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

APPROVED
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‘___’___________2022

GRADUATION WORK

(EXPLANATORY NOTES)

FOR THE DEGREE OF BACHELOR
SPECIALTY 173 ‘AVIONICS’

Theme: ‘System of analysis of deterioration of flight quality during landing approach’

Done by: __________ R.D. Suzanskyi
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Standard controller: __________ V.V. Levkivskyi
(signature)

Kyiv 2022

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

ФАКУЛЬТЕТ АЕРОНАВІГАЦІЇ, ЕЛЕКТРОНІКИ ТА ТЕЛЕКОМУНІКАЦІЙ
КАФЕДРА АВІОНІКИ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
_________С.В. Павлова
«___»__________
_2022

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ
БАКАЛАВР ЗА СПЕЦІАЛЬНІСТЮ 173
«АВІОНІКА»

Тема: «Система аналізу погіршення якості польоту при заході на посадку»

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Київ 2022

NATIONAL AVIATION UNIVERSITY

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Department of avionics

Specialty 173 ‘Avionics’

APPROVED

Head of department

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‘___’___________2022

TASK for execution graduation work

R.D. Suzanskyi

1. Theme: ‘System of analysis of deterioration of flight quality during landing approach’, approved by order №352/ст of the Rector of the National Aviation University of 04 April 2022.
2. Duration of which is from 16.05.2022 to 16.06.2022.
3. Input data of graduation work: Methods and algorithms for assessing the quality characteristics of piloting techniques in special cases of flight. Models and programs of human factor consideration and training crews to fly in difficult conditions.
4. Content of explanatory notes: List of conditional terms and abbreviations; Introduction; Chapter 1: Analysis of current problems of aircraft control processes; Chapter 2: Analysis of existing problems of human factor during landing approach; Chapter 3: Development of methods and algorithms

for assessing the quality characteristics of piloting techniques during landing approach.

5. The list of mandatory graphic material: figures, charts, graphs.

6. Planned schedule

№	Task	Duration	Signature of supervisor
1.	Validate the rationale of graduation work theme	16.05-20.05	
2.	Carry out a literature review	20.05-24.05	
3.	Develop the first chapter of diploma	24.05-30.05	
4.	Develop the second chapter of diploma	30.05-07.06	
5.	Develop the third chapter of diploma	07.06-06.06	
6.	Tested for anti-plagiarism and obtaining a review of the diploma	12.06-16.06	

7. Date of assignment: May 16 2022 year

Supervisor _______________ Y.V. Hryshchenko

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The task took to perform _______________ R.D. Suzanskyi

(signature) (surname, name, patronymic)

ABSTRACT

The explanatory notes to the graduate work ‘System of analysis of deterioration of flight quality during landing approach’ contained 32 pages, 13 drawings, 1 table, 19 reference books.

Keywords: AIRCRAFT, HUMAN FACTORS, DIRECTOR MODE, ERGATIC SYSTEM, LANDING APPROACH, QUALITY CHARACTERISTIC, PILOTING TECHNIQUE.

The purpose of the graduate work is an assessment of the quality of the crew piloting technique when landing in the ergatic system in the director's mode when approaching the glide path.

The object of the research is the quality of piloting technique during landing approach.

The subject of the research is the assessment of the quality of piloting technique during landing approach in the airline.

Research Method: method of expert evaluation, trend algorithms, standard square deviation, method of expert evaluation, algorithm of relative difference at a minimum, coefficient strengthening.

CONTENTS

LIST OF SYMBOLS, ABBREVIATIONS, TERMS

ICAO – International Civil Aviation Organization;

DS – a dynamic stereotype;

AC – an aircraft;

HF – a human factors;

SOMS – a system operator machine environment SOMS;

AOA – Air Operations Authority;

APDS – an amplitude amplification of the dynamic stereotype;

FO – a factor overlay

QPT - a quality of piloting technique

SOMS – system operator machine environment

CAS – complex aircraft simulator

Introduction

Relevance of the topic. Flight safety is an important part of civil aviation, along with passenger turnover and economic activity.

On modern aircraft, most flights are automatic. When approaching the landing, piloting takes place in the director's mode, or, even more difficult, in the steering mode. Flight process automation is associated with high reliability of avionics and other aircraft systems.

According to ICAO, the number of aviation accidents due to human factors is increasing every year. This is due to the fact that the crew is increasingly difficult to land in the director's mode.

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.

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.

As mentioned above, ICAO pays great attention to training pilots to operate an aircraft in an automated mode. Accordingly, a dynamic stereotype should be developed during crew training to facilitate the pilot task.

But when performing a pilot task, the pilot has more external factors that increase the human factors in flight. Therefore, there are on-board analysis systems for assessing the quality of piloting technique.

The purpose of the graduate work is the improvement of the analysis system for assessing the quality of piloting technique during landing approach and the accuracy of approach to glide path.

The object of the research is the quality of piloting technique during landing approach

The subject of the research is the assessment of the quality of piloting technique during landing approach in the airline.

Research Method: method of express analyses, trend algorithms, standard square deviation, method of expert evaluation, algorithm of relative difference at a minimum, coefficient strengthening.

CHAPTER 1: ANALYSIS OF CURRENT PROBLEMS OF AIRCRAFT CONTROL PROCESSES

1.1. Concept of engineering psychology, ergonomics and human factors

Ergonomics has been used by specialists in psychology, physiology and occupational hygiene for many decades, but only in recent years ergonomics has formed into an independent branch of science, which has its subject, object, tasks and research methods.

The system operator machine environment (SOMS) is the object of ergonomics. In the literature you can find synonyms of the name: ergatic system, human-machine system, operator-machine system.

Machines are devices designed to convert information, energy, matter.

The environment covers the entire environment that affects the operator and the machine (microclimate, light and colour modes, external information, etc.).

The quality of the system "man-machine" - a cumulative characteristic of equipment and its attendants, which ensures the functioning of this system within the requirements set for it, reliability and recoverability of technical means, their periodic prevention, error-free actions of the operator, its medical and biological reliability at rest, the possibility of restoring the working condition, the readiness of technical means and operators to work. As a general indicator of the reliability of the system "man-machine" can be used the probability of timely error-free and trouble-free use (operation) of the anthropotechnical system. The reliability of the "man-machine" system depends on the conditions and modes of work of people, their functions, design, modes and features of the functioning of technical means. Reliability of the human operator - a set of human properties that ensures the performance of the necessary functions in the system "man-machine".

