 1.

Procedural or rule-based errors occur during highly structured tasks of this kind. In almost all phases of flight, very clear procedures must be followed. However, errors can and often do when a situation is either not recognized or misdiagnosed and the wrong procedure is applied. This is especially true when pilots are caught in a time critical emergency such as an engine malfunction during takeoff.

Visual illusions, for example, arise when the brain tries to “fill in the gaps” with what it thinks belongs to a visually poor environment, as it does at night or when flying in bad weather. Likewise, spatial disorientation occurs when the vestibular system cannot determine a person's orientation in space and therefore makes a “best guess” — usually when visual (horizontal) cues are absent at night or when flying in adverse weather. In any case, the unsuspecting person is often left to make a decision based on false information, and the likelihood of making a mistake increases. However, it is important to note that it is not an illusion or disorientation that is classified as a perceptual error. Rather, it is the pilot's mistaken reaction to illusion or disorientation. For example, many unsuspecting pilots have experienced approaching a "black hole" only to launch a perfectly good plane into terrain or water. This continues to happen even though it is well known that flying over dark, featureless terrain at night (such as a lake or a field devoid of trees) creates the illusion that the plane is actually taller than it is. As a result, pilots are taught to rely on their core instruments rather than the outside world, especially during the approach phase.

However, some pilots are unable to control their instruments while flying at night. Unfortunately, these and other crews, deceived by illusions and other disorienting flight modes, can end up in a fatal plane crash.

It is possible that unsafe actions by pilots can be directly linked to nearly 80% of all accidents. However, simply focusing on unsafe activities is impractical without understanding the root cause. For a deeper understanding, Figure 2 presents two main subdivisions of unsafe conditions for crews - subnormal operating conditions for operators and substandard practices that they undertake.

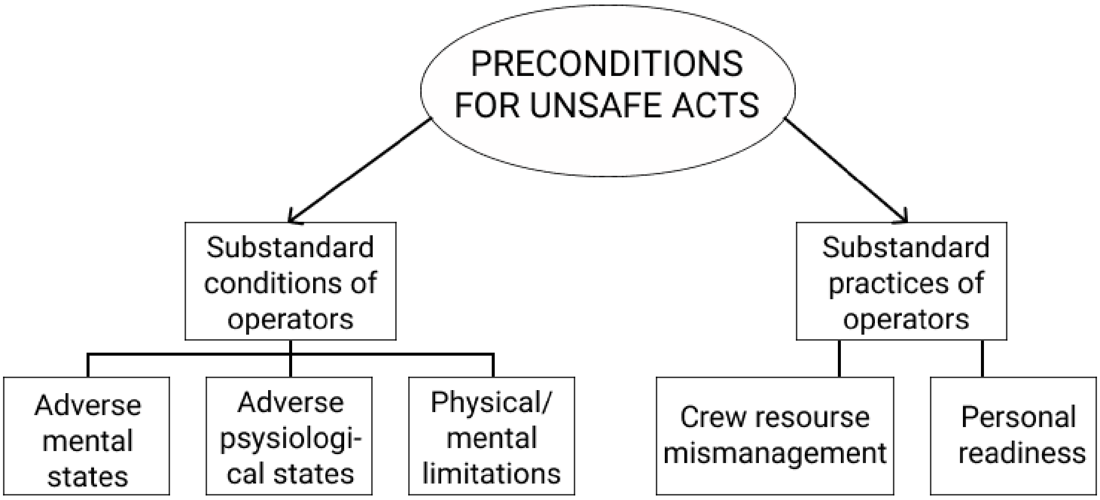


Figure 2. Categories of preconditions of unsafe acts

1.2.5. Skill-based errors

Skill-based behavior within the context of aviation is best described as “stick-andrudder” and other basic flight skills that occur without significant conscious thought. As a result, these skill-based actions are particularly vulnerable to failures of attention and/or memory. Skill-based behavior usually occurs without serious, conscious thought. As a result, these skill-based activities are particularly vulnerable to attention and / or memory failures. In fact, attention deficits have been associated with many skill-related errors, such as violation of visual scan patterns, task fixation, inadvertent activation of controls, and incorrect sequence of steps in a procedure, among others, in Table 1. Unlike attention deficits, memory impairments often show up as missing checklists, lost space, or forgotten intentions. It is not hard to imagine that under stress conditions during in-flight emergencies, important steps in emergency procedures can be overlooked. However, even when they are not under a lot of stress, people forget to close the approach or lower the landing gear - at least an annoying oversight.

1.2.6. Technique errors

Skill errors found in many accident investigations are due to technical errors. Regardless of training, experience, and education, the way a particular sequence of events is carried out can vary greatly. That is, two pilots with the same training, flight class and experience can differ significantly in the manner of maneuvering their aircraft. While one pilot can fly smoothly, others can fly with abrupt transitions. However, while both can be safe and equally adept in flight, the techniques they use can tune them into specific failure modes. In fact, such techniques are not only a factor in innate abilities, but also a clear expression of one's own personality, which at best makes it difficult to prevent and eliminate technical errors.

Table 1. Selected examples of Unsafe Acts of Pilot Operators

No	ERRORS	VIOLATIONS
1	Skill-based Errors	Failed to adhere to brief
2	Breakdown in visual scan	Failed to use the radar altimeter
3	Failed to prioritize attention	Flew an unauthorized approach
4	Inadvertent use of flight controls	Violated training rules
5	Omitted step in procedure	Flew an overaggressive maneuver
6	Omitted checklist item	Failed to properly prepare for the flight
7	Poor technique	Briefed unauthorized flight
8	Over-controlled the aircraft	Not current/qualified for the mission
9	Decision Errors	Intentionally exceeded the limits of the aircraft
10	Improper procedure	Continued low-altitude flight in VMC
11	Misdiagnosed emergency	Unauthorized low-altitude canyon running
12	Visual illusion	
13	Wrong response to emergency	
14	Exceeded ability	
15	Inappropriate maneuver	

1.2.7. Failure conditions

They are defined as the impact on the aircraft and its occupants, both direct and indirect, caused by one or more failures, taking into account the associated adverse operating conditions or the environment. Failure conditions can be classified according to their severity as follows:

1) Minor. Failure conditions that cannot significantly reduce the safety of the aircraft and involve crew actions that are within their capabilities.

2) Major. Failure conditions that would reduce the aircraft's ability or the crew's ability to cope with adverse operating conditions to such an extent that it would, for example, result in a significant reduction in safety margin or functionality, a significant increase in crew workload, or conditions that reduce crew efficiency, or causing discomfort to passengers, possibly including injury.

3) Hazardous. Failure conditions that would reduce the aircraft's ability or the crew's ability to cope with adverse operating conditions to such an extent that:

-Significantly reduced safety margin or functionality

- A physical disaster or higher workload in which the flight crew cannot be relied upon to complete their tasks accurately or completely, or

- Serious or fatal injuries to a relatively small number of passengers.

4) Catastrophic. Refusal conditions that will prevent safe flight and landing.

Each of the above probabilities has a maximum value assigned, which depends on the type of aircraft considered—for example, for large aircraft, extremely improbable is 10^{-9}, as we have already seen; extremely remote is 10^{-7}; remote is 10^{-5}, and so on.

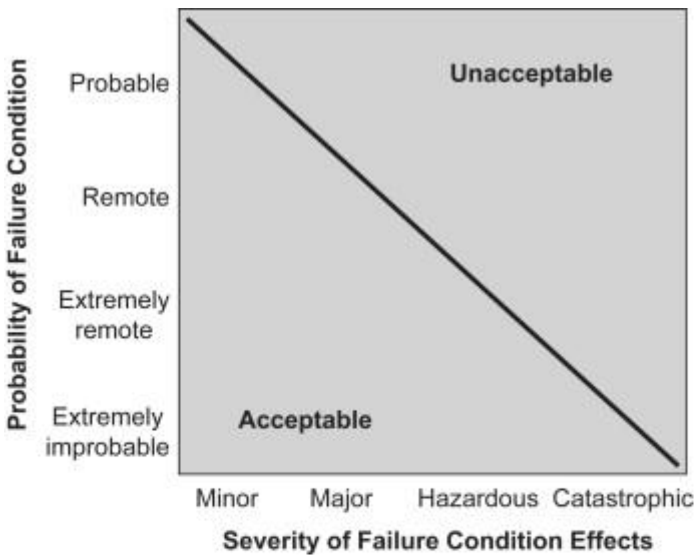


Figure 3. Relationship between probability and severity of failure conditions.

We can gain a better indication of the safety levels relating to the above figures through another example. A single aircraft might fly a total of 5×10^4 hours and a large fleet of 200 aircraft (same type) might then accumulate a fleet total of 10^7 hours.

1) A catastrophic failure condition (at worst 10^{-9}) would be unlikely to arise in the whole fleet's life.

2) A hazardous failure condition (at worst 10^{-7}) might arise once in the whole fleet's life.

3) A major failure condition (at worst 10^{-5}) might arise once in an aircraft's life and would arise several times in the whole fleet's life.

4) A minor failure could arise several times in the aircraft's life.

The safety assessment of equipment, systems, and installation is a very important (and fascinating) part of aircraft design. It is of paramount importance to start the assessment from the very beginning of the design. A late assessment could bring unpleasant surprises, leading to expensive design changes.

As mentioned before, the techniques of safety assessment are a specialist matter. [2]

1.3. Pitot-Static System

The pressure source for the airspeed indicator, vertical speed indicator (VSI) and altimeter is the static pitot system. The main components of the static pitot system are the shock pressure chamber and lines, and the static pressure chamber and lines, each of which may be completely or partially blocked by ice, dirt and/or other foreign objects. A blockage of the pitot-static system will adversely affect the performance of the instrument shown in Figure 4.

Partial static blocking of the system is insidious in the sense that it can go unnoticed until the critical phase of flight. During takeoff, climb and leveling at cruising altitude, the altimeter, airspeed indicator and vertical orientation may work normally. There can be no signs of malfunction until the plane starts descending.

If the static reference system is severely constrained but not completely blocked when the aircraft descends, the static reference pressure on the gauges begins to lag behind the actual outside air pressure. During descent, the altimeter may indicate that higher than actual airflow from the static port to the altimeter is obstructing. The VSI validates the rate of change information of the altimeter because the reference pressure does not change at the same rate as the outside air pressure.

Airspeed indicator can not determine whether it is experiencing a greater pressure pitot or minimal static pressure reference, but indicates a higher air velocity than actual. To the pilot, the instruments indicate that the plane is too high, too fast, and descending at a much slower speed than would be desired. If the pilot levels off and then begins to climb, the altitude indication may still lag behind. The VSI shows that the aircraft is not climbing as fast as it actually is.

However, the indicated airspeed may begin to decrease at an alarming rate. The smallest pitch tilt can cause the airspeed needle to show dangerously close to stall speed. Managing static system failure requires the pilots know and understand the aircraft's pitot-static system. If a system malfunction is suspected, the pilot should confirm this by opening an alternate source of static electricity. This should be done during a climb or descent. If the needles of the instruments move while doing this, there is a static pressure problem. Failure of the pitot-statics system can also have serious consequences for electronic aircraft systems (EFIS).

Fault indications of conventional instruments and electronic flight indicators may be completely different, and indications of faults in electronic systems are not standardized. Due to the wide variety of glass cab system designs, the primary display and the backup display can react differently to any data entry interruption, and both displays can operate differently than conventional instruments under the same conditions. It is imperative that pilots receive equipment-specific information, both aircraft and avionics, that fully prepares them to interpret and properly respond to faults in electronic flight instrument display equipment. Rapidly changing equipment, complex systems, and the complexity or inability to model failure modes and functions can impose learning constraints. Pilots must still be able to respond in a timely manner to equipment failures without disrupting other mission-critical flight missions.

Effect of Blocked Pitot/Static Sources on Airspeed, Altimeter, and Vertical Speed Indications	Indicated Airspeed	Indicated Altitude	Indicated Vertical Speed
Pitot source blocked	Increases with altitude gain, decreases with altitude loss.	Unaffected	Unaffected
One static source blocked	Inaccurate while sideslipping; very sensitive in turbulence.		
Both static sources blocked	Decreases with altitude gain, increases with altitude loss.	Does not change with actual gain or loss of altitude.	Does not change with actual variations in vertical speed.
Both static and pitot sources blocked	All indications remain constant, regardless of actual changes in airspeed, altitude, and vertical speed.		

Figure 4. Effect of blocked pitot-static sources.

Pilots and flight instructors should refer to FAA-H-8083-15 for instructions on how to perform these tasks and to the relevant PTS (Practice Test Standards) for information on the standards by which these required tasks must be performed for a given certification level and/or rating. However, the pilot must remember that if these tasks are not performed on a consistent and regular basis, skill erosion will begin almost immediately. In a very short time, the pilot's expected confidence level is much higher than the performance that he or she can actually demonstrate when needed. Accident statistics show that a pilot who has not been trained in instrument flight, or a pilot whose instrument skills have deteriorated, will lose control of the aircraft approximately 10 minutes after having to rely solely on instrument data.

The purpose of this section is to provide limited time control of the aircraft when a VFR pilot encounters Instrumental Meteorological Conditions (IMC). The main goal is not accurate instrument flight; rather, it helps the VFR pilot to keep the aircraft under adequate control until suitable visual references are restored.

The first steps required to survive a VFR collision with an IMC pilot are as follows:

• Acknowledging and accepting the seriousness of the situation and the need for immediate remedial action.

• Maintaining control over the aircraft

• Obtaining appropriate assistance in landing aircraft safely on the ground.

Many hours of VFR flight, using the artificial horizon as a guide to control the aircraft, can lull the pilot into a false sense of safety based on overestimating his or her personal ability to fly an aircraft solely by instruments. In VFR conditions, even if the pilot thinks he is controlling the aircraft with the instrument, the pilot also gets an overview of the natural horizon and may subconsciously rely on it more than the orientation indicator. If the natural horizon suddenly disappears, the untrained instrument pilot will be subject to dizziness, spatial disorientation, and an inevitable loss of control.

1.3.1. Failure emergence in Pitot-static system

Erroneous airspeed and altitude readings caused by pitot anomalies and the static system can be misleading for the untrained flight crew. Failure of the crew to respond correctly can lead to an accident or incident.

Good flight reference charts are important for diagnostics, and the following table can provide useful data:

Table 2. Failure influence on Indicated airspeed and Indicated attitude

Failure	Indicated airspeed	Indicated attitude
Pitot source blocked.	Increased with alt gain. Decreases with alt loss.	Unaffected.
Once static port blocked.	Inaccurate during sideslipping. Very sensitive in turbulence.	
Both static sources	Decreases with alt gain.	Does not change with

blocked.	Increases with alt loss.	actual gain or loss of altitude.
Both static and pitot sources blocked.	All indications remain constant, regardless of actual changes in airspeed or altitude.	

During pitot-static failures, typical reliable information includes:

•Pitch and role indicators

•Engine thrust indication

•Radio Altitude

•Basic GPWS (EGPWS/terrain avoidance warning system may not)

•Stick Shaker

•Ground Speed (uses inertial information)

•Airplane position (uses inertial information).

During pitot-static failures, typical unreliable information includes:

•Autopilot

•Auto throttle

•Airspeed indication

•Altimeter

•Vertical speed

•Wind information

•Vertical navigation

•EPGWS

•Overspeed warning

•Windshear warnings.

Always remember that basic airmanship is vital:

• Fast recognition is very important - the longer deviation from the intended flight path, the more difficult it will be recovering.

• Find or maintain favorable flight conditions - Find visual cues (e.g., daylight, climb above the clouds).

• Train for unusual failure conditions to:

• Recognize unusual or suspicious signs (e.g., cross-checking instruments, maintaining standard conventions, etc.);

• Maintain a safe flight first (i.e., fly with basic pitch and power settings), and only then carry out diagnostics (or troubleshoot);

• Make a precautionary mistake (e.g., gentle incline, speeding, etc.);

• Distinguish between true/false information.

1.4. Divergence of crew mental model of system state

Divergence is defined as a discrepancy between the mental model of the state of the human operator's system and the actual state of the system, significant enough to have consequences for the outcome of the situation. In commercial aircraft, pilots use both continuous modern parameters, such as airspeed and altitude, and discrete parameters, such as autopilot (A/P), to mentally model the system and fly the aircraft. Provided that the control of the aircraft includes control of continuous parameters as well as discrete parameters, the flight can be described as a hybrid control problem (Branicki, Borkar and Mitter 1998). The corresponding crew parameters are adapted depending on the aircraft configuration as well as the flight situation. Figure 5 shows one example of possible discrepancies in the crew's mental model. At the moment
t = t0, the state of the system and the mental model are consistent.

Between the time t = t0 and t = t1, both the state of the system and the mental model pass into state II and remain consistent. The discrepancy occurs at time t = t2, when the environment goes back to State I, but the crew believes that the system remains in State II. Figure 1 is an example of one classification (type D-1) of divergence in which the actual transitions between states and the mental model of the crew are not updated to reflect the transition. Divergence types are defined below.

• Type D-1: Actual state transitions and crew mental model are not updated to reflect the transition.

• Type D-1a: actual transitions between states without crew intervention.

• Type D-1b: actual transitions between states due to upstream crew actions.

• Type D-2: The actual state does not change, however the mental model of the crew suggests a change in the state of the system.

• Type D-3: Actual state transitions and the crew's mental model is updated to reflect the other transition.

