MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
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ADMIT TO DEFENSE

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GRADUATE WORK

(EXPLANATORY NOTE)

GRADUATE OF EDUCATIONAL AND QUALIFICATION LEVEL "MASTER"

Theme: «The trends in aircraft flight parameters under varying pilot factor loading**»**

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МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
Кафедраавіоніки

ДОПУСТИТИ ДО ЗАХИСТУ

Завідувач кафедри

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КВАЛІФІКАЦІЙНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСНИКА ОСВІТНЬО-КВАЛІФІКАЦІЙНОГО РІВНЯ

“МАГІСТР”

Тема:«Трендипараметрівпольотулітака при різному факторному навантаженніпілотів»

Виконавець: ____________________________________Сузанський Руслан

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Київ 2023

NATIONAL AVIATION UNIVERSITY

FacultyofAeronautics, ElectronicsandTelecommunications.

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TASK

Ruslan Suzanskyi

1. **The topicofthethesis:**“The trends in aircraft flight parameters under varying pilot factor loading”, approved by the rector's order from «05» October 2023 №2040/ст.

2. **The term of the work:** from 05.10.2023 to 01.12.2023.

3. **Initialdatafor work:**Methods and algorithms for assessing the quality characteristics of piloting techniques under factor loading. Programs and models of human factor consideration and training crews to fly in difficult conditions.

4. **Contentsoftheexplanatorynotes:** List of conditional terms and abbreviations; Introduction; Chapter 1:Analysis of the ergatic system in the control of an aircraft; Chapter 2: Human factor’s issue during landing approach; Chapter 3: development of methods and algorithms for assessing the quality characteristics of piloting techniques during landing approach under factor loadings; Chapter 4: Labour protection; Chapter 5: Environmental protection; References; Conclusions.

5. **A listofmandatorygraphicmaterial**: figures, charts, graphs.

6. Planned schedule

№ п/п	Task	Deadline	Performance note
1	Validate the rationale of masterswork theme		
2.	Carry out a literature review		
3	Develop the first chapter of diploma		
4.	Develop the second chapter of diploma		
5.	Develop the third chapter of diploma		
6.	Labour protection		
7.	Environmental protection		
8.	Tested for anti-plagiarism and obtaining a review of the diploma		
9.	Issuance of an explanatory note		

7. Consultantsfromindividualdepartments

Section	Consultant (post, Name)	Date, signature	
		Issuedthetask	I acceptedthetask
Labour protection			
Environmentalprotection			

8. Issuedateoftheassignment: «____» ____________ 2022.

Supervisorofthethesis ___________Y.V.Hryschenko

The task took to perform __________ R.D. Suzanskyi

ABSTRACT

Explanatory notes to magister work ‘The trends in aircraft flight parameters under varying pilot factor loading’ contained XX pages, 14 figures, 2 charts, 16 references.

Keywords:AIRCRAFT, HUMAN FACTORS, DIRECTOR MODE, ERGATIC SYSTEM, QUALITY CHARACTERISTIC, PILOTING TECHNIQUE, TREND ALGORITHMS, DYNAMIC STEREOTYPE, LANDING APPROACH, FACTOR LOADING.

Object of research –process of accessing parameters of piloting quality technique under factor loadings during landing approach.

Subject of research –assessment of piloting technique during landing approach under factor loadings in the airline.

Purpose of the master work – to systemize and improve the quality of piloting technique under factor loading, which is caused by human factor, during landing approach.

Research Method –trendalgorithms, coefficient strengthening, standard square deviation, methodofexpertevaluation, methodofexpertevaluation, algorithmofrelativedifferenceat a minimum.

Scientific novelty – proposed a methods, systems and algorithms for improving pilot technique.

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CONCLUSIONS

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LIST OF ABBREVIATIONS

ICAO - International Civil Aviation Organization;

HF – human factor;

SOME - operator - machine – environment;

AC – aircraft;

QPT – quality of piloting technique;

Human operator – HO;

CS – control system;

SPIs – safety performance indicators;

fNIRS – functional near-infrared spectroscopy;

EEG – Electroencephalogram;

DS – dynamic stereotype;

AC – aircraft;

IAAFP – phenomenon of the flight data amplitudeincrease;

FO – factor overlay;

CAS – complex aircraft simulator;

FOM – flight operation management;

IDDS – integro-differentiated dynamic stereotype;

INTRODUCTION

Actuality. Flight safety holds a crucial role in civil aviation.Understanding how pilot workload influences the flight parameters is important for designing aircraft systems and training programs that minimize the risk of accidents and incidents.

During the landing approach, piloting transitions to the director's mode or, in more challenging situations, the steering mode. The automation of the flight process is closely tied to the high reliability of avionics and other aircraft systems.

Despite the prevalence of automation, the International Civil Aviation Organization (ICAO) notes a concerning trend of increasing aviation accidents due to human factors. This rise is described to the growing complexity of crew operations, particularly during the challenging phase of landing approach in the director's mode.

The proficiency of piloting technique hinges on maintaining accurate flight parameters and executing timely and correct actions in adherence to the flight operations manual. Similarly, the quality of the landing approach is depended on pilot training technique.

In the realm of aviation, the verification of pilot information plays a main role in enhancing piloting safety. This involves analyzing piloting techniques, implementing systematic control, and evaluating the crew's professionalism. Various methods and algorithms for processing flight information facilitate these analyses.

Recognizing the escalating importance of automated flight, ICAO emphasizes the need to train pilots to proficiently operate aircraft in automated modes. Consequently, there is an emphasis on developing dynamic stereotypes during crew training to optimize pilot tasks.

However, despite training efforts, pilots encounter numerous external factors during task performance, intensifying human factors during flight. Therefore, onboard analysis systems are implemented to assess the quality of piloting techniques, providing an additional level of safety assurance.

Purpose of the work is tosystemize and improve the quality of piloting technique under factor loading, which is caused by human factor, during landing approach.

Following tasks should be done to achieve this purpose of the work:

1. Analysis of existing studies of the human factor in the context of piloting an aircraft;

2. Analysis of the influence of the human factor in the existing methods of pilot training;

3. Analysis of how pilot training on the simulator under the influence of factor loadings affects the quality of piloting technique;

4. Analysis of flight parameters under factor loadings;

5. Development of an automated system and algorithms to improve piloting techniques

Object of the researchare the parameters of piloting quality technique during landing approach.

Subject of the researchis theassessment of piloting techniqueduring landing approach in the airline.

Research Method:trendalgorithms, coefficient strengthening, standard square deviation, methodofexpertevaluation, methodofexpertevaluation, algorithmofrelativedifferenceat a minimum.

Scientific novelty – proposed a methods, systems and algorithms for improving pilot technique

CHAPTER 1: ANALYSIS OF THE ERGATIC SYSTEM IN THE CONTROL OF AN AIRCRAFT

1.1. Analysis of the concepts of the ergonomic and human factor

The human factor in civil aviation is a critical aspect that encompasses the study of how human performance, capabilities, and limitations impact the safety, efficiency, and overall operation of the aviation system.

This multifaceted field involves understanding and optimizing the interaction between individuals and various elements within the aviation environment, including aircraft, technology, procedures, and organizational structures.

We will analyze the concept of an ergatic system to understand the issue of flight parameters and understand how automatization doesn't tend to reduce the stress in real experiments.

Ergonomics, also known as human factors (HF) or human engineering, is the scientific discipline concerned with designing products, systems, and environments that are optimized to enhance human well-being and overall system performance.

The main goals of ergonomics are:

- Evaluating and designing workstations to ensure they are ergonomically sound, taking into consideration factors such as desk height, chair design, and the arrangement of tools and equipment to promote user comfort and productivity.
- Designing interfaces between humans and machines that are intuitive, user-friendly, and support efficient interactions. This involves considering the layout of controls, displays, and feedback mechanisms.

– Analyzing the tasks individuals perform in various environments to understand the physical and cognitive demands placed on them. This analysis informs the design of systems and processes to match the capabilities and limitations of the human operator.

– Applying ergonomic principles to the design of products to ensure they are comfortable, safe, and easy to use. This includes considerations for product shape, size, and controls.

– Providing training and education on ergonomic principles to individuals in various fields, including workers, designers, and managers. This helps create awareness and ensures that ergonomic considerations are integrated into everyday practices.

– Developing strategies to prevent musculoskeletal disorders and other work-related injuries by addressing factors such as repetitive movements, awkward postures, and excessive force during tasks.

– Considering cognitive aspects of human performance, such as memory, attention, and decision-making, in the design of systems and processes. This includes optimizing information presentation and reducing cognitive workload.

– Designing environments, both physical and digital, to promote user comfort and efficiency. This involves considerations for lighting, temperature, noise levels, and other environmental factors.

– Ensuring that designs are inclusive and accessible to a diverse population, including individuals with different abilities, sizes, and ages. This involves creating environments and products that can be used by a broad range of users.

– Continuously gathering feedback from users and evaluating the effectiveness of ergonomic interventions. This iterative process helps refine designs and ensure ongoing improvement.

– Integrating safety considerations into ergonomic design to minimize the risk of accidents and injuries. This includes addressing potential hazards and ensuring that emergency procedures are user-friendly.

Automatization gives high opportunities and convenience for flights.

However, it should be noted that there is no tendency to decrease the share of the human factor in aviation events.

In order to teach the pilot how to counteract FN, it is necessary to know the nature of the mechanism of enhanced reflected movements, which were considered for the first time in the work of the psychologist I.M. Sechenov "Reflexes of the brain" and in the scientific developments of E.M. Khokhlova, S.V. Korneeva, Yu.A. Khalafa and others.It follows,in the scientific school V.G. Denisov,that the object of ergonomics is a system operator - machine – environment (SOME).

The interaction between a system operator, machine, and environment is a fundamental concept in various domains, including engineering, human-computer interaction, and control systems.

A human operator refers to an individual who interacts with and controls a system, machine, or process. Human operators play a crucial role in various domains, including aviation, manufacturing, healthcare, transportation, and more. Their responsibilities often involve monitoring, decision-making, and taking actions to ensure the proper functioning of the system or process they are overseeing.

Characteristics and considerations related to human operators include:

– Control and Monitoring. Human operators are responsible for controlling and monitoring the operation of machines, systems, or processes. This may involve using interfaces, control panels, or other tools to input commands and receive feedback.

