MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY

Department of Avionics

ADMIT TO PROTECTION
Head of Department
_____________ S. Pavlova
“_____” ____________2020

GRADUATE WORK

(EXPLANATORY NOTE)

EDUCATIONAL DEGREE
"MASTER"

Theme: «Algorithms for automating flight quality assessment in case of avionics failures»

Done by: Evelina Nych
(name and surname) (signature, date)

Supervisor: Y. Hryshchenko
(name and surname) (signature, date)

Consultants on individual sections of the explanatory note:

Occupation Safety: O. Konovalova
(name and surname) (signature, date)

Environmental protection: V. Frolov
(name and surname) (signature, date)

Controller: V. Levkivskyi
(name and surname) (signature, date)

Kyiv 2020

ABSTRACT

The total volume of the explanatory note to the thesis on "Algorithms for automating flight quality assessment" is a page and contains figures, tables and sources of information used.

1. AUTOMATION: ISSUES AND PROBLEMS

1.1 The impact of the technological approach on automation.

1.1.1 To illustrate the impact of the technological approach on automation, there is a sufficient amount of information obtained from both information systems indicating deficiencies that threaten flight safety and from reports of aviation incidents. In 1985, the Human Behavior Technology Committee (G-10) of the Society of Self-Propelled Transport Engineers (SSPTE) established a subcommittee to consider cabin automation. The G-10 Committee (Figure 1.1) brings together pilots, engineers and human factors specialists (HFs), representing airlines, the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration (NASA), and the Air Force. United States of America (US Air Force), Department of Transportation (MT), National Transportation Safety Authority (NTSB) and aircraft manufacturers.

1.2.1 The G-10 subcommittee held several meetings to identify more than 60 issues related to automation (Figure 1.2). These questions were divided into nine categories:

- knowledge of the situation;

- a sense of complacency caused by automation;
- fear that arises from the automation of fear;
- retention of command authority of the commander of the aircraft (AF);
- design of means of interaction (interface) between crew members and automated systems;
- selection of pilots;
- staff training and methods of its implementation;
- the role of the pilot on board the automated aircraft.знання обстановки;
- fear that arises from the automation of fear;
- retention of command authority of the commander of the aircraft (AF);
- design of means of interaction (interface) between crew members and automated systems;
- selection of pilots;
- staff training and methods of its implementation;
- the role of the pilot on board the automated aircraft.

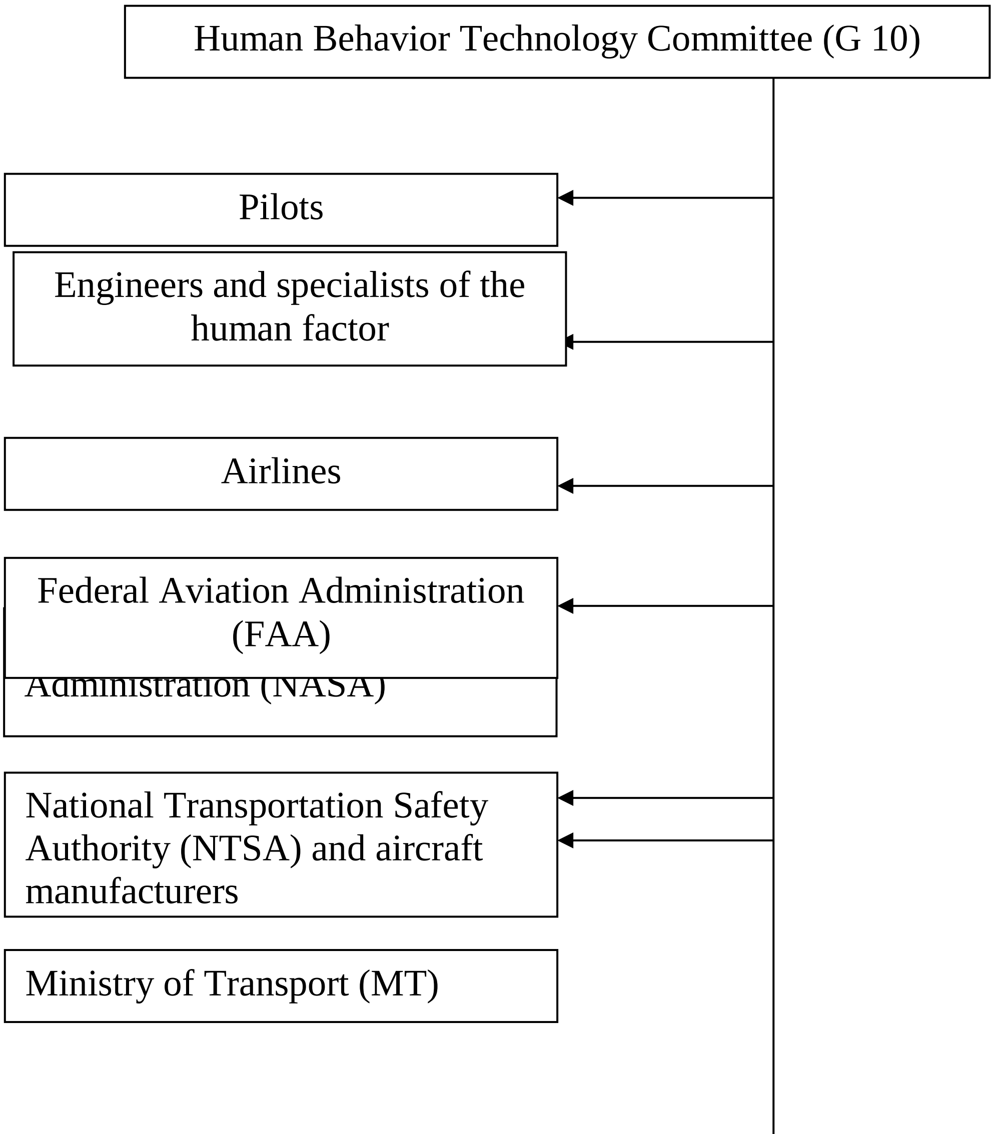


Figure 1.1. Block diagram of the Committee on Human Behavior Technology (G 10)