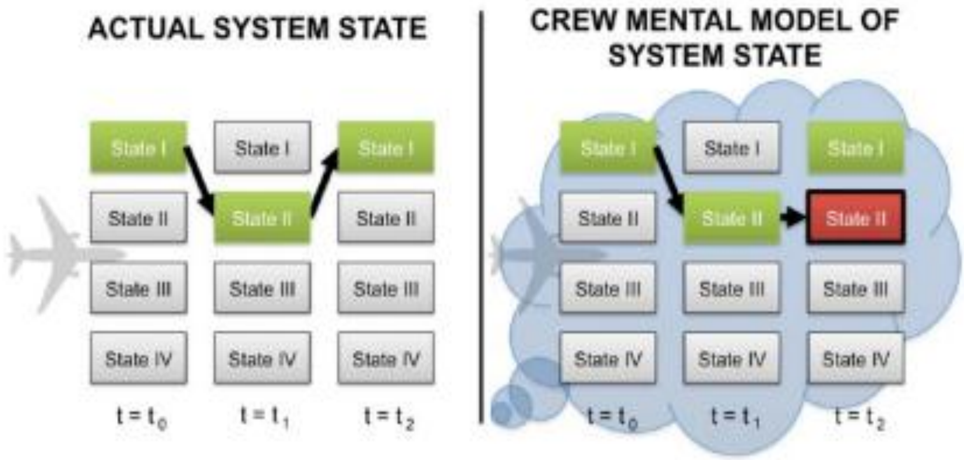


Figure 5. Schematic of possible divergence between actual system state and crew mental model

1.4.1. Development of Model of Divergence

The model was developed based on the concept of mental model divergence. This new model provides a framework for understanding these discrepancies and communicating mitigation. Figure 6 depicts the developed model and expands on previous work to include direct comparisons between the state of the system and a working mental model. The framework developed includes situational awareness processes, decision-making processes and execution processes, constantly interacting with a working mental model. The working mental model and its interaction with situational awareness are especially important given the potential positive and negative consequences for decision making and execution (Endsley, 1999; Histon & Hansman, 2008). Provided that the working mental model is the "engine" for simulating the outcome of possible actions, the mental model needs to have access to the perceived state of the environment (Rouse & Morris, 1985). Thus, the integrity of perception and experience included in the mental model must be unchanged in order for the working mental model to process information properly.

• Perception of the environment usually occurs directly or through intermediaries such as displays or instruments.

• Experience also feeds the mental model, creating a framework on which understanding is possible.

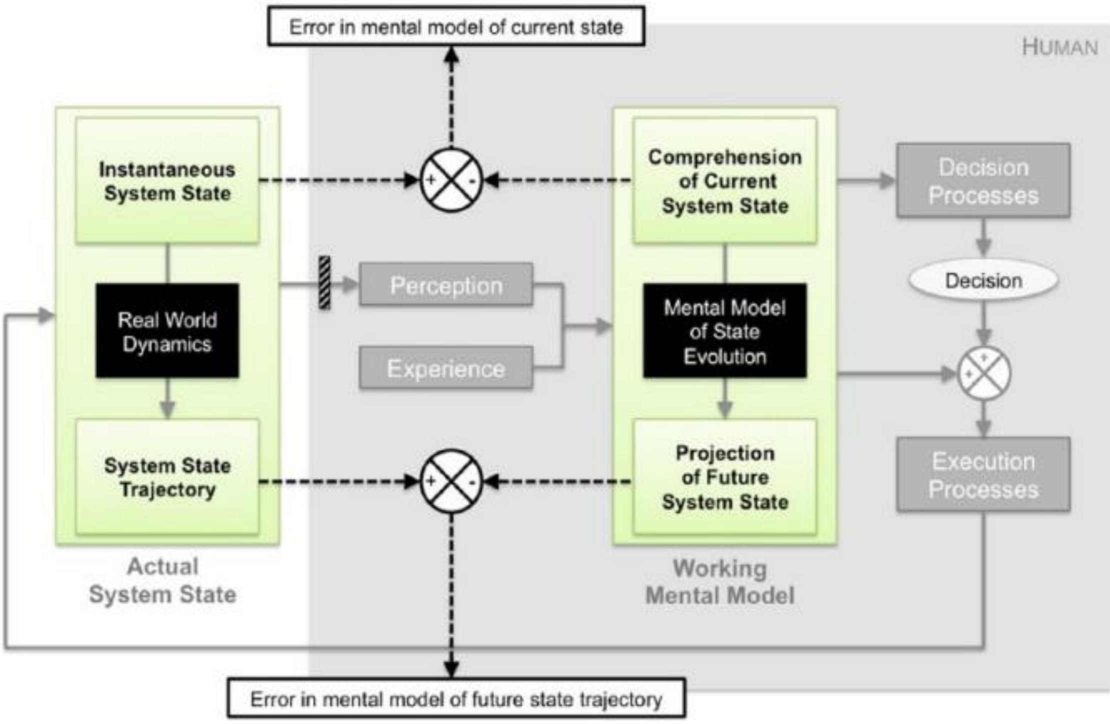


Figure 6. Novel model of divergence between crew mental model and actual system state

It develops on the basis of the pilot's previous flying experience, including flight and ground training. It is this framework that allows pilots to construct meaningful patterns/understanding of perceived information input from the environment. This affects both the phase of understanding the situation and the phase of projection, since a certain dynamics of the situation is expected.

Awareness of the situation - perception, understanding and projection - of the environment influences pilot decision-making and execution processes (Endsley, 1999). From a repository of decisions built up from prior experience, the pilot selects a possible solution and feeds it into a working mental model to “model” the outcome of this action. This process is repeated until a solution is selected and used in the execution processes. Previous experience of executing decisions is transferred through the working mental model to the execution processes. The result of the execution directly affects the actual state of the system, and this change is then perceived by the pilot, completing the feedback loop. This interaction occurs constantly when the pilot interacts with the environment (Endsley, 1995; Histon & Hansman, 2008). Using this framework of the cognitive process, it becomes possible to use the model to assess cases and sources of discrepancy by comparing the mental model and the actual state of the system.

As seen in Figure 6, two comparisons arise. An error in the current and / or future state is the occurrence of a discrepancy.

• The error in the mental model of the current state is determined by comparing the instantaneous state of the system and understanding the current state of the system in the working mental model.

• The error in the mental model of the dynamics of the future state is determined by comparing the trajectory of the state of the system and the projection of the future state of the system in the working mental model. The model can also be used to assess sources of discrepancy. According to this scheme, failures in perception, understanding and projection will affect the integrity of a working mental model. In addition, more complex interactions, such as expectation bias, can affect the cognitive process, manifesting itself as a glitch in perception or perhaps in projection if steps in the cognitive process have been skipped. To test the occurrence of the discrepancy, as well as the causes and cognitive impairment leading to the discrepancy, an analysis was performed on a subset of automation accidents.

1.4.2. Breakdowns in perception

Perceptual glitches usually include a lack of detection of the automatic throttle control mode. The analysis did not distinguish between whether the crew scanned and misread the information, or whether they scanned the relevant information. Thus, perceptual glitches refer to cases where effective perception has not been achieved, the cause of which may include a number of different sources. Of the accidents, 75% showed signs of impaired perception, and three different sources were observed in the analysis of the incidents:

• Insufficient feedback: there was evidence based on crew behavior that the crew was not receiving the signal. In these cases, crew feedback (if any) was ineffective in getting their attention. A possible mitigation to improve the lack of feedback would be to increase signal signature. The importance of the correct signal can be, for example, in the form of an automation message or a low-speed signal. Given that visual indicators already exist for both of these messages, it may be worthwhile to improve the visual indicators or add an audio or tactile component to the messages.

• Expectation bias: There was evidence that the crew were holding on to an assumption that may have biased their perception of the incoming information, which may conflict with the current assumption, also called confirmation bias. Waiting bias is a cycle in which the erroneous expectation of a future state affects the perception of incoming information. Reducing expectations bias should break this cycle. Cognitive Reboot is a response to cognitive tunneling, or anticipation bias, that pilots may encounter in stressful situations.

• Attentional Limitations: There was evidence of other actions or signals that distracted the crew's attention during the divergence. This could include individual resource constraints, additional workload or distraction due to an unstabilized approach, or a non-standard approach that could increase the workload. Countermeasures for attention restrictions may include adhering to standard procedures or ensuring maximum nominal operations, for example, when crews are denied visual approach clearances.

In addition to training, cognitive reloading can be accomplished through procedures such as automation or speed cross-checks during flight or approach. Failures in understanding and projection. Failures in understanding and prediction were identified by specific comments or actions by the crew that indicated a misunderstanding. All accidents analyzed showed failures in understanding/ prediction, and four comprehension problems were identified during the in-depth analysis.

• Interference: There is evidence of a separate signal that has been confused with a signal of interest. In these cases, perception may have remained intact, but misapplication of experience may cause impairment of understanding. Mitigation for countering interference can be training teams to cross-check several different sources of information to validate the signal.

• Feedback ambiguity: There were at least two different likely reasons for the signal feedback. In these cases, it is possible that the perception remained intact, however, if a misinterpretation of the signal was applied at the stage of understanding, the projection will also be broken. To counteract the ambiguity of the feedback, designers can include specific feedback for signals that have different meanings to the flight crew.

• Lack of experience: There was evidence of insufficient crew understanding of the consequences of certain system (or automation) conditions, such as FLCH or A/P shutdown. It can be argued that understanding the consequences of the conditions relies on correct projection. Thus, at this level, it is impossible to distinguish between understanding and projection.

• Misapplication of experience in abnormal situations: there was evidence that the situation involved abnormal procedures that could be confused with normal counterparts. In these cases, it is possible that nominal experience instead of abnormal experience is applied to understanding, causing a denial of understanding. Mitigation for these types of failures could take the form of procedures that force nominal procedures, such as standardized approach criteria or the use of ILS in visual environments. Crew training may also include further familiarity with unusual situations. [3]

CONCLUSION

In aviation, human factor is dedicated to better understanding how humans can most safely and efficiently be integrated with the technology. That understanding is then translated into design, training, policies, or procedures to help humans perform better. The main goal of human factors specialists is to promote safety in the aviation field working to reduce the occurrence and impact of human error in aviation systems and improve human performance.

Among operator unsafe acts distinguish errors and violations.

The structure of HFACS and the information obtained from the analysis of the database have been used to develop innovative accident investigation methods that have improved both the quantity and quality of human factors information collected during accident investigation. However, safety professionals are not only better suited to studying human error in the field, but with the help of HFACS, they can now track those areas that are responsible for accidents.

Also, a static pitot system was taken as an example. The main errors that can occur during the flight and the impact on IAS, IA and IVS. Recommendations for the crew were identified to eliminate errors.

It was regarded the model based on the concept of mental model divergence. This new model provides a framework for understanding these discrepancies and communicating mitigation. Awareness of the situation - perception, understanding and projection - of the environment influences pilot decision-making and execution processes. So, the crew should be training both A/P and manual airplane control to decrease divergence in mental cognition of pilots and state of the system.

Improving human performance can help the industry reduce the commercial aviation accident rate, much of the focus is on designing human-airplane interfaces and developing procedures for both flight crews and maintenance technicians. Also, better understanding of human factor leads to improve usability, maintainability, reliability, and comfort.

CHAPTER 2

CONCEPTS OF FLIGHT CONTROLING AND PRINCIPLES OF CREW TRAINING ON FLIGHT SIMULATOR

2.1. Concept of dynamic stereotype of the flight crew and the phenomenon of its amplification

A stable system of conditioned neural connections in the cerebral cortex, interconnected and manifested as a result of a single trigger signal, is called a dynamic stereotype.

A dynamic stereotype is an integral system of conventional conditioned reflex reactions. It corresponds to the signal, ordinal and temporal characteristics of the stimulus. The concept was presented by I.P. Pavlova in 1932. The neural processes underlying the formation of a dynamic stereotype are combined because the current reflex response becomes a signal for the next response and is supported by it. With the strengthening of the stereotype, this sequence of nervous processes is fixed. All reactions can be reproduced with the preservation of sign, intensity and sequence, even if only one of the stimuli is presented.

Multiple repetition of the system of stimuli with the simultaneous flow of processes in the central nervous system leads to the fact that they are fixed in the internal stereotype.

A dynamic stereotype, which is the physiological basis of any skill, yet has a psychological characteristic.

2.1.2. Influence of the overlays factor on the crew

The influence of factor loadings (FL) in some operators is manifested in the strengthening of the dynamic stereotype (DS). It consists in an increase in the amplitude of control movements while maintaining their general structure.

Operational actions become meaningless, traumatized operations are performed, which sometimes end in confusion or wrong actions, and wrong decisions are made.

Experimental data confirming the phenomenon of stereotype amplification and "flying handwriting" under complex refusals.

During the flight, pilots do not always manage to avoid false actions. Moreover, as the static data collected on the flight simulaor show, the duration of incorrect aircraft piloting increases with an increase in the number of simultaneous factors (in this case, failures).

The most common mistakes in technique: non-observance of the glide path and non-observance of speed on the glide path, approaching the course on a turn, non-observance of the course, correction in the wrong direction, non-observance of the vertical speed.

Moreover, after the pilot begins to correct the error, the dynamic stereotype is amplified in amplitude and frequency, which is recorded using flight registration. In existing literary sources, there is a diametrically opposite idea, when the actions of factor loads are not amplification, but the so-called "destruction" of the dynamic stereotype of action. Experiments on flight simulator and statistics do not confirm this. A particularly good discrepancy can be seen on the oscillograms for the roll angle parameter. Verification of this position is important for the development of new training programs, as well as for issuing practical recommendations to the pilot to improve his piloting skills.

The pilot begins to rotate the plane around the required parameter, indicating that the pilot is in the zone of reflected motion, that is, we see the muscular (qualitative) or temporal (quantitative) sweep of the pilot, which starts with spatial, is obtained from visual and purely tactical receptors. Moreover, visual sensations are objective, and muscle ones are subjective.

Erroneous and allogical actions during the flight are associated, first of all, with changes in the mental processes of spatial signals from the action of factor loads. Having received spatial signals from the action of factorial loads with a sufficient number of them, the pilot can get into the zone of reflected motion, but spatial. Failure to actively counteract factor loading can lead to improper actions by onboard engineers (interconnection of levers, toggle switches, buttons, etc.).

An important element of crew training is this kind of delay that can serve as the logic of flight training. This serves as an important basis for his training, as well as the choice of the only correct solution to counter unexpected stimulus.

2.2. Loss of control (LOC)

In many pilot error accidents, flight crews had inconsistent assumptions about the actual state of the system when responding to a failure or abnormal situation. The rapid increase in loss of control in general aviation in recent years is a cause for concern. Loss of control refers to a unique characteristic in which external and internal events act in concert.

Aircraft accidents are recognized as the most tragic of all modes of transport due to their serious nature and the high number of injuries and deaths. However, the increase in air travel over recent decades reflects consumer acceptance of air travel as the safest and fastest mode of transport. An aviation accident can occur at any time due to various factors: aircraft types, combat crew skills and experience, environmental changes, etc. A fight is categorized according to its purpose (e.g.

commercial, private or military) and operations (farming, sightseeing, grazing, ambulance/ambulance (EMS) and border surveillance).

Various aviation communities have worked to improve safety parameters, categorizing combat phases as take-offs, landings, traffic patterns, stalls, altitude recovery, and controlled terrain combat.

The Federal Aviation Administration (FAA) established the Joint General Aviation Steering Committee (GAJSC) to investigate and provide suggestions and recommendations for reducing the accident rate.

Te GAJSC has determined that Loss of Control Accidents (LOCs) are usually due to poor combat team practice and account for 70% of fatalities.

The Joint Safety Analysis Group (JSAT) defined LOC as “a significant, unintentional departure of an aircraft from controlled flight, operational range or conventional combat, including ground events. The term "significant" refers to an event that leads to an accident or incident. This definition excluded catastrophic explosions, runway collision, total loss of thrust without loss of control, and any other incident scenarios in which the crew remained in control. This does include loss of control due to aircraft structure, aircraft malfunction, human actions and other such events.

We have determined that the most significant events that contribute to maneuvering accidents are obstacles, tedious operations, inadequate situational guidance, and poorly visible terrain. These events have a catalytic effect, triggering other events, especially when fighting at low altitude. Without considering these parameters, it is difficult to cope with the loss of control during the maneuvering phase. The risk mitigation approach has shown that the current procedural methods are good enough to withstand the specific risks associated with the crew and equipment. This reflects the need to improve the level of crew training in order to avoid disability and distraction. [4]

2.3. Maintaining airplane control

Once the pilot understands and accepts the situation, he or she must understand that the only way to safely operate the aircraft is to use and trust the flight instruments. Attempts to partially control the aircraft using flight instruments while searching outside the aircraft to visually confirm the information provided by these instruments lead to inadequate aircraft control. This can be followed by spatial disorientation and complete loss of control. The most important point to emphasize is that the pilot should not panic. The task at hand may seem overwhelming, and the situation may be exacerbated by extreme fears. Therefore, the pilot must make a conscious effort to relax. The pilot must understand that the most important task is to keep the wings level. An uncontrolled turn or roll usually results in difficulty reaching any desired flight conditions. The pilot finds that good roll control makes it much easier to control the pitch. The pilot should remember that a person cannot feel the control pressure with a firm grip on the control lever. Relaxing and learning to "control the eyes and the brain," and not just the muscles, usually requires significant conscious effort.

The pilot must believe what the flight instruments indicate about the position of the aircraft, regardless of what the natural senses say. The vestibular sense (the perception of movement by the inner ear) can be confusing to the pilot. Due to inertia, the sensory regions of the inner ear cannot detect subtle changes in aircraft position, nor can they accurately detect changes in position that occur at a constant speed over a period of time. On the other hand, there are often false sensations that lead the pilot to believe that the attitude of the aircraft has changed, when in fact it is not. These false sensations lead to spatial disorientation of the pilot.

2.3.1. Attitude Control

The aircraft is designed as a stable platform and, with the exception of turbulent air, maintains an approximately straight and level flight when properly balanced and left alone. It is designed to maintain a balance in pitch, roll and yaw. However, the pilot should be aware that changing one axis affects the stability of others. A typical light aircraft exhibits good yaw stability, slightly less on the pitch axis and even less on the roll axis.