The broader definition of ergonomics, adopted in 2010 by the International Association of Ergonomics (IEA), reads as follows: human and optimizing the overall performance of the system.

Human operator reliability analysis is a method used to assess human reliability. The closely related system suitability characteristic of the system suggests that the system or its component can be used as needed.

The theory of the human factor is the science of people who live and work in certain conditions, their interaction with machines, procedures and the environment, as well as the interaction of people with each other.

The subject of the theory of the human factor are the processes, properties, laws of origin, development and change of the psychophysiological state of man during the performance of their duties, under conditions of special activities and relationships between people.

Some authors identify the definition of "ergonomics" and the human factor. Many believe that ergonomics is only for design.

In the scientific school V.G. Denisov the following definitions are given:

Aviation engineering psychology as a branch of general engineering psychology is one of the sciences of man. She studies the psychophysiological capabilities of the human operator in the process of its interaction with aircraft.

Engineering psychology - the science of the interaction of man and technology.

The object of ergonomics is SOMS. The subject of ergonomics - the processes of interaction of the MHI, the laws of creation, operation and optimization of the MHI.

It should be noted, that failures and failures negatively affect psychophysiological state of the human operator. In flight with simultaneous failure of several systems significantly increases psychophysiological pilot tension. Therefore, the calculation of system failure rates the avionics of a particular aircraft can give a hint to increase readiness for special cases of flight.

Uncertainty caused by digital system failures is causing increased tension of the crew in flight. Need more introduction of new methods of anti-stress training. To detect change the quality of airplane piloting should be developed a new principle of detection deterioration of this ergatic system.

1.2. Characteristics of normal, emergency and stressful situations

Normal situations are situations that occur over a long period of time under normal operating conditions of ergatic systems.

In a normal Situation, the human operator remains normal working condition, which is characterized by a moderate change in physiological and psychological reactions of the body, stable and confident performance course actions.

The following situations may occur during the flight:

- a special situation that arises due to the influence of certain adverse factors or a combination of them and leads to a threat or violation of aircraft flight safety;

- complication of flight conditions - such a special situation, which is characterized by a slight increase in psychophysiological load on the crew and (or) a slight deterioration of flight characteristics, stability, controllability of the aircraft and does not interfere with the successful completion of the flight;

- difficult situation - such a special situation in which the flight there is a marked increase in psychophysiological load on the crew, a marked deterioration in flight characteristics, stability and controllability of the aircraft, the output of one or more parameters for operational restrictions, but without reaching the limit limits;

- emergency situation - a special situation that is characterized significant increase in psychophysiological load on the crew, significant deterioration of flight characteristics, stability and controllability of the aircraft, which leads to the achievement or exceeding of limitations or flight conditions:

- catastrophic situation - a special situation in which it is almost impossible to prevent the destruction of aircraft and deaths.

Special situations in flight can have different consequences - depending on the factors that cause them. Such factors are the level of crew preparation for the neutralization of adverse events, flight mode, environmental parameters. In other words, special situations with the consequence of special flight conditions and special cases that occur in flight.

Special flight conditions include:

- flights in areas of icing, thunderstorms and heavy rains, strong oscillations, increased electrical activity of the atmosphere, wind shear, dust storm:

- flights in mountainous and mountain-oriented areas, in deserts and above 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:

- hit of the aircraft in a dangerous meteorological phenomenon:

- failure of aircraft engines (aircraft engine);

- failures of aircraft systems. which may lead to the need to change the plan, flight profile, forced landing;

- fire on the aircraft:

- loss of stability, controllability, violation of the strength of the aircraft structure;

- attack on the crew (passengers);

- forced landing outside the aerodrome;

- injury or sudden deterioration of the health of crew members (passengers),

- failure of radar means of air traffic control and radio equipment at the landing aerodrome;

- failure of radio communication (failure of onboard and terrestrial 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 a situation that arises due to an unexpected failure of the functional system of the aircraft or its exposure to conditions requiring the crew actions other than piloting in a normal situation.

A stressful situation can be the result of any other situation that occurs in conditions of significant deviations from normal. The name of the situation is associated with the emergence of the operator's highest degree of tension - stress - functional state due to the assessment of the situation as life-threatening operator or other people. One of the main causes of stress in the operator is the idea he has formed of the insurmountable complexity of the situation that has arisen, and which he considers dangerous and does not know how to get out of it. Stress can also be caused by other factors: intensity and continuity of activity, which in turn causes great physiological and mental tension; the possibility of a sudden special situation that poses a certain risk to work; retraining for new aircraft: the impact of physical environmental factors, etc. Most often, stress occurs when the operator is not one, but a set of factors that have different people have different weights in different circumstances. It should be noted that stress is a very characteristic feature of flight work, and a stressful situation is not an exceptional event in the activities of flight crews.

1.3. The operation of SOMS and the activities of the operator in different situations

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.

Variometer is shown on Fig. 1.1

Fig. 1.1

During the turn, almost half of the fixations of the gaze fall on the air horizon, 30% - on the variometer, 10% - on the speedometer and altimeter, and the rest of the time - on the compass; when leaving the turn 30% - on the air horizon and variometer, about 20% - on the compass, respectively, reduces the time for speed and altitude control - about 5%; at: transition to a set of altitude by 30% - on the air horizon and variometer. 10% - on the speed indicator, due to the reduction of attention paid to altimeter and compass (3-4%), the pilot 7% of the time looks at the rev counter: when switching from altitude to horizontal flight by 30% - on the air horizon and variometer. 10% - on the speedometer, and by reducing the attention paid to the compass, more attention is paid to the altimeter.

Such general patterns in the distribution of attention are observed in pilots, regardless of their qualifications.

A characteristic feature of flight work is retraining for new equipment. Usually, the design of each new PS involves new operations, as well as changes in the implementation of the old. In addition, the constant increase in the number of devices, alarms, controls are accompanied by a restructuring of the layout of the cabin equipment, which requires a change in the order of distribution of attention and work with the interface of the cabin. The main problem of retraining is always the optimal formation of new skills and prevention of the possibility of transfer to previously acquired skills - the so-called negative transfer.