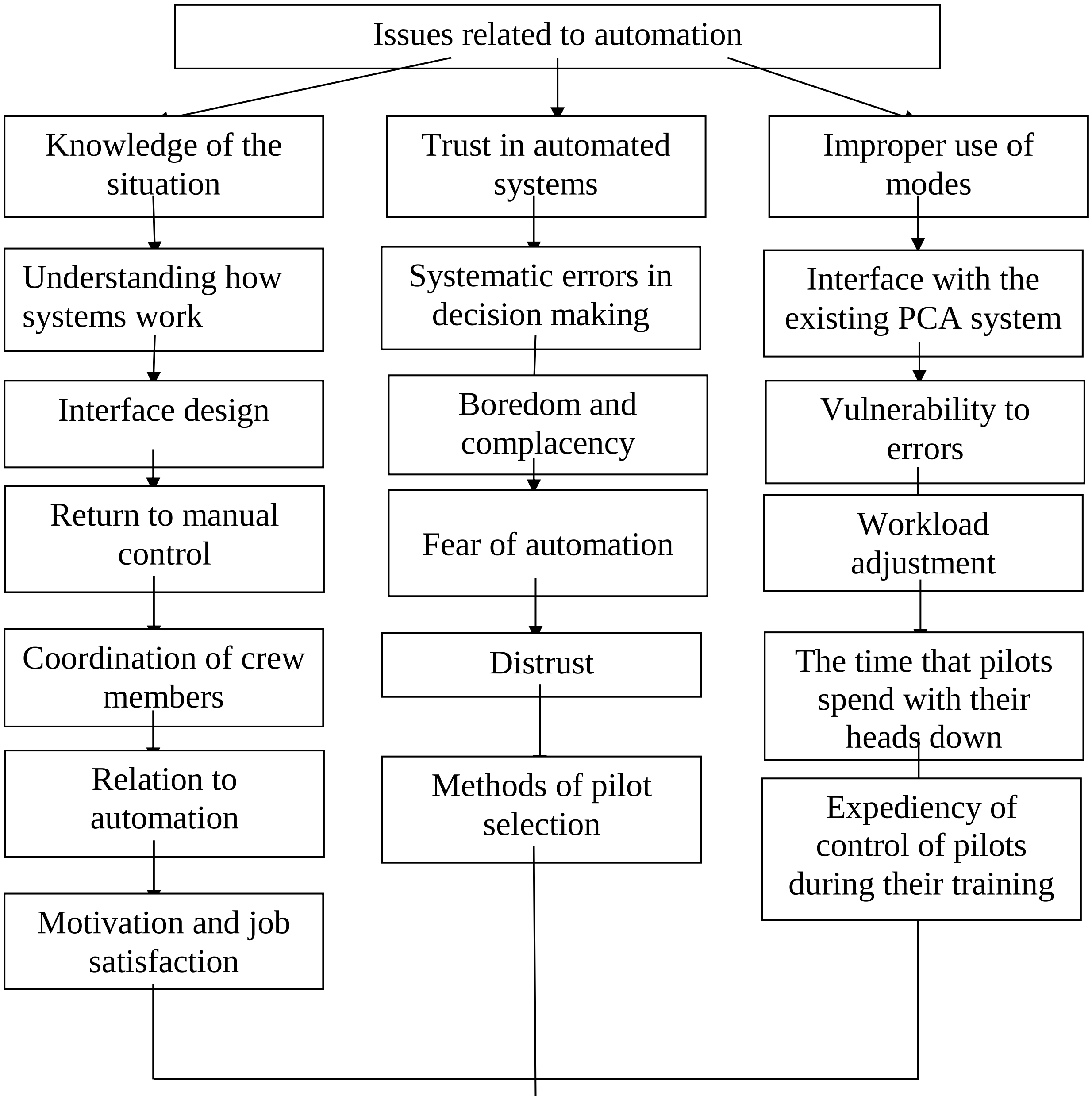


Fig.1.2. Issues of crew cabin automation.

1.2. The main list of issues that is widely developed

The following is a broad list of issues, with particular emphasis on those issues related to operating personnel:

- **Loss of knowledge** of the situation occurs in the absence of perception or misperception of the state of the aircraft and its relationship with the outside world.
- **Loss of understanding** of the systems occurs when the pilot does not know the basic capabilities and limitations of automated systems or a misconception of how systems can work in a particular environment.
- **Unsuccessfully designed interface** that is associated with a system capable of adapting to changes in operating conditions (eg when changing the runway scheduled landing) with such complex and time-consuming human-machine interaction that the system's usefulness is limited where it could be most effective . Unsuccessfully designed interface can be combined with the length of time required to disable the automation and take control (transitional period of control) and can be an important factor in reducing the quality of performance or causing deficiencies in the actions of the crew due to lack of preparedness to respond to one or another event. If this is combined with a lack of knowledge of the situation, then a dangerous situation can arise. To reach the peak of efficiency, a person is usually required to formulate the appropriate mental mood and proper neuromuscular condition. Relative inactivity, caused by the work of automation, reduces a person's readiness for action and his initial skills.
- **Returning to manual control** is a consequence of the understandable fear that some pilots of automated aircraft have because they are afraid of losing basic flying skills. Many pilots prefer to operate their aircraft manually to maintain these skills. However, in other cases, pilots are reluctant to switch from aircraft equipped with automated systems to aircraft that do not have

such systems, for fear that they have lost the necessary skills. This factor is influenced by the adequacy (or inadequacy) of training for flights on new aircraft, the methodology of its conduct and the philosophical approach of companies.

- **Automation-induced changes** in crew coordination are due to the fact that many functions previously performed by the crew (human behavior that is easily observable) have been transmitted to the computer (this is machine behavior that is hidden and difficult to observe).). The need to improve communication between crew members can be easily proven.
- **The attitude to automation** expressed by some pilots shows frustration with the operation of automated systems in unfavorable conditions for the user, although improvements in human-machine interaction have to some extent reduced this perception of the automation process. This feeling of frustration is best reflected in the question asked by the pilots: "Who is in command: the plane or me?" Automation has been accepted by crews not without criticism, as it should be. Some aspects of automation are accepted unequivocally, while others are completely rejected; in some cases, this is due to the fact that the pilots worked with automated equipment in real conditions, not getting enough pleasure from it. In particular, this applies to the first versions of traction machines. Some pilots accepted automation in general, while other pilots rejected it. Most pilots say they enjoy flying modern aircraft, but they are still concerned about flight safety due to the likelihood of automation errors.
- **Motivation and job satisfaction** include issues such as the pilot's loss of sense of the importance of their work, their perceived loss of faith in the value of professional skills, and the pilot's lack of feedback on their personal qualities. Much has been said about changing the role of the pilot, but many believe that the main task of ensuring the safe delivery of passengers and cargo from point A to point B remains unchanged, and automation only offers additional opportunities to perform this task. It

should be clearly understood that this problem cannot be solved by using a whole series of operating instructions or bulletins alone.

- **Overconfidence in automated systems** is due to the rapid habituation to the wide possibilities and quality of new automated systems: when something goes wrong, the crew may be reluctant to turn off automated equipment (some argue that there is also an element complacency). In addition, there is also a tendency to use automation, in order to cope with rapidly changing circumstances, even if there is not enough time to enter new data into the computer.
- **Systematic errors in decision making**. It is not always common for a person to make optimal decisions, especially in times of lack of time or in other stressful situations. Impartiality or bias can further limit a person's ability to make optimal decisions. One method of eliminating bias in decision-making is to use automated decision-making tools at a time when the need arises. When using any of these systems, a person can accept or reject the recommendation given by the machine. Statistics show that such machine-to-human decision-making systems deteriorate rather than improve decision-making quality. Improper ordering can also lead to systematic errors.
- **Boredom** and automation-related complacency can occur because some stages of the flight are so automated that pilots become inattentive and either bored or feel complacent. With regard to specific cases of complacency, the probability of such cases, when a person becomes so confident in the effectiveness of automated systems, that is less vigilant and very tolerant of errors in performing the necessary operations. A person's readiness for immediate action can sometimes decrease. It is desirable to ensure the involvement of the pilot in the operation of systems and their understanding of all stages of the flight, while maintaining the flight efficiency provided by automation. The inclusion of pilots in the control loop, at least after certain periods of time, is more appropriate than

requiring them to simply monitor the operation of the systems for long periods of time.

- **The fear** of automation is due in part to an increase in the number of system components. This increase creates a problem of reliability, because the more components in the system, the greater the probability of failure of one of them. However, some pilots are very reluctant to interfere with automated processes, despite the presence of any signs of failure. This is partly due to the insufficient training of pilots and partly to the pressure exerted on them by difficult circumstances in the process of piloting the aircraft.
- **Distrust** is caused by the fact that the person and the automated system evaluate the situation differently. If the system performs certain operations not as a person would do, or not as the crew suggests, and if the man is not sufficiently prepared, it leads either to the wrong actions of the person, or to his concern about the operation of automation. This is exacerbated by errors in system design that lead to annoying human false alarms that were characteristic of the first generation of ground approach warning systems (GPWS).
- **Pilot selection methods** need to be revised to take into account the relative importance of flight experience and flight time. It is believed that automation will reduce the requirements for the selection of pilots. In fact, the selection methods will have to pay more attention due to the fact that modern crew cabins are equipped with automated systems. It is necessary to make distribution of functions between the person and the car taking into account knowledge of consequences of such distribution. An important aspect of such consequences here is a number of pre-necessary qualities that a pilot must have when starting work to perform a certain role. This means that existing selection criteria need to be re-evaluated or more up-to-date and specific criteria developed in order to properly screen all candidates and recruit only the most appropriate crew to work in crew

cabins equipped with advanced equipment. With the help of careful and systematically tested methods of selection, it will be possible to reduce the duration of flight training, increase operational safety and efficiency.