Thus, the key to emergency attitude control of an aircraft is:

• Trim the airplane with the elevator trim to maintain level, hands-free flight at cruising speed.

• Resist the tendency to over-control the aircraft. Use your fingers to operate the orientation indicator. Position may not be changed unless the flight instruments indicate a clear need for change.

• Make all attitude changes smooth and small, but with positive pressure. Remember that a small change indicated on the horizon is proportional to a much larger change in the actual position of the aircraft.

• Use any available attitude controls such as autopilot or wing leveler.

The main orientation control tool is the orientation indicator. Once the airplane has been trimmed so that it maintains level flight without arms at cruising speed, this speed should not change until the airplane is lowered for landing. All turns, ups and downs can and should be done at this speed. Direct flight is maintained by keeping the wing level with the help of “fingertip pressure” on the steering wheel. Any pitch change should be made using a strip no more than one width up or down.

The pitch angle controls the flight speed. Thus, the engine power (translated by the propeller into thrust) maintains the selected height. After a decrease in power, even a small one, there is an almost imperceptible decrease in flight speed. However, even a small change in speed results in less stress on the tail, with the result that the estimated nose weight of the aircraft causes the aircraft to descend just enough to maintain the speed it was tuned to. Then the plane descends at a speed directly proportional to the value of the removed thrust. The power derate must be in 100 rpm or 1 inch manifold pressure increments, and the resulting descent rate must never exceed 500 fpm. The wings must be held horizontally at the orientation indicator and the pitch must not exceed the width of the strip below the level.

EFIS failure indications can be completely different from those of conventional instruments, making it much more difficult for the pilot to recognize a system failure. The lack of system standardization exacerbates the problem by making equipment-specific information and knowledge necessary to troubleshoot electronic display faults. The inability to simulate certain failure modes during training and assessment makes the pilot less prepared for a real emergency. As electronic avionics becomes technically advanced, the training and skills required to safely operate these systems must keep pace with the times.

The key to successfully managing an emergency and/or preventing an abnormal situation from escalating into a real emergency is to be thoroughly familiar with and followed by the aircraft manufacturer's FAA procedures. (FAA) approved aircraft flight manual and/or pilot's manual (AFM/POH).

2.3.2. Psychological hazards during airplane control

There are several factors that can affect a pilot's ability to act quickly and correctly in an emergency. Some of these factors are listed below.

• Reluctance to accept an emergency. A pilot who allows his mind to be paralyzed at the thought of a plane on the ground in a very short time, regardless of the pilot's actions or hopes, is seriously failing to deal with an emergency. Unconscious desire delaying a dangerous moment can lead to such errors like: inability to lower the nose to maintain airspeed, delay in choosing the most suitable landing zone within reach, and hesitation in general. Desperate attempts to fix what went wrong by flying the plane fall into the same category.

• Desire to save the airplane. A pilot who has been trained during training to expect to find a relatively safe landing zone whenever the flight instructor closes the throttle to simulate a forced landing can ignore all basic flight rules to avoid landing in terrain where damage to the aircraft is imminent.

Typical consequences are: making a 180° turn back to the runway when the available altitude is insufficient; stretch the glide path without taking into account the minimum reference speed in order to enter a more attractive field; acceptance of an approach and landing situation that leaves no room for error. The desire to save an aircraft, regardless of the risks involved, can be influenced by two other factors: the pilot's financial interest in the aircraft and the assurance that the undamaged aircraft will not result in bodily harm. However, there are times when the pilot must be more interested in donating the plane so passengers can get away from it safely.

Anxiety about getting hurt – fear is a vital part of the self-preservation mechanism. However, when fear leads to panic, we invite what we most want to avoid. Survival records favor pilots who maintain their composure and know how to apply general concepts and procedures developed over the years. The success of an emergency landing depends not only on skill but also on intelligence.

2.4. General principles of crew training on simulators

Simulators play a special role in pilot training. This is due to the fact that simulators are one of the main technical means of training aircraft crews. Aviation simulators for various purposes create such information models of reproducible flight conditions in real time so that the visual perception and motor response of a trained pilot do not differ from real ones. For this purpose, in the cockpit (or its fragment) of the aircraft simulator is installed, as a rule, equipment identical to the real one. The geometrical sizes of models of cabins of aircraft, an arrangement of devices, indicator devices and controls correspond to the real ship. However, the general similarity, although of great importance, does not yet ensure the reproduction on the simulator of the most important moments of the pilot's work, which allow to form the necessary professional skills.

The question of what factors of flight conditions of the aircraft, in what completeness and with what accuracy should be simulated on the simulator, is weighed on the basis of psychological analysis of the pilot's interaction with the real environment and determined by the specifics of the tasks. This takes into account the psychological structure of the formed skills, which includes the purpose of the action, the peculiarities of perception, attention, thinking, the nature of movements.

2.4.1. Analyses of the existing training methodology and crew training devices in the flight process

To perceive the conditions of the real process on the simulator implements a mathematical model of the movement of the aircraft and models of all its major systems. In this case, in accordance with the control effects of the trained pilot, which are introduced into the model, reproduce in real time situations similar to those arising in flight.

The parameters received as a result of modeling are deduced on devices and means of indication of the pilot's panel. At the same time in optical devices and portholes the external visual situation is reproduced as much as possible, by means of the corresponding simulators connected with model of dynamics of PS so that the picture observed on the simulator corresponds to a real at a similar condition in flight.

As a rule, the simulators simulate the physical factors of flight conditions, which cause the trained pilots to feel adequately related to their activities in real flight conditions.

Optimization of pilot training on simulators is also achieved by such methodological techniques as re-reproduction of particularly complex control elements of the aircraft, input of faults, fixation of training exercises for prompt analysis of errors by the instructor, self-control and other methods.

In some cases, for example, to develop skills to perform transient control processes of the aircraft there is a need for their slower reproduction (learning in an unrealistic time scale), followed by a gradual transition to real time.

The specificity of the pilot's training on simulators is associated with such a feature as the inability to create on one simulator the full range of physical conditions and factors that accompany the flight. Therefore, the formation of the necessary professional skills of pilots is carried out element by element on simulators for various purposes. At the final stage of pilot training, they consciously integrate a generalized internal image of future activities. The task of forming such an image in the pilots on the simulators is solved by psychologists and instructors who guide the training. In this regard, the planning of training cyclograms is of particular importance. It is based on the stages associated with the element-by-element mastery of complex types of professional skills. The sequence of stages of preparation for dynamic operations on the simulators is as follows:

• theoretical training and acquisition of general operator culture;

• formation of a range of private skills that are part of the integrated skill required to perform this dynamic operation;

• formation of skills to perform individual isolated operations;

• formation of skills of performance of separate operations in a complex of consecutive actions;

• formation of skills of performance of dynamic operation in emergency situations and non-standard ways;

• transfer of skills from training models to a real control object.

The leading role in achieving this goal belongs to the crew instructor, who directly carries out the training process and determines the readiness of the crew to fly. At the same time he solves a number of problems in two main directions.

Psychologically:

• study of individual psychological characteristics of crew members, their language and style of activity;

• research of influence of mental tension, fatigue, emotional influences and features of the neuropsychic organization of the pilot on efficiency of its activity and variation depending on it of intensity of its loading;

• identification of "reserves" and the possibility of using them in extreme conditions;

• accounting for the price of physical and mental costs of the pilot when reaching a given level of professionalism in order to ensure the reliability of the task;

2.4.2. Training conditions of pilots

During the training, pilots consistently and purposefully form a conceptual model of flights. However, the imaginary image and general intellectual baggage of the pilot are only the basis for his work. It includes a range of psychological processes, such as active perception, memory, thinking, decision-making, and then motor operations that require not physical activity, but precise and coordinated movements.The generalized structural scheme of the modern simulator irrespective of its type and appointment contains five basic blocks: a workplace of the pilot, system of simulation of a visual situation, computer system, the control panel and the coordination device. The technical level of implementation of this structure determines the ratio of training conditions and flight conditions, i.e. the degree of their similarity.

Modern simulators for professional training of pilots are implemented on the basis of training systems or networks.

2.4.3. Pilot's workplace

Full-size models or fragments of aircraft, the interior of which corresponds to a real aircraft, are installed on specialized and complex aircraft simulators. All equipment, information display system and aircraft controls, with which the crew works or comes into contact, correspond to the regular ones in all characteristics. The same part of the equipment that is not included in the circuit of modeling the control processes of the aircraft (this applies primarily to specialized simulators or stand-simulators), made in the form of weight and dimensional models.

The means of information equipped with the information display system on the simulator facilitates the creation of the illusion of the flight of the aircraft, its position in space and the operation of various systems and units. The illusion of pilots flying during the training exercise is also enhanced by the creation of a real acoustic environment in the aircraft model by simulating engine noise, noise from the operation of mechanics, hydraulics and pneumatics, as well as simulation of radio communication with air traffic control and ground stations.

Further approximation of the simulator conditions to the flight when performing various operations is carried out by simulating the physical movement of the aircraft by installing its layout on a moving platform. In the general case the mobile platform should have six degrees of freedom - three linear movements and angular: on a course, a roll and a pitch. The acceleration sensations of the pilot in this case are synchronized with changes in the external visual environment in the portholes and optical devices of the aircraft layout.

Reproduction of real speeds and accelerations of the aircraft at different stages of flight on a dynamic simulator in full is impossible. But there is no special need for this. This is due to the peculiarities of the human vestibular apparatus, which perceives primarily the transients of both linear and angular velocities.

In order to create an adequate perception on the simulator of the real accelerations of the aircraft and simulated, the fronts of the transients are reproduced at a scale of 1:1 to moments corresponding to the limit of sensitivity, ie saturation of the human vestibular apparatus. The pilot, performing dynamic operations in the moving cockpit, receives from the front of the acceleration all the initial sensations of movement, which are necessary for adequate perception of real and simulated conditions.

After reproducing the real acceleration front, the platform is braked, and the decline of the braking front is below the threshold of sensitivity of the vestibular apparatus of the pilot, otherwise he may have erroneous sensations. Thus, proceeding from limiting sizes of movement of a mobile platform on linear and angular movements, it is transferred to neutral position with the speeds and the accelerations imperceptible to the vestibular device of the pilot.

The "reaction" of the external visual situation in the portholes and optical means of observation of the aircraft layout to the pilot's control influences during the training exercise also greatly contributes to the creation of a psychologically adequate real environment at the information display system.

2.4.4. Visual training simulation system

Of all the information about the state of the aircraft, perceived by the sensor field of the pilot, more than 80% comes through the visual channel. That is why the role of means of simulating the visual environment on the simulator is so important.

The pilot, perceiving on the simulator the visual information and the information arriving on other channels of a sensory field (auditory, vestibular, etc.), forms influences on controls of the aircraft from what the spatial position of the aircraft, and hence a visual situation changes. After its change, the pilot controls the movements of the aircraft, performs the necessary maneuvers with orientation on the ground or in space. According to the relevant landmarks, it determines the orientation angles of the aircraft, the increase of these angles, angular velocities, velocity and direction of movement, as well as the current coordinates (planar or spatial).

The nature of the change in the visual situation in the portholes and optical means of observation of the aircraft is determined by the characteristics of the objects of observation and the dynamic characteristics of the aircraft.

Due to the fact that the movement of the aircraft in the General case is carried out in three-dimensional space, the image structure of the visual environment is dependent on six coordinates (three Cartesian and three Euler), which requires proper transmission of the perspective of reproduced visual conditions. An important role is played by the characteristics of the means of observation.

In addition, the "reaction" of the visual environment to the control effects given by the trained pilot must be identical to the flight conditions, otherwise the control characteristics of the aircraft on the simulator will be distorted and the perception of the simulator conditions will not be adequately real.

When moving the aircraft in space in the field of view of the pilot there is a continuous change in perspective and relative size of the observed objects as the distance to them changes. Changing the perspective of the visual environment is strictly related to the movement of the aircraft in time and space. The movement observed by the pilot in real conditions agrees with the physical movement that affects the vestibular apparatus and tactile system of the pilot. Therefore, a special role in the simulator is given to the synchronization of the dynamics of the visual environment with the control effects of the pilot. With the appearance of delays, the visual environment can be misinterpreted, which can lead to the formation of negative skills in pilots.

2.4.5. Control and management

Training pilots on modern simulators is a controlled process in which their professional qualities are purposefully changed. This process is carried out in stages under the guidance of a crew instructor and a psychologist.

At the initial stage, pilots get acquainted with the interior of the pilot's workplace (RMP), its equipment, the location of information display facilities, optical devices and aircraft controls.

At the stage of training on specialized simulators pilots consolidate theoretical knowledge and acquire professional skills to perform certain operations, techniques, control modes in normal and abnormal flight modes of the aircraft. The duration of training on each of the simulators depends on the individual abilities, level of knowledge, specialization and past experience of the crew members. After formation of confident skills of performance of separate operations and receptions transition to complex simulators where the most comprehensive preparation of crew is carried out is carried out.

Comprehensive training is the final stage of preparation, when all stages of the flight of the aircraft are consistently worked out. On complex simulators, the crew commander, compared to other members, performs the largest number of trainings, which is due to his personal responsibility for the implementation of vital stages of the flight. A significant number of trainings on complex simulators are aimed at the crew acquiring skills in detecting emergency and emergency flight situations and finding ways out of them.

Each session on the simulator includes instruction and analysis of training. The briefing covers the most important aspects of the future training exercise: characteristics of the stages of the aircraft flight, information about the aircraft systems, the order of the crew in normal and emergency situations, information about the restrictions imposed by the simulator, etc.

At the end of each training the instructor makes an analysis, during which the performed training exercise is analyzed in detail and conclusions about the achieved successes are made, mistakes are noted and unlearned sections of the theoretical course are revealed.

As you gain professional experience, the duration and frequency of instruction and analysis decreases.

At all stages of training, the simulators include devices and devices that provide: control over the progress of training, assessment of the actions of the trained pilot, operational management of the training process, adjustment of the training program.

The control and evaluation of the pilots' activity is carried out on the basis of objective criteria that take into account accurate, temporary and reliable performance indicators that characterize the probable probability of fulfilling the tasks assigned to the crew.

Improving the effectiveness of training on simulators is achieved by solving the following tasks:

- registration of actions of pilots n on control of aircraft in dynamic modes;
- control and registration of the trajectory of the aircraft or controlled parameters;
- prompt presentation of any learner objective indicators that characterize the errors in size and sign;
- registration and reproduction in real time of the performed training exercise or its phase in which mistakes were made;
- formation of objective assessments of pilots' professionalism;
- assessment of psychophysiological tension of pilots during training;
- registration of the visual environment observed by students at the RMP and its reproduction during the analysis of training.

2.4.6. Antistress pilots training

Methodical recommendations for increasing the level of counteraction to pilot pilot linings, developed on the basis of a process approach, are intended to fill this theoretical and methodological gap, and is one of the first methods that allow the instructor and pilot initially theoretically, and then practically to understand the processes of flight in conditions of unexpected influence various negative factors (factor overlays).

In the process of flight training pilots are purchased and fixed certain flight skills in various special situations. The complex simulator aircraft (CSA) simulates the behavior of the aircraft in the event of functional failures, adverse weather conditions, the occurrence of fires and their various combinations. The pilots successfully mastered the appropriate algorithms of action, and it would seem that this should limit the preparation process. However, in practice, we often encounter incorrect decisions made by pilots, with the flight parameters being exceeded for restrictions imposed by the Aircraft Flight Operation Manual (AFOM).

The above problem is proposed to allow a special type of training pilots to fly in special situations training against any one simultaneously affects the pilot negative factors (factor overlays) antistress program.

To the negative phenomena should include the process of factor resonance. An assessment of the first signs of its appearance is fundamentally important for preventing aviation events. The first signs of the phenomenon of factor resonance (FR) are the following areas of factor fluctuations in the flight process, which, with an increase in the number of simultaneously acting factors the appearance of factor lining (FL) can lead to an emergency or catastrophic situation. The first sign of FR is a resonant curve with a small amplitude and period.

In the process approaches, the concept of "antistress training" was proposed by E. M. Hohlovym in 1973.

The simulation of the FN on the CCS has made it possible to find out that pilots may have the effect of amplifying the amplification of dynamic stereotype (DS) piloting in special situations of flight. This phenomenon of strengthening of the DS can occur in 70% of pilots and is accompanied by an exit beyond the permissible limitations of flight parameters.

If eliminating this negative phenomenon, occurring in 70% of pilots, then there is the possibility of preventing such flight accidents.

To detect PADS we use qualitative and quantitative methods for determining the change of DS. The methodology of flight preparation for the analysis of flights with the presence and absence of FL is proposed. Compares the oscillograms of a pair of training flights (with or without FL) on a simulator or on an airplane.

It is especially important to determine the quantitative change of the DS using trend algorithms. To analyze the change in the quality of the flight, according to some parameters that are fixed by the DS, algorithms for the relative difference are used to identify the PADS. For the account of PADS and estimation of the quality of piloting equipment in the process of flight preparation algorithms of absolute difference in the parameters of zones through the poly-parametric algorithms of double delta are proposed.

For the analysis of the graph of autocorrelation function, the following basic parameters are used:

1) the average period of oscillations that characterizes the dominant frequency (it can be found by multiplying the number of quantization steps in one period by the value of the quantization step in seconds);

2) the correlation interval or the attenuation rate – the period of time in the course of which the correlation function "extinguishes". The longer the correlation interval, the higher the regularity of the waves in the EEG, and the smaller this interval, the more rigorous processes in the EEG are expressed in the EEG;

3) the area under the curve of the autocorrelation function;

4) the ratio of the periodic and random component. To quantify this parameter, enter the coefficient: $K_{P/R}$=A/(R -A).

The power of the periodic component is calculated as half the average amplitude of the waves of the autocorregram (A = 1/2a, where a is the average amplitude of the values of the autocorrelation function), and the power of the random component is the difference between the maximum value of the autocorrelation function A/(R = 1) and the power of the periodic component.