- Decision-Making. Operators are often required to make decisions based on the information available to them. This could include responding to unexpected events, handling emergencies, or adjusting the system to optimize performance.
- Training and Competence. Adequate training is crucial for human operators to perform their tasks effectively. Understanding the functionalities of the system, safety protocols, and potential issues helps ensure competent operation.
- Human Factors. Considerations related to human factors, including cognitive abilities, attention, perception, and physical capabilities, are important in designing systems that are user-friendly and support optimal operator performance.
- Human-Machine Interaction. The interaction between humans and machines, often referred to as human-machine interaction (HMI), is a critical aspect. Designing interfaces and controls that are intuitive and efficient contributes to smoother operation.
- Workload and Stress. Monitoring and controlling complex systems can be demanding. Managing workload and stress levels is essential to prevent fatigue and ensure that operators can maintain a high level of attentiveness and performance.
- Automation Integration. In many modern systems, automation plays a significant role. Human operators may work alongside automated processes, and their ability to understand and interact with automation effectively is crucial.
- Safety Protocols. Operators must be familiar with safety protocols and procedures to handle emergencies or abnormal situations. Training and regular drills contribute to preparedness in critical situations.

Themachine represents the technical system or equipment that the operatorinteracts with. This could be a computer, a manufacturing machine, an aircraft, or any other complex system that requires human control and monitoring.

Theenvironment encompasses the external factors and conditions in which the system operates. It includes physical surroundings, external inputs, and potential disturbances that can impact both the machine and the decisions made by the system operator.

1.2Analysis of stress and activities of operator in different situations

Normal conditions are conditions that occur over a long period of time under normal operating conditions of the ergatic system. Under normal circumstances, the human operator remains in a normal working condition, which is characterized by moderate changes in the physiological and psychological reactions of the body, behavior with stable and confident course performance.

During the flight, you may encounter the following situations:

- Special circumstances arising from the influence of certain adverse factors or a combination of them and leading to a threat or violation of the flight safety of the aircraft;

- Complications of flight conditions - characterized by a slight increase in the psychophysiological load of the crew and (or) a slight deterioration in flight characteristics, stability, and controllability of the aircraft, which can lead to the development of flight conditions.;

- A difficult situation - when a flight is accompanied by a significant increase in the psychophysiological load of the crew, a significant deterioration in flight characteristics, stability and controllability of the aircraft, one or more reasons for operational limitations.;

- An emergency situation is a special situation characterized by a significant increase in the psychophysiological load of the crew, a significant decrease in flight characteristics, stability and controllability of the aircraft, which leads to reaching or exceeding flight limits or conditions.:

- Catastrophic situations are special situations in which it is almost impossible to prevent the destruction of aircraft and loss of life.

Special situations in flight can have different consequences, depending on the factors that cause them. Such factors are the level of readiness of the crew to neutralize adverse events, flight modes, and environmental parameters. In other words, a special situation with the consequences of special flight conditions and the consequences of special cases that occur during flight.

Special flight conditions include:

- Flights in areas of icing, thunderstorms and heavy rains, strong vibrations, increased electrical activity of the atmosphere, wind shear, dust storms:

- Flights in mountainous or high-altitude areas, deserts and on the water surface:

- Flights in the polar regions of the northern and southern hemispheres of the Earth,

- Flights in difficult ornithological conditions.

Special cases in flight include:

- Aircraft collisions during dangerous weather events:

- Failure of the aircraft engine (aircraft engine);

- Failure of aircraft systems; this may lead to the need to change the flight plan, flight profile and emergency landing;

- Aircraft fire:

- Loss of stability, controllability, violation of the structural strength of the aircraft;

- Attack on the crew (passengers);

- Emergency landing outside the airfield;

- Injuries to crew members (passengers) or sudden deterioration of well-being,

- failure of radar air traffic control and radio equipment at landing airfields;;

- Radio communication failure (failure of on-board and ground radio communication systems);

- Loss of orientation.

Based on the above list of special cases in flight, the term "special case in flight" can be considered as a situation arising from an unexpected failure of an aircraft's functional system or exposure to conditions requiring the crew to act other than maneuvering in normal circumstances.

Stressful situations can be the result of other situations that arise in a state of serious deviations from the norm. The name of the situation is associated with the occurrence of the highest degree of tension-the stress-functional state of the operator to assess the situation as life-threatening to the operator or other people. 1. One of the main causes of stress for the operator is the thoughts that he has formed from the insurmountable complexity of the situation that has arisen, he considers himself dangerous and does not know how to get out of it. Stress can also be caused by other factors.The intensity and continuity of activity, which, in turn, causes great physiological and mental stress.The possibility of sudden special situations that pose a certain risk to work. Stress most often occurs when the operator is not equal to 1, but the set of factors for different people has different weights in different situations. It should be noted that stress is a very characteristic feature of flight work, and stressful situations are not exceptional events in the activities of flight personnel.

Flight work is one of the most complex human activities, and the effectiveness of the SOMS in aviation depends on a wide range of different conditions, uncharacteristic of most ergatic systems used on earth.

Flight work is a kind of camera work, it has its own characteristics, which include: work in unusual for people conditions of separation from the ground; fast movement in space: forced high speed and obligatory continuity of crew activity, which forces to adhere to the necessary rhythm of flight; combination of intense mental work with coordinated and precise movements: pronounced emotional nature of work; influence on the body of physical factors (acceleration, noise, vibration, atmospheric pressure drop, temperature fluctuations, etc.), which significantly affect the mental processes of man.

The pace of the pilot's activity on modern airplanes does not reach the limits of human capabilities, however, at some, the most difficult stages of the flight, he begins to approach them. This reduces the reserve of time, the reserve of psychophysiological capabilities of the human operator. Increasing the pace of activity requires greater automation of actions. increases the tension of attention, memory, thinking, sense of determination and adequacy of action in suddenly changing circumstances. The work of the pilot becomes mental, because during the flight he receives an extremely large flow of information, complex and diverse in nature, which he must analyze. The analysis and synthesis of this information at a strict time limit and the need for necessarily error-free and accurate actions have also significantly increased the burden on the human psyche.

Thus, in the flight of instruments, the idea of the spatial position of the aircraft is created by complex mental work: evaluation of aerobatic instruments, analysis and generalization of these indicators and mental translation (recoding) of information into a visual image.

Reading indicators of aviation devices is quite fast. The study of the change in the direction of the pilot's gaze with the help of filming showed that on average he moves his gaze behind the instruments 100-120 times per minute in flight. Moreover, in horizontal flight, when descending, gaining altitude and reversal - the main attention was paid to two devices that ensure compliance with the regime: the air horizon and variometer. About a third of the attention is on the air horizon and a third on the variometer is controlled by the pilot about 35 times per minute; 40% of the views of the transfer are from the horizon to the variometer and back. The rest of the attention is divided approximately equally into three mode control devices: speedometer, altimeter and compass, each of which is monitored 9-10 times per minute.The rest of the attention is divided approximately equally into three mode control devices: speedometer, altimeter and compass, each of which is monitored 9-10 times per minute.

1.3Analysis of existing methods of assessing the quality of piloting technique.

Analysisofthepilot'sactivityis a keystageintheunderstandingandimprovementofergaticaircraftcontrolsystem. Thisprocessinvolves a detailedstudyandevaluationofvariousaspectsofthepilot'sinteractionwithautomatedsystems, includingtechnologiesaffectingthepilot'spsychophysiologicalstateandperformance.

The implementation of ergatic aircraft control systems prompts the need for careful analysis and assessment of their effectiveness and impact on the human factor. There are several methods for conducting such an assessment, each of which interacts with different aspects of the use and interaction of ergative systems with the operator.

Expert assessment is an important stage in the analysis and improvement of ergatic aircraft control systems. During this process, highly qualified experts with deep professional experience in the field of aviation technology and psychophysiology determine the efficiency, safety and reliability of energy systems. Analyzing the processes of interaction with operators, experts assess the extent to which ergatic systems take into account the needs of pilots and contribute to their productivity. Important aspects of the assessment are also error prevention systems, ensuring comfort and naturalness of interaction, as well as studying the impact on the psychophysiological state of operators. The information obtained during the expert assessment serves as a foundation for further improvements and optimization of energy systems, contributing to the development of safer and more efficient technologies in aviation.

Psychophysiologicalmetricsor safety performance indicators (SPIs)playanimportantroleintheprocessofassessingandimproving ergaticaircraftcontrolsystems. Thesemetricsincludemeasurementsofvariousphysiologicalparametersthatreflectthe mentalandphysicalhealthofpilotswhenusingautomatedsystems. Expertstakepulserate, stresslevel, electroencephalogramandotherindicatorsintoaccounttoassesstheimpactofergativesystemsonthepsychophysiologicalstateofoperators.

Theanalysisofpsychophysiologicalmetricsallowstodetectemotionalandphysicalstressthatmayariseduetotheuseofnewtechnologies. Evaluatingreactionstodifferentscenariosandsituationshelpstodeterminehowwellthe ergativesystemscanadapttotheindividualcharacteristicsandneedsofthepilots.

Thisassessmentapproachprovides a comprehensiveviewoftheinteractionbetweentechnologyandhumanfactors, helpingtocreatemoreergonomicanduser-friendlyenergymanagementsystemsintheaviationindustry.

Several specific metrics are used to better understand the impact of technology on the human body.

- Measurement of galvanic skin. Recording the electrical conductivity of the skin, which can indicate the level of arousal and emotional state of the pilot.

- Rating of Recorded Electrodermal Feedback. Analysis of changes in electrodermal activity to determine the level of excitement and stress response.
- Measurement of Brain Oxygenation. Using technologies such as functional near-infrared spectroscopy (fNIRS) to measure oxygenation levels in the brain, which provides information about cognitive processes.
- Positioning and Movement. Using sensors to track the pilot's body movements and position, which can indicate comfort and fatigue levels.
- Electroencephalogram (EEG). Measurement of the electrical activity of the brain to assess the level of attention, concentration, and degree of fatigue.

It is also important to mention the rudder as a metric for assessingergatic systems. It is not only a physical object, but also an interface through which the pilot interacts with the automated control system. Assessment of how comfortable and natural the pilot can interact with the rudder, in particular, how easily he can control the aircraft in various flight modes.Consideration of the possibilities of built-in sensors in the rudder that can detect some aspects of the pilot's physical and psychological state of fatigue or stress.

Using SPIs on rudder can indicate the force a pilot applies to it during stressful situations. Changes in strength may indicate increased stress and the need for more physical support.A prolonged clamp may indicate continued stress or an inability to quickly adapt to the situation.Investigating how well the rudder and ergatic systems respond to clamping and whether they provide feedback that can help the pilot control the situation and analysis of the relationship between steering wheel clamp and other psychophysiological metrics such as heart rate, stress level, and electroencephalogram.

1.4. Analysis of existing methods of anti-stress training of pilots

Currently, the share of air accidents related to the human factor (HF) is 80-90%. However, such events are unlikely by their nature. Historically, the transition from one state-owned company to a dozen private companies has not led to their interest in solving this problem. Despite the emerging problems, work is currently underway to reduce the frequency of accidents on the part of human factor.

The main goal of anti-stress training is to reduce the risks associated with training operators to work with factor overloads(FO) and to create optimal aircraft control systems from the point of view of ergonomics.