- **The inability to select the desired mode of operation** of the systems and improper use of modes is the result of many opportunities offered by automation, as well as the result of insufficient training. With new computer equipment, the crew may assume that the aircraft is in a certain control mode, when in fact this is not the case. The problem may also be in the training of pilots or in the methodology of its implementation. With the help of the appropriate indication, the crew must be clearly informed about the mode in which this or that system is operating, as well as about the change of mode. The number of modes used should not be too large, just as the difference between the modes should not be very inconspicuous.
- **An interface with an existing aircraft control system** (APS) can be easily provided if there are no changes to the flight plan. However, if changes are required - and they happen in every flight - data entry may take longer than the conditions in which the PCA bodies operate, especially at low altitudes. Air traffic controllers must understand the capabilities of the new generation of aircraft (to the same extent pilots must understand the problems of air traffic controllers).
- **The vulnerability to gross errors** is due to the fact that automated systems are designed to eliminate small errors and create opportunities for gross errors. It can be illustrated by a simple example: a digital electronic alarm clock. It can be set very accurately, but unlike an analog alarm clock, it works on a 24-hour cycle, so the call time can be mistakenly set for the second half of the day, instead of the first. Simultaneously with the introduction of the digital system, an "exact gross error" was born: an exact 12-hour error. With the increase in the number of automated systems on transport aircraft, most of the gross errors are related to incorrect input of digital data into the system of the flight optimization computer and related

control.

- **Workload regulation** due to the fact that the load, especially in the control pilot, as well as especially at low altitudes in aerodrome areas, is very high. Loads can move quickly from low to excessive, as the reduction in efficiency in systems does not necessarily occur slowly. The development of automation was partly based on the assumption that it would help reduce the load, but the available information suggests that this goal has not yet been achieved. Indeed, data from some automation studies show that pilots' perception is that automation does not reduce workload because it requires even more control.
- **The time that pilots spend with their head down** should be specially studied. This applies to such actions of the crew that require his attention inside the cabin, as reading instrument readings, computer programming, working with maps, etc. These actions prevent the crew from inspecting the outside space. The amount of time pilots spend with their heads down, particularly at altitudes below 10,000 feet (3,048 m) in the aerodrome area, is a problem. Significant periods of time spent by pilots in a position with the head down (and the resulting load) are associated with the appointment of a new runway, with deviations from the standard arrival and departure schemes for instruments, changes in speed and intersection of flight restricted areas. All this is a normal part of the current conditions.
- **Expediency of control of pilots during their training**. Among many other issues, there are issues related to the selection for the training program in order to introduce or disable automatic devices according to what the pilot considers appropriate during his training or what the examiner pays attention to when testing the knowledge and skills of this pilot. . It was suggested that the current rules did not fully meet the technical and operational requirements of modern flights, and it was suggested that they be revised.

1.3. Practical research in the field of automation.

1.3.1 Pilot training is a very important and very expensive process. No one disputes the importance of this process, but there is not always a consensus on the types and scope of training needed to allow pilots to operate new types of aircraft safely and efficiently.

1.3.2 The controversy over the impact of automation on learning is a completely separate issue. According to some, working with automated systems requires additional skills, while others believe that automation reduces the cost of training and reduces the level of traditional flight skills needed to operate aircraft of earlier generations (with a conventional crew cabin). According to the opposite view, one of the most misconceptions about automation is the idea that it reduces training requirements. Despite all these opposing views, there is no doubt about the importance of training. The interface between transport aircraft and their pilots is as important as the relationship between the pilot and the manufacturer, methods, techniques, standard operating rules and airline operating principles. The purpose of this section is to identify issues related to the preparation for work in the cockpits of aircraft crews equipped with advanced equipment.

1.3.3 One of the contentious issues is the changing role of the flight crew in an aircraft with an automated cockpit. It includes at least two initial questions:

Is the pilot a manipulator of the controls, a person who controls the systems, or both? If there is a difference between these concepts, is it in the role of the pilot or in the elements of this role?

According to the analysis, the main role of the transport aviation pilot has not changed at all, because the goal (still) is to safely and efficiently perform the planned flight while providing maximum comfort for passengers, and the role is to achieve this goal - to fly safely and efficiently from point A in point B. The pilot's functions still include control, planning and decision-making regarding certain operations, and tasks also remain traditional (communication, navigation and operational functions). The question is how to ensure the most optimal training of pilots to work on aircraft equipped with advanced technology.

1.3.4 The unanimous view is that automation, according to the general approach, should play a more significant role in maintaining the basic stability and controllability of the aircraft. Functions at a higher level, such as early flight planning, system mode management and decision-making, should be performed primarily by humans through automation. Training should reflect the increased importance of the pilot's decision-making, knowledge of the systems, ability to control and coordinate the actions of crew members. However, the following point is indisputable: automation has not reduced the need for basic skills that are part of the concept of flying skills, as well as the knowledge that has always been necessary for pilots. The importance of these basic principles should be emphasized in the initial stages of training, and a general acquaintance with the aircraft should always precede a detailed study of automated systems. The training should reflect the full variety of needs of pilots, which are characterized by wide differences in such areas as general flight experience, experience in different airlines, time elapsed after the last retraining to switch to a new type of aircraft, computer literacy, etc.

1.3.5 One of the lessons learned by aircraft equipped with advanced technology is that the assessment of pilot training requirements should be carried out at a time when a new type of aircraft is still being designed. Defining the general training requirements required for pilots to acquire the skills to operate new equipment safely and efficiently should be considered as an integral part of the design process. These requirements should not be too detailed. They must clearly state that the system designer offers to know the pilot so that he can ensure the safe and efficient operation of the system. The next reason for presenting such instructions is related to the commissioning of a new type of aircraft. This allows for operational changes, but any kind of inefficient practices existing during commissioning will tend to persist for a long time. It is at this time that the manufacturer's purpose for design and operation should be assessed and understood, as they have a significant impact on training and operation issues. Authorities responsible for the commissioning of new types of aircraft or the development of a training system should have more initial information on the basic design philosophy than has been the case in the past. This is very important, as most of the existing pilot training programs for aircraft equipped with new technology were originally designed for conventional aircraft.

1.3.6 The adequacy of the retraining program when switching from one aircraft type to another should be carefully considered. The complexity of many systems may require a higher level of initial understanding and operational skills than was necessary to control aircraft of previous generations. The main question is: do pilots, after completing the retraining, have sufficient skills, knowledge and understanding of new aircraft in order to operate them safely and effectively. Although some believe that a traditionally high level of manual control skills will be required to a lesser extent, due to the complexity of the systems and the conditions in which they operate, increased demands will be placed on the intellectual or mental abilities of pilots. It is also obvious that typical operations using automatic modes cannot provide adequate learning opportunities. Observations of the work of pilots in the cockpit showed that they use only part of the available devices due to insufficient knowledge of these devices and methods of their use. This largely indicates the inadequacy of training, as well as the complexity of systems and regimes.