Many events in the air are the result of human error, but most pilots (and this is humanly understandable) are reluctant to admit that they could have made mistakes. Therefore, today the latest flight simulators have video cameras, which allows you to have a complete audio - visual recording of everything that happens. Instructors and students then review this record together. The instructor points out the mistakes of the students, after which the group analyzes them. Another advantage of the video is that it reveals shortcomings in the interaction between the commander and the co-pilot. You can create many more situations on the simulator than in a real plane. He can simulate almost any situation - good and bad, and in the plane it is impossible. It is important for students to know what to do if they encounter such situations in real flight.

When conducting exercises on the simulator, you can change the weather, you can get snow, thunderstorms and even a typhoon on the simulator. All this is very realistic. But for training in real flight conditions for the trainee should always be good weather.

Intensive use of training equipment in the preparation (retraining) of the flight crew significantly reduces the time to acquire stable skills in the technique of piloting the mastered type of aircraft. According to military experts, about 80%. flight tasks can be successfully completed on flight simulators. In addition to a significant reduction in flight training time, it provides significant savings in material costs. It is established that the preliminary practice of the elements of flight tasks on the simulator contributes to a better assimilation of them during the training flight.

In the learning process, an important role is given to the instructor, which is like a link between all the elements of the training program. He instructs and analyzes classes on the simulator, monitors the pilot's program, linking the entire training system into one whole and ensuring the continuity of the learning process. The teaching staff pays maximum attention to the training of students and much less - to the performance of administrative duties.

Complexation of the educational process is carried out by connecting the monitor of the training system using a computer on the instructor's console, work consoles of those who are trained, and personal computers to the local computer network.

In general, modern training systems have the following advantages:

• The capabilities of the listener and instructor are expanded; the workload is greatly reduced. With the help of the PAC, you can quickly program various output data and enter information about emergencies and other parameters into the computer in real time. If required, the entire programming process can be fully automated.

• The instructor's ability to use the necessary information during instruction and analysis of classes is increased. The teacher always has a record of avionics readings made during the last lesson.

• Effective training and active intervention of the instructor in the system. Success data is compiled using a computer based on the data contained in the training program. If necessary, the instructor may recommend that the student conduct additional classes, and enter the necessary data into the system or into the curriculum.

Modern complex aircraft simulators have the maximum realism and proximity of the simulated situation and the implementation of full flight training of crew members due to the following technical capabilities:

• Carrying out all types of training;

• High accuracy of simulation of real flight conditions and operation of aircraft systems;

• Maximum approximation of the interior of the simulator to a particular aircraft;

• Application of adequate mathematical models created on the basis of data obtained from the aircraft developer;

• Visualization system with a sufficient level of detail and quality of display of external space;

• Extensive possibilities of scene modeling;

CONCLUCIONS

An important element of crew training is the training of air strikes on the simulator. Attempts to partially control the aircraft using onboard instruments while searching outside the aircraft to visually confirm the information provided by these instruments lead to inadequate aircraft control. This can be followed by spatial disorientation and complete loss of control. It is important to emphasize that the pilot should not panic. The pilot must believe what the flying instruments are showing about the position of the aircraft, regardless of what the natural senses say.

The vestibular sense (the perception of movement by the inner ear) can be confusing to the pilot. there are often false sensations that lead the pilot to believe that the attitude of the aircraft has changed, when in fact it is not. These false sensations lead to spatial disorientation of the pilot.

The main orientation control tool is the orientation indicator. Once the aircraft has been balanced so that it can maintain level flight unarmed at cruising speed, that speed should not change until the aircraft is lowered for landing. All turns, ascents and descents can and should be done at this speed. Straight flight is maintained by holding the wing in a horizontal position using "fingertip pressure" on the steering wheel. Any change in pitch should be done in a strip no more than one width up or down.

Modern simulators for professional training of pilots are implemented on the basis of training systems or networks. During the training process, pilots consistently and purposefully form a conceptual flight model. At the stage of training on specialized simulators, pilots consolidate theoretical knowledge and acquire professional skills to perform certain operations, techniques, control modes in normal and non-standard aircraft flight modes. The duration of training on each simulator depends on the individual abilities, knowledge level, specialization and past experience of the crew members. After the formation of confident skills in performing individual operations and techniques, the transition to complex simulators is carried out, where the most comprehensive training of the crew is carried out.

A significant number of trainings on complex simulators are aimed at acquiring the skills of the crew in detecting emergency and emergency flight situations and finding ways out of them.

It is especially important to quantify the change in DS using trend algorithms. To analyze the change in flight quality for some parameters that are recorded by DS, relative difference algorithms are used to identify PADS. To take into account PADS and assess the quality of flight equipment in the process of preparing for a flight, algorithms for the absolute difference in zone parameters through polyparametric double delta algorithms are proposed.

Intensive use of training equipment during training (retraining) of the flight crew significantly reduces the time for acquiring stable skills in the technique of piloting the aircraft being mastered.

CHAPTER 3

ROLE OF ALARMING SYSTEM AND METHODOLOGY OF CREW ACTING IN CASE OF FAILURES IN AVIONICS

3.1. Analysis of alerting system failures in commercial aviation accidents

The role of an alerting system is to make the system operator aware of an impending hazard or unsafe state so the hazard can be avoided or managed successfully. A review of 46 commercial aviation accidents (between 1998 and 2014) revealed that, in the vast majority of events, either the hazard was not alerted or relevant hazard alerting occurred but failed to aid the flight crew sufficiently. For this set of events, alerting system failures were placed in one of five phases: Detection, Understanding, Action Selection, Prioritization, and Execution. This study also reviewed the evolution of alerting system schemes in commercial aviation, which revealed naïve assumptions about pilot reliability in monitoring flight path parameters; specifically, pilot monitoring was assumed to be more effective than it actually is. Examples are provided of the types of alerting system failures that have occurred, and recommendations are provided for alerting system improvements.

3.1.1. The Role of Alerting in a Safety-Critical System

Successful hazard identification during development of a safety-critical system results in reduced hazards and/or mitigations for managing hazards when they occur, and, therefore, these hazards are unlikely to lead to an airplane upset or loss. For commercial aviation, hazards can take many forms; for example, there are hazards tied to:

• airplane systems failures; e.g., a hydraulics system failure that could lead to an inability to move control surfaces

• airplane smoke and fire

• external threats; for example, high terrain or obstacles, icing, or windshear

• hazardous changes to the flight path; for example, airspeed dropping too low or rolling to a high bank angle

• ensuring the airplane is configured appropriately prior to initiating certain phases of flight; for example, for take-off

Airplane developers strive to create an alerting system for the hazards that cannot be designed out. Alerting, ideally, can allow the flight crew to become aware of a hazard’s presence before it becomes a threat to safe flight, or, if it does become a threat, manage it to avoid an airplane upset or loss. In any safety-critical system, the alerting system should initiate the appropriate flight crew/pilot response for managing a hazard. The alert, along with related elements of the flight deck interface and operational procedures, need to help the pilot do the following:

1. Orient to an important change. Some salient element, such as a loud sound or bright light or both, needs to attract the flight crew’s attention that some important change has occurred.

2. Understand the nature of that change. Some interface element needs to describe this important change. Information about the nature of the change, as well as the urgency of response and importance of response, need to be presented clearly and simply. Ideally, the interface and associated procedures should convey the implications for operational decision making.

3. Identify appropriate actions to take. When there are flight crew actions that are recommended to manage the failure or hazard, those actions have to be presented to the pilot although, in some cases, an action or small set of actions is memorized by the pilot. The alert needs to create a link to those actions, either by making them part of the alert or by directing the flight crew to a set of actions to ensure they perform the right procedure.

4. Identify the priority for the actions. In some non-normal situations, there may be a number of actions for the flight crew to take, especially when there are multiple alerts. The system interface needs to aid the flight crew in assessing which actions have the highest priority.

5. Execute the actions efficiently, accurately, and completely, including a safe recovery. The system interface and the operational documents need to support the flight crew in executing the prescribed actions in a timely manner (i.e., before there is an airplane upset or loss). Ideally, the interface allows the flight crew to evaluate how well the hazard is being managed as actions are being taken.

These five steps can be referred to as the integrated alerting-to-recovery sequence, and this sequence can be used to analyze how well the alerting system works when hazards are encountered. This approach broadens the usual bounds of alerting to make the point that there needs to be an integrated approach between the initial “alert,” the system interface, and operational procedures to ensure all five steps are supported. These steps in the integrated alerting-to-recovery sequence can also be used to understand the point at which a breakdown in alerting contributes to an accident or incident. For example, there have been aviation accidents and incidents in which the flight crew oriented to a change but did not understand the nature of the change, or, cases in which the flight crew oriented and understood the nature of the change but failed to identify the appropriate actions to respond to it. This type of analysis can aid in identifying vulnerabilities in an airplane’s alerting system or in the use of the accompanying procedures.

	Lack of External Visual References	Flight Crew Impairment	Training	Airplane Maintenance	Safety Culture	Invalid Source Data	Distraction	Systems Knowledge	Crew Resource Management	Automation Confusion / Awareness	Ineffective Alerting	Inappropriate Control Actions	Total
Formosa Airlines Saab 340	x	x			x		x	x	x		x		7
Korean Air 747-200F	x			x		x	x		x		x		6
Flash Airlines 737-300	x		x		x		x		x	x	x	x	8
Adam Air 737-400	x		x	x			x	x	x	x	x	x	9
Kenya Airways 737-800	x		x				x		x	x	x	x	7
Aeroflot-Nord 737-500	x	x	x	x	x		x	x	x	x	x	x	11
Gulf Air A320	x		x				x		x		x	x	6
Icelandair 757-200 (Oslo)	x						x		x	x	x	x	6
Armavia A320	x	x			x		x		x	x	x	x	8
Icelandiar 757-200 (Baltimore)	x				x	x	x	x	x	x	x	x	9
Midwest Express 717	x				x	x	x		x		x	x	7
Colgan Air DHC-8-Q400	x	x	x		x		x	x	x	x	x	x	10
Provincial Airlines DHC-8	x		x				x			x	x	x	6
Thomsonfly 737-800	x		x	x	x		x			x	x		7
West Caribbean MD-82	x	x			x		x	x	x	x	x	x	9
XL Airways A320		x	x	x	x	x	x	x	x	x	x		10
Turkish Airlines 737-800	x			x	x	x	x		x	x	x		8
Empire Air ATR-42	x	x			x		x		x	x	x		7
Overall	17	7	9	6	12	5	18	7	16	14	18	12	

Fig. 3.1. The events and contributing factors

3.1.2. Alerting System Basics for Commercial Transport

Aircraft Alerting, for the purposes of this report, refers to a change in the interface that is meant to attract attention, which could be a sound or voice (e.g., “pull up”), onset of a light or a message in a specified area (e.g., Master warning light), a pop-up of a message in a central location (e.g., traffic collision avoidance system [TCAS] graphics on the primary flight display [PFD]), or flashing of a display element (e.g., airspeed tape indicator). Alerting systems in large, commercial transports (i.e., 14 CFR part 25) are complex and widely distributed. In most modern airplanes, alerting for airplane system failures are managed largely through a central alerting system (e.g., Boeing engine indication and crew alerting system [EICAS] or Airbus electronic centralized aircraft monitor [ECAM]). These alerts are prioritized by urgency and can be inhibited (for some alerts in certain flight phases). In addition to centralized aircraft system alerting, other elements of alerting can be found on the PFD, glareshield/mode control panel, the head-up display (HUD), the control column, overhead panel, and other parts of the forward panel.

14 CFR 25.1322 and Advisory Circular (AC) 25.1322-1 provide regulatory requirements and guidance for aircraft alerting. Airplane alerts are organized into warning, caution, and advisory categories (called Level 1, 2 and 3 in an Airbus airplane) according to 14 CFR 25.1322.

The definitions for these are

• Warning: Conditions that require immediate flight crew awareness and immediate flight crew response.

• Caution: Conditions that require immediate flight crew awareness and subsequent flight crew response.

• Advisory: Conditions that require flight crew awareness and may require subsequent flight crew response. Warning- and Caution-level alerting must contain at least two sensory modalities of alerting, typically a visual and an aural alert. Most modern airplanes have a Master Caution/Master Warning system that presents a visual alert in the central field of view and salient aurals. Warning-level visual alerts are red, and Caution-level visual alerts are amber/yellow. Below are some examples of Warnings and Cautions:

• Warning-level hazards of interest – Autopilot Disconnect – Engine Fail or Engine Out – Windshear – Ground Proximity – Stall/Stick shaker (approach to stall) – TCAS Resolution Advisory (TCASRA) – Overspeed – Cabin Altitude – Take-off Configuration

• Caution-level hazards of interest – Autothrottle Disconnect – Low Airspeed – Unreliable Airspeed – Bank Angle

Data Gathered Each of the selected event reports was reviewed to capture the following information:

• event date

• airline/operator and flight number (when the report gave one)

• location of event

• accident category (e.g., controlled flight into terrain [CFIT])

• airplane manufacturer and type (e.g., Boeing 737-800)

• phase of flight when event occurred

• local time when event occurred

• weather/visibility (instrument meteorological conditions [IMC] or visual meteorological conditions [VMC])

• on-board fatalities

• Captain’s total flight hours and time on type

First Officer’s (FO) total flight hours and time on type

• who was the pilot flying (PF) when the event occurred (Captain or FO)

• what airplane-related hazards occurred during the flight;

these included:

– Autopilot disengages. A change from engaged to disengaged, but we only counted the cases in which the flight crew was unaware of the autopilot disengagement since it is often the result of the pilot disengaging it.

– Auto throttle disengage. A change from engaged to disengaged without pilot input.

– Ground proximity (Terrain Awareness and Warning System [TAWS]): sink rate, terrain, pull up).

The airplane inappropriately flew near terrain.

– Impending collision (TCAS). The airplane was on course to collide with another airplane.

– Bank angle. the airplane rolled or was rolled beyond 35°.

– Low airspeed. Airspeed dropped below normal operating speeds.

– Approach to stall/stall. Airplane angle of attack increased to a point where the airplane was close to stalling or stalled.

– Overspeed. Airspeed exceeded normal operating speeds.

– Unreliable airspeed. Airspeed indication became erroneous due to a fault in air data; at least one of the airspeed indicators became invalid but was not labeled as invalid.

– Airplane icing. Icing on the airplane sufficient to change the aerodynamic properties of the airplane.

– Unreliable attitude information. One of the attitude indicators became invalid (but was not labeled as invalid).

– Take-off configuration. The airplane was not properly configured for take-off, leading to insufficient lift to fly at the expected take-off speed.

– Take-off performance. There was insufficient thrust for take-off with the available runway length.

– Landing configuration/high-energy approach. The airplane landed fast, or the approach was above the glidepath or fast, making it difficult to manage the landing.

– Asymmetric thrust. Thrust on the engines was not matched on the two engines.

– Flap asymmetry. Flap position was not matched on the two wings.

– Windshear.

A change in wind speed—in some cases, a downward microburst of air—that creates sudden shifts in airspeed.

– Cabin altitude (pressure).

Pressure was not maintained in the airplane as it climbed, and the airplane could not sustain human life. Engine fail/engine out. Loss of an engine in flight.

• whether any hazard that occurred had an alert tied to it

• all the airplane alerts that occurred, in order, during the flight (taken from the flight data recorder [FDR] and cockpit voice recorder [CVR])

• what action(s) the PF should have taken in response to the hazard

• what action(s) the PF actually took

• what action(s) the PM (pilot monitoring) took

• a short synopsis of the event, including a context for the alerting

• whether alerting was mentioned in the report as a factor in the accident

3.2. Detailed Results: Approach to Stall

Approach to stall or full aerodynamic stall is at the heart of many LOC events; indeed, this hazard occurred in 16 of the 28 events analyzed here. Table 4 shows the ways in which this hazard occurred in the 16 events; the columns show the sequence of hazards (the different paths to the 16 occurrences). In six cases (1st grouping), approach to stall followed a low airspeed event that was either not alerted or not detected. In three other cases (2nd grouping) a different hazard preceded the low airspeed à approach to stall sequence, and again low airspeed was not alerted. Note that one of these cases (Thomsonfly) was recovered effectively so it does not get tallied in the alerting failures in Table 3.1. In two other events (3rd grouping) unreliable airspeed was the specific hazard that preceded the low airspeed à approach to stall sequence. And, in two events (4th grouping) unreliable airspeed directly preceded the approach to stall. The final three cases (5th grouping plus last event) include two in which some hazard other than low airspeed or unreliable airspeed preceded the approach to stall, and one case in which no other hazards preceded the approach to stall.

Table 3.1. Various Paths to an Approach to Stall Hazard

	Low airspeed	Approach to stall	Colgan 3407
			West Caribbean 708
			Provincial Airlines
			Turkish Airways 1951
			Ethiopian Airlines 409
			Asiana 214
Other	Low airspeed	Approach to stall	*Empire Airlines 8284*
			Air Algerie 6289
			Thomsonfly
Unreliable airspeed	Low airspeed	Approach to stall	XL Airways 888
			Swift Air 5017
	Unreliable airspeed	Approach to stall	*Iceland Air 662*
			Air France 447
	Other	Approach to stall	ADC 53
			Bhoja Air 213
		Approach to stall	Air Asia 8501

3.2.1. Examples

14/07/14 Swiftair 5017 MD-83 116

Fatalities Synopsis: In cruise, the flight crew had apparent ice crystal icing, causing erroneous air data; A/T decreased thrust in response and airspeed decreased. Airplane slowed into a stall; the crew did not respond (in actions) to the SPD LOW alert; they did not react to the STALL warning (they did not disconnect A/P until 25 secs after STALL warning), also they kept in nose-up inputs on the controls, leading to a LOC (there is no CVR so some information is missing regarding flight crew intentions.)