The degree of complexity of the situation is assessed by the suddenness of its occurrence, the number of tasks to be solved, the time limit and the concentration of the pilot.

An emergency situation can develop, for example, according to the following scheme: cause of complication - complication - wrong decision (or distortion of information) - favorable conditions - emergency situation.

To prevent the "chain reaction" of the emergency situation, the timeliness of detecting deviations from normal flight and making the right decision to eliminate them, the ability to act correctly in special cases in flight, self-control, interaction and mutual control, determination, confidence, reserve and experience are of particular importance. making the necessary decisions. On the pre-landing line, for example, one of the methods of stopping the "chain reaction" and getting out of an emergency situation is to make a timely decision to go to the second round. On the other hand, when leveling the aircraft, it is more rational to complete the landing, taking into account the complications that have arisen.

1.4. Analysis of existing means and methods for assessing the quality of piloting technique

Flight safety issues are one of the main places in the air transport system. The quality of endurance of the flight trajectory depends on both the means of navigation and aeronautical navigation equipment, and the quality of training of the aircraft crew. Deterioration of the quality of piloting is most often observed in the event of special situations in flight. Practice shows that such training is needed.

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.

Factor overlays are the simultaneous action on pilots of more than 2 negative factors, which may be simultaneous failures of equipment that operate in one period of time.

In the process of flight training, pilots acquire and consolidate certain flight skills in various special situations. The complex simulator of the aircraft simulates the behavior of the aircraft under functional failures, adverse weather conditions, fires and their various combinations. Pilots are successfully mastering the appropriate algorithms of action, and it would seem that this should limit the training process.

The main task of anti-stress training is to reduce the risks associated with the training of operators to counteract factor overlays and to establish optimal from the standpoint of ergonomics aircraft control systems.

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.

In civil aviation, flight information processing plays an important role in improving the safety of air transport. Flight information is the only objective source of information about the crew's activities during the entire flight, therefore, systematic monitoring and evaluation of the flight activities of the crew based on the processing of flight information provide a significant increase in the level of professional training of crews.

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

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

Express analysis is the main type of information processing used in civil aviation, recorded by on-board flight information collection tools (BFSPI), 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 equipment performance control".

Comparison of flight parameters with acceptable ones is carried out according to special algorithms, instructions for the technical operation of systems and equipment, and other regulatory documents. Algorithms are mathematical and logical expressions that implement the requirements and recommendations of other documents on the establishment of aircraft flight modes and operation of systems and equipment, crew actions at various stages of flight and in various situations. When compiling algorithms, the constants included in them are introduced taking into account the tolerance for the error in measuring and processing flight information.

For each aircraft, the algorithms are summarized in message catalogs, which indicate the regulatory documentation used to compile the algorithm, its symbolic record, the symbol of the message issued on the express analysis form in case of failure of the algorithm (a logical variable exceeds the tolerance limit recommended by the regulatory documentation), additional information explaining the use of the algorithm.

Algorithms are 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, 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. To confirm and clarify the reliability of violation reports displayed on the express analysis form, the data of physical or code values of parameters are displayed on an overview graph.

In the secondary automated processing, specialized programs are used, in which, as a rule, calculation methods are implemented to determine the spatial trajectory of the aircraft, failures of systems and equipment, the technical condition and resource 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 the high labor intensity and duration of processing.

The need for subsequent manual processing of the obtained results 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 events of flight parameters going beyond the permissible values, a significant part turns out to be false. Before transferring information to the flight or aviation engineering service, all messages about flight events are checked manually according to the schedule for changing flight parameters and false reports are canceled. In addition, the information provided by the express analysis program is not enough to evaluate the piloting technique. Guiding documents oblige the calculation and analysis group to fill in, based on the results of interpretation, a table of actual indicators of piloting technique, containing the values of flight parameters at characteristic points of the aircraft trajectory.

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.

CHAPTER 2: ANALYSIS OF EXISTING PROBLEMS OF HUMAN FACTOR DURING LANDING APPROACH

2.1. Dynamic stereotype

Much attention is paid to the training of pilots to operate automated aircraft. Accordingly, in the process of training pilots should develop a dynamic stereotype of piloting a modern aircraft, which will facilitate the process of performing the flight task.

Dynamic stereotype - an integrated system of habitual conditioned-reflex responses, which corresponds to the signal, sequential and temporal characteristics of the stimulus. The concept was introduced by I.P. Pavlov in 1932. The neural processes underlying the formation of a dynamic stereotype are combined due to the fact that the flow reflex response (functional state) becomes a signal for the next response and is supported by it. With a strengthened stereotype, this sequence of nervous processes is fixed, all the answers can be reproduced while maintaining the sign, intensity and sequence - even with only one of the stimuli.

Repeated repetition of the system (set) of stimuli with the simultaneous course of processes in the central nervous system lead to the fact that the stench is fixed in the internal stereotype.

A stable system of conditioned nerve connections in the cerebral cortex (reflexes), connected into one whole and manifested as a result of a single trigger signal, is called a dynamic stereotype.

Dynamic stereotype, being the physiological basis of any skill that also has a psychological characteristic.

But despite the importance of pilot training, the right actions need to be given knowledge of the mechanism of delay of enhanced reflected movements leading to inappropriate control action on aircraft controls and pilot erroneous action. Accordingly, it is necessary to purposefully indicate that the pilot is affected by the woofer, he has enhanced reflected movements, which he usually does not notice.

Therefore, modern simulators and aircraft must be purposefully provided with an indication of the occurrence of complex failures. It is also necessary to provide an indication of inappropriate movements of pilots, which can be judged by changes in the amplitude of flight parameters. According to statistics, changes in flight parameters in the process of steering mainly has the form of a sine wave (increasing, decreasing, etc.)

It should be noted that each pilot has his own handwriting of piloting and in order to inform him about the occurrence of enhanced reflected movements, it is necessary to analyze the amplitude increase in the values of flight parameters at low frequencies, compared with flights in normal conditions.