1.3.7 The degree of in-depth training should ensure that pilots have carefully mastered the knowledge concerning the systems and their interconnection. This understanding of systems should no longer be intuitive, even for pilots with extensive experience. Training should provide more specific information about systems than previously needed, when the relationship between systems was much less clear. The training time allotted for flights on aircraft with automated systems that have failed will increase the pilot's confidence in their actions, allowing him to switch to manual control in a timely and efficient manner.

1.3.8 It should also be remembered that the "ground competence" in the normal operation of the new system can be significantly different from the "real competence", when the pilot can withstand high voltage and high workload. To learn to withstand such stress, you need to review your previous skills. This is the basic knowledge that is not always applied in practice. In order to provide the necessary amount of intensive training in manual control, the value and suitability of simulators with partial performance of tasks was recognized. These tools include a model of a certain system with high reliability (or even the actual part of the equipment), allowing the learner to focus all his attention on it without situations with additional workload and distraction that can be created. The possibility of using home computers to meet the requirements of training and voluntary self-examination should be explored. There is a possibility of misuse, but at the same time there is significant potential to meet the needs and wishes of pilots, as well as orders from management and authorities. Although the implementation of this idea can be associated with various problems, experience shows that the acquisition of certain basics of computer literacy (such as the ability to use alphanumeric keypad) will facilitate the transition to work in crew cabins equipped with new equipment.

1.3.9 The time elapsed since the last retraining is an important factor in considering and accounting for everything that pilots need. Flight control systems and other automated systems are undoubtedly more complex than on-board aircraft of previous generations, but it has been noted that quite often a number of pilots, switching to other types of aircraft, have not undergone ground retraining for long periods. up to 15 years. This could contribute to the difficulties of some of these pilots, for whom retraining to work with new equipment could not always go smoothly and could be associated with higher-than-expected retraining costs. Lack of sufficient flight experience (which may not coincide with the total flight time), which should be expected in the period immediately following training. One way to solve this problem may be to create for the crews very realistic flight situations on simulators that simulate such situations with a high degree of reliability. In many countries, such training is known by the English abbreviation LOFT (Line-Oriented Flight Training - flight training in near real conditions). Due to the complex equipment of the simulator, it can simulate many different situations, and with modern high-tech training techniques, the simulator allows pilots to gain experience in flight operation (in addition to training), which in some cases can have even greater effect than real flight. Some issues related to retraining also include the transition from electromechanical devices to electronic aerobatic devices, training taking into account cases of failure of all electronic indicators (the aircraft in such conditions is controlled by spare devices, which are basically the same as on aircraft of previous generations, but the amount of information provided by them is much smaller); and the use of autopilot, flight control system and mode control panel. The method by which these systems provide flight performance allows the pilot to separate from the immediate condition of the aircraft (location, speed, altitude, etc.). The procedure of crew members and training methods should provide a situation in which this process does not contribute to the feeling of complacency associated with the use of automation, and the pilot retains a satisfactory ability to keep abreast of developments. The training should include training on the transition to manual control and be carried out in conditions close to the real conditions of flight work in airlines, as well as focus on optimal flight practice.

1.3.10 Instructions for using automated equipment should be provided. They must instruct the crew when they need to use automated systems and, more importantly, when they should not be used. Even with such guidelines (which are usually developed in the form of a company policy statement or its standard operating rules), they reflect the predominance of practices in the context of the specific flight conditions to which they are given. The presence of such guidelines does not necessarily mean that they are universally applicable; nor does it mean that the purpose of this collection is to present them.

1.3.11 In accordance with the well-established practice of programming wind shear profiles as part of training on a simulator that simulates real flight conditions, it would be appropriate to study the usefulness of playing those aviation incidents and events in which automation is considered one of the indirect causes. The flexibility of modern "simulator-computer" systems and the information provided by the systems for collecting notifications on safety issues, makes the latter quite possible. Similarly, according to some statements, there is a need to include in the curriculum and to consider in the course of pilot training problems and incidents that arise in the daily practice of flight production.

1.3.12 The idea of the need for control should be constantly reinforced both during training and during the qualification examination of trainees. Extensive vigilance literature shows, however, that not all people are able to perform the required controls with equal efficiency and often do not notice system malfunctions or errors in setting up, adjusting, and adjusting various installations and devices. This feature is sometimes exacerbated by working in low-stimulation conditions, such as during long flights to destinations where their hands are moved backwards to set the clock to local time. As one of the possible ways it was suggested to conduct an additional or different from the main course of study, although it is difficult to expect the achievement of any cost-compatible results. Particular emphasis was placed on creating incentives (displays, established procedures, additional targeted tasks) that enhance the pilot's ability to exercise control. It is known that pilots can very well exercise certain types of control, such as control over the flight during landing from an external marker beacon to landing. However, many believe that studying the impact of systems design could be an alternative way to address the severity of this problem.

1.3.13 When a new aircraft is considered to be "the same" as an older aircraft, consideration should be given to the adequacy of "difference" recognition training. Operators often use not only different layouts of crew cabins for one basic model of the aircraft, but also different computers and software. When a merger of airlines and amalgamation of aircraft fleets is added to this situation, pilots are forced to frequently change aircraft with cockpits of completely different configurations. In addition, the fact that pilots stop flying on aircraft equipped with advanced technology for a very long period of time can lead to a significant reduction in the level of their professional skills. As already demonstrated in practice, this has a more negative impact on the piloting experience than a similar break in flights on aircraft equipped with less new equipment. This loss of high flight skills is directly related to working with the flight control system.

1.3.14 Retraining in cases where pilots return to less automated aircraft should be carried out very carefully. The main focus of the training should be on "deprogramming" the pilot's expectations: for example, systems that provide automatic access to the altitude and alignment for horizontal flight, which are a common accessory of the automated cockpit, may be absent on board aircraft equipped with older equipment . Evidence from automation research suggests that pilots are also concerned about the decline in their cognitive (mental) skills due to their habituation to ease of navigation and the use of electronic maps to keep abreast of developments. which consist. Management should be aware of the potential hazards arising from such transfers of pilots to other aircraft.

1.3.15 The need to standardize and simplify the operation of an automated cabin for a two-man crew should be considered in all its aspects on a priority basis. Standardization is one of the main means of security, and its importance has increased with the advent of organizations that lease aircraft, as well as as a result of associations and consolidations of airlines, etc. Flight crews may encounter different names of the same object, different rules of operation of the same systems, different symbols used to display the same information, and all this can happen in quite difficult conditions. Such problems may arise in part as a result of the constant modernization of the aircraft, its onboard systems and the symbols used in the cockpit. Significant and well-deserved attention is currently being paid to the standardization of symbols. Symbols must be intuitive and their meanings compatible when designing each new system. The importance of standardization should be emphasized, and this priority should also be reflected in the flight and equipment manual, operating rules and checklists.

1.3.16 Operational rules and checklists should be carefully studied, paying particular attention to the workload required to perform them. When operating aircraft with a cabin designed for a crew of two, many operators did not take into account the achievements in the development of new equipment for cockpits and the progress made in understanding the behavior of the flight crew. Consideration should be given to the special training of flight crew members to switch from airplanes with a cabin for a crew of three to aircraft with an automated cabin for a crew of two. In the following paragraphs, it is proposed to use flight training in near real conditions (LOFT) to demonstrate conditions with a high workload. In addition, LOFT can be an ideal tool for determining workload resulting from incorrect policies or regulations, as significant workloads can be created in conditions where the crew has to perform tasks not related to flight operations at inappropriate times (customer reviews to connect them with passengers, to solve problems related to meeting the needs of the organization of food on board the aircraft or with wheelchairs, etc.). These problems have existed before, but they have become more critical in the use of automation and the rapid increase in the level of flight density (some aspects of these problems are solved on many new aircraft with separate means of communication for the cockpit).