Analysis: The unreliable airspeed hazard was not alerted. Low airspeed alerting was a visual alert (not aural) that was present for 8 seconds before the stick shaker, and there is no evidence that it was detected. For the approach to stall (stick shaker) alert, the appropriate actions were not trained or training did not result in knowing appropriate actions.

Hazards: 1. Unreliable Airspeed - No Alert no alert exists in the airplane for loss of air data.

2. Low Airspeed - alert - Alert Not Detected there was no response to low airspeed alerting.

3. Approach to Stall - alert - alert detected - alert understood - Crew Selected Wrong Actions. Swiftair did not train crew on stall recovery; it was assumed airplane protections would prevent entry into stall

Alerts (in order of occurrence) (Note: no CVR and some of these are from analysis)

- A/T disengage (visual only)
- SPD LOW (visual only)
- stick shaker/stall (continuous)
- altitude (continuous)
- Autopilot disengage (visual only)

27/11/08 XL Airways 888 Airbus 320-232 7

Fatalities Synopsis: Airspeed was allowed to go very low (99 kts); crew was trying to slow to alpha floor (for testing) but due to frozen AoA vanes, alpha floor was not at the right place on speed tape; airplane pitched up to try to manage the lower airspeed and pilot was unable to overcome pitch because he didn't transition to manual trim.

Analysis: The only “alert” for unreliable airspeed was the visual-only CHECK GW (gross weight) message, which was probably present for several minutes; there was no low airspeed alert; finally, for the approach to stall hazard, the flight crew did not understand they needed manual trim to reduce pitch.

Hazards: 1. Unreliable Airspeed - alert - Alert Not Detected there was no response to the CHECK GW message.

2. Low Airspeed - No alert an AoA alert existed but failed to perform due to frozen AoA sensors.

3. Approach to Stall - alert - alert detected - alert understood - crew selected right actions - Inadequate Performance pilot didn't use manual trim to reduce pitch Alerts (in order of occurrence) - CHECK GW (on MCDU) - Stall warning - Direct Law Master Caution - USE MAN PITCH TRIM message - Stall warning - EGPWS TERRAIN Warning.

27/01/09 Empire Airlines 8284 ATR 42-320 0

Fatalities Synopsis: Initially, there was an unrecognized flap asymmetry due to icing. Captain had taken over the controls from the FO after a stick shaker and A/P disengage. The FO was unable to manage the controls; the airplane was hard to handle due to the flap asymmetry. The airplane slowed down, got to stick shaker and GPWS pull up warnings. The Capt reduced power instead of increasing power per procedure. Then, later pulled back on column leading to another stick shaker, leading to the loss of control. Analysis: There was no alert for flap asymmetry or low airspeed; for the approach to stall, the pilot performed actions different from those trained or in operational guidance.

Hazards: 1. Flap Asymmetry - No alert no alert exists in the airplane for flap asymmetry

2. Low Airspeed - No alert no alert exists in the airplane for low airspeed

3. Approach to Stall - alert - alert detected - alert understood - Crew Selected Wrong Actions pilot actions did not involve nose down and increased thrust Alerts (in order of occurrence) - aural stall (cricket) and Stick Shaker (3 times) - EGPWS "Pull up, pull up" - Stick Shaker 1 more time. [5]

3.3. The system alarm about the dangers

Hazard Communication System (HCS) is a complex of technical aids for civil aviation intended for the transmission of information on the occurrence of a dangerous situation on board an aircraft by crew and crew flight operators to ground control centers through the communication channels of the VHF.

The MTR is an important pillar of technical support for combating air piracy and terrorism. It consists of two subsystems - internal and external. Internal MTRs are simple electrical signaling circuits for transmitting an alarm from the salon stewardess or passenger compartment to the flight deck. The external SSO includes an electronic unit for automatically displaying the earth signal code d via a VHF radio transmitter and a power button masked under the pilot cabin accessory, such as an electrical outlet.

Alarms are alarms signals designed to alert of danger or the onset of action when people can be in a hazardous area. The duration of the signal should allow a person in the danger zone to leave it or prevent the impact of danger. Typically, signals are generated automatically. Used sensors of various measuring devices, which react to the parameters of technological processes and the production environment.

There are two types of signaling: sound and light.

Audio signal should be preferred in case:

– if the employee's opinion is distracted from monitoring the process;

– if the visual perception of a signal prevents the environmental impact.

Light signaling prevails:

– if the noise level is high;

– if there are many beeps.

Types of sound alarm signals:

– speech signals (single-sentence sentences);

– non-voice signals (bells, sirens, etc.)

Requirements to the signals:

1. It should be heard in the background of noise or other sound signals;

2. Signals must be different from other audio signals;

3. Signals must draw attention without affecting other important and important work functions.

Light signaling is used to inform about working conditions: normal mode, inoperative position, emergency situation. Elements of the light signal can be used to transmit commands or information.

Characteristics of the signal: brightness, color, flashing frequency.

Signal requirements:

1. The light element should be 2 times brighter than the surrounding background;

2. Signal elements must be placed in dark places or protected by special canopies.

3. It is recommended to use flashing light as a signal and avoid sharing colors that are easy to confuse.

The assignment of signals should be familiar to all employees. Tables of signals are placed in the workplace or in the working mechanism. Every mis-presented or obscure signal should be taken as a "stop" signal.

A flight with all established restrictions, as well as observance of meteorological minims, ensures the safe passage of all obstacles. However, there is a risk of collision of airplanes with obstacles. This is primarily about the human factor. This may be a mistake in navigating the crew or a dispatcher error during vectorization. In addition, although it is extremely unlikely that navigational equipment may fail.

GPWS and EGPWS prevention systems for dangerous proximity to the ground are the latest line of protection from collisions with obstacles.

In the 1970s, the term CFIT (Controlled Flight to Terrain) was first introduced in the United States, which means a collision of an aircraft with the ground (ICAO translation), or a collision of a plane with relief in a controlled flight, which would be more correct, since the definition ICAO does not provide an understanding of what to call a collision with the surface of the water. Further, by the term "earth" we will understand the surface of the water.

From the state of the art, there are two approaches to addressing the problem of delaying alarms.

In the simplest case, a speed indicator is displayed on the aircraft, which displays the speed of the head in conditions of true speed at sea level. Typically, the speed scale uses colored or monochrome characters that indicate the braking rate Vst and the maximum permissible velocity Vmax, which are determined taking into account the stock of strength and rigidity of the design.

The advantage of the speed indicator as a means of preventing failure is the possibility of an early assessment of the possibility of dangerous lowering or exceeding speed, because before the stop active rate falls preceded by an active increase in speed to some extent angle of attack. This is due to the fact that, against the background of linear loss of speed, the angle of attack increases nonlinearly and the stronger, the closer the moment of achieving Vst.

The main disadvantage of the standard speed indicator as a means of stopping the stop is the need for a long distraction pilot's attention. Obviously, a one-time short shift of attention to the speed indicator does not give an idea of the dynamics of the speed change process, because in the short period of time (average 0.25 seconds), the average pilot is not able to catch a potentially dangerous speed of decrease in speed, while the current during cheat in the case of a pointer, the speed of the air may seem safe for the pilot.

Therefore, due to the need to distract control of the space position of the aircraft, control other parameters of the device, provide radio broadcasting, the pilot cannot often look at the speed indicator for as long as possible, or transmit as often as necessary to correctly assess the longitudinal airplane dynamics.

As an example of an effect to solve this problem, it can be specifying the main flight indicator of the A320. An important feature of this device is the display of a vertically oriented arrow on the column speed indicator, the direction, size and color of which give the pilot the necessary information about the trend of flight speed, along with its current value, which is displayed in digital form.

The disadvantage of this technical solution, as well as other major flight indicators, is the large amount of heterogeneous information that is harder to understand in times of temporary shortage than reading the readings of classical flight instruments. The problem of lack of time to evaluate the instrument's performance is characteristic of small aircraft, where the transient processes occur very quickly due to the small mass of the aircraft.

The approach to solving a pilot warning problem is to install on the aircraft warning systems of dangerous flight conditions based on reading the current or threshold angle of attack and the presence of warning devices with a certain threshold.

As an example of a more serious approach to this problem, the AUASP device, automatically at the corners of the attack and alarm overloads, is widespread on domestic aircraft. [6]

The advantage of AUASP is the possibility of correction of the limiting value of the angle of attack on accelerometer and counter signals, eliminating false alarms and allowing AUASP to be used on high-speed, including supersonic aircraft.

The first disadvantage of AUASP is the difficulty of reading the readings of the indicator with two indicators, since in a time deficit only a well-trained pilot can interpret the position of the hands. The second disadvantage of AUASP is the late sound and light signaling and siren sound signal throughout the time when the aircraft is in critical condition, which increases the voltage of the crew and prevents its adequate action.

Also known is a "plane stop warning system" as described in US Pat. Patent No. 4,908,619, published March 13, 1990 and filed November 13, 1984. According to its technical solution, this warning system is the closest analogue of the present invention and comprises a control unit, at least one speed sensor and a precautionary device.

The advantage of this solution is the adaptability of the warning system to the specifics of the aircraft with a pronounced lower decent ration of the thrust vector of the engines, in which the stall speed in the mode of full thrust decreases due to the vertical component of the traction/t force, and sharply increases with thrust.

The disadvantage of this system in addition to the extraordinary technical complexity is also the impossibility of giving in advance warning about the approach of a dangerous flight regime, since this system does not take into account the dynamics of changes in the velocity of air in its work.

Also known is "A method for predicting the approach of an aircraft wing to a stopping position" as described in US Pat. No. 4,563,684, published 01/01/1986, Submission Date 10/03/1983. [7]

This method is based on the simultaneous measurement of airborne velocity fluctuations in several zones of the aerodynamic profile, which allows the formation of an output signal corresponding to the state of the flux around the wing in the form of the ratio of air velocity to its oscillations, in particular aerodynamic wing profiles.

The disadvantage of this method is the constructive complexity and high cost, as well as a late warning about the extinction.

Also known is "a method for preventing a flight stops with a roll and a method for implementing the method" described in US Pat. No. 6,169,496, published May 2, 2001, submission date 9.12.1998.

This method is aimed at improving the safety of flights, including by solving one of the most urgent tasks of the flight - the choice between landing "before you" and the transformation into a lane when the engine does not fly, and based on a comparison of values of the roll, speed, flight height and other parameters, while the algorithm of the system provides an assessment of the danger of a known angle of the roll in terms of speed and height.

The disadvantage of this system is that in the presence of the five most important parameters is not the flight altitude, but the speed of flight. It is the tendency to an active fall in the speed of flight, combined with a roll of more than 45 degrees, most often means a very rapid breakdown in the corkscrew, especially as the failure rate increases with C and overload. In addition, the active increase in the angle of attack to destructive values in such cases is calculated in fractions of a second, and even the presence of a sufficient height reserve may not help in case of false or delayed actions of the pilot in the removal of the aircraft from braking or rotation

Number of accidents caused stopping on types of aircraft equipped with speed thresholds and speed indicators indicates that the devices described above may not be considered as effective measures to prevent braking and other hazardous things separately or in combination. Flight modes, because they either require constant monitoring of any device parameter, or they work so late that only indicate a critical situation. The choice between these means can also be defined as the choice between lack of attention and lack of time. [8]

3.4. Regarding of additional pilot notification system in case of failure in attack angle sensors or speeds

It is known that the requirements of the regulatory and technical documentation for the operation of the aircraft and systems allow certain levels of occurrence of special flight situations: complicated flight conditions, a difficult situation, emergency, catastrophic situation.

Of course, the quality of signaling information systems (SIS) directly affects the level of flight safety, including the properties of the crew-aircraft system.

As a rule, given the relatively low level of quality of SIS and the extremely complex functions of decision-making by the crew, failures of SIS are still associated with emergency and catastrophic situations. This is due to the fact that the existing ASCs in their quality have a number of disadvantages:

– low level of reliability;

– a very high false positive rate;

– the absence of special devices for the recognition of dangerous flight situations at the first moment of occurrence;

– the formation of significant uncertainties in making the decision by the crew. [9]

If the plane for some reason went to a big angle attacks, it is automation can

cause stalling and spin. Autopilot always deflects ailerons against spontaneous roll, that is, doing what in the regime close to dumping, absolutely cannot be done. It means that when flying at high angles of attack autopilot must be disabled.

In this case, it not only does not help, but hurts as when dumping, and when withdrawing from a spin. The main problem can occur in the deviation of such parameters as speed indicator and angle of attack.

There is relation between both parameters: if speed is increasing, angle of attack should be decreased, and if speed indicator shows decreasing, angle of attack should increase.

At a certain time, a failure can only occur in one device. The attention of the pilot should be directed to him. Its formulated by the next property.

Ordinary property: the probability of occurrence for an elementary period of time more than one event can be neglected compared to the probability of occurrence during this period of no more than one event (i.e., the probability of two or more events occurring simultaneously is zero).

In such case, the alarming system can work under the following failures:

1. Failure of the index of angle of attack. An increase in angle of attack results in an increase in both lift and induced drag, up to a point. Too high an angle of attack (usually around 17 degrees) and the airflow across the upper surface of the aerofoil becomes detached, resulting in a loss of lift, otherwise known as a stall.

2. Failure of the index of speed indicator. If the pitot probe is blocked but the pitot drains and static ports are free, then in straight and level (cruising) flight the displayed IAS will tend to reduce, eventually indicating zero.

On the figure there is a scheme, which shows alarming system “Look-check” in case, when any of indicators may cause failure.

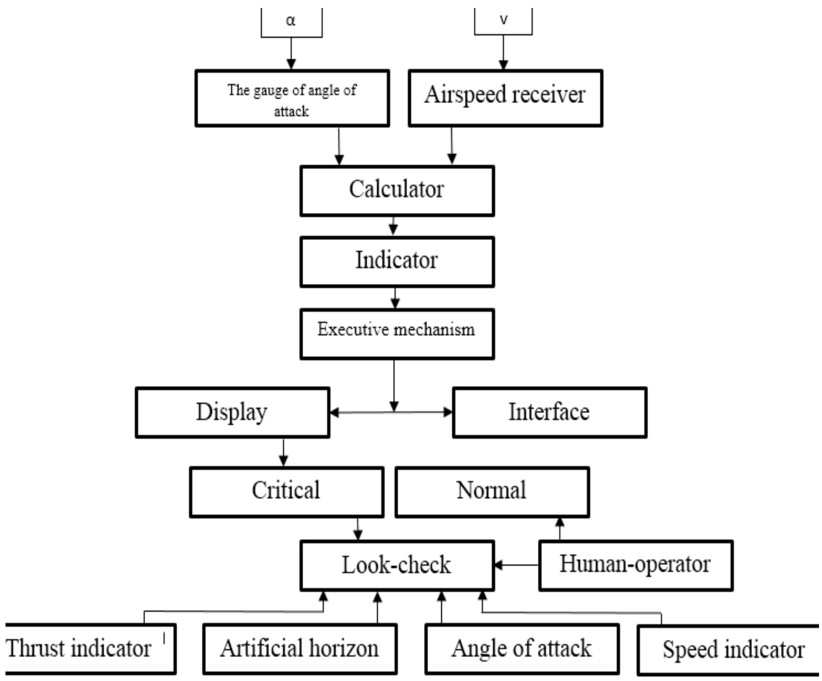


Fig. 3.2 Scheme of signaling in case of failure of indicator

Fig. 3.2 illustrates the way of signal’s path from accepting of different parameters to the indications on display.

Initially, sensors (angle of attack, speed indicator) accepted parameters. The gauge of the aerodynamic angles of the vane is designed to measure local aerodynamic angles - angle of attack and angle of slip. Airspeed receiver (pitot tube) receives the parameter of airspeed. To determine the airspeed is used speed indicators, in which the aerodynamic method of determining the speed is applied.

Then both parameters come to the calculator, where the difference of parameters is calculated. This value is further via the executive mechanism displayed on the interface (display).

If an incorrect discrepancy is found, then most likely a failure occurs in one of the sensors. In this case, the check-look system is triggered. It instantly attracts the attention of the pilot (human-operator) and gives an indication of a quick data check parameter, as well as others (for example, look the level of the tag and on artificial horizon).

The influence of factor loadings (FL) in part of the operators has a phenomenon of amplification of dynamic stereotype (PADS), which consists in increasing the amplitude of control motions while preserving their general structure.

Operational actions become meaningless, there is the execution of traumatized operations, which sometimes end up in confusion or inappropriate action, wrong decisions are made.

Experimental data proving the phenomenon of strengthening the stereotype and "flying handwriting" under the action of complex refusals. [10]

3.5. Regarding of FL graphics

Let’s regard the graphs landing with idle engine №4. It was taken from MK-400. Experiment137.

It has such parameters: G=326t, M=0.43, H=2300 m, starts from=0 degrees. MCA+15.