2.2. Application of trend algorithms to assess the quality of flight technology.

In the process of flight training, pilots acquire and consolidate certain flight skills in various special cases. The complex simulator of the aircraft (CSA) simulates the behavior of the aircraft in case of functional failures, adverse weather conditions, fire and their various combinations. Pilots are successfully mastering the appropriate algorithms of action, and, it would seem, this should limit the training process.

However, in practice, we are often confronted with the fact that pilots make the wrong decisions, leaving the flight parameters beyond the limits set by the Air Operations Authority (AOA) of the aircraft (AC). There were also cases when the console touched the wing of the earth, which led to the destruction of aircraft.

Under normal circumstances, pilots cope with the flight task, and without passing the regulatory training and certificate, no one will let him fly. Thus, the conclusion is that the existing method of training pilots to fly in special situations is not enough. At the heart of such techniques is the principle of response to various actions, ie the theory of "stimulus response" (SR) and its various varieties.

The above problem is proposed to be solved by a special type of preparation of pilots for flights in special situations - training to counteract any negative factors (factor overlays) that simultaneously affect the pilot, according to the anti-stress program.

Modeling the flight process based on trend algorithms expands the possibilities of analyzing the activities of pilots in extreme situations and allows you to more adequately create models of emergencies, identify general trends in the development of positive or negative phenomena in flight activities.

Amplitudes can be measured and plotted on the coordinate axis when working with numbers in degrees, and when working with graphs - in conventional units, and periods in seconds and conventional units, respectively.

Using trend algorithms and computer processing program, according to the number of printing, we can obtain specific comparison data for flights with woofer and without them

$$\Delta\Delta A_{\gamma,\psi,\vartheta} = \sqrt{\Delta A_{\gamma}^{2} + \Delta A_{\psi}^{2} + \Delta A_{\vartheta}^{2}}. \quad (2.1)$$

The algorithm and training program of counteraction with the minimum trend is expressed in "Methodical recommendations on increase of level of counteraction of pilots to overlays of factors (for instructors and engineers)" in 1990 in IGA the author of this work. The difference between $\Delta\Delta A_{FO}$ and norms can be judged on the degree of resistance of FO pilots, the smaller the difference, the greater the degree of resistance, qualitative changes to quantify.

Erroneous and illogical actions of crew members during the flight, associated primarily with changes in mental processes due to the action of factor loads on them. Receiving spatial signals from the action of factor loads, with a sufficient number of them, the pilot can get into the area of reflected movements. The inability of pilots to actively counteract the factor load can lead to incorrect actions in the process of controlling the aircraft (confusion of levers, toggles, buttons, etc.). The counteraction to this phenomenon is the spatial delay of movements.

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.

During the flight, pilots cannot always avoid the appearance of erroneous actions. Moreover, according to statistics, the duration of improper piloting of the aircraft increases with increasing number of simultaneously acting factors.

The most characteristic errors in the technique of piloting under the influence of negative factors are: not maintaining the glide path and not maintaining the speed on the planning glide path, not maintaining the course, correcting it in the wrong direction, not maintaining the vertical speed, etc. Moreover, after the pilot begins to correct the error, there is an increase in the dynamic stereotype of the amplitude and frequency, which is fixed by the means of flight registration.

Erroneous and illogical actions in the process of flight, associated primarily with changes in mental processes, spatial signals from the action of factor loads. Receiving spatial signals from the action of factor loads with a sufficient number of them, the pilot can get into the zone of reflected movements, but spatial. The inability to actively counteract the factor load can lead to incorrect actions in flight engineers (confusion of levers, toggles, buttons, etc.). Hence, we see the importance of training the spatial delay of the entire crew. An important element in learning delays of this kind can be learning the flight logic. This is an important basis for his training, as well as choosing the only right solution when dealing with an unexpected stimulus.

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

3.1 APDS detection device using analysis of maximum amplitudes of several flight parameters.

To instruct the full picture of the amplitude amplification of the dynamic stereotype (APDS) of the pilot, it is necessary to consider the dynamics of the aircraft in space on several parameters. To do this, we offer the following device. Ultimately, we need to obtain a quantitative description of the APDS by an integrated assessment of the negative effect.

In this device, we have to calculate the standard deviation of several parameters to characterize the flight as a whole. Signal information on the roll from the complex simulator is fed to the peak detector (Fig. 3.1).

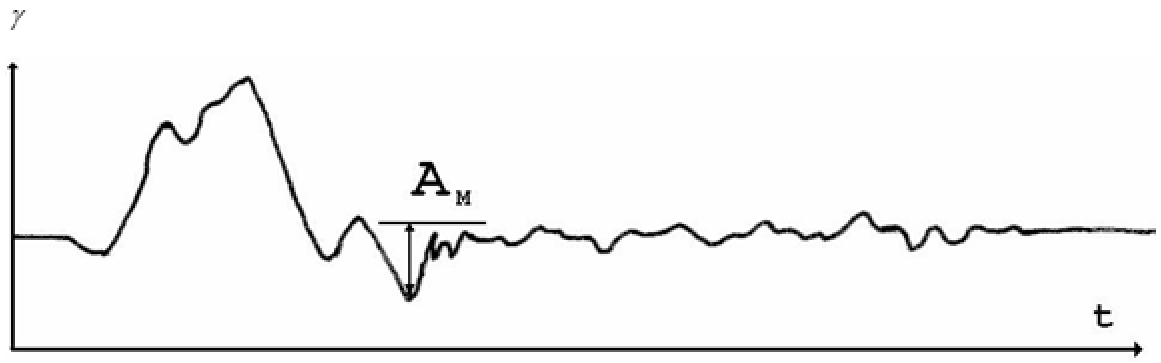

Fig. 3.1

Where the roll information is analyzed and the maximum amplitude is recorded at a certain point in time, which serves as a rectangular signal to start the calculation (Fig. 3.2).

Fig 3.2

In the differential circuit at the beginning of the signal is formed go-string pulse, which serves to trigger (Fig. 3.3).

Fig. 3.3

When a signal is applied to the trigger, a strobe impulse signal with τc = 10-15 seconds is formed in it (Fig. 3.4).