1.3.17 Previously, it was assumed that training programs to optimize the work of the crew in the cabin (CRM) depend on the models. However, it is becoming increasingly clear that at least in some respects the conditions for coordinating the actions of crew members and their communication with each other in the automated cockpit are qualitatively different from those in the cockpit of older aircraft. Recent experiments have shown, for example, a tendency to reduce oral communication between crew members with each other as the number of automated systems increases. If the correctness of this hypothesis can be confirmed experimentally, it is necessary to develop specially tailored to consumers modules of CRM training programs to take into account these differences. Such modules should also take into account the nature and needs of the training organization. The following are areas of issues related to CRM pilot training for automated aircraft. They are identified as a result of observations during real flights and show that in the field of coordination of crew members and optimization of their work in the automated cabin may require special research, both in the distribution of tasks and in standardizing methods and means of their implementation.

Compared to traditional models, it is now physically difficult for one pilot to see what another pilot is doing. For example, on previous-generation aircraft, the autopilot control panel was clearly visible to both pilots; in the automated cab, switching is performed on a central control and indication unit (CDU) that is not visible to another crew member until the same CDU page is turned on. To solve this problem, it seems necessary to ensure the correct procedure and communication in the middle of the cabin.

It is more difficult for the commander of an aircraft to control the work of the co-pilot, and vice versa. Again, the obvious solution is to introduce a new or revised procedure and provide communication in the middle of the cab.

Automation may disrupt the traditional roles of pilot-in-command and pilot-in-command, and there is no clear differentiation between their actions. This is especially important in this area, because, as already noted, standardization is one of the foundations of security. The solution to this problem can be found in establishing an appropriate procedure and introducing standard operating rules.

Automated crew cabins may cause a redistribution of authority between the commander of the aircraft and the co-pilot with the transition of some of them from the first to the last. This process is objective and in some cases is the result of higher qualification of some co-pilots compared to commanders in terms of data entry into the control and indication unit (CDU), and in addition to this performance of such functions is officially transferred to the co-pilot. In particular, during periods of heavy workload, the commander may delegate some of the responsibilities to the co-pilot so that this task can be performed. Such a redistribution of authority can lower the power gradient of the aircraft commander in the cockpit, although commanders, recognizing that their co-pilots have more CDU skills, may follow good CRM principles and use them to their advantage.

As workloads increase, crew members tend to assist each other in programming systems, which can lead to blurring of the clear boundaries between crew responsibilities. Since such a situation is not observed on non-automated aircraft, it is likely that this behavior of crew members is the result of the use of computers.

1.3.18 Although little is known about the implications of aircraft automation for planning and conducting flight training in near real conditions, several specific issues can be identified. Crew cabin automation provides new opportunities for scripting. If during the training in a normal cabin it was necessary to introduce system failures to really increase the load on the crew and create a tense situation for him, then in the automated cabin for this there is a sufficient number of "built-in sources" of stressful situations, especially those that related to the implementation of the instructions of the PCA dispatchers. The electronic indication system in the cockpit opens up wider prospects for the development of scenarios that do not require abnormal or emergency situations - for this quite complex problems associated with the interaction of "man-machine". It is now possible to write scenarios that will address the problems and working conditions in the automated crew cabin, where you can highlight its characteristics and where you can easily practice the principles of CRM. For example, the use in the scenario of the instructions of the PCA manager, which includes a flight on an unforeseen and unmarked scheme in the waiting area over the control point determined by the values of the VOR radical and DME range, provides ample opportunities to practice CRM principles without the need for any system failure .

1.3.19 In the manufacture of aircraft attach great importance to the issue of human performance in the automated cockpit. In any case, one of the manufacturers has already joined forces with a company developing a training program to include existing and future cabin crew optimization (CRM) programs in the pilot retraining program for its aircraft. Pilots - instructors of this aircraft company will be trained in CRM. CRM training programs will also be part of pilot and maintenance training courses. In particular, this manufacturer claims that the planned CRM training courses will be conducted for aircraft, and for each individual model of aircraft in series production, a specific CRM training course will be created. This decision is justified by the need to bring this type of training in line with the long-term mastery of the principles of behavior in the cockpit, as well as the need to focus on the responsibilities distributed among flight crew members. The most important point in this regard is the tacit recognition that familiarization with the human factor during training is no longer the exclusive responsibility of operators, but becomes an integral part of the modern system operation process.

1.3.20 Appropriate training of instructors and pilot inspectors is required, and special attention should be paid to this, as some inspectors may not have much useful experience (in the field of flight operations) and relevant knowledge than cadet pilots. There are compelling arguments in favor of introducing practical experience in the training of instructors and pilots. It was also suggested that more attention be paid to behavioral issues in CRM and LOFT training programs. Although human rights experts have acknowledged this problem, the training of instructors in connection with the introduction of aircraft automation has not yet received sufficient attention, and teachers do not have the sources to guide them in the field of automation training. The selection and training of instructors are still determined by the same time-honored methods and criteria used for crew cabins on conventional aircraft, although the issues of preparation for work in an automated cabin are completely different.

The role of the regulatory body in the development of training programs and in the training of instructors can not be ignored. During the certification process, the regulatory body evaluates the information provided by the manufacturer.

The certification data obtained in this case should be passed on to the operator, as such data is the basis on which training programs should be created. For example, knowing the design purpose of the manufacturer, the operator can develop rules within which the relevant tasks can be correctly defined. The preparation of the training program in this way must then be approved on the basis of the same sources of information, thus closing the loop "manufacturer - regulatory body -

operator". Training should be an integral part of systems design and should be seen as part of an approach to systems engineering.

1.3. Management methods and types of strategies for overcoming difficulties.

1.3.1 According to one assumption, all aviation events, regardless of severity, are the result of a failed organization. The significance of this assumption becomes clear in the context of aircraft flight control. Despite this, the role of such management was often overlooked. In matters related to automation, the impact of management is vital. This is due to the fact that now we are still in the implementation phase and are going through a period of "shock", which always accompanies change. Many decisions need to be made or modified regarding the design, layout and selection of equipment, the establishment of appropriate rules and the implementation of appropriate policies, and the development of staff training strategies. At the system level, the benefits of using management frameworks outweigh those that could be obtained by contacting an individual operator.

1.3.2 The main requirement for flight control is to provide an unambiguous understanding of the method of flight, for example by fully explaining the extent to which the crew expects the automated equipment in the cabin of the aircraft. Such an understanding must be expressed in a clear and concise manner, and then the intentions expressed must be communicated to the flight crew by effective means. It is equally important that pilot pilots and inspector pilots, pilot pilots and senior executives in charge of aircraft flight management follow the rules and procedures that have been adopted. Such a system should facilitate the establishment of an appropriate leadership atmosphere and indicate the commitment to take action, which can be further expanded through the application of appropriate pilot selection methods and the implementation of appropriate comprehensive training programs for their training.

1.3.3 Support from management structures is also important in the production and use of operational information media. Flight manuals, flight manuals, checklists, equipment manuals, operating bulletins and - for automated crew cabins - software are important means of disseminating materials that reflect a particular philosophy of flight operations. However, establishing effective channels of communication with pilots requires more than just the publication of manuals and directives. It is important to have constant contact with the pilots during the maximum exchange of information, opinions and opinions on the policy pursued. At the same time, the proposed types of equipment, procedures and rules should be discussed and substantiated. Only then can pilots understand the reasons for choosing certain types of equipment or procedures, and only under these conditions can we expect that they will be interested in all these things and will be involved in the process of their coordinated use. The importance of involving pilots in the decision-making process and in the development of procedural guidelines is also related to motivation, self-satisfaction, etc.