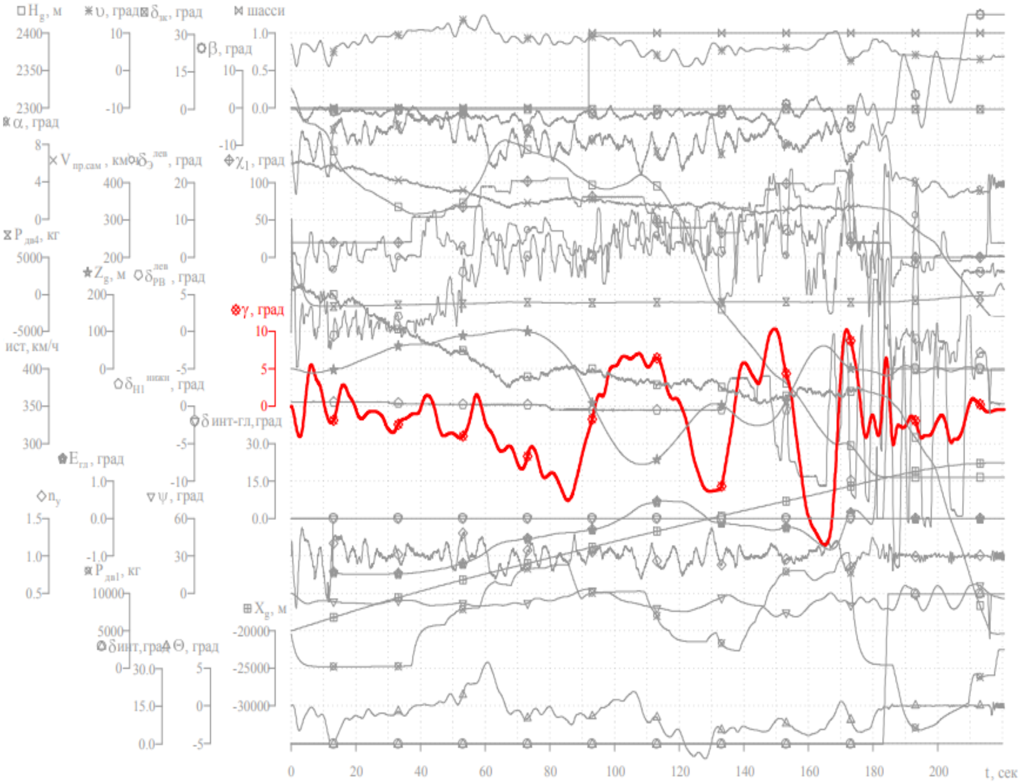


Fig. 3.3 Oscillogram of factor linings when landing with idle engine number 4

MK-400. Exp.138, G=296 t, M=0.45, H=3100 m, starts from=0 degrees. MCA+15. Landing with not issued end flaps.

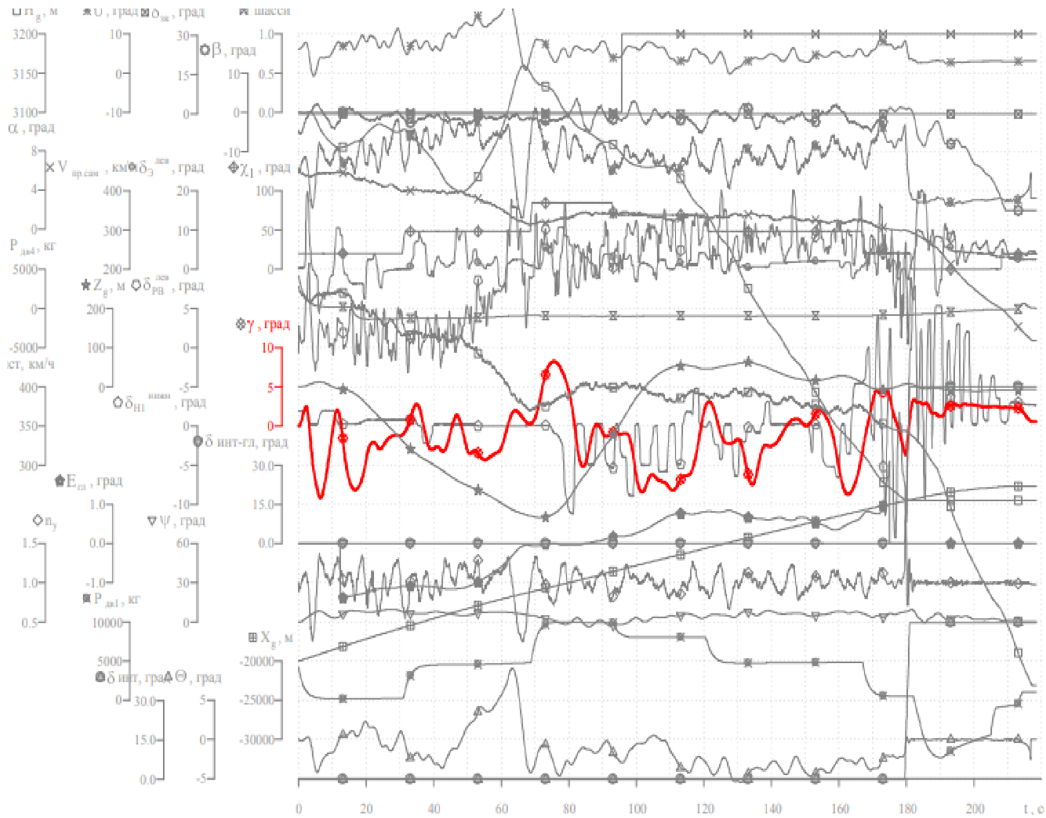


Fig. 3.4 Oscillogram of factor linings when landing with non-released finite flaps

It is necessary to measure the amplitude of the change of the angle of the roll when assessing the quality of piloting. If you follow the nature of the change of the parameter of the roll under the influence of factor loads, even in normal flight (without failing the input), then you can be sure that the plane of the plane changes constantly. [11]

Large pitch angles associated with the psychophysiological state of the pilot affect the quality of flight in the horizontal plane. Below is regarded analyzes of the quality of the flight in the horizontal plane in pitch in the real flight of the An-148 aircraft from the end of the second turn to landing.

$$\gamma := \begin{pmatrix} -32 & -15 & -25 & -15 & -18 & -13 & -14 & -8 & -17 & -7 & -24 & 12 & 3 & 12 & -3 & 4 & -10 \\ -4 & -25 & -4 & -25 & 10 & -23 & 0 & -33 & -17 & -20 & -9 & -14 & 1 & -18 & 1 & -4 & 2 \\ -10 & -2 & -3 & 7 & 12 & 4 & -1 & 7 & -10 & 9 & -2 & 10 & -10 & 1 & -17 & -3 & -19 \\ -6 & -17 & -5 & -20 & -10 & -18 & -3 & -5 & 5 & -4 & 4 & -5 & 3 & -9 & 2 & -3 & 5 \\ -3 & 4 & -3 & 3 & -7 & -13 & -2 & -4 & 6 & 1 & 6 & 3 & 9 & -3 & 1 & -7 & 0 \\ -11 & -6 & -5 & -9 & -3 & -4 & 6 & 4 & 9 & 6 & 12 & -2 & 3 & 13.5 & -4 & -9 & -2 \\ -5 & 2 & 0 & 8 & 0 & 5 & 2 & 5 & -3 & 0 & -5 & -4 & -7 & 0 & -13 & -6 & -13 \\ 4 & 3 & 4 & 2 & 1 & 3 & 0 & 3 & 3 & 2 & -3 & -2 & -3 & 1 & 3 & 0 & 3 \end{pmatrix}$$

$$\gamma := \begin{pmatrix} 32 & 15 & 25 & 15 & 18 & 13 & 14 & 8 & 17 & 7 & 24 & -12 & -3 & -12 & 3 & -4 & 10 \\ 4 & 25 & 4 & 25 & -10 & 23 & 0 & 33 & 17 & 20 & 9 & 14 & -1 & 18 & -1 & 4 & -2 \\ 10 & 2 & 3 & -7 & -12 & -4 & 1 & -7 & 10 & -9 & 2 & -10 & 10 & -1 & 17 & 3 & 19 \\ 6 & 17 & 5 & 20 & 10 & 18 & 3 & 5 & -5 & 4 & -4 & 5 & -3 & 9 & -2 & 3 & -5 \\ 3 & -4 & 3 & -3 & 7 & 13 & 2 & 4 & -6 & -1 & -6 & -3 & -9 & 3 & -1 & 7 & 0 \\ 11 & 6 & 5 & 9 & 3 & 4 & -6 & -4 & -9 & -6 & -12 & 2 & -3 & -13.5 & 4 & 9 & 2 \\ 5 & -2 & 0 & -8 & 0 & -5 & -2 & -5 & 3 & 0 & 5 & 4 & 7 & 0 & 13 & 6 & 13 \\ -4 & -3 & -4 & -2 & -1 & -3 & 0 & -3 & -3 & -2 & 3 & 2 & 3 & -1 & -3 & 0 & -3 \end{pmatrix}$$

$$N := 136$$

$$\mu := 3.57$$

$$K := 7$$

$$k := 0..K-1$$

$$\nu := \frac{\sigma}{\mu} = 2.603$$

$$\gamma := -13.5..33$$

$$c := \frac{1}{\mathrm{mean}(\gamma)} = 0.28$$

$$\Delta\gamma := \frac{q1 - q}{K} = 6.643$$

$$b := 1.75$$

$$int_k := -13.5 + \Delta\gamma \cdot k$$

$$n := \mathrm{hist}(8, \gamma) = \begin{pmatrix} 11 \\ 34 \\ 34 \\ 26 \\ 14 \\ 10 \\ 5 \\ 2 \end{pmatrix} \qquad fg := \mathrm{histogram}(9, \gamma) = \begin{pmatrix} -10.917 & 10 \\ -5.75 & 18 \\ -0.583 & 39 \\ 4.583 & 33 \\ 9.75 & 11 \\ 14.917 & 12 \\ 20.083 & 6 \\ 25.25 & 5 \\ 30.417 & 2 \end{pmatrix}$$

Below is constructed a histogram of the pitch angle distribution when approaching the pilot after the 2nd turn (excluding the pitch during turns) before landing. It was chosen an appropriate theoretical distribution.

mean(γ) =

-13.5
-12.5
-11.5
-10.5
-9.5
-8.5
-7.5
-6.5
-5.5
-4.5
-3.5
-2.5
-1.5
-0.5
0.5
...

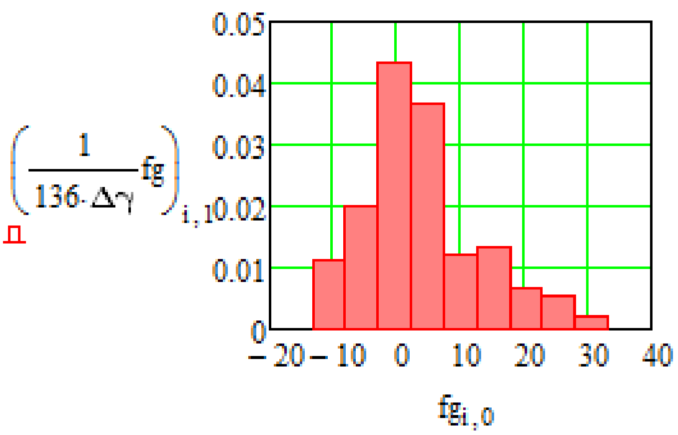
Normal

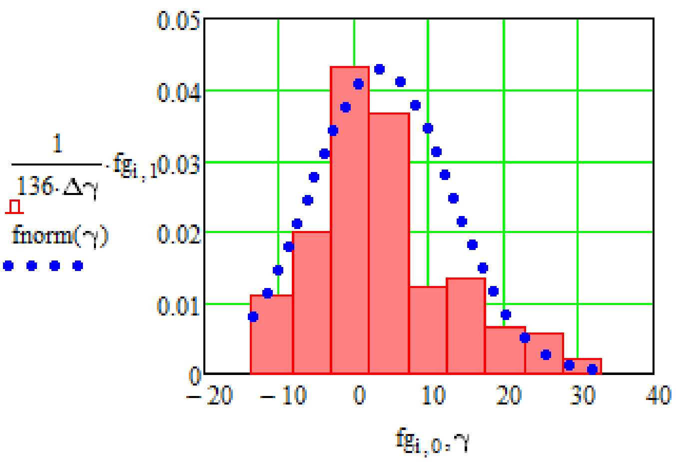
$$fnorm(\gamma) := \frac{1}{\sigma\sqrt{2\cdot\pi}}\cdot\exp\left[-\frac{(\mu-\gamma)^2}{2\cdot\sigma^2}\right]$$

var(γ) =

0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
...

$$n = \begin{pmatrix} 11 \\ 34 \\ 34 \\ 26 \\ 14 \\ 10 \\ 5 \\ 2 \end{pmatrix}$$





$a := 0..K-1$

$$\int_{-30}^{40} fnorm(\gamma)\,d\gamma = 1$$

k =

0
1
2
3
4
5
6

Analysis of consent Norm-model

The theoretical probability of failure in the k-th interval Δt

$$Qnorm_a := \int_{int_a}^{int_a+\Delta\gamma} fnorm(\gamma)\, d\gamma$$

$$Qnorm_0 := \int_{-\infty}^{int_0+\Delta\gamma} fnorm(\gamma)\, d\gamma$$

$$int = \begin{pmatrix} -13.5 \\ -6.857 \\ -0.214 \\ 6.429 \\ 13.071 \\ 19.714 \\ 26.357 \end{pmatrix}$$

$$Qnorm_{K-1} := 1 - \sum_{a=0}^{K-2} Qnorm_a$$

$Qnorm_a =$

0.131
0.211
0.279
0.226
0.112
0.034
$7.092\cdot10^{-3}$

$$n = \begin{pmatrix} 11 \\ 34 \\ 34 \\ 26 \\ 14 \\ 10 \\ 5 \\ 2 \end{pmatrix}$$

$N\cdot(Qnorm_a) =$	$n_a - N\cdot(Qnorm_a)$
17.799	-6.799
28.699	5.301
37.936	-3.936
30.726	-4.726
15.246	-1.246
4.631	5.369
0.964	4.036

$$\chi2norm := \sum_{a=0}^{K-1} \left[\frac{\left[(n_a) - N\cdot Qnorm_a\right]^2}{N\cdot Qnorm_a} \right] = 27.925$$

$\Sigma n := 136$ $\quad m := 3.57$

It can be seen the correspondence of the theoretical normal distribution to the statistical one according to the Pearson agreement criterion

n	$N \cdot (Qnorm_a)$	$n_a - N \cdot (Qnorm_a)$
11	17.799	-6.799
34	28.699	5.301
34	37.936	-3.936
26	30.726	-4.726
14	15.246	-1.246
10	4.631	5.369
5	0.964	4.036
2		

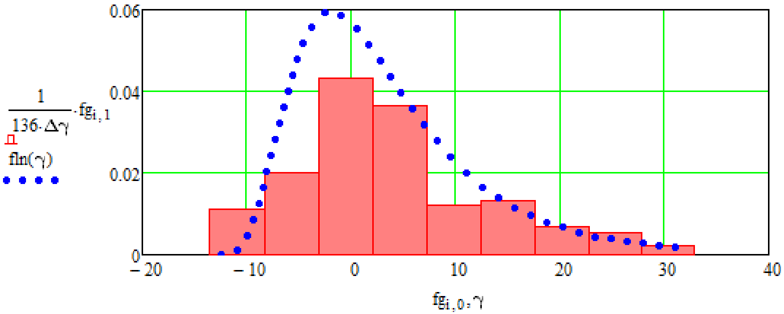
$$\chi 2norm := \sum_{a=0}^{K-1} \left[\frac{\left[(n_a) - N \cdot Qnorm_a \right]^2}{N \cdot Qnorm_a} \right] = 27.925$$

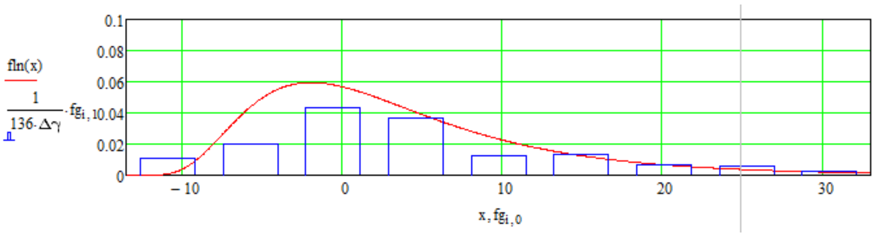
$\Sigma n := 136$ $\qquad m := 3.57$

Lognormal LN

$$\sigma := \sqrt{\ln\left[\frac{d + (m-q)^2}{(m-q)^2} \right]} = 0.509 \qquad \mu 1 := \ln(m-q) - \frac{\sigma^2}{2} = 2.708$$

$$fln(\gamma) := \frac{1}{(\gamma - q) \cdot \sigma \cdot \sqrt{2 \cdot \pi}} \cdot \exp\left[\frac{-(\ln(\gamma - q) - \mu 1)^2}{2 \cdot \sigma^2} \right]$$





$$\int_q^{10000} fln(x)\,dx = 1$$

$a := 0 .. K - 1$

$$Qln_a := \int_{int_a}^{int_a + \Delta\gamma} fln(\gamma)\,d\gamma$$

$$Qln_0 := \int_q^{int_0 + \Delta\gamma} fln(\gamma)\,d\gamma$$

$$Qln_{K-1} := 1 - \sum_{a=0}^{K-2} Qln_a \qquad \int_q^{int_0 + \Delta\gamma} fln(\gamma)\,d\gamma = 0.055$$

Qln_a	n	$N \cdot Qln_a$
0.055	11	7.482
0.351	34	47.761
0.306	34	41.562
0.158	26	21.429
0.071	14	9.714
0.032	10	4.317
0.027	5	3.736
	2	

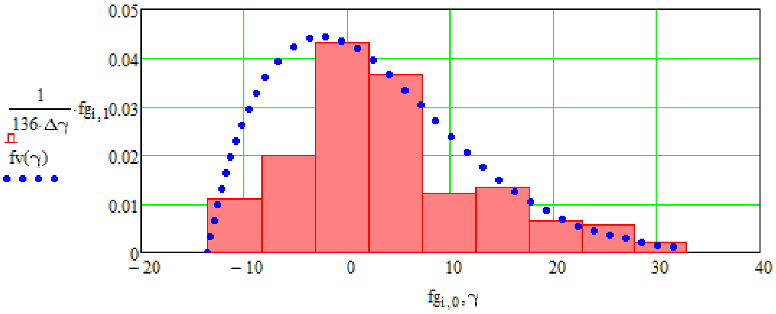
$$\chi 2ln := \sum_{a=0}^{K-1} \left[\frac{\left[(n_a) - N \cdot Qln_a \right]^2}{N \cdot Qln_a} \right] = 17.772$$

Three-parameter Weibull distribution
Scale parameter, Form parameter, Shift parameter

$a1 = 17.867$

$b = 1.75$

$q = -13.5$



$$fv(\gamma) := \frac{b}{a1}\cdot\left(\frac{\gamma - q}{a1}\right)^{b-1}\cdot e^{-\left(\frac{\gamma-q}{a1}\right)^{b}}$$

3.6. Methodological algorithms for crew training on flight simulator

The use of flight simulators has become widely accepted in both civil aviation and military training. Simulators allow the practice of specific levels of training as well as potentially life-threatening maneuvers in the comfort of a training center. Therefore, the aviation industry has led the world in the use of simulation technology to improve training and safety.