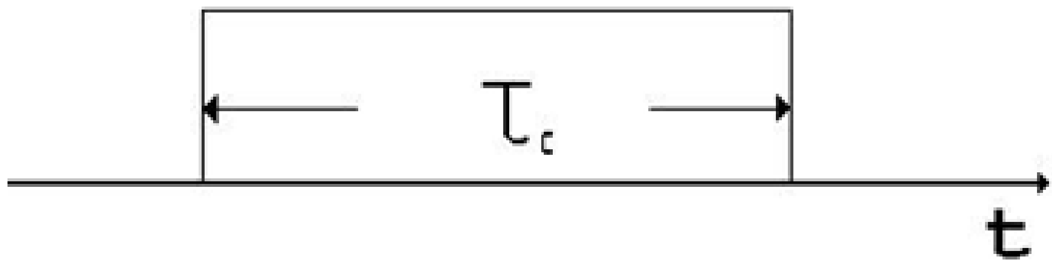

Fig. 3.4

After applying to the scheme of equalization of the strobe impulse and the roll parameter, the output we will have a real roll of the aircraft limited by the boundaries of the strobe (Fig. 3.5).

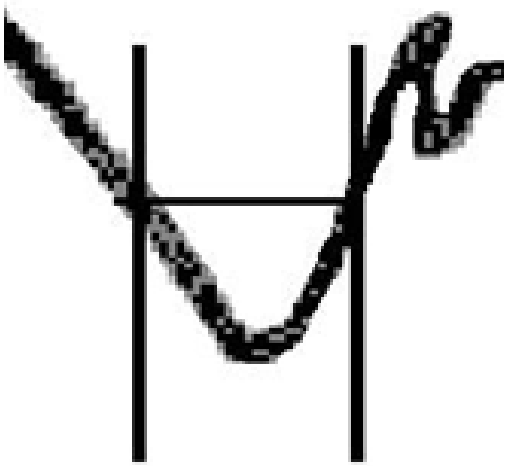

Fig. 3.6

3.2 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.

Let's choose some parameters in our opinion most characterize the quality of piloting: vertical load, aircraft roll, instrument speed, deviation of the left rudder height, aircraft pitch, course, rotor speed on the engine.

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 (Fig. 3.7).

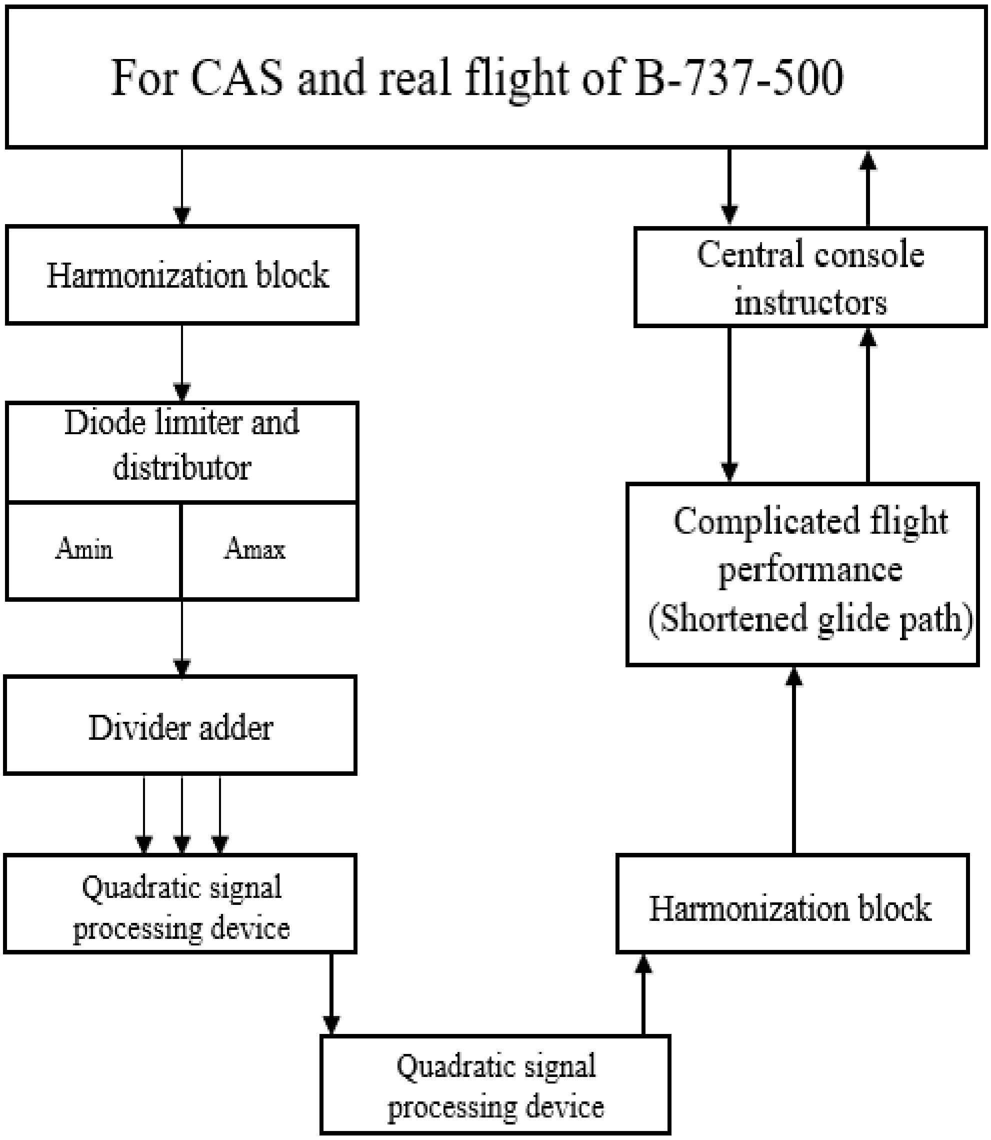

Fig. 3.7 Functional diagram

The calculation of the standard deviation is performed by the formula (3.1):