Analyzing the changes in the integer-differentiated dynamic stereotype of the pilot (IDDS), it is possible to conclude that the negative influence of the factor load affects the quality of the piloting technique. This is done to increase the amplitude of the flight parameters beyond the limits set by the flight manual. Stress caused by factor loads also leads to erroneous actions. In our case, we solve the boarding procedure at the airline. At the same time, the crew in most cases must follow the course of landing and landing drift, which is determined by electronic systems of ground aviation. Under these conditions, changes in many aircraft control parameters are ergodic and stationary in nature.

Requirements and limitations and for increasing the accuracy of the quality of piloting technique (QPT) assessment on CAS:

1. Compare identity changes with both your own and your ideal identity.

2. Compare crew QPT by changing IDD on the same fault block.

3. We need an automated system for collecting and storing information.

4. Provide integer-differentiated dynamic stereotype data to instructor pilots in a convenient format for analysis.

5. We need an automated system for collecting and storing information.

The quality of the maneuvering technology is determined by the accuracy of the flight parameters and the timely and correct actions of the crew in accordance with the flight operation manual. The final stage of landing (landing) depends on the quality of the entrance to the glide path.

The factor overlay is a simultaneous action on the pilot of 2 or more negative factors, which can be a simultaneous failure of the equipment operating within 1 period of time.

In the course of flight training, the pilot acquires and integrates certain flying skills in various special situations. The complex simulator of the aircraft simulates the behavior of the aircraft under dysfunction, bad weather, fire, and various combinations of them. The pilot has successfully mastered the appropriate behavioral algorithms, and this seems to limit the training process.

The main task of anti-stress training is to reduce the risks associated with the training of the operator, to counteract the factor overlays, to establish optimal from the point of view of ergonomic aircraft control systems.

However, in practice, while the pilot makes the wrong decision, the flight parameters exceed the limits set by the management of the flight operation of the aircraft (AC) In some cases the console touched the wings on the ground, which led to the destruction of the aircraft.

In civil aviation, flight information processing plays an important role in improving the safety of air transport. Since flight information is the only objective source of information about the activities of the crew in flight, systematic monitoring and evaluation of the flight activities of the crew based on the processing of flight information provides a significant increase in the level of professional training of the crew.

Improving the organization of flight work on the basis of objective control means provides for systematic monitoring of each flight performed, the identification and systematization of violations by the crew and the development of effective measures to increase the level of safety.

The flight information processing device is designed to process the flight information accumulated by the flight recorder.

Express analysis is the main type of information processing used in civil aviation and provides an objective analysis of flight information recorded by the in-flight Flight Information Collection Tool (BFSPI), which enters a high-speed analysis program, comparing the flight parameters recorded in the carrier (or a combination thereof) with the allowable values formed in the memory of the device. The system includes "Maneuvering Technology Control" and "Aeronautical Equipment Performance control".

Comparison of flight parameters with acceptable ones is carried out in accordance with special algorithms, instructions for the technical operation of systems and equipment and other regulatory documents.The algorithm is a mathematical and logical expression that establishes the flight mode of the aircraft and implements the requirements and recommendations for the operation of systems and equipment, the behavior of the crew at different stages of flight and other documents in different situations. It's a good idea. When compiling the algorithm, the constants contained in them are introduced, taking into account the tolerance of errors in the measurement and processing of flight information.

For each aircraft, the algorithm is summarized in the message catalog, including the regulatory document used to compile the algorithm, its symbolic record, the symbol of the message issued in the Express analysis form in the event of an algorithm failure (the logical variable exceeds the allowable limit recommended by the regulatory document), and the symbol of the message issued in the express analysis form (the logical variable exceeds the allowable limit recommended by the regulatory document). It provides additional information that explains the use of the algorithm.

The algorithm is compiled and adjusted only with the knowledge and permission of the general designer of the aircraft.

The result of the express analysis of flight information is a special form that displays, in addition to service information about the flight number, aircraft and flight date, the number of messages about violations of flight modes, breakdowns, malfunctions of aircraft equipment, the start and end times of events, the extreme physical value of the determining parameters in the course of the violation, or its maximum and minimum values. To verify and clarify the reliability of the violation reports that appear in the fast analysis form, data for the physical or code values of the parameters are displayed in the summary graph.

In secondary automatic processing, special programs are used in which, as a rule, calculation methods are implemented to determine the spatial trajectory of the aircraft, the failure of systems and equipment, the technical state and resources of units, systems and equipment, statistical characteristics for assessing the strength and reliability of aircraft elements.

The main disadvantages of the flight information processing systems that have been used so far are high labor intensity and processing period.

The need for subsequent manual processing of the results obtained is due to the fact that special software does not use methods of statistical processing of flight parameters, as a result of which the output information has low reliability. Of all the messages issued about the event of flight parameters exceeding the permissible values, a significant part turned out to be false. Before transferring information to the flight or aeronautical engineering service, all messages about flight events are checked manually according to the schedule for changing flight parameters, and incorrect reports are canceled. In addition, the information provided by the express analysis program is not enough to evaluate the maneuvering technique. The guide document obliges the calculation and analysis group to fill out, on the basis of the results of the interpretation, a table of actual indicators of the maneuvering technique, including the values of flight parameters at the characteristic points of the trajectory of the aircraft.

Therefore, with the help of the flight information processing system, automatic processing of flight information is not carried out and is mixed with a fairly large percentage of manual labor. In addition, modern methods of statistical analysis of the results of the processing of flight information are not used to predict the indicators of flight performance, condition and reliability of the crew.

1.5. Special cases oncomplex aircraft simulator (CAS).

A simulator is a model of a real object, designed to develop the skills needed by a human operator to work with this object in real conditions or to teach certain functions, such as tracking.

Unlike sophisticated simulators, conventional simulators are not designed to accurately simulate the specific system the operator is working on. He applies only those models that are necessary to increase the functional capabilities of a person for a certain type of activity. Analysis of the operator's performance shows that there are people who work effectively under normal conditions and really use their knowledge, skills and abilities well, but in an emergency situation they get confused and do not quickly take appropriate measures to eliminate accidents, but make serious mistakes or completely exclude positive actions. to normalize the situation. Taking this into account, it is very important to determine the behavior of the operator in such a situation, to choose only the appropriate person in this matter and to ensure professional training.

Western specialists should note that the method of pilot training in KTL is based on the concept of system processes (input–process–conclusion).

Despite the existence of scientific disciplines, such as operations research and system analysis, there is still no generalized methodology for evaluating the effectiveness of the training process on the simulator, except for the evaluation of economic efficiency.

It is very important to study the relationship between flight safety and the influence of the factor deck. Both sequential action and simultaneous interaction of factors.

The peculiarity of this relationship lies in the fact that the criterion for the effectiveness of the simulator training for the management of countermeasures and anti-aircraft pilots is the method of factor overlay, taking into account multifactorial influence.

Therefore, we must teach the operator not only to act, but also to react in special flight situations. It should be noted that the widely popular Isao SHEL program does not apply this principle.

According to ICAO, about 80-90 percent of disasters are caused by the human factor. The situation in civil aviation has not changed recently, and this indicator remains at the previous level. Consider Isao's approach to solve this problem.

The human factor is involved in most plane accidents and incidents, as evidenced by recorded data from plane crash investigations dating back to the 1940s. Accident investigation reports are often clear about what happened and, but often do not explain exactly how or why the incident happened.Attempts to recognize, analyze, and understand the problems underlying a particular event that led to disruptions in a person's work and thus to such an event are sometimes inconsistent. When they claim that the pilot did not follow the rules of operation, they mean that these rules are properly justified, and their implementation should ensure the necessary safety. As a result, investigative reports often limit the findings to phrases such as "pilot error," "failed to notice and take action," "improper use of controls," or "failed to follow prescribed standard operating procedures (SOPs)." This narrow approach is nothing more than one of the many obstacles to effective human impact research. This narrow approach is only one of many obstacles to effective human factor research.

If an event is linked and interacts in a way that leads to a disaster, the Air Accidents Investigation Branch must ensure that all elements of the complex system are investigated to understand why the event occurred.

In chapter 1 of Annex 13 of ICAO an aviation event is defined as an event related to the use of an aircraft that occurs from the moment any person boards the aircraft with the intention of taking flight until the moment when all persons on board have left the aircraft, and during which any person receives bodily injury resulting in death or serious bodily injury, the aircraft is damaged or its structure is destroyed, or the aircraft but he disappears without a trace and appears in such a place where access to him is absolutely impossible.

An incident is an event, other than an aviation incident, related to the use of an aircraft that affects or may affect the safety of operations.

There are many different approaches that help researchers to recognize the positive and negative factors in crashes and accidents, such as Reason's model.

In addition to the model, a conceptually new "SHEL" model is used to facilitate the data collection task. This 1972 model SHEL was originally developed by Professor E. Edwards and was later developedby F.Hawkins (Fig. 1.1).

In this model, matching or mismatching block boundaries (interfaces) are as important as the properties of the block itself. Boundary inconsistencies can be the cause of human error.

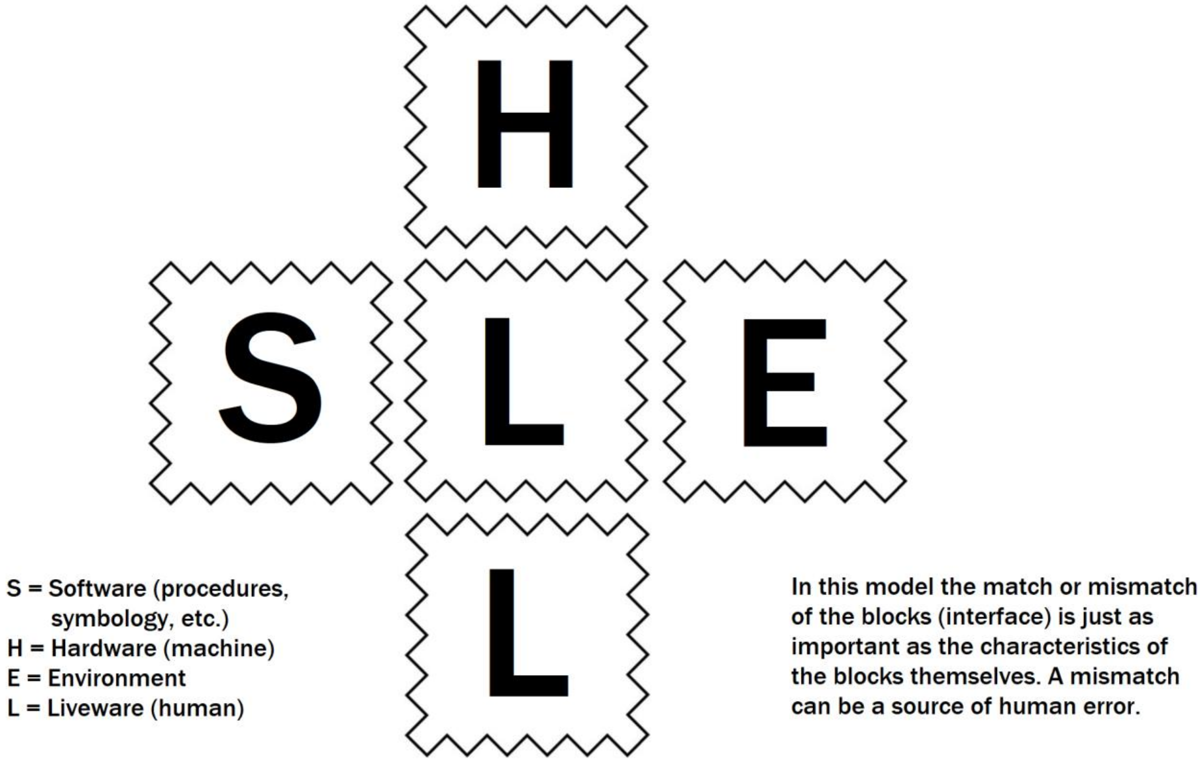

Fig. 1.1 The SHEL model

ThismodelisanextendedversionoftheMan·Machine·Environmentmodelofthe ICAOAviationAccidentPreventionGuidelines (Doc9422). The SHEL modeldemonstratestheimportanceofoptimizingoperatorinteractionandprocessingthe receivedinformation.