1.3.4 Operators and pilots involved in the operation of the equipment should be involved in the procurement process. Aircraft equipped with advanced technology embody the changes, the significant achievements that exist, but they also raise many controversial issues. The cost of any design error that is not corrected at the design or acquisition stage will increase many times over and will be paid for throughout the life, whether it is a display, computer or related software and hardware. A well-designed training system, as well as the methodology of its implementation, which cannot be properly applied due to the incompatibility associated with errors in equipment design, lead to more new problems than the number of problems they solve. At the same time, there is no unanimous opinion on the degree of probability with which one can reasonably expect from professional pilots to adapt to equipment of less than optimal design.

1.3.5 It is hardly surprising that the preparation and methodology of its implementation have been identified as problematic areas in the early reviews of the operation of aircraft equipped with advanced technology. To the extent that erroneous design of equipment prevents proper training and application of appropriate techniques, it should also be recognized that even a well-designed system will not work optimally if the related training and methods are ineffective. Establishing a feedback loop between operating personnel and the company's training department is necessary because pre-flight training has some impact on them. With regard to automation, there is some evidence to suggest that flight crews may not have received the amount of training materials or information from management or other sources they need to understand the systems used on automated aircraft. courts, namely they are expected to operate in the future.

1.3.6 Differences in training for flights performed by crews of two and three people. It may be important to provide pilots with a two-man crew in the initial and recurrent training phases more training opportunities for on-board systems than on previous three-man aircraft. The transition from three-person crews to two-person crews leads to a significant change in standard operating rules and checklists, requiring a different approach to optimizing cabin crew performance.

1.3.7 The policy of promotion of pilots and the practice of drawing up flight schedules create additional problems. The promotion policy is usually based on collective agreements and length of service, and a pilot who has worked as a co-pilot on aircraft with an automated cockpit can move to an older jet to become a commander. In this case, the pilot is recommended to undergo additional retraining on the basics of piloting this aircraft.

1.3.8 The responsibilities of the pilot-in-command and the pilot-in-command should be clearly delineated and the tasks properly distributed, with particular emphasis on the role of the pilot-in-command. With regard to the latter, it should be noted that a significant deviation from any operational standard in flight is usually preceded by a mistake made in the preventive control, and from the point of view of system safety, this error of the pilot is as critical as the error control pilot. The information available in the databases indicates that the risk increases when the pilot-in-command performs the duties of the pilot-in-command, as a number of aviation incidents and incidents occurred at the same time as the co-pilot. Part of the problem is the ambiguous role of the commander of the aircraft when he exercises control. The controversy over this issue is beyond the scope of this collection, but is undoubtedly related to the field of automation.

1.3.9 In order to dispel the atmosphere of boredom and maintain the required level of vigilance and control during periods of forced low pilot activity, some suggested additional targeted work at this time. Recently, the concept of a filling training break has been considered as one of the ways to achieve this goal. Such training includes the use of on-board computers. It should be noted that the purpose of this paragraph is not to address issues related to vigilance, but ways to use the time when pilots are not required to be highly active in flight. As a caveat, there is very little guidance on resolving the conflict between the need to continuously maintain a state of effective control of the situation in flight and an effective "filling pause training".

1.3.10 In many parts of the world, the development of the PCA service has not kept pace with developments in the field of cockpit automation. The current PCA system does not meet the great capabilities of new aircraft, and this poses a certain threat, as it is designed to service mainly jet transport aircraft such as "DC-8/9", "B-737-100 / 200", "B -727 "and other similar aircraft. Conversely, state-of-the-art transport jets are so complex that they can be easily and efficiently operated in a modern PCA system, and therefore the crews of these aircraft are unable to use their latest systems and devices. The flight control and data display systems of modern aircraft are very impressive: the capabilities of navigation systems in the vertical and transverse planes, advanced traction machines, navigation using an inertial reference system (IRS) and IRS navigation displays have become quite familiar. They are ideal for flying in difficult conditions, but attempts to coordinate their work with the instructions of the PCA cause flight crews some difficulties. To some extent, it is believed that this is based on the lack of awareness of controllers about the capabilities of new aircraft, as well as insufficient knowledge of pilots of the problems of the PCA service. Experience has shown that the PCA service has become more sophisticated as air traffic controllers become acquainted with new generations of aircraft. Familiarization flights on these aircraft allow PCA personnel to better understand the capabilities provided in modern crew cabins.

1.3.11 It has already been mentioned that companies provide flight crews with relevant documentation (flight plans, schedules with weighting calculations, weather reports, etc.) and establish a feedback loop between the operational unit (flight planning, flight training center). etc.) and the training unit (although it depends on the model, more critical such feedback is provided for pilots working in automated crew cabins). The established feedback loop will allow operators to review their checklists, procedures, rules and all documentation that requires them to make sure that they are suitable for modern crew cabins and the specific operations performed in them.

1.3.12 There is an assumption that non-flight control tasks are required to be performed at inappropriate times (eg calling terrestrial subscribers to communicate with passengers, resolving power issues on board aircraft, wheelchairs and other issues passenger service) can lead to a significant increase in the workload of the flight crew. Although this problem is not new, it has become more critical due to the increased workload of a two-man crew during a flight in high-traffic areas. While pilots will be explained how to prioritize and reduce workloads, airline management should develop policies to review or eliminate the above tasks. In developing this policy, due regard shall be paid to the interaction between flight crew members and flight attendants, with a clear definition of the relationship between the two-person flight crew and the three-person crew. Some governing bodies have acknowledged the problem and call for the installation of separate radios for flight attendants, which should be used for purposes other than flight control.

1.3.13 The establishment of an international reference system for the collection and dissemination of information on issues such as the selection of the optimal level of automation and other issues reflected in the operating rules is desirable.

This system will be linked to existing aviation incident and incident reporting systems. There is a significant body of evidence to suggest that some of the problems associated with automation may well be the result of differences in learning and established rules and procedures. The creation of such a reference system could be defined as a medium-term goal, and this collection is a step in this direction.

1.4. Practical research in the field of automation.

Practical research (research in flight and other places of operation) is a window into the real world. Another window into the real world is several established systems for reporting security breaches. This appendix contains only an overview of existing practical research in the field of automation. The Secretariat will assist anyone interested in obtaining more detailed information for obtaining this information directly from its sources.

Practical research is important for several reasons:

- Flight crew members are those people who know everything about the methods of flight operation of aircraft in the real world. They are actual participants in the application of these methods, so you should seek to use their experience and advice.
- Problems often do not arise until the practical experience of flying on airlines is accumulated. Airline flights are a real test of a project, because here the designed equipment is used in different conditions. An additional purpose of practical research is to provide feedback from operating personnel to those professionals who are not directly involved in the operation.
- Practical research allows for an unbiased evaluation of the system, as researchers are not involved in the design, sale and operation of aircraft or in the process of monitoring compliance. Practical research

provides important feedback to designers and operators, as well as to other researchers.

The main sources of information in case studies are questionnaires for volunteer crew members and their feedback included in the voluntary reporting system. Oral interviews with staff, including pilot instructors, pilot pilots, simulator instructors and instructor instructors, are also used. Researchers may also attend ground training courses on the appropriate aircraft type and participate in cockpit flights as observers.

1.5 Introduction of new equipment in crew cabins. Research of the human factor.

A previous study showed that pilots accept new equipment and want to use it because they find it useful.

Pilots are aware of the possibility of losing flight skills in the presence of automation, and to avoid this, they fly in manual control mode (usually using a command aerobatic device). The data collected during the study do not indicate any loss of skills.