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

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

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

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

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

Flight №1

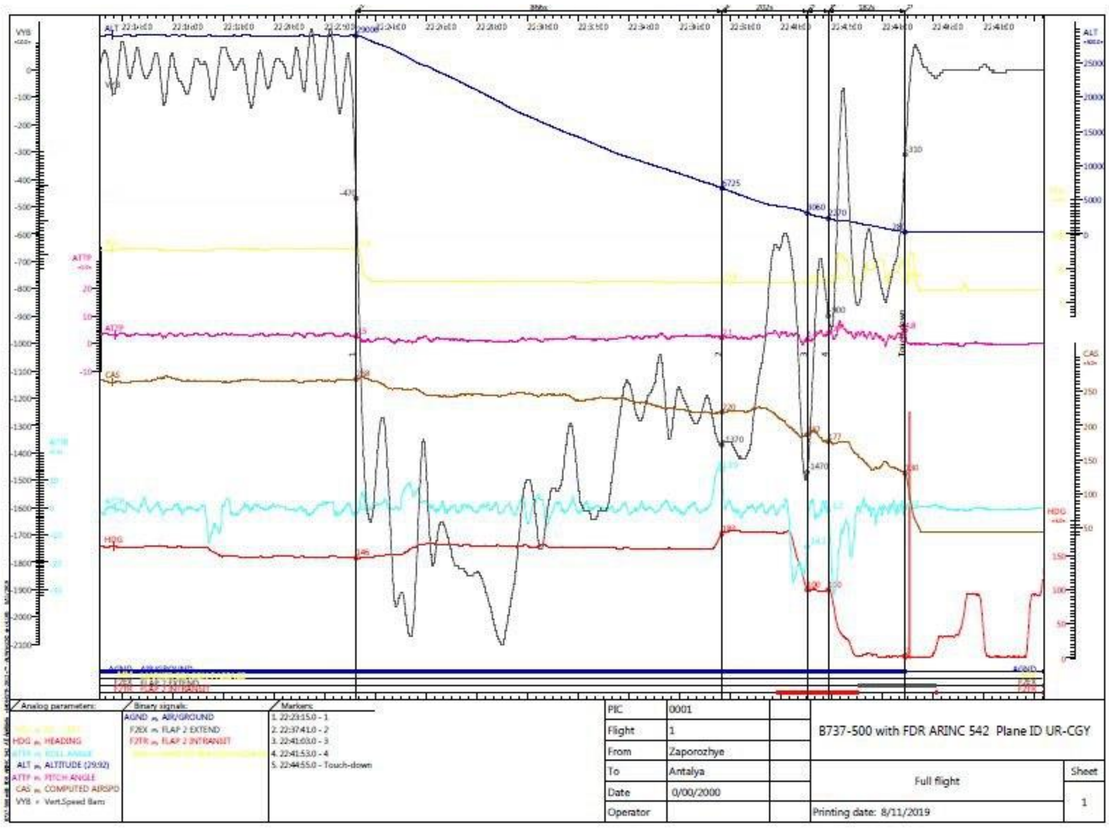

Fig. 3.8

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

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

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

The calculation of the standard deviation:

$$\Delta\Delta A = \sqrt{\Delta V^2{}_{A_{max}} + \Delta\gamma^2{}_{A_{max}} + \Delta\psi^2{}_{A_{max}}} = \sqrt{(-21)^2 + 3.14^2 + 0.99^2} = 21.26.$$

Flight №2

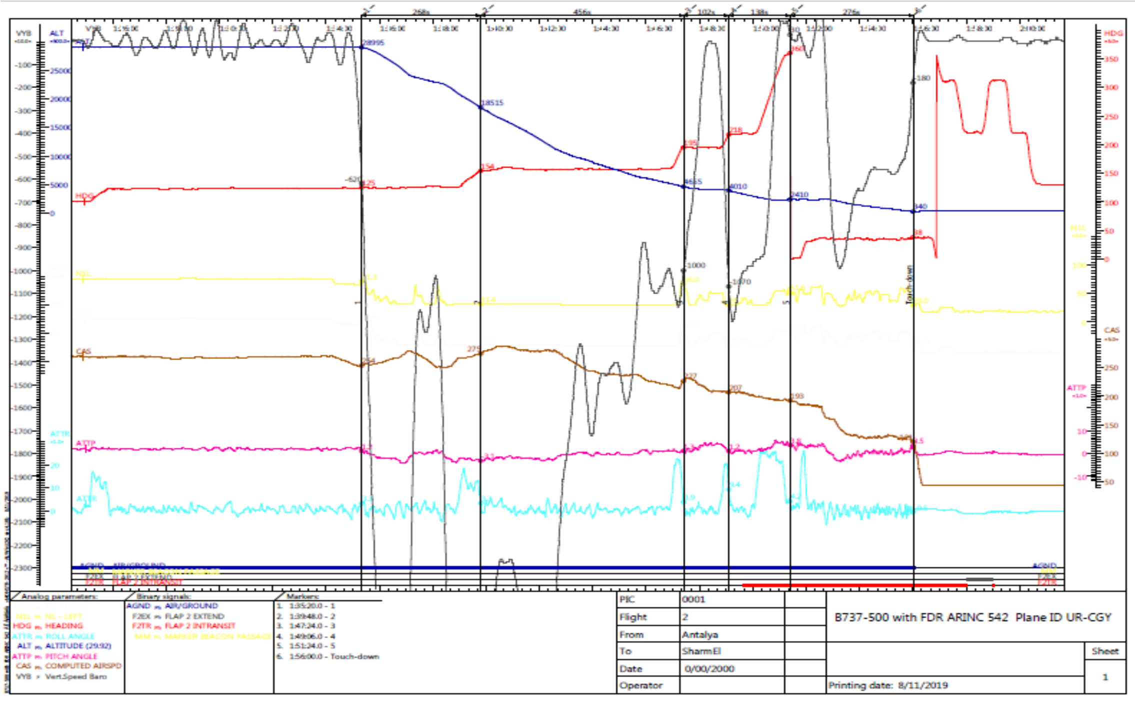

Fig. 3.9

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

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

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

The calculation of the standard deviation:

$$\Delta\Delta A = \sqrt{\Delta V^2{}_{A\max} + \Delta\gamma^2{}_{A\max} + \Delta\psi^2{}_{A\max}} = \sqrt{26^2 + 1.33^2 + 1^2} = 26.05.$$