Eachcomponentofthe SHELL modelrepresentsoneofthemainprinciplesofhumanfactorsresearch. Thesubjectorhumanelement, isthecoreofthemodelandrepresentsitsmostimportantandflexiblebuildingblocks. Butithasitsflawsandcanbealmostpredictableinmostcases.

Thecentralhumancomponentdoesnotactbyitself, butinteractswithalltheotherelementsin a uniqueway. Theboundariesofhumanblocksaresimpleandunequal, sothenextblockmustbecarefullyadjustedtopreventtensionandpossibleconfusion (events).

Whenconsideringissuesrelatedtothehumanfactor, thelinebetweenwhatappliestoitandwhatdoesnotapplytoitisoftenblurred. Datathatatfirstseemedtohavenothingtodowitheventscanturnouttobeveryimportantaft erestablishing a connectionbetween a particulareventorfactor. Toestablishthedegreeofsignificanceoftheinformationobtainedduringtheresearch, ofcourse, commonsenseisnecessary.

Informationrelatingtoaviationaccidentscanbeobtainedfromseveraldifferentso urces. Themainsourcesdirectlyrelatedtotheproblemofhumanfactorsareequipmentdata, documents, voiceandflightrecorders, interviewswithwitnesses, directmonitoringoftheactionsofaviationpersonnelandsimulationofthesituation. Auxiliarysourcesincludedatabasesonaviationevents, directories, specialists, specialistsinthefieldofhumanfactors. Thecollectionofinformationonthehumanfactorrelatedto

For a specificeventorincident, theresearcherbeginsitsanalysis. Inmostcases, theresearcherswereabletoanalyzedatathatcouldbemappedtohumanfactors, suchasthemuscleeffortrequiredtomovethesteeringcolumn, thelightingrequiredtoreadthedisplay, aswellastherequiredtemperaturecharacteristicsandpressurereadings. Unfortunately, mostofthekeycomponentsofhumanfactorsarenoteasilymeasuredandthereforenotfull ypredictable. in

As a result, thelargeamountofinformationaboutthehumanfactorpreventsresearchersfromdrawing indisputableconclusions. Afterthecollectionandanalysisofrelevantdataiscomplete, thepersoninvolvedintheinvestigationofthecasemustpreparеaninvestigationreport.

AccordingtotheprovisionsoftheIsaoguidelinesforthepreventionofaviationacci dents, preventivemeasuresintheeventofsucheventsshouldbeaimedateliminatingallhazardsi ntheaviationsystem, regardlessoftheirorigin. Annex 13 ofthe ICAOguidelinesplacesconsiderableemphasisonsuchmeasures. Recommendation 7.1. Itsays: "atanystageoftheinvestigationofaviationaccidentsandincidents, wherevertheyoccur, thecompetentauthoritiesfortheinvestigationofaviationaccidentsinthecountryconductingtheinvestigationmusturgentlyrecommendtotherelevantauthorities, includinginotherstates, allpreventivemeasures , whichmustbetakentopreventsimilarevents."

Section 4 ofthe ICAOAviationAccidentInvestigationGuidelinesforAviationSafetyGuidelinesstatesthat "theultimategoalof a trulyeffectiveinvestigationistodeterminethelevelofaviationsafety, whethertoinclude, andwhereappropriate, theaviationsafetyguidelinesdesignedtopreventaviationaccidents." asanintegralpartofthereportorsubmittedseparately (dependingontheproceduresadoptedbythestate). "Itisworthnotingthatthemostimportantthingistoincreasethelevelofproductquality. Tothisend, recommendationsshouldbemadegenerallyoronanadhocbasis, takingintoaccounttheproblemsarisingfromtheinvestigation, whetherdirectlyrelatedtocausalfactorsorcausedbyotherfactorsidentifiedduringtheinvestigation."

CONCLUSION TO CHAPTER 1

Further conclusions can be drawn from the first chapter:

An analysis of the literature and methods of evaluating the energetic aircraft control system was carried out. Here, such concepts as the erratic system and how subjective control affects the process of controlling the aircraft were analyzed according to the analyzed literature.

It was stated that the anti-stress training algorithm should be included in the pilot training course.

It was analyzed that in practical terms the invariance of the "man-machine" system makes it possible to determine the invariant properties and characteristics of the human operator based on machine outputs without placing contact and non-contact psychophysiological sensors.

CHAPTER 2: HUMAN FACTOR'S ISSUE DURING LANDING APPROACH

2.1. Aircraft accidents and incidents analysis

As it was mentioned before, the percentage of air accidents related to the human factor (HF) is dominating. But let's analyze the statistics about aircraft flightsaccidents and incidents records

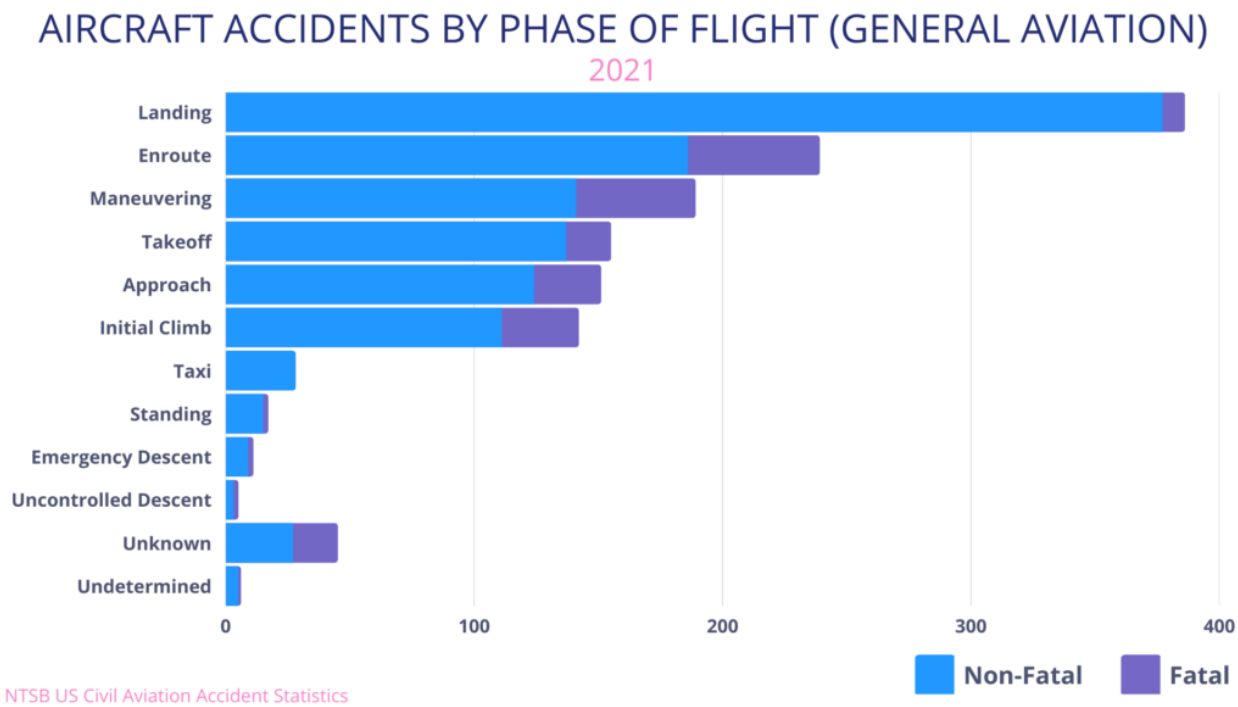

Fig. 2.1. AC accidents by phase of flight

Analyzing this statistic of AC accidents by NTSB US Civil Aviation Statistics, we can make a conclusion that the largest number of errors by pilots were committed during the approach to landing.

If we look a closer at the statistics for 2021, the most common type of pilot-related accident occurs during landing, accounting for 47% of all accidents. Fortunately, 99% of them are not fatal, but they still lead to aircraft damage, erosion of trust and increased premiums for the aviation community. October, the frequency of these events is Decaying, and these so-called "fender benders" should not be ignored.

Landing accidents are often accompanied by loss of control, such as runway trips and ground loops. It is not surprising that tailwheel aircraft have a higher representation in this category.

The second most common cause of landing accidents is a stalling, and this is followed by a violent descent. Very few accidents occur due to short runways or contaminated runways.

These may seem like common scenarios, but that's exactly what makes them dangerous. Since these accidents are the most frequent, improving landing skills should be the first priority. Flying a slow flight, maintaining a consistent airspeed during final approach, knowing when to get around and staying up to date on a regular flight are important to prevent accidents. This is especially important for tailwheel airplane pilots, because many accidents involve too little wind gust or skilled pilots trying to land on unfamiliar runways.

The second leading cause of pilot-related accidents is descent and approach. Stall/spit accidents lead to the deadliest accidents, but it is worth noting that there are more stall accidents during the take-off and climbing stages than during landing and approach.

Collisions cause the majority of accidents at this stage and are a reminder that it is important to follow standard procedures and maintain situational awareness when entering the pattern at uncontrolled airports.

Pilots in the general aviation category often overlook important procedures, such as the use of standard phrases in the cockpit and on the radio. In addition, the implementation of standardized procedures, such as traffic model entries, should not be dismissed asredundant.