Feelings of confusion or shock caused the pilots mostly failures in the interaction of traction machines with the autopilot. The autopilot turns in the "wrong direction" or refuses to bring the aircraft on a given course, and achieves (or fails) the desired results using the flight optimization system / control unit and display (FMC / CDU). The pilots believe that FMC / CDU training can be improved, and they especially wanted to have more experience in manual control mode. It was also noted that during the training it is necessary to pay more attention to the operation of the control panel modes and perform more training flights in the manual control mode.

Linear pilots do not always manage to obtain the necessary information, especially about "techniques" (methods) of operation, from system designers.

Piloting aircraft with sophisticated equipment and a high level of automation allows pilots to be distracted from control functions, which in turn leads to the loss of constant control functions.

Pilots should be taught to, if necessary, "cut it all down" (ie, turn off automated systems) and not try to "program" a way out of a difficult situation.

These data obtained at the research sites confirm some existing principles of human factor accounting, suggest new principles and raise issues that require further research.

1.6. Crew cabin automation taking into account the human factor: a practical study on the overload of the flight crew to switch to another aircraft.

This group of two pilot pilots (from one airline) participated in this practical study for 2 years to determine what factors affect the retraining of pilots to switch from an aircraft with a conventional cockpit to an automated cockpit (from a DC - 9/10/30/50 "on the plane" MD-80 "). The findings of the study are as follows:

The MD-80, its flight control system and other automated devices are generally considered by pilots working on it to be properly designed and well-designed, and they are highly rated by pilots in their operation.

The pilots expressed a generally favorable view of automation. However, even the most loyal proponents of automation have expressed concern that the need to control it increases when working with automated equipment. In addition, some concern was expressed that when working in automatic mode, pilots are "outside the control circuit" or "invited to accompany the trip." In general, automated devices were used to a high degree, but the degree of their individual use varied widely. Pilots believe that automation should be provided by the company, but each pilot should decide for himself when and under what circumstances to use or not to use automated devices. After an initial period of doubt about the reliability of automated equipment, most crews realized that it had a high degree of reliability. The main concern expressed by the pilots was that this equipment required a degree of control to which the pilots were not accustomed, working on early types of DC-9 aircraft. Different views were expressed on the issue of reducing the workload. But everyone agreed that the numerical reduction in load was about 15%, which did not coincide with the forecasts for the aircraft "MD-80". The pilots were unanimous that in comparison with the aircraft "DC-9 automation" and the layout of the cockpit on the aircraft "MD-80" do not allow pilots to have extra time for inspection of the cockpit devices.

Most pilots did not see any safety benefits in using automation. Their attitude to security aspects when using automation was mostly neutral.

In the course of this study, no data were obtained on issues related to the loss of qualifications due to the very high emphasis on automation. Even with some concern, no one called it a serious problem. This is partly due to the fact that at the beginning of the study, the crews flew simultaneously on the aircraft "MD-80" and "DC-9".

During the study period, a "separate status" was established between conventional and advanced models. The pilots noted that the transition went largely smoothly due to the ability to fly only on the plane "MD-80" at the initial stage of getting used to the new cockpit.

Mastering the functions of control in the cockpit, equipped with new equipment, requires a different approach to pilot training. To prepare for the acquisition of skills related to data entry or programs, as well as the development of cognitive (mental) abilities, it is advisable to use a multi-profile simulator. This requires a group of dynamic interacting tools capable of demonstrating in real time to the training pilot the dynamics of the onboard systems and the sequence of actions of the pilot. An important remark regarding the quality of training is the repeated indication by crew members that in the event of the slightest unforeseen event, such as a change of runway, they turned off the automation and switched to manual mode.

Constant attention should be paid to the main and traditional problems associated with the human factor that arise in the design of crew cabins, in particular in the design of controls, keyboard devices for data entry, warning and alarm systems, crew cabin lighting. The effective use of new equipment in the cockpit depends on the consideration of time-sanctified principles relating to the human factor. The study found no signs of psychological problems caused by automation, such as a negative attitude towards flying work as a profession or a loss of self-esteem.

1.6. Advanced technology (electronic indication system) taking into account the human factor on transport aircraft.

The following is a report on the results of a three-year case study involving the line crews of two major airlines and using an advanced aircraft, the B-757. Two previous studies focused on the initial retraining of crews and their first experience. topics: training to work with advanced automated equipment, crew errors in the cabin and reduce their number, regulation of the workload in the crew cabin, the general attitude to the automation of the crew cabin.

General conclusions. The pilots showed great enthusiasm for the use of the above aircraft, training and the ability to fly on state-of-the-art transport aircraft. It is more difficult to generalize the attitude of pilots to automation in general, here "mixed feelings" prevailed. Of particular note are two critical issues: safety (pilots feel that they are often "outside the control loop" and lose situational orientation) and workload (according to pilots, it increases during the flight stages, which are already characterized by heavy loads, and decreases in those stages when it is usually small). During heavy-duty stages, pilots prefer to switch to manual control.

Equipment. Pilots express satisfaction with the overall layout of the cockpit; few problems traditionally associated with the human factor have been noted. According to most pilots, the warning and alarm systems of the aircraft "B-757" deserve high praise.

Teaching. During the study, the training of B-757 piloting on both airlines was generally well planned and organized. The most common criticisms related to the excessive emphasis on automation by excluding from the training program basic knowledge about this aircraft and its piloting skills. It became obvious the need for simulators equipped with computers to work out certain parts of the flight tasks.

Crew errors in the cockpit. The study did not provide data that could be used to state where crew errors are more common: low or high levels of automation. Arbitrary departure from a given height, which is always of great concern, usually occurs more often, according to established cases, through no fault of man than equipment.

Coordination of crew members. Compared to traditional models, it is physically difficult for one pilot to see and understand what another is doing. In the automated crew cabin, there are fewer differences in their actions than in the usual, due to the desire of crew members to "help" each other in programming systems during periods of increased workload. In the modern cockpit there is an unintentional redistribution of authority with the transfer of some of them from the commander to the co-pilot. Workload. The study did not show an overall reduction in workload in the automated cab, especially in stages with high load levels, when such a reduction is most needed. It was noted that although some automated devices were installed on board the aircraft in the hope that they would reduce the load, they were perceived by pilots as increasing it. From this it is concluded that the current generation of aircraft equipped with advanced technology, do not fulfill their task of reducing the load, both internal and external in relation to the design of equipment and software reasons. Air traffic control. The existing PCA system does not fully utilize the flight control capabilities of automated aircraft. The PCA aircraft and ground systems appear to have been established as independent, unconnected systems.

In conclusion, the participants of this study offered the following recommendations:

- Research on human-automation interfaces should be continued.
- Research on the transformation of ATC systems to increase their susceptibility to advanced capabilities of advanced aircraft should be

conducted as a matter of priority before a new generation of ATP system enters service.

- Training departments should review curricula and syllabi, training equipment and manuals to reflect changes in new aircraft.
- Operators of modern two-pilot airplanes should review their rules, procedures, checklists, flight plans, fuel calculation, guidance and flight crew requirements to reduce workload and reduce operational errors by providing optimal provision of materials and abolishing unnecessary rules.
- It is necessary to begin scientific research in the field of optimization of work of crew in a cabin as work in the automated cabin differs from work in a traditional cabin. Authorities should review certification procedures in order to carefully identify human-related issues related to new models. It is the human factor that should be taken into account, not just the results of the workload assessment using error prediction methods.
- Agencies should encourage research into non-fault-tolerant systems and other methods of using machine intelligence to prevent, detect and correct flight crew errors, or make them more obvious to make them more visible. Manufacturers and users should standardize the terminology and designations of navigation aids on CDUs, maps, and computer-generated flight plans.
- In general, future crew cabins should be designed so that the automation implemented in them has as its central link a person, not equipment.