Flight №3

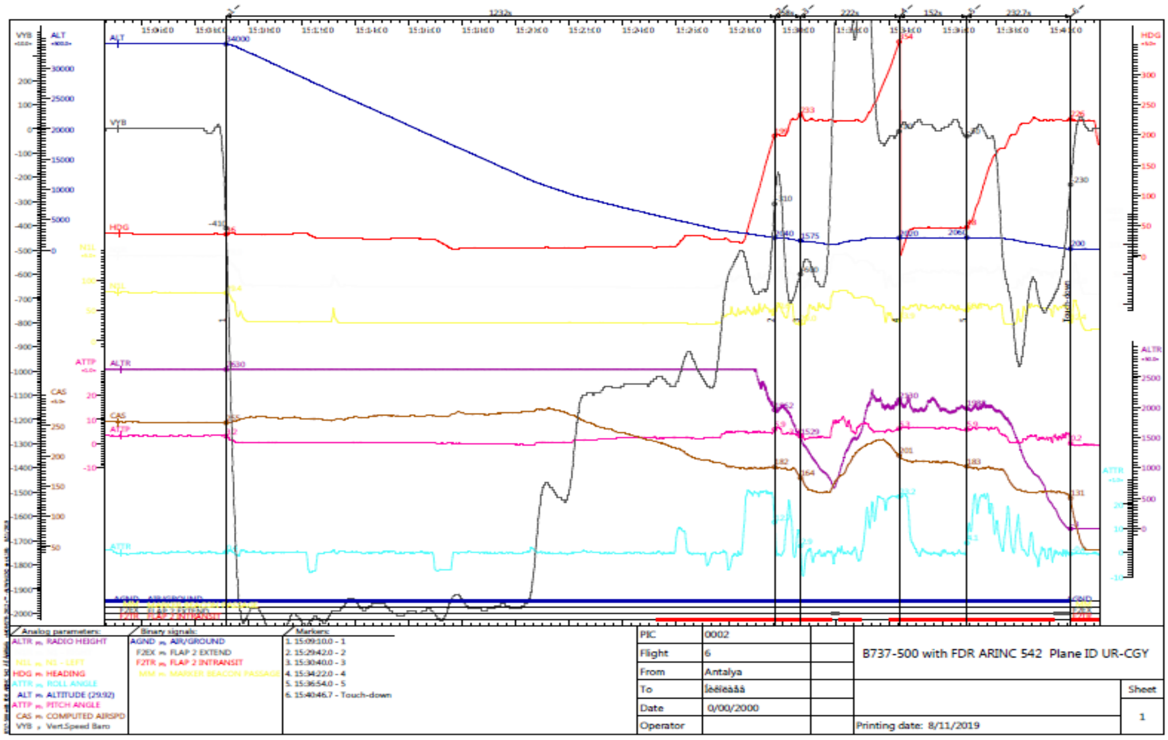

Fig. 3.10

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

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

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

The calculation of the standard deviation

$$\Delta\Delta A = \sqrt{\Delta V^2{}_{A\max} + \Delta\gamma^2{}_{A\max} + \Delta\psi^2{}_{A\max}} = \sqrt{6^2 + 1.34^2 + 0.99^2} = 6.23.$$

Flight №4

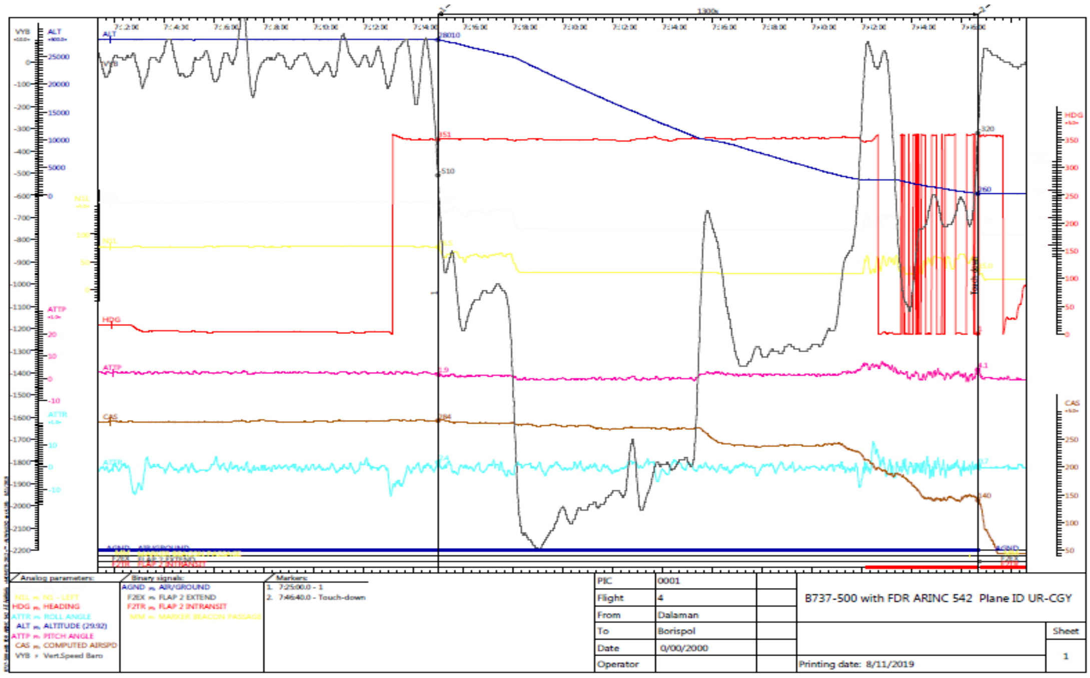

Fig 3.11

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

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

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

The calculation of the standard deviation:

$$\Delta\Delta A=\sqrt{{\Delta V^2}_{A_{max}}+{\Delta\gamma^2}_{A_{max}}+{\Delta\psi^2}_{A_{max}}}=\sqrt{23^2+1.36^2+0.99^2}=$$