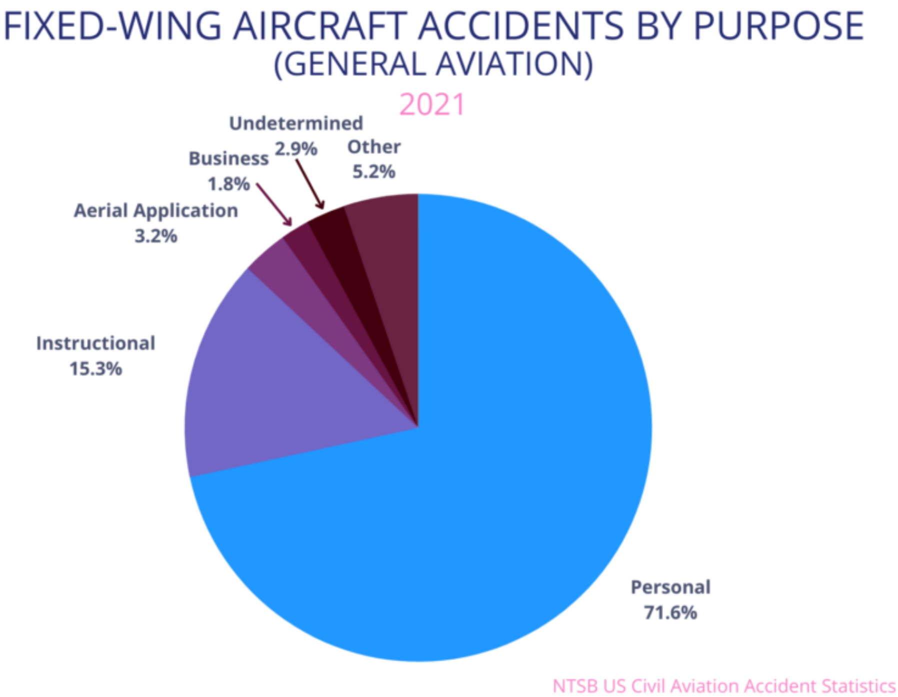

Fig. 2.2. Fixed-wing AC accidents by purpose

Often overlooked general aviation statistics are statistics of aircraft accidents by purpose. The data shows that, as expected, most of the common air accidents are personal flights, followed by training.

KNKT, an Indonesian aviation accident investigator, has released its final report on the 2021/1 crash of the Sriwijaya Airlines Boeing 737, where 62 people died. Investigators determined that the fatal incident was caused by a faulty automatic throttle system that was not properly monitored by the pilots. The Boeing 737-500 aircraft registered to PK-CLC made its last flight on 9 January, 2022. The plane was scheduled to fly from Jakarta's Soekarno Hatta International

Airport (CGK) to Pontianak's Spadio International Airport with 62 passengers, including two pilots, four cabin crew, 50 passengers and six crew members. However, it suddenly lost altitude and the jet dropped 10,000 feet in 1 minute while flying over the Java sea sky near Lake Island. The crew did not declare a state of emergency and did not report any technical problems before the Boeing 737 disappeared from radar.

The investigation found that during a crash flight, the pilot should have had enough time to monitor the asymmetry of the thrust lever and be able to recognize the deviation of the flight path, but the pilot did not identify the flight anomaly before turning into an upset situation.

As out of all commercial fatal accidents from 1950s to 2010s about 23% were caused by a pilot error (improper procedure, flying VFR into IFR conditions, controlled flight into terrain, descending below minima, spatial disorientation, premature descent, excessive landing speed, missed runway, fuel starvation, navigation error, wrong runway take-off/landing, midair collision caused by primary pilot) (table 2.1-2.2).

CAUSES OF FATAL ACCIDENTS BY DECADE								
DECADE	1950s	1960s	1970s	1980s	1990s	2000s	2010s	All
Pilot Error	50%	53%	49%	42%	49%	50%	57%	49%
Mechanical	26%	27%	19%	22%	22%	23%	21%	23%
Weather	15%	7%	10%	14%	7%	8%	10%	10%
Sabotage	4%	4%	9%	12%	8%	9%	8%	8%
Other	5%	9%	13%	10%	14%	10%	4%	10%

RAW DATA								
Cause	1950s	1960s	1970s	1980s	1990s	2000s	2010s	All
Pilot Error	82	119	112	67	77	48	28	533
Mechanical	43	62	45	36	35	22	10	253
Weather	25	15	22	22	10	8	5	107
Sabotage	6	9	20	20	13	9	4	81
Other	9	21	31	16	22	10	2	111
	165	226	230	161	157	97	49	1,085

Table 2.1.-2.2. 2 Fatal accident data throughout the decades provided by http://www.planecrashinfo.com/

As we can see, most of the tragic plane crashes occur due to the inability of the pilot to react to stressful situations that arise during the flight. The most difficult such stage is the descent to the approach, where, unfortunately, fatal incidents most often occur. Therefore, new methods of anti-stress training of pilots in various cases of flight should be developed and improved

2.2. The impact of a dynamic stereotype

In the previous parts, the relationship between the presence or absence of the pilot's slow reflex movement (presence or absence of response to factor overlays) and the extent of ds changes during flight behavior and the absence of FO was analyzed and proved.

This research is aimed at carrying out a qualitative and quantitative analysis of the changes in the dynamic stereotype when the pilot gets into an extreme flight situation, i.e. Confirmation that there have been quantitative changes in DS is that, in fact, IAAFP that the qualitative aspect has not changed. As already mentioned above, the main research is performed at the entrance to the glissade.

In a fully formed DS, the control of consciousness always remains in a normal working state. However, as research has shown, under the influence of factor loading, some operators experience the phenomenon of increased amplitude, which consists in increasing the amplitude of control movements while preserving their overall structure. FN refers to the simultaneous influence of 2 or more negative factors, in contrast to the orthogonal factor charge. In addition, operational actions become meaningless, learned actions may be performed, leading to confusion or wrong actions, and wrong decisions are made.

By introducing complex obstacles into the simulator, modeling the effects of factor coatings creates great opportunities for pilots and other crew members to fly in extreme situations. About 70% of pilots do not have resistance to FO, and these same pilots demonstrate the phenomenon of DS IAAFP increase. This is already negative due to the increase in the amplitude of the control movement, which the operator, as a rule, does not notice. In addition, from this, the IAAFP indicates that the pilot has entered the reflex movement zone, indicating that he is not opposed to fn. All of the above indicates that the negative consequences of this phenomenon can lead to flight accidents.

The zone of reflex movements refers to the area of human operator behavior from the point of view of time management and operating room, and his actions and movements under the influence of adverse factors (or for other reasons) are not controlled by the higher departments of the cerebral cortex. thus, when the pilot is in extreme conditions. In a flight situation, he is in a state of performing incorrect (wrong) actions and disproportionate movements.

There are complex methods of determining the psychophysiological stress of the operator by determining pinching and increased pressure for control or emotional stress using the heart rate, sound signal parameters or electrical conductivity of the operator's skin.

However, they do not provide insight into changes in the quality of maneuvering techniques or data on the functional state of the brain using brain waves.

In the simulator of the action of FO in flight and in the failure of complex avionics in pilots who do not know how to counteract them, IAAFP appear, which are manifested in an increase in the amplitude of control movements while preserving their general structure. To calculate the degree of strengthening of dynamic stereotypes in flight, it is necessary to compare the dynamic stereotypes of pilots under the influence of factor slopes and under normal conditions (on simulators without complex failures). It is easiest to compare the maximum and minimum deviation of the flight without factor coverage by setting a certain limit of the minimum deviation. The DS of the "double" flight operator is preserved and can only be improved, so that the maximum and minimum values of the selected parameters correspond to the normal DS and extended DS. Thus, it is possible to quantitatively analyze qualitative changes in the psychophysiological state of the pilot. Of course, pilots with different experience (which is confirmed by statistics) do not always have different IAAFP rating indicators. However, the primary benefit of training pilots to counter factor duplication by eliminating IAAFP is the accuracy of measuring deviations and counting factors, rather than a flight performance evaluation method, simply by eliminating the negative effect of IAAFP and demonstrating the countermeasure to the FO pilot. The general physiognomy of movement is preserved during IAAFP, therefore the maximum and minimum amplitudes of changes in the flight parameters of the machine correspond to each other when flying with FO and without it.

When comparing multiple flights, it is necessary to determine both qualitative and quantitative changes in ds using stochastic and statistical methods. For example, use autocorrelation function analysis to detect both

Qualitative and quantitative changes in DS. We recommend using a trend algorithm program to calculate quantitative changes in ds. Using mathematical methods describing DS, it is possible to analyze the flights.

In addition, operational actions may become unclear to the crew, memorized operations may be performed, which will lead to confusion and incorrect actions, as a

2.3. The phenomenon of increasing amplitude of the parameters of the flight of an aircraft (IAAFP) when preparing pilots for flights in special cases.

During flight training, pilots acquire and integrate certain flight skills in various specific situations. The complexaircraftsimulator (CAS) simulates the aircraft's behavior in the event of functional failure, bad weather, fire and various combinations in another words – factor overloads. Pilots successfully master the appropriate algorithm of actions, and this should limit the training process.

However, in practice, when the pilot made the wrong decision, the flight parameters exceeded the limits set by the flight operation management (FOM) of aircraft, in some cases the wing console touched the ground, resulting in the destruction of the aircraft.

Under normal conditions, the pilot copes with flight duties, no one can control him without passing regulatory training and certification. Thus, the result shows that the existing methodology of training pilots for flights in special situations is not enough. Such methods are based on different actions, that is, on the theory of "stimulus reactions" and the principle of their correspondence to different types.

CONCLUSION TO CHAPTER 2

The following conclusions can be drawn from this chapter:

It is shown that the flight crew must be prepared for adequate actions in the event of factor overlays. It is impossible to work out all situations at KTL. The occurrence of simultaneously acting negative factors is unlikely, as is the occurrence of aviation events related to the human factor.

The model of action and counteraction is aimed at limiting the area of error existence by normal (non-accident) flights and introducing training in the skills of suppressing heightened conditioned reflexes for flights in conditions of suddenness and surprise. This is the theoretical basis and logical premise.

Psychophysiological sensors about the characteristics of the human operator mainly carry information that is mathematically described by the general theory of oscillations. The oscillatory nature of the output characteristics of the human operator allows us to conclude for tracking systems that the machine outputs of the systems are invariant in relation to the input characteristics of the system, if a human operator works at the input of such a system.

CHAPTER 3: DEVELOPMENT OF METHODS AND ALGORITHMS FOR ASSESSING THE QUALITY CHARACTERISTICS OF PILOTING TECHNIQUES DURING LANDING APPROACH UNDER FACTOR LOADINGS

3.1 Experimental data on the evaluation of the effectiveness of the training of pilots on the CTS according to the counteraction criterion.