Simulating usual situations helps the pilot to get familiarized with the techniques and environment of a real flight. Actually, simulators nowadays are basic tools when training pilots because they allow a good preparation in front of situations that otherwise would be catastrophic.

Moreover, the possibility to simulate in a realistic manner all these catastrophic situations turn a good flight simulator into a basic mean to study accidents after they have happened. The repetition of the situation with the same environment and exact values used in the flight makes possible a trustable reconstruction of the actual facts. This plays an important role in aircraft design because it leads to an improvement of the parameters of the flight in order to prevent the repetition of that kind of situation.

This methodology has been developed after analyzing of plenty sources concerning human factor in aviation, pilots’ types of errors and violations, reasons of making mistakes during flight, piloting process under different conditions, such as influence of stress. It has been regarded cases of LOC and emergency situations.

That’s why it proposed the following method of forming crew actions in case of failure in avionics systems. It includes a few steps.

–Analyzing. Research the worlds aviation market, learn updates concerning new training methods. Analyze air crash investigation. Collect the flight data. Compare them withing two and more flights. It helps to find the weakness. Then it will be regarded on the next stages.

–Planning. Both trainee and instructor should have a rest before session. Lesson plans, Flight Manual (FM), check lists, reference cards and any performance calculations should all be prepared in advance of the pre-flight briefing. Following the training, the instructor must ensure any snags, defects, failures and lost time caused by faulty FSTD operation.

–Pre-flight and briefing. On this phase should be presented the general goal of the training session: the list of the all enabling objectives that will be covered in the flight to achieve the aim of the flight.

–Flight. FSTD provides some benefits that can be used during the flight training phase. Conversely, some drawbacks need to be understood by the instructor in order to avoid any negative training. The training needs to be progressive with a gradual level of complexity according to the trainee competencies and his capability to assimilate the training. However, during training sessions, the difficulty should increase progressively. In the case of a complex maneuver, it might be beneficial if the instructor first demonstrates and gives a brief explanation either before, during or after the demonstration. The trainee generally needs supervision and oral guidance during first practice of a new maneuvers.

A major benefit of FSTDs is the ability to simulate realistic training environments on demand and create specific training opportunities for various situations such as:

• Adverse weather conditions such as fog, rain, snow, strong wind, etc...;

• Adverse visibility conditions in day/night, Degraded Visual Environment (DVE), etc.;

• Training to react to environmental safety factors (congested airport, diversion, air traffic, etc.);

• Adverse terrain condition (mountain, maritime, city, etc.).

FSTDs offer extensive possibilities in emergency and malfunction training. One of the most effective forms of learning is by “hands-on” practice and from the ability to make errors under safe, controlled conditions. FSTDs provide safe environments in which the actions can be repeated, and trainees can make errors without risk to themselves, other people, the aircraft and the surrounding environment.

Simulation can therefore be used to mitigate the risks inherent which are not possible to the same extent on a real aircraft.

Examples include, but are not limited to:

• Total engine failure and autorotation;

• Loss of Tail Rotor in critical flight phase – for example with sling load Vortex Ring (Settling with power);

• Undesired Aircraft State (UAS) following entry into Degraded Visual Environment (DVE).

Therefore, it is possible to train for “real” malfunctions on the FSTD which is not possible on the real aircraft. For example, the engine malfunction is never performed on the real airplane by switching off the engine, but generally by using the training mode available on the airplane; on the FSTD you can perform a total engine failure without taking any risks. A possibility is to activate malfunctions without previous warning to the trainee. However, it is recommended not to give multiple failures to the trainee at the same time, unless simulating a realistic scenario, as this can cause unnecessary confusion.

Automation training in FSTD should incorporate the aircraft manufacturers’ operating philosophies and recommended practices. This should include:

• Understanding the integration of autopilot modes;

• Understanding pilot-system interfaces (pilot to system communication and system to pilot feedback);

• Understanding all mode transition and reversion sequences;

• Awareness of available guidance (PFD/ND, modes armed or engaged, active targets);

• Alertness to adapt the level of automation to the task and/or circumstances, or to revert to hand flying.

FSTD is a powerful teaching tool as it can include real experience to achieve the learning goal. Once the student is competent in the maneuver, skills, specific LOFT or work scenarios can provide an opportunity to experience the situation what can happen during a real flight. Scenario-based learning teaches systematic risk reduction, critical thinking skills are the most effective way to prepare the pilot to make safe decisions while flying.

LOFT is effective in both aircraft and FSTDs. FSTDs now provide efficient tools for reproducing complex operational scenarios to immerse the student in a realistic situation. During the flight, while discussing the trainee's mistake, the instructor could either freeze the FSTD or take over to enable the student to fully focus on these instructions. However, always instructors do not be too critical of minor faults in the early stages. Serious faults should be corrected first, and then, as noted for improvement, minor bugs were fixed.

It is also possible to let the script unfold and not interfere. During debriefing and through questions. Relevant questions, learners can themselves come up with better ways to deal with the situation. Choice depends on the instructor and on the appropriateness in the specific situation.

–Post-flight and Debriefing phase. Before leaving the simulator, the instructor should check his notes before summing up, as there may be points requiring clarification before leaving the cockpit. The debriefing is done to evaluate, guide and facilitate open discussion. Frame work should be:

- Start with constructive points;

- Identify errors, causes of errors and improvement strategies. Maximum three key areas for improvement for the next flight to prioritize and make memorization easier;

- Technical and non-technical errors should also be clearly identified and explained;

- Complete with a promotion;
- Open discussion.

Flight safety is an important aspect of practical training. Instructors can influence the attitude and discipline of prospective pilots. To be successful, a safety program requires the right attitude, proper oversight, strict adherence and proper workout.

For summarized, the following basic principles can be distinguished when training pilots on TD:

1) Set a clear goal on training.
2) Establish and maintain a good instructor/trainee relationship.
3) Avoid negative training.
4) Master the basics before moving into the complex.
5) Manage malfunction training appropriately.
6) Let the trainee make errors and improve fault analysis.
7) Experience complex and emergency situations on the FSTD first.
8) Promote the good flight safety practices.
9) Make FSTD flight as realistic as possible. [12]

CONCLUSIONS

An alerting system is the greatest method to make the system operator aware of an impending hazard or unsafe state. Understand it properly and act immediately helped to avoid hazard or managed it successfully.

One of the worthiest successions in LOC can be approach to stall. This is dangerous because airspeed control is a very delicate moment.

Hazard Communication System is a complex of technical aids for civil aviation intended for the transmission of information on the occurrence of a dangerous situation on board an aircraft by crew and crew flight operators to ground control centers through the communication channels of the VHF. Alarms are alarms signals designed to alert of danger or the onset of action when people can be in a hazardous area. There are two types of signaling: sound and light. The advantage of the speed indicator as a means of preventing failure is the possibility of an early assessment of the possibility of dangerous lowering or exceeding speed, because before the stop active rate falls preceded by an active increase in speed to some extent angle of attack. The approach to solving a pilot warning problem is to install on the aircraft warning systems of dangerous flight conditions based on reading the current or threshold angle of attack and the presence of warning devices with a certain threshold.

Nowadays crusual situations are still occurred. There were such accidents during flight when unespectable situations starts. Pilots were confused and act wrong under the sharply changing of personal state. They become uncontrolled and do under stress state. This position pushed them to act reflexively, without thinking or either based on old experience.

A decision to introduce a new alarming system which helps pilots to resist stress state had regarded in graduate work. Sometimes pilot did mistake and pull steering wheel to himself. This can happen at a critical angle of attack or low speed.

Crew member can only confuse devises. Result can be disappointed. An alarm method in failing cases for pilots has been developed. Such system should warn pilots. They, in turn, should get together and determine which devises fail. The main objective of this method is to prevent pilots from state of stress, which makes it difficult to assemble and act correctly. And also, methodical recommendations were developed by the pilots.

The trainers are especially suitable for training situations that are impractical, difficult, dangerous or expensive to reproduce in a live environment. There are many potentially dangerous situations in which crews may be infrequent. If such situations arise, they need to be dealt with effectively to avoid serious consequences. The simulators can present such unusual scenarios to the listeners in a repeatable and controllable way without risk to the crew, aircraft, other operators or environment.

CHAPTER 4
OCCUPATIONAL SAFETY

Labor protection is a system of legal, socio-economic, organizational and technical, sanitary and hygienic, treatment and prevention measures. It aimed at preserving human life, health and ability to work.

The concept of labor protection actually reveals the main directions that create a system of safety of life and health of workers in the course of their work. This system includes measures that are aimed at creating working conditions that meet the requirements of life and safety health of employees in the process of work.

The main provisions on labor protection are enshrined in the Code of Labor Laws. It provides responsibilities for labor protection, the content and procedure for approval of instructions on labor protection, requirements for production facilities and equipment, free issuance of special clothing and personal protective equipment for work with hazardous conditions of labor, etc.

Labor protection is based on a set of state legislative acts. The general laws of Ukraine that determine the main provisions on labor protection are the Constitution of Ukraine, the Code of Labor Laws, the Law of Ukraine "On Labor Protection", the Law of Ukraine "On Ensuring Sanitary and Epidemic Welfare", the Law of Ukraine "On Fire Safety", the Law of Ukraine "On compulsory state social insurance against accidents at work and occupational diseases that caused disability" and bylaws on labor protection.

The main legislative document on labor protection is the Law of Ukraine "On labor protection", which was adopted by the Verkhovna Rada of Ukraine on October 14, 1992.

The Law of Ukraine on Labor Protection defines t he provisions on the implementation of the constitutional right of citizens to protection of their life and health in the work, regulates relations between the owner of the enterprise, institution and organization or its authorized body and employee on safety, occupational health and production environment and establishes a single procedure for the organization of labor protection in Ukraine.

Occupational safety at civil aviation enterprises can be at a high level only when the country's legislation, industry standards, norms, rules and requirements for occupational safety of workers are strictly complied with.

4.1 Analysis of harmful and dangerous production factors

During work in production, a person can be affected by one or a number of dangerous and harmful production. The safety of a technological process can be determined by their number and the degree of danger of each of them separately. Occupational safety at work is determined by the degree of safety of individual technological processes.

The working place of operator is flight simulator in the laboratory. The square of the room is 24 m². There is one flight simulator An-24 in a room with two workplaces. There is natural lighting, heating, air-conditioning systems and ventilation systems in the laboratory. The worker uses the flight simulator which consumes from electricity.

According to ДСТУ 12.0.003-74 the following dangerous and harmful production factors can impact on the worker:

- increased and decreased values of temperature, humidity and air flow rate depending on the microclimate of the laboratory, simulator or crew cabin, which can lead to colds – physical harmful factor;

- increased voltage in the electrical circuit, the short circuit of which can occur through the human body when touching damaged parts of electrical equipment in the cockpit, erroneous voltage supply during maintenance and repair and inspection of the device and equipment in the cockpit, laboratory and on simulators, as a result of insulation damage, etc . – physical harmful factor;

- the appearance of electrical sparks that occur during operations with disconnecting devices, as well as other short circuits, which can lead to burns – physical harmful factor;

- neuropsychiatric state of overload associated with mental tension and emotional overload – psychophysiological harmful factor;

- physical static overload occurs after sitting on place without moving for several hours – psychophysiological harmful factor.

The most dangerous factor is connected with electricity problems in systems. In the event of an impingement of a person with electricity, it can lead to the worst consequences.

4.2 Measures to reduce the impact of harmful and dangerous production factors

The flight simulator device considered in this paper for the analysis of flight multifactoriality is powered by an electric current. Data on the failures entered by the instructor from the control panel of the instructor enter the system in the form of electrical signals. Therefore, in the following list of measures, special attention is paid to electrical safety.

To reduce or eliminate the level of dangerous and harmful factors, the following measures have been taken:

1. Complex automation and mechanization of production processes, which eliminates human contact with conductive elements.

2. Improved technological process that prevents damage to the insulation, the occurrence of short circuits, excess voltage in the boundary network. Careful systematic control of electric current parameters in the limit is carried out.

3. Workers are provided with the necessary overalls and special equipment, as well as other personal protective equipment.

4. Additional lighting is provided in the locations of system elements on the simulator.

Sanitary and technical propaganda and training in safe work methods under different working conditions were carried out.

4.2.1 Calculation of protective grounding

Calculate the protective grounding for a comprehensive aircraft simulator.

According to the state standard ГОСТ 12.1.030-81 the initial data for the calculation are according to PUE at U <1000V R = 4 Ohms;

Let's determine the calculated value of the resistivity of the soil for vertical grounding ($\rho'_{\text{calc.}}$) and strip ($\rho''_{\text{calc.}}$):

$$\rho'_{\text{calc.}} = \rho \cdot k'_n \qquad (4.1)$$

$$\rho''_{\text{calc.}} = \rho \cdot k''_n \qquad (4.2)$$

where ρ is the resistivity of the soil, ρ = 0.4Ohm • m • 10^2;

k'_n, k''_n - climatic zone coefficient, k'_n, k''_n= 0.5 and 2.0;

$$\rho'_{\text{calc.}} = 0{,}4 \cdot 10^2 \cdot 0{,}5 = 20\text{Ohm} \cdot \text{m}$$

$$\rho''_{\text{calc.}} = 0{,}4 \cdot 10^2 \cdot 2{,}0 = 80\text{Ohm} \cdot \text{m}$$

Determine the current resistance of one vertical grounding by the formula:

$$R_{p.} = 0{,}366 \frac{\rho'_{\text{calc.}}}{l} \left(lg \frac{2l}{d} + \frac{1}{2} lg \frac{4H+l}{4H-l}\right) \qquad (4.3)$$

where *l* is grounding conductors - steel pipes, *l*=2.5m;

d is the diameter of the pipe, d=0.05m;

H is laying depth, H = 1.5m;

$$R_{p.} = 0{,}366 \frac{20}{2{,}5} \left(lg \frac{2 \cdot 2{,}5}{0{,}05} + \frac{1}{2} lg \frac{6+2{,}5}{6-2{,}5}\right) = 6{,}14\text{Ohm}$$

Calculate the required number of pipes:

$$n' = \frac{R_{\text{p.}}}{R_{add.}} \qquad (4.4)$$

$$n' = \frac{6{,}14}{4} \approx 2.5 \leq 3$$

The coefficient of use of a single ground factor, which takes into account the mutual shielding of pipes: $\eta_{p.} = 0{,}8$

Determine the actual number of vertical grounding:

$$n = \frac{n'}{\eta} = \frac{3}{0{,}8} = 3{,}75 \leq 4 \qquad (4.5)$$

Calculate the length of the strip that connects the vertical grounding:

$$L = 1{,}05 \cdot a \cdot n \qquad (4.6)$$

where a – distance between grounding conductors, 2.5m;

$$L = 1{,}05 \cdot 2{,}5 \cdot 4 = 10{,}5\text{m}$$

Connection strip current resistance:

$$R_c = \frac{0{,}366}{L} \cdot \rho''_{con.} \cdot lg\frac{2L^2}{b \cdot h} \qquad (4.7)$$

where h – depth of laying the strip, 0.8m;

b – width of the strip, 0.04m.

$$R_c = \frac{0{,}366}{10{,}5} \cdot 80 \cdot lg\frac{2 \cdot 10{,}5^2}{0{,}04 \cdot 0{,}8} = 10{,}7\text{Ohm}$$

Coefficient taking into account the mutual shielding of the strip and vertical grounding:

$$\eta_c = 0{,}83$$

Determine the current resistance of the entire grounding device:

$$R_з = \frac{R_{p.} \cdot R_c}{R_{p.} \cdot \eta + n \cdot R_c \cdot \eta_{p.}} \qquad (4.8)$$

$$R_з = \frac{6.14 \cdot 10{,}7}{6.14 \cdot 0{,}83 + 4 \cdot 10{,}7 \cdot 0{,}8} = 1{,}7\text{Om}$$

The resistance of the grounding device satisfies the requirement $R_з$<4Ohm.

4.3 Occupational Safety Instruction

Instruction on labor protection when working on flight simulator.

4.3.1 General safety requirements

1) Persons who have studied the design of the device, the procedure for working with it and past safety instructions and who have passed the test on labor protection are allowed to service the device and its operation.

2) Repair and maintenance of the device do only the serviceable tool having external isolation and the corresponding marking.

3) Repair and maintenance of the device do only at the disconnected power supply.

4) It is allowed to install fuses only with the nominal data indicated in the diagram.

5) Replace fuses only after the mains has been de-energized.

6) Measure the voltage only with certain approved devices.

7) Do not change the assembly and schematic diagram.

8) It is strictly forbidden to leave the free ends of the wires uninsulated.

9) It is forbidden to connect wires in the places which are not provided by the assembly scheme.

10) It is forbidden to wipe parts of the device with the liquids connecting combustible materials.

11 Be able to use primary fire extinguishing means.

12) The employee must be able to provide first aid to victims of electric current and other accidents.