$$30.97.$$

Flight №5

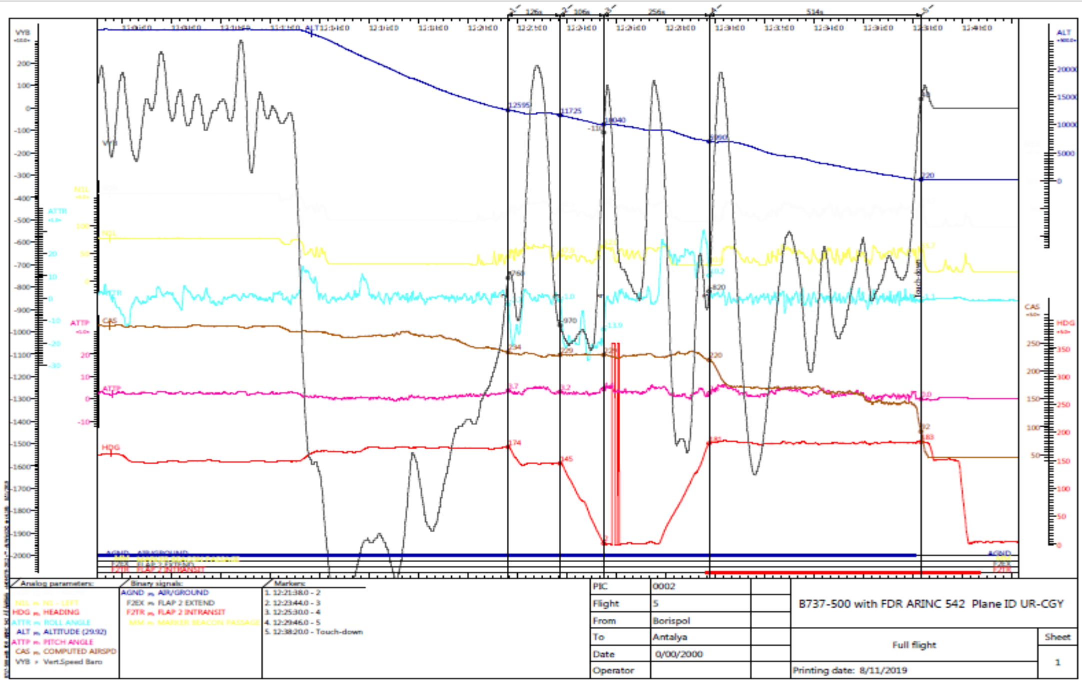

Fig. 3.12

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

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

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

The calculation of the standard deviation

$$\Delta\Delta A = \sqrt{\Delta V^2{}_{A_{max}} + \Delta\gamma^2{}_{A_{max}} + \Delta\psi^2{}_{A_{max}}} = \sqrt{17^2 + 1.97^2 + 1^2} = 17.31.$$

Table №1

№ of flights	ΔV	$\Delta \gamma$	$\Delta \psi$	$\Delta\Delta A$
1	-21	3.14	0.99	21.26
2	26	1.33	1	26.05
3	6	1.34	0.99	6.23
4	23	1.36	0.99	30.97
5	17.31	1.97	1	17.31

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, rotor speed on the engine.

Conclusions

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.

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.

But when performing a pilot task, the pilot has more external factors that increase the human factors in flight.

REFERENCES

[1] Pavlov V.V., Skrypets A.V. Ergonomic issues of creation and operation of aviation electrified and aeronautical-navigation complexes of aircraft. - К.: КИИГА, 2000. - 460 с.

[2] Skrypets A.V. Fundamentals of aviation engineering psychology: textbook. manual. - К .: НАУ, 2002. - 532 с.

[3] Skrypets A.V. Fundamentals of ergonomics: textbook. manual. - К.: НАУ, 2001. - 400 с.

[4] Skrypets A.V. Fundamentals of ergonomics: textbook. manual. - К.: Вид-во НАУ «НАУ-друк», 2009. - 124 с.

[5] Skrypets AV, Pavlov VV, Varchenko O.I., Pavlova SV Engineering psychology and means of displaying information: laboratory workshop. - К: НАУ, 2002. - 76 с.

[6] Skrypets AV, Pavlov V.V., Varchenko OI, Pavlova S.V. Fundamentals of ergonomics: laboratory workshop. - К: НАУ, 2002. - 80 с.

[7] The human factor in the system of air traffic organization / I.S. Bykovets, B.M. Gladkov, VS Demyanchuk and others.

[8] Makarov R.N. Man and civilization in the light of science of the XXI century: an encyclopedic reference book. - M .: 2006. - 1153 с.

[9] International Academy of Human Problems in Aviation and Astronautics: Handbook / Pod. ed. R.N. Makarov. - M .: 2008. - 138 с.

[10] Safety Management Manual (FMS). - Montreal: ICAO, 2013.

[11] Man in the dimensions of the twentieth century. Progress of mankind in the twentieth century / Ed. and author RN Makarov. - M .: 2007.

[12] T. Sheridan, W. Ferrell. Man-machine systems. M.: Mashinostroenie, 1980. - 398 s.

[13] Helmreich, R.L., Wilhelm, J.A., Klinect, J.R. & Merritt, A.C. (2000). Culture, error ... In E. Salas, C.A. Bowers & E. Edens (Eds.), Applying resource

management in organizations: A guide for professionals. Hillsdale, NJ: Erlbaum (pp. 305-331).

[14] https://kuliahdianmardi.files.wordpress.com/2016/03/handbook-of-human-factors-and-ergonomics-fourth-edition-2012.pdf.

[15] https://industri.fatek.unpatti.ac.id/wp-content/uploads/2019/03/104-Introduction-to-Human-Factors-and-Ergonomics-for-Engineers-Mark-Lehto-Steven-J.-Landry-Edisi-2-2012.pdf.

[16] Hryshchenko Y.V. Dissertation "Methods for assessing the characteristics of ergatic control systems aircraft" – Kyiv, 2021.

[17] Hryshchenko Y.V. Analysis of change dynamic stereotype of pilots in the process light training on a complex simulator aircraft.

[18] Hryshchenko Y.V. Assessment of the quality of flight performance at the stage of aircraft landing // International scientific conference "Statistical methods of signal and data processing". - K .: NAU, 2013. - S. 132-137.

[19] Hryshchenko Y.V. Evaluation of the quality of the entrance to the glide path of an aircraft / Y.V. Hryshchenko, V.G. Romanenko, M.Y. Zalissky // Information management systems and technologies (IUST - ODESSA-2020).