Thuman operator makes inappropriate movements and erroneous actions during the action of HF. This is primarily legitimate for those types of operator activity when a person has a well-established DS. An increase in the flow of comments indicates that the pilot has entered the zone of enhanced displayed movements.

1. Action indicator:

$$O_{Д} = \frac{N_{"5"}}{N_{O_{Б}}}$$

2. Resistance index:

$$O_{ПД} = \frac{N_{З\gamma}}{N_{OЗ}},$$

where $O_{Д}$ - rating according to the five-point system, $O_{ПД}$ - rating according to the instructor's remark flow, $N_{"5"}$ - the number of excellent ratings of the pilots by the instructor, $N_{З\gamma}$ - the number of the instructor's remarks on the roll, $N_{OБ}$ - the total number of ratings, N_{O3} - the total number of the instructor's remarks.

It should be noted that in those detachments where the instructors, despite the existing crew training programs, give comprehensive refusals and monitor the flow of remarks, the state of flight safety is much higher.

3.2.The flight information processing device for analyzing flight parameters

The quality of piloting equipment is determined by the accuracy of flight parameters and timely and correct actions of the crew according to the flight operations manual. The final stage of landing (landing) depends on the quality of the entrance to the glide path.

However, in practice, we are often faced with the fact that pilots make the wrong decisions, while the flight parameters are beyond the limits set by the management of the flight operations of the aircraft (aircraft). There were also cases when the console touched the wing of the ground, which led to the destruction of aircraft.

The flight information processing device is designed to process flight information accumulated by flight recorders (fig 3.1).

Express analysis is the main type of information processing used in civil aviation, recorded by on-board flight information collection tools, which provides an objective analysis of flight information, which provides an objective analysis of flight information. It is carried out by comparing the flight parameters (or their combinations) recorded on the carrier with the permissible values formed in the device's memory, by entering the express analysis program. Express analysis programs include the subprograms "Piloting technique control" and "Aviation technique performance control".

The result of the express analysis of flight information is a special form, which, in addition to service information about the flight number, aircraft, flight date, displays the numbers of messages about violations of flight modes, failures, malfunctions of aviation equipment, start and end times of the event, the extreme physical value of the determining parameter in the process of violation or its maximum and minimum values.

Thus, with the help of flight information processing systems, not automated processing of flight information is carried out, but mixed with a fairly large proportion of manual labor. In addition, modern methods of statistical analysis of the results of processing flight information are not used to predict the indicators of flight performance of the crew, condition and reliability.

The information provided by the express analysis program is not enough to evaluate the piloting technique.

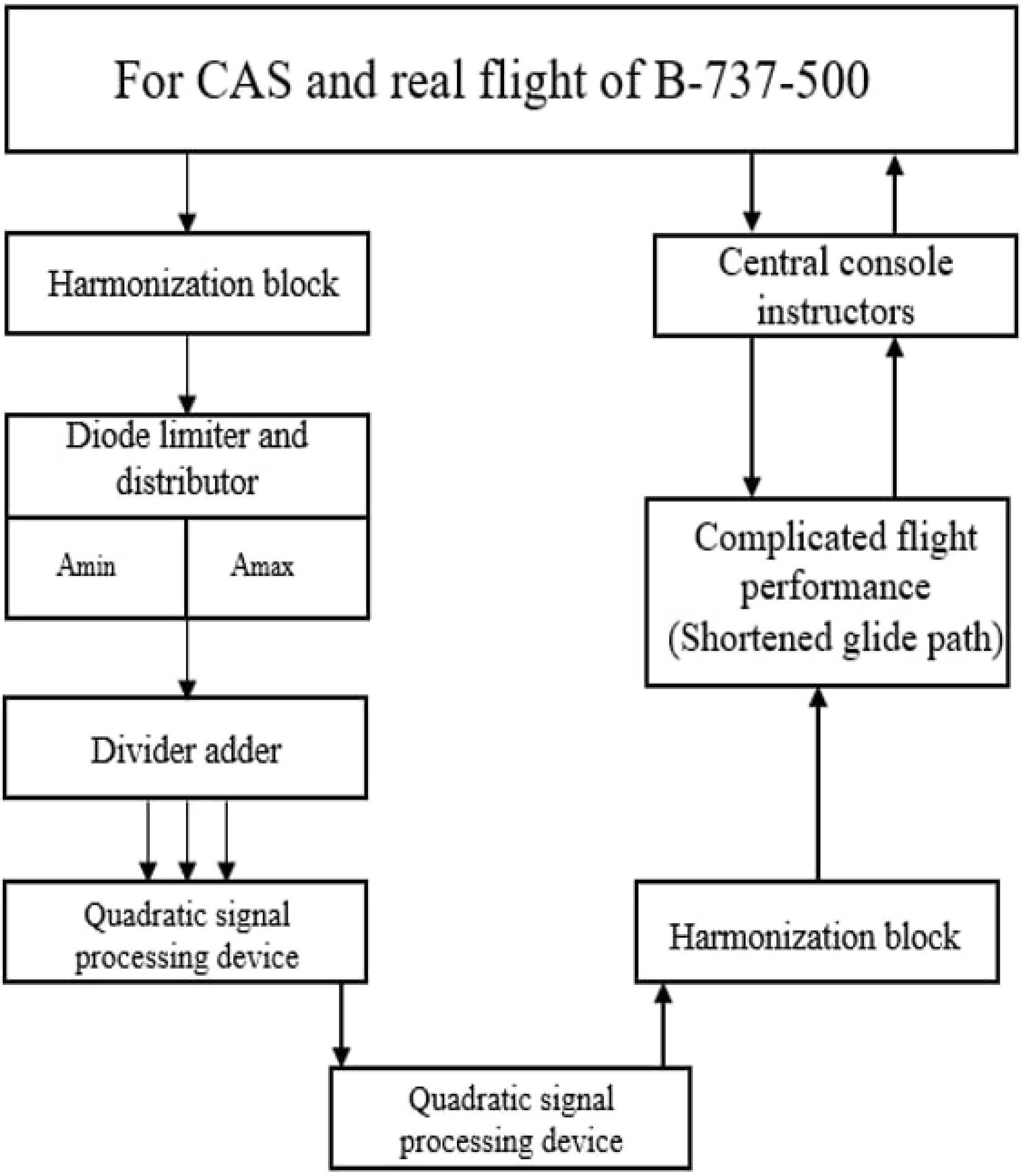

Fig. 3.1 Functional system of flight information processing device

The problem of transition to dimensionless coefficients in the processing of oscillograms of flight information of the transition from instantaneous to interval estimation is successfully solved by using trend algorithms.

The trend means the steady changes in the process that are observed and give an opinion on its forecasting in the future. According to the processed statistics, the above method revealed a number of patterns that indicate the need for anti-stress training of most pilots.

For a more complete analysis of piloting, we need to analyze the quality of piloting based on several flight parameters. To do this, we provide the adder separator with several parameters by which we will characterize the flight as a whole.

3.3 An experiment to verify the effectiveness of trend algorithms for assessment of the quality of the piloting technique for the crew of the B-737-500 aircraft in the airline

For a more complete analysis of piloting, we need to analyze the quality of piloting based on several flight parameters. To do this, we provide the adder separator with several parameters by which we will characterize the flight as a whole.

We use Boing 737-500 data to compare a group of flights, roll, heading, pitch and vertical speed. Comparing amplitudes of flights for 5 pilots, we can see that the amplitude gain DS is significantly higher than others.

In order to give us a quantitative characteristic of the flight, which is expressed in standard deviation. From the divider adder we give the amplitude data to the quadratic signal processing device.

Thecalculationofthestandarddeviationisperformedbytheformula (3.1):

$$\Delta\Delta A = \sqrt{\Delta V^2{}_{\mathrm{A_{max}}} + \Delta\gamma^2{}_{\mathrm{A_{max}}} + \Delta\psi^2{}_{\mathrm{A_{max}}} + \Delta\theta^2{}_{\mathrm{A_{max}}}} \quad (3.1),$$

where V-vertical speed, γ-roll angle, ψ-heading, θ – pitch angle.

$$\Delta V = \frac{\mathrm{V_{A_{max}}} - \mathrm{V_{A_{min}}}}{\mathrm{V_{A_{max}}}} \quad (3.2);$$

$$\Delta\gamma = \frac{\gamma_{\mathrm{A_{max}}} - \gamma_{\mathrm{A_{min}}}}{\gamma_{\mathrm{A_{max}}}} \quad (3.3);$$

$$\Delta\psi = \frac{\psi_{\mathrm{A_{max}}} - \psi_{\mathrm{A_{min}}}}{\psi_{\mathrm{A_{max}}}} \quad (3.4).$$

$$\Delta\theta = \frac{\theta_{A_{max}} - \theta_{A_{min}}}{\theta_{A_{max}}} \ (3.5).$$

The flight №1

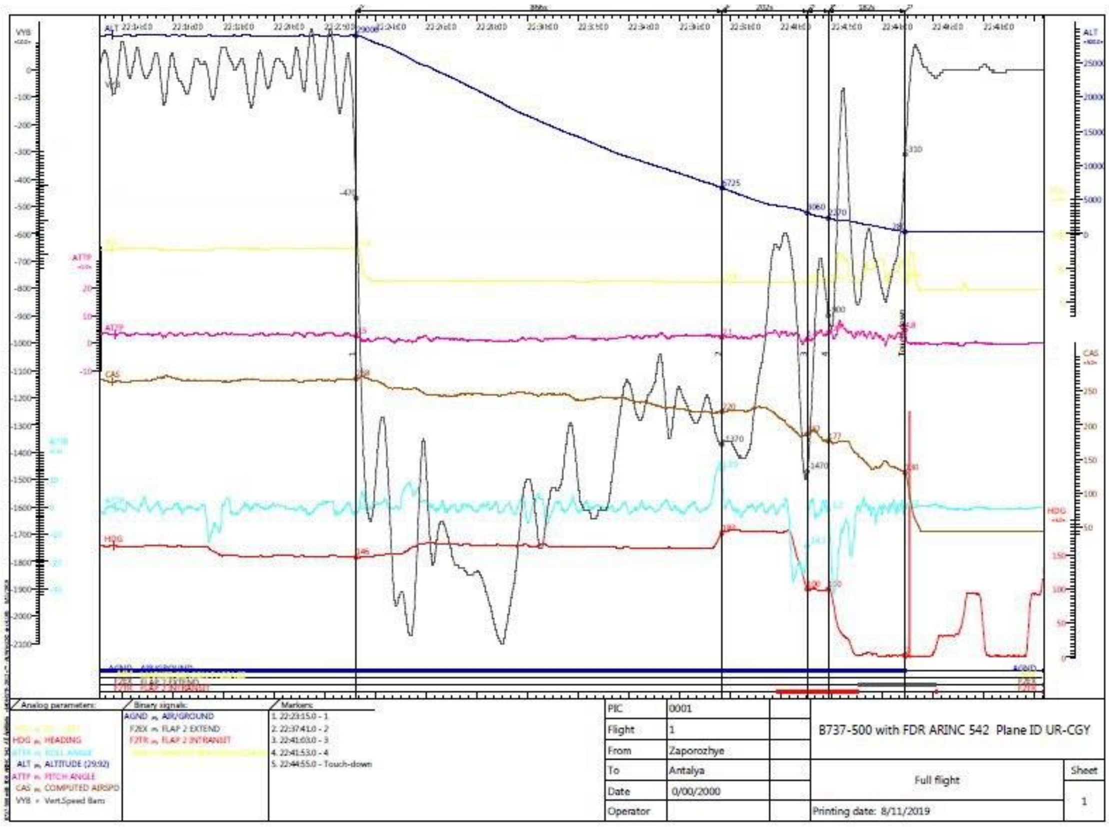

Fig. 3.7

$$\Delta V = \frac{V_{A_{max}} - V_{A_{min}}}{V_{A_{max}}} = \frac{-100-(-2200)}{-100} = -21;$$