4.3.2 Safety Requirements before starting work

Before starting work on the simulator, the operator must check:

• workplace lighting;

• serviceability of the available means of the alarm system, control and measuring devices;

• availability and completeness of the first aid kit;

• serviceability of all displays and devices of the dashboard;

• visually - serviceability of grounding and starting equipment;

• cleanliness and uncluttered workplace objects;

• presence at the workplace of the log of change, instructions for operation of equipment, instructions on labor protection and fire safety, as well as instructions on alarm.

All problems and violations detected during the reception should be reflected in the variable log and the master should be notified.

If the time of acceptance of the change coincided with the moment of accident or unacceptable deviations in the mode of operation of the unit, the change must be accepted only with the permission of the master or shift manager.

The employee is prohibited from:

-use improper and incorrectly sharpened tools and devices;

-touch to live parts of electrical equipment, open doors of electrical cabinets. If necessary, contact the operational maintenance personnel.

4.3.3 Safety Requirements during operation

It is necessary to stop the machine and turn off the electrical equipment in the following cases:

• follow signals that warn of danger, observe personal safety measures;

• faulty sound and light alarm system;

• turning off the lights;

• equipment malfunctions, the operation of which is prohibited by the rules of technical operation;

• leaving the machine even for a short time;

• in case of temporary suspension of work;

• during a power outage;

• when cleaning, lubricating, cleaning the machine;

• upon detection of any malfunction;

• when tightening bolts, nuts and other fasteners.

4.3.4 Safety Requirements after work

- switch off the device;
- tidy up the workplace;
- track off all the panels;
- turn off the lights in the room;
- inform the work supervisor about all the shortcomings noticed during work and the measures taken to eliminate them.

4.3.5 Safety Requirements at emergency situations

In case of a break in the grounding of the machine and other malfunctions that can lead to an emergency and accidents, it is necessary:

4.3.5.1 Immediately stop the operation of the machine until the malfunctions are rectified and notify the work supervisor.

4.3.5.2 Under the guidance of the person responsible for the performance of work, promptly take measures to eliminate the causes of accidents or situations that may lead to accidents or accidents.

In the event of a fire, rags, equipment or fire:

4.3.5.3 Immediately notify the fire brigade by phone "101", notify the workers, notify the head of the unit, report the fire to the guard post.

4.3.5.4 Open emergency exits from the building, de-energize, close windows and close doors.

4.3.5.5 Start extinguishing the fire with primary fire extinguishing equipment, if it is not associated with a risk to life.

4.3.5.6 Arrange a meeting for the fire brigade.

4.3.5.7 Leave the building and stay in the evacuation zone.

In case of accidents:

4.3.5.8 Immediately arrange first aid for the victim and, if necessary, deliver him to a medical organization;

4.3.5.9 Take urgent measures to prevent the development of an emergency or other emergency situation and the impact of traumatic factors on other persons;

4.3.5.10 Before starting the investigation of the accident, preserve the situation as it was at the time of the accident, if this does not threaten the life and health of other persons and does not lead to a catastrophe, accident or other emergency, and if it is impossible to preserve it, to fix the current situation (draw up diagrams, carry out other activities).

CONCLUSIONS

The issue of labor protection is one of the most important at the present stage of our society, at a time when employers set themselves the main task - as soon as possible and with minimal investment, to extract the largest amount of profit, and taking advantage of recent shortages in the country. pay, and sometimes even ignore the requirements of occupational safety.

The increase in the number of occupational diseases, accidents at work, which lead to injuries and sometimes deaths, all this makes us think about the perfection of our legislation in the field of labor protection. One of the activities of the state to improve the situation in the field of labor protection - is to expand the use of local norms, which allows the features of labor protection of a particular enterprise to reflect in collective and employment agreements.

Chapter 5
ENVIRONMENTAL PROTECTION

Environmental protection is a system of legislative acts and measures aimed at reducing the impact of harmful and industrial factors on soil, water, atmosphere, vegetation and fauna.

Environmental protection and environmental issues have become one of the most important issues of our time in recent years. At this time in the world is a huge struggle to preserve the nature of animals and everything around.

The main directions of economic and social development are the section where the main tasks are set:

- increase the effectiveness of measures for nature protection;
- more widely implement advanced dead-end technologies and processes;
- to develop combined production that provides comprehensive and full use of natural resources, raw materials and supplies;
- significant reduction of harmful effects on the environment.

Nowadays, the problem of recycling is becoming more common, even when there are many organizations that monitor compliance with environmental laws, there are cases when companies bury or dump industrial waste into the ground or into water bodies. These illegal actions cause huge, often irreparable damage to nature.

In modern aviation, operator activity is becoming increasingly important. By its nature, it is increasingly approaching and many other types of employment of specialists in the management, control and maintenance of aircraft.

Its main feature is that a person engaged in work, does not have the opportunity to interact directly with the subject of work.

This interaction is mediated by complex technical systems that transmit information to the person about the subject and means of labor, and through which it realizes in this subject a conscious goal.

This diploma project considers the means of advanced training of pilots, which would improve the technique of piloting, simplify and accelerate the stage of training and preparation of the response of the pilot in the event of a complex failure in avionics system.

Accordingly, the development considered in this project is not able to cause direct damage to the environment, because it does not form any substances of carcinogenic, toxic or other harmful nature that affect the air, water bodies, humans, animals, vegetation or soil. Since this development concerns acting on flight simulator, there is an indirect damage to the environment:

- energy consumption;
- creation of electromagnetic fields;
- utilization of used parts and mechanisms.

Normative documents that regulate design on the topic of the diploma project:

1. ДСТУ 2420-94 Energy saving. Terms and definitions.
2. Р 50-081-2000 Energy saving. Methods for assessing the energy status of energy supply systems of industrial enterprises for their certification.
3. Ministry of Health of Ukraine dated 01.08.96 No. 239 STATE SAHITARY HORMS AND RULES OF PROTECTION OF POPULATION FROM THE INFLUENCE OF ELECTROMAGICAL RADIATORS.
4. ДСТУ В В.1.1-8: 2003 – Fire protection CABLE PASSES. FIRE RESISTANCE TEST METHOD.

5.1. The effect of electromagnetic radiation on humans

Electromagnetic field (electromagnetic radiation) occurs when free electrons move in a conductor. The transfer of electrical energy is accompanied by intense electromagnetic radiation. It has been scientifically proven that electromagnetic radiation has a more detrimental effect on the body of living beings than radiation.

The fact is that the radiation background has always been on our planet and at certain times its level was higher than in the Hernozone "Chernobyl". The level of the earth's electromagnetic field increases every year, which is associated with human activities. In the CIS (Commonwealth of Independent States), the total length of only 500-kV transmission line exceeds 20,000 km. (except for the transmission line-150 transmission line-300 transmission line-750). Power lines and some other power plants create electromagnetic fields of industrial frequencies (50 Hz) hundreds of times higher than the average level of natural fields. The field strength under the transmission line can reach tens of thousands of V/M. The greatest field strength is observed at the place of maximum sagging of wires, at the point of projection of extreme wires on the ground and five meters from it around the longitudinal axis of the route: for 330 kV transmission line - 3.5 - 5.0 kV/m, for transmission line - 500 kV - 7.6 - 8 kV/m, for transmission line-750 kV - 10.0 - 15.0 kV/m.

The negative effects of electromagnetic fields on humans or other components of ecosystems are directly proportional to the field strength and irradiation time. The adverse effect of the electromagnetic field generated by the transmission line is detected already at a field strength of 1000 V/m. In humans, the endocrine system, metabolic processes, functions of the brain and spinal cord, and others are disturbed.

To date, according to environmentalists and hygienists, it is known that all ranges of electromagnetic radiation have an impact on human health and performance and have long-term consequences. The effect of electromagnetic fields on humans due to their high prevalence is more dangerous than radiation. Electric fields of industrial frequency surround a person around the clock, thanks to radiation from wiring, lighting, household electrical and electronic appliances, power lines, etc. The energy load from electromagnetic radiation in industry and in everyday life is constantly increasing due to the rapid expansion of the network of sources of physical fields of electromagnetic nature, as well as with an increase in their capacity. A person is not able to physically feel the surrounding electromagnetic field, but it causes a decrease in its adaptive reserves, reduced immunity, efficiency, under its influence a person develops chronic fatigue syndrome, increases the risk of disease. The effects of electromagnetic radiation on children, adolescents, pregnant women and people with impaired health are especially dangerous.

5.1.1. Possible mechanisms of biological action of the electromagnetic field

The mechanism of action of electromagnetic radiation on living organisms has not yet been definitively deciphered. There are several hypotheses that explain the biological effects of the electromagnetic field. They are mainly reduced to the induction of currents in tissues and the direct action of the field at the cellular level, primarily with its effect on membrane structures. It is assumed that under the action of the electromagnetic field can change the rate of diffusion through biological membranes, the orientation and conformation of biological macromolecules, in addition, the state of the electronic structure of free radicals. Apparently, the mechanisms of biological action of the electromagnetic field are mainly non-specific and are associated with changes in the activity of regulatory systems of the body.

5.1.2. Influence of electromagnetic field on a cell

The target for initiating any adaptive effect, in the first place, are membranes, plasma and intracellular, limiting the various intracellular components. There is a high sensitivity of cell membranes to the action of various chemical and physical agents, in particular to radiation. Morphological and functional disorders of the membranes are detected almost immediately after irradiation and at very low doses. The change in the ionic composition that occurs in this case can initiate proliferative processes in the cell. In addition to changing the permeability of biological membranes and accelerating the active transport of sodium cations, under the influence of electromagnetic radiation is the activation of peroxidation of unsaturated fatty acids and the separation of oxidation and phosphorylation in mitochondria.

It is assumed that all these changes at the cellular level develop for the following reasons:

The electromagnetic field affects charged particles and currents, as a result of which the field energy at the cell level will convert into other types of energy. Atoms and molecules in an electric field are polarized. Polar molecules are oriented in the direction of propagation of the magnetic field. In electrolytes, which are liquid components of tissues, ionic currents occur after the action of an external field. The alternating electric field causes the heating of the tissues of living organisms both due to the variable polarization of the dielectric (tendons, cartilage, bones) and due to the appearance of conduction currents. The thermal effect is a consequence of the absorption of electromagnetic field energy. The greater the field strength and duration of action, the more pronounced these effects. To the value of J=10 MW/m, conventionally taken as the thermal threshold, excess heat is removed due to the thermoregulatory mechanism. In addition, the sensitivity of organs to overheating is determined by their structure. The most sensitive to overheating are the organs of vision, brain, kidneys, gallbladder and bladder.

5.1.3. Influence of electromagnetic field on the nervous system

The first experimental studies on the effects of electromagnetic fields on the nervous system were conducted in the Soviet Union. In the monographs of Professor Y. Kholodov published the results of his many years of research on the effects of electromagnetic and magnetic fields on the central nervous system. The presence of a direct action of the electromagnetic field on the brain, neuronal membrane, memory, conditioned reflex activity was established. Model experiments show the possibility of the influence of weak electromagnetic fields on the synthesis processes in nerve cells. There are clear changes in the impulses of cortical neurons, leading to a violation of the transmitted information in the more complex structures of the brain. R. Krutikov discovered that under the action of an electromagnetic field in the ultrahigh frequency range, short-term memory disorders can develop.

5.1.4. The effect of electromagnetic radiation on the immune system

Currently, sufficient data have been accumulated to indicate that the processes of immunogenesis are disrupted by the action of the electromagnetic field. It is established that under the influence of an electromagnetic field the character of infectious process changes, there are disturbances of a protein metabolism, decrease in the content of albumins and increase in gamma globulins in blood is observed. In addition, the electromagnetic field can act as an allergen or a trigger, causing severe reactions in patients with allergies in contact with the electromagnetic field.

5.1.5. Influence of weak electromagnetic fields on living organisms

Weak electromagnetic fields at an intensity less than the threshold of the thermal effect also affect changes in living tissue. Research on the biological effects of cell phones, computer units and other electronic devices has been conducted in a number of Russian research centers, including the Faculty of Biology of Moscow State University. The harmfulness of electronic means was tested both in the working and off state of the device, including without power supplies. The results of studies evaluating the effect of cell phones, computers and other modern electronic devices on various organisms, both in working and off state, were disappointing and showed their extremely negative impact on the state of biological objects, which was:

- in reducing the motor activity of microorganisms;
- in increasing the mortality of microorganisms;
- in the deterioration of tissue regeneration;
- in violation of embryonic and larval development;
- in the reduction of biochemical reactions, metabolic disorders;
- in reducing the energy potential of all vital
body systems.

5.2. Calculation of electricity consumption

The calculation of electricity consumption is determined depending on the power of the device (projected and base), the number of operating hours, taking into account the load factor, network losses and efficiency, and is carried out according to the formula:

$$\sum_{\mathrm{i}=1}^{n} W_{en} = \frac{\sum M_{yi} F_{af} K_{ie} K_{u}}{\eta K_{l}} \qquad (5.1)$$

where M_{yi} is total power of the designed and equipment (0.15kW) without backup equipment;

F_{af} is actual fund of time and equipment (5000);

K_{le} is load factor and equipment (0.90);

K_u is update factor (0.85);

η is the efficiency (0.85);

K_l is loss factor in networks (0.95).

$$\sum_{\mathrm{i}=1}^{n} W_{en} = \frac{0{,}15 \cdot 5000 \cdot 0{,}90 \cdot 0{,}85}{0{,}85 \cdot 0{,}95} = 794{,}118;$$

Depending on the task, it is possible to determine the consumption of electricity for lighting the i-th production site by the formula:

$$\sum_{\mathrm{i}=1}^{n} W_{\text{о}y} = \frac{\sum P_y F_{\mathrm{y}i} F_{l\mathrm{i}} \mathrm{K}}{1000} \qquad (5.2)$$

where P_y is the specific consumption of electricity per 1 м^2 (0.01 kW);

F_{yi} - the area of the i-th section;

F_{li} - the number of hours of lighting fixtures in 3-shift operation of the i-th shop (3100 hours);

K - loss ratio: (K = 1,05).

$$\sum_{\mathrm{i}=1}^{n} W_{\text{о}y} = \frac{0{,}01 \cdot 100 \cdot 3100 \cdot 1.05}{1000} = 3{,}255;$$

The total electricity consumption is determined by the formula:

$$W = \sum_{i=1}^{n} W_{\text{об}} + \sum_{i=1}^{n} W_{oy} \qquad (5.3)$$

Environmental damage caused to the environment is determined by the formula:

$$y_{el} = W\, y_{el}, \qquad (5.4)$$

where y_{el} is specific environmental damage 24.36cents/kWh.

$\sum_{i=1}^{n} y_{el} = (794{,}118 + 3{,}255) \cdot 0{,}2436 = 194{,}25$UAH.

As a result of the development, the possibility of erroneous measurements must be eliminated and thus air pollution as a result of emissions of harmful substances must be eliminated.

Initial data: total power of electrical equipment (without backup) - 0.15kW; The total ecological and economic damage caused to the natural environment during the project implementation is determined by the formula:

$$У_{ne} = \sum_{i=1}^{n} y_{el} \quad (5.5)$$

where $\sum_{i=1}^{n} У_{el}$ - the total damage caused to the natural environment from electricity consumption.

Thus, the total environmental and economic effect obtained as a result of the project will be $у_n$ = 194.25UAH.

CONCLUSIONS

This section discusses the effects of electromagnetic radiation on the human body, namely the effects of computers and other computer equipment. Also, the ecological and economic effect and some recommendations for further modernization, additional factors influencing the environment and measures to eliminate them:

1. Ecological and economic effect is approximately 194.25UAH per year (for the enterprise).

2. At the further modernization of development it is necessary to consider norms and norms of ecological safety.

3. When working with an electronic analyzer, it is necessary to take into account the effect of electromagnetic radiation on humans, as well as ergonomic features of work.

4. It is necessary to develop measures to ensure the neutralization of negative effects, or if possible, reduce the damage to the environment, namely:

- use of "clean" electricity - obtained from alternative sources;

- introduction of new technologies with a lower level of electromagnetic radiation and energy consumption, and with better technical characteristics;
- the use of waste-free technologies, which, although they do not completely eliminate environmental pollution, but can significantly reduce it.

CONCLUSIONS

The main role in aviation is to increase the safety of transportation. This can be achieved by analyzing current research methods and application in real practice. In psychology, such a science as the human factor is excellent. It reveals the full depth of pilot errors and the possible causes of their occurrence. By researching this science, you can understand how the human brain works in different conditions, ranging from changes in the weather to emotional burnout. Considered many different errors that can lead to a not very good situation.

The concept of loss of control is discussed, why it occurs, how to keep the steering wheel in such conditions. A delicate moment occurs when the plane pours into a stall. Then it remains a matter of minutes to align it. This is not easy. You need to skillfully and quickly approach the solution of this problem. Also considered is such a concept as divergence in perception. It is at such a moment that the pilot needs to pay attention not only to personal perceptions, but also to instrument instruments.

Various light and signal sensors help to understand what is happening and make decisions. They are working under an aid.

The only current method of working to improve the quality of piloting is more practice. As for piloting in critical, abnormal or dangerous situations, it is better to practice different situations on the simulator. Indeed, in flight, it is dangerous to turn off the engine like this just to understand how to proceed. Moreover, when it comes to the responsibility of hundreds of passengers.

This paper proposes a technique for improving the actions of the crew in cases when the avionics systems give out any failures or malfunctions. First of all, it is necessary to conduct a deep analysis of the previous actions of the crew members, to find out the technical problems, to analyze the data from the flight recorders, to follow the development of the aviation industry entirely.

Also, in the thesis, the flight data and schedules of the An-148 and An-26 aircraft were analyzed.

Calculations have been made and a histogram has been constructed according to the distribution law of the flight by the pilot's roll after the third turn. It is proposed to implement this analysis in the training system.

I think that this method can be applied in an airline environment, constantly improving the skills of the crew members. They will become more trained, and therefore more prepared for different situations. This will lead to much more improved aviation safety.

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