$$\Delta\gamma = \frac{\gamma_{A_{max}} - \gamma_{A_{min}}}{\gamma_{A_{max}}} = \frac{14-(-30)}{14} = 3.14;$$

$$\Delta\psi = \frac{\psi_{A_{max}} - \psi_{A_{min}}}{\psi_{A_{max}}} = \frac{185-2}{185} = 0.99;$$

$$\Delta\theta = \frac{\theta_{A_{max}} - \theta_{A_{min}}}{\theta_{A_{max}}} = \frac{9-(-2)}{9} = 1.22$$

Thecalculationofthestandarddeviation:

$$\Delta\Delta A = \sqrt{\Delta V^2{}_{\mathrm{A_{max}}} + \Delta\gamma^2{}_{\mathrm{A_{max}}} + \Delta\psi^2{}_{\mathrm{A_{max}}} + \Delta\theta^2{}_{\mathrm{A_{max}}}} =$$

$$\sqrt{(-21)^2 + 3.14^2 + 0.99^2 + 1.22^2} = 21.29.$$

The flight№2

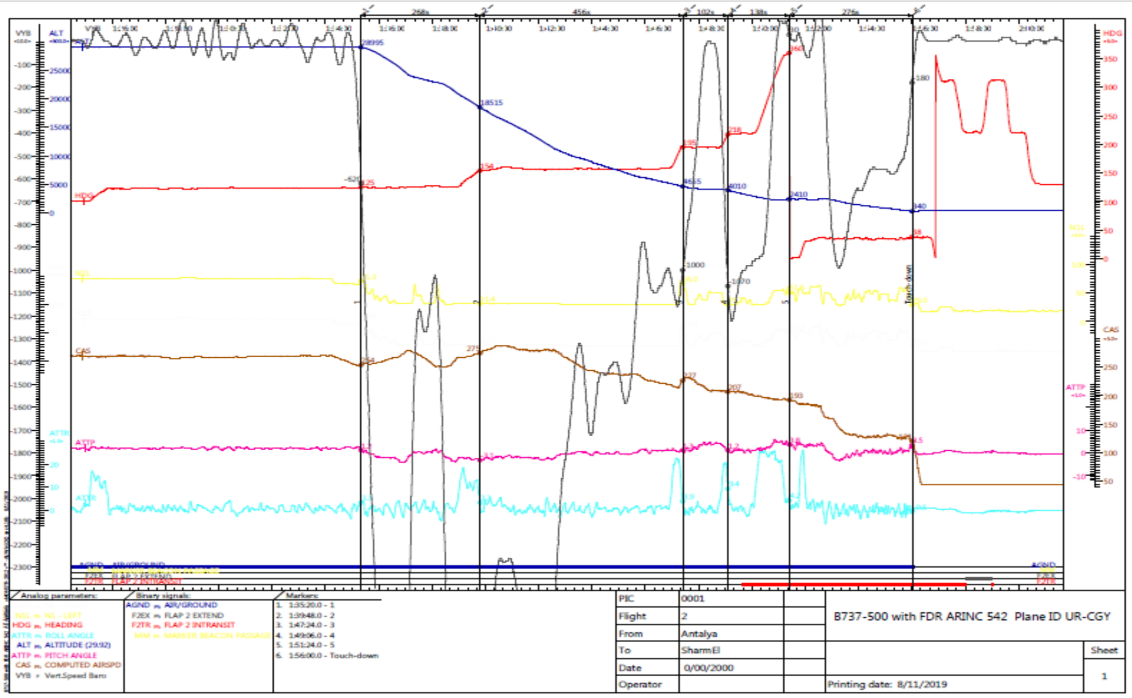

Fig. 3.8

$$\Delta V = \frac{\mathrm{V_{A_{max}}} - \mathrm{V_{A_{min}}}}{\mathrm{V_{A_{max}}}} = \frac{100-(-2500)}{100} = 26;$$

$$\Delta\gamma = \frac{\gamma_{\mathrm{A_{max}}} - \gamma_{\mathrm{A_{min}}}}{\gamma_{\mathrm{A_{max}}}} = \frac{30-(-10)}{30} = 1.33;$$

$$\Delta\psi = \frac{\psi_{\mathrm{A_{max}}} - \psi_{\mathrm{A_{min}}}}{\psi_{\mathrm{A_{max}}}} = \frac{360-0}{360} = 1;$$

$$\Delta\theta = \frac{\theta_{\mathrm{A_{max}}} - \theta_{\mathrm{A_{min}}}}{\theta_{\mathrm{A_{max}}}} = \frac{5-(-4)}{5} = 1.8$$

Thecalculationofthestandarddeviation:

$$\Delta\Delta A = \sqrt{\Delta V^2{}_{A_{max}} + \Delta\gamma^2{}_{A_{max}} + \Delta\psi^2{}_{A_{max}} + \Delta\theta^2{}_{A_{max}}}$$

$$= \sqrt{26^2 + 1.33^2 + 1^2 + 1.8^2} = 26.12.$$

The flight№3

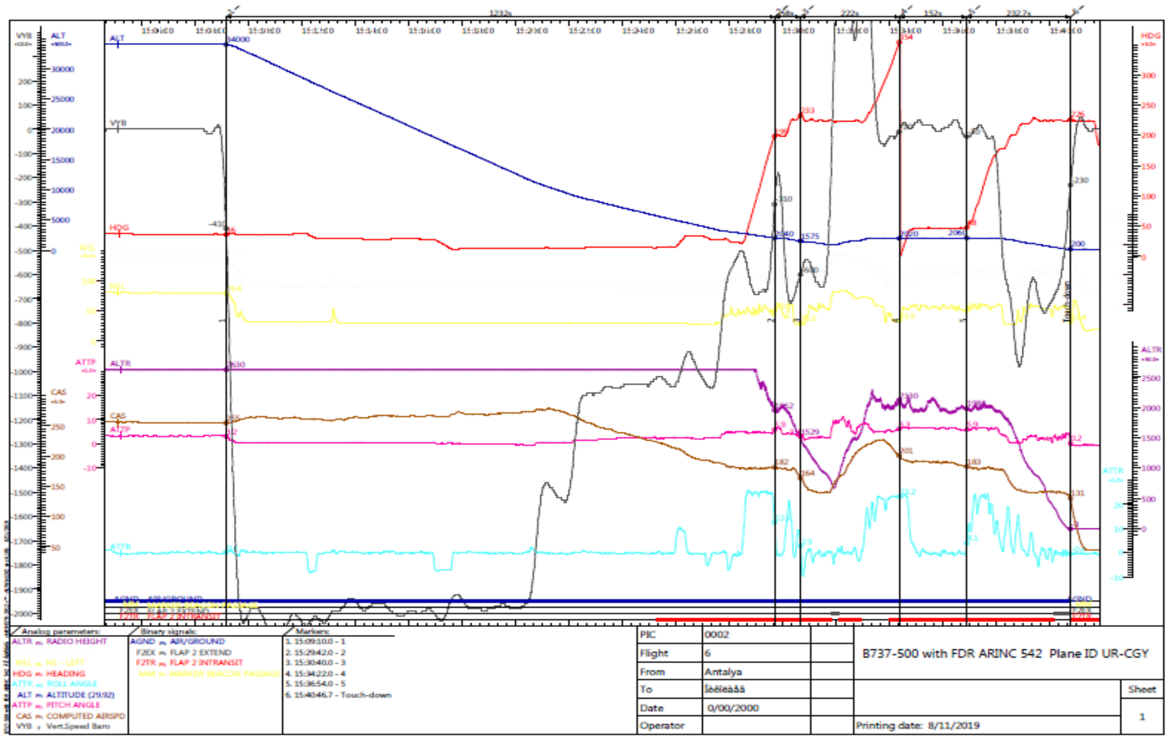

Fig. 3.9

$$\Delta V = \frac{V_{A_{max}} - V_{A_{min}}}{V_{A_{max}}} = \frac{400-(-2000)}{400} = 6;$$

$$\Delta\gamma = \frac{\gamma_{A_{max}} - \gamma_{A_{min}}}{\gamma_{A_{max}}} = \frac{26-(-9)}{26} = 1.34;$$

$$\Delta\psi = \frac{\psi_{A_{max}} - \psi_{A_{min}}}{\psi_{A_{max}}} = \frac{354-1}{354} = 0.99;$$

$$\Delta\theta = \frac{\theta_{A_{max}} - \theta_{A_{min}}}{\theta_{A_{max}}} = \frac{15 - 2}{15} = 0.87$$

Thecalculationofthestandarddeviation

$$\Delta\Delta A = \sqrt{\Delta V^2{}_{A_{max}} + \Delta\gamma^2{}_{A_{max}} + \Delta\psi^2{}_{A_{max}} + \Delta\theta^2{}_{A_{max}}} =$$

$$\sqrt{6^2 + 1.34^2 + 0.99^2 + 0.87^2} = 6.29.$$

The flight№4

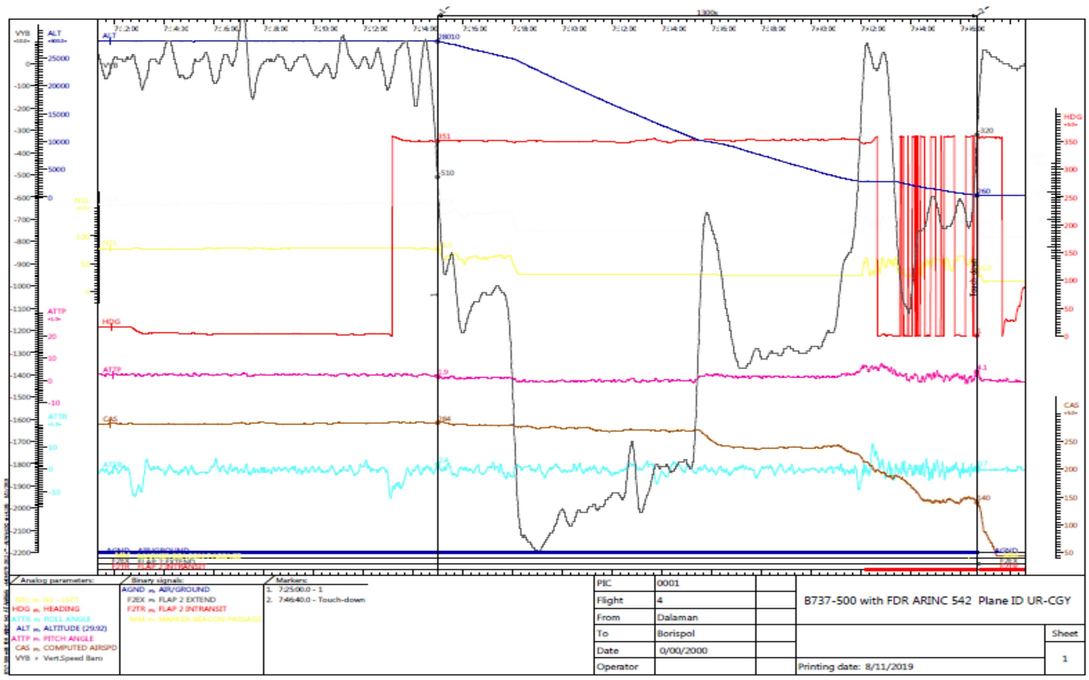

Fig 3.10

$$\Delta V = \frac{V_{A_{max}} - V_{A_{min}}}{V_{A_{max}}} = \frac{100-(-2200)}{100} = 23;$$

$$\Delta\gamma = \frac{\gamma_{A_{max}} - \gamma_{A_{min}}}{\gamma_{A_{max}}} = \frac{10-(-9)}{14} = 1.36;$$

$$\Delta\psi = \frac{\psi_{A_{max}} - \psi_{A_{min}}}{\psi_{A_{max}}} = \frac{352-2}{352} = 0.99;$$

$$\Delta\theta = \frac{\theta_{A_{max}} - \theta_{A_{min}}}{\theta_{A_{max}}} = \frac{8-4}{8} = 0.5.$$

Thecalculationofthestandarddeviation:

$$\Delta\Delta A = \sqrt{\Delta V^2{}_{A_{max}} + \Delta\gamma^2{}_{A_{max}} + \Delta\psi^2{}_{A_{max}} + \Delta\theta^2{}_{A_{max}}} =$$

$$\sqrt{23^2 + 1.36^2 + 0.99^2 + 0.5^2} = 23.07.$$

The flight№5

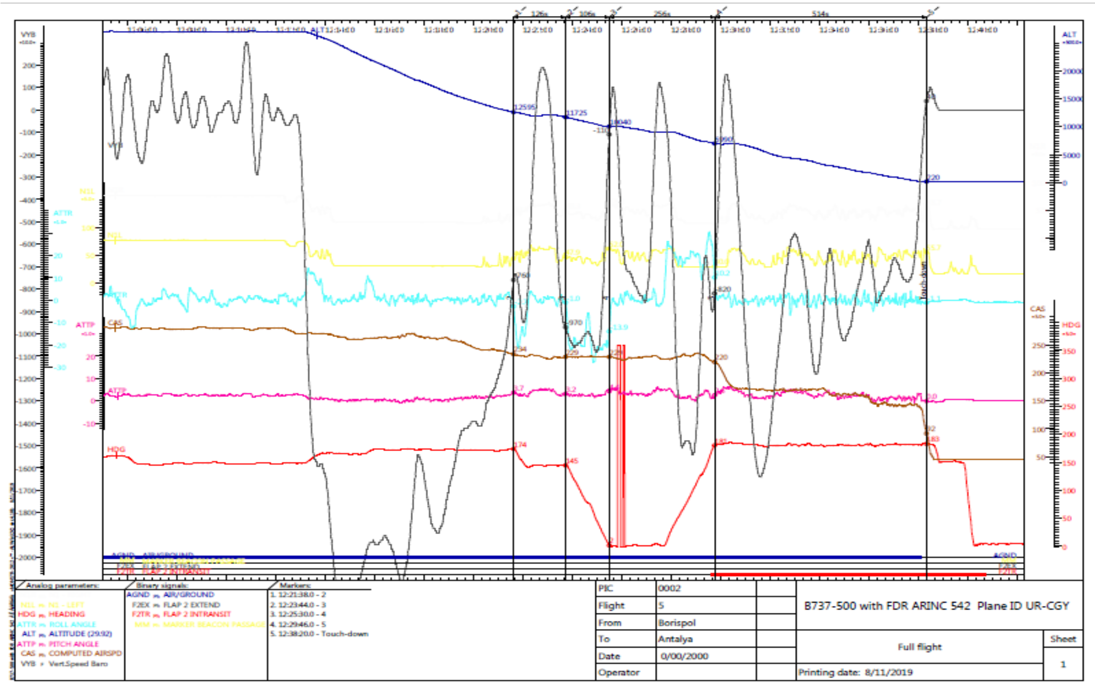

Fig. 3.11

$$\Delta V = \frac{V_{A_{max}} - V_{A_{min}}}{V_{A_{max}}} = \frac{150-(-2400)}{150} = 17;$$

$$\Delta\gamma = \frac{\gamma_{A_{max}} - \gamma_{A_{min}}}{\gamma_{A_{max}}} = \frac{29-(-28)}{29} = 1.97;$$

$$\Delta\psi = \frac{\psi_{A_{max}} - \psi_{A_{min}}}{\psi_{A_{max}}} = \frac{360-0}{360} = 1;$$

$$\Delta\theta = \frac{\theta_{A_{max}} - \theta_{A_{min}}}{\theta_{A_{max}}} = \frac{5-1}{5} = 0.8.$$

Thecalculationofthestandarddeviation

$$\Delta\Delta A = \sqrt{\Delta V^2{}_{A_{max}} + \Delta\gamma^2{}_{A_{max}} + \Delta\psi^2{}_{A_{max}} + \Delta\theta^2{}_{A_{max}}} =$$

$$\sqrt{17^2 + 1.97^2 + 1^2 + 0.8^2} = 17.16.$$

Table №1

№ offlights	ΔV	$\Delta\gamma$	$\Delta\psi$	$\Delta\theta$	$\Delta\Delta A$
1	-21	3.14	0.99	1.22	21.29
2	26	1.33	1	1.8	26.12
3	6	1.34	0.99	0.87	6.29
4	23	1.36	0.99	0.5	23.07
5	17.31	1.97	1	0.8	17.16

These oscillograms of real flights serve as an illustration of how factor overlays work in real flights. Examples show that the landing process is sharply complicated - this can be seen in the qualitative changes in almost all flight parameters. In this case, there are control and non-control pilots' changes in the following parameters: vertical load, aircraft roll, instrument speed, deviation of the left rudder, aircraft pitch, course,pitch, rotor speed on the engine.

3.4 Ehe algorithm of actions of pilots during flight and on CAS in special conditions

The problem of the crew members' operational load is related to the specifics of the pilots' work - increased tension, the special nature of piloting with a shortage of time and bad weather conditions - and is characterized by a large number of actions that a crew member must perform. Operational load arises as a result of the appearance of factor overlays in flight, which, in turn, accompany special situations in flight.Previouslyconductedexperimentsprovethis.

One of the ways to improve the effectiveness of training crew members is the professional training of pilots based on the criterion of countering factor overlays and the development of ways to optimize flight operation procedures.

To identify the number of procedures that would not overload the pilot, it is necessary to compare his flights with the effect of factor overlays (complex failures on simulators) and in their absence. In the further development of optimization, show and emphasize the presence of this phenomenon for removal in subsequent flights. Therefore, a program is needed to detect the effect of factor overlays in order to improve flight safety.

For the process of flight operation both on an airplane and on a simulator, in the conditions of the occurrence of special situations in flight, such a situation is characteristic when the control of the ship changes during the development of a special situation. Therefore, it is most appropriate to use the method of adaptive control withusing technologies.

The development of recommendations to pilots in the event of a difficult situation may be accompanied by the following items:

1. BE AWARE OF THE SITUATION: the crew member recognizes malfunctions, names them clearly and precisely.

2. MAINTAIN AIRCRAFT CONTROL: Mandatory when the pilot is flying (PF) and the copilot is monitoring (PM). But it is recommended to make maximum use of the automatic control system to reduce the load on the pilot.

3. ANALYZE THE SITUATION: the implementation of the procedure for eliminating a difficult situation in flight should be carried out only after the exact determination of the malfunction.

WARNING! Pilots should put on oxygen masks and check all systems for "oxygen starvation" even if there were no such notifications.

4. TAKE APPROPRIATE ACTION: All difficult situations in flight require immediate and correct action, but difficulties can arise if the pilot-in-command and the co-pilot take inconsistent actions. The command of the commander must be clear, precise and take into account the time of confirmation by the co-pilot for its execution before the next one. All crew members must report their actions or their inability to perform clearly and succinctly, without minimizing or exaggerating the nature of the situation. This eliminates confusion and ensures efficient, effective and prompt collaboration.

5. ANALYZE THE NECESSITY OF LANDING: the procedures in the flight operation manual in the event of a difficult situation may have several options: 1) send to the nearest airport for a safe landing approach; and 2) not to direct for landing. Then, in case 2, the commander himself has to make a decision about a safe landing.

CONCLUSION TO CHAPTER 3

During the analysis of the system of deterioration of the quality of piloting equipment during the approach, several useful conclusions were made on this topic.

During the study it was detected that the quality of piloting technique is determined by the accuracy of flight parameters and timely and correct actions of the crew according to the flight operations manual. Similarly, the quality of the approach to landing depends on the accuracy of the course in the glide path.It is necessary to compare the amplitude value when analyzing the flights of the same pilot without failures and with introduced failures. Thus, based on this difference, we can determine the amplitude gain that occurs in the pilot under the influence of factor loads, which are simulated by complex failures on aircraft flight simulators. Preliminary calculations showed that in 80% of pilots this leads to IAAFP, an increase in the flow of comments on pilot errors.

In aviation, the analysis of pilot information plays an important role in improving the safety of piloting, analysis of piloting techniques, systematic control and assessment of the level of professionalism of the crew. To do this, there are methods and algorithms for processing flight information.

It was proposed a new device for assessing the pilot technique during the most dangerous part of the flight – landing approach. This device shows in real time the data of parameters of flight such as pitch angle, roll angle, heading, vertical speed. It shows the amplitude changes of the parameters.

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