2. COMPARATIVE ANALYSIS OF THE PROBLEM OF AUTOMATION OF ICAO AND HUMAN FACTORS

2.1 . The main causes of failures and malfunctions of avionics

Modern avionics is an extremely complex technical system, which includes many functionally interconnected elements, components, blocks, systems and complexes. A natural question arises - why the components of such complex technical systems put into operation at the same time have different service life, fail at different times, and in many cases it is impossible to determine in advance the moment of failure of a particular product of onboard equipment. This can be explained as follows:

- each component of the on-board aeronautical and electronic equipment has a well-defined purpose, which is provided by providing it with specific operational properties (eg, accuracy, coordination of inputs and outputs, etc.);
- each property of aviation and electronic equipment is detected only during its interaction with the environment, which is a set of factor loads that are perceived by the onboard equipment due to the presence of certain properties.

The loss of at least one of the properties of the on-board equipment leads to the fact that it can not accept the factor load of the environment, which is equivalent to loss of performance or failure. It should be noted that disability in this case should not be considered as an absolute loss of an object of a certain property, as the operating documentation determines the allowable limits of parameters or properties of the components that ensure their operability. Therefore, only the deviation of the parameters beyond the permissible limits should be considered as one of the forms of loss of properties necessary to ensure the operability of the object.

Experience shows that the occurrence of failures of technical devices during operation is subject to a certain pattern. you are not universal. There are elements that do not have the first period (for example, a well-organized control eliminates defective elements). There are elements that do not age over time. However, most elements of avionics have a long period in which the risk of failure is relatively low and almost constant. Due to miscalculations that could have been made in the design and determination of operating conditions, the distribution curve may shift towards lower resistance values.

In the process of flight maintenance, elements of aviation and electronic equipment are affected by loads of different magnitude and direction, which are often random. The density of load distribution can be a characteristic of the operating conditions of facilities. Due to the fact that elements of on-board equipment with different resistance to factor loads are put into operation, and "weak" elements can fail under the action of small loads, the main part of failures at the initial stage of operation are these "weak" or substandard elements. Therefore, both the failure rate and the density of the failure time distribution at the initial stage of operation can be relatively high.

Failures caused by the commissioning of "weak" or substandard products are called running-in times, and the period during which they occur is called the running-in period. At the same stage, there is an increase, for various reasons, the number of erroneous actions of the operator. In the case when the objects of aeronautical and electronic equipment have a high homogeneity, and hence little scattering of resistance values, and the operating loads are much lower than those allowed for these objects, the period of commissioning may not be. In turn, the failure of mostly "weak" and substandard objects during the run-in period leads to a decrease in the scattering of the resistance of the remaining products, and some increase in its average value. Due to this, the load resistance of individual objects of aviation and electronic equipment is almost not observed. Failures occur only at significant random concentrations of loads and are called sudden. In some types of objects, sudden failures are predominant, in others they may not be typical. In general, this period of the life cycle of aviation equipment is called the initial stage of flight maintenance. For many on-board equipment products, it is possible to determine the period of operation when the running-in phase is over, but there are no noticeable structural changes in their properties, which are characterized by the ability to withstand external factor loads. Facility failures during this period occur only under the influence of significant concentrations of operating loads. Therefore, even if there are some failures, they are sudden. The failure rate does not change and remains minimal. At the stage of normal operation, due to the accumulation of irreversible changes in the products of aviation and electronic equipment under the influence of operating loads, there is a period when the resistance to these loads is significantly reduced. The number of cases of operating loads exceeding the resistance of on-board equipment increases. In this case, there are failures, which are manifested both in the form of breakdowns and in the form of the output of the main parameters of the products beyond the established limits. This period is called the period of wear or aging. It is characterized by an increase in failures: the failure rate first increases and then decreases. This is not due to an increase in the reliability of the products, but to the small number of products that have functioned properly so far, as a result of which the number of products of on-board equipment that failed will also be small.

What is the difference between aircraft failures at different stages of its flight maintenance? It is the reason for failure. Thus, in the initial period of operation the main part of failures is due to the commissioning of aircraft a number of objects of the technical complex with "weak" resistance, at the stage of normal operation - random, significant concentrations of external loads, and in the period of wear - reducing resistance load. Of course, this does not exclude the possibility of sudden or gradual failures at all stages of aircraft operation.

Now let's briefly consider the features of the initial stage of operation of aviation and electronic equipment. In the initial period of operation of such complex systems, which are the objects of avionics, increases, as noted earlier, the number of start-up failures, as well as the number of operator errors, which leads to aviation accidents and incidents. This stage of operation of aircraft is characterized by improvements and modernization of new equipment. During this period, there are often weaknesses in the training of personnel, the lack of specialists with the necessary skills for operation and maintenance of new, almost always - more complex than previously mastered, equipment. New aircraft requires increased attention from both flight and engineering staff. The efficiency of aircraft and their onboard equipment is in some way influenced by a kind of uncertainty about the new, unusual, as well as - the old stereotype, not completely overcome in the study of new, more complex aircraft. To this should be added the imperfect ground control and diagnostic equipment, as well as the lack of the necessary set of spare parts and tools. Operational documentation for new aircraft is often imperfect, it does not take into account all the features of the initial stage of operation of products and systems of aviation and electronic equipment. The work of engineering and technical staff is often performed in a limited time for completion (refinement) and modernization of onboard equipment. Also affect the efficiency of aircraft operations and significant shortcomings in technology and application of methods and means of maintenance, ignorance of the weaknesses of the aircraft, the lack of proper organization of work. During the period of development of aircraft it is difficult to carry out a uniform loading of aircraft personnel, as the operation process is irregular, and the complexity of certain types of maintenance is determined only tentatively. In addition, the costs associated with the elimination of defects and malfunctions that occur during the operation of products and systems of aeronautical and electronic equipment are unknown. In addition, it is not always possible to conduct an accurate and detailed analysis of erroneous actions of aviation specialists, to identify their true causes, to develop effective preventive measures. During this period, 25 percent of failures, such as aerobatic navigation equipment, are due to the fault of the personnel operating it; 45 percent of units, assemblies and units of aerobatic navigation systems, which are removed for testing in the laboratory, are quite serviceable, they could not be tested. For the same reason, unproductive downtime associated with the maintenance of faultless aircraft accounts for about 20 percent of the calendar time of the initial stage of its operation.

Decision-making by a human operator is often based on incomplete information, which in many cases leads to errors in work. This is especially true of stressful situations that often occur in the initial period of operation of aircraft. Collecting data on the flow of errors is a rather difficult task. It should be borne in mind that the higher the level of training of the operator, the more difficult it is to identify the structure of possible real errors, because these errors are subject to the law of unlikely events. Numerous models of flows of erroneous actions of operators (in the form of various exponents and functions) are given in the literature, however these flows often take without taking into account influence of set of negative factors (stressors) accompanying real work of operators. Experience shows that in the structure of anti-stress training of operators in flight operation and maintenance of aircraft it is necessary to change the traditional definition of the characteristics of the flow of operator errors and introduce more generalized anti-stress models of this flow. For example, one such model involves the division of errors into two areas (the area of frequent and the area of rare errors), which are interconnected by boundary transitions (forward and reverse).

During the training and coaching of operators, a direct transition from frequent to liquid errors is more often observed, while under the action of a set of negative factor loads - a reverse transition (jump from rare to frequent errors).

Thus, the professional training of aviation operators, in particular, members of aircraft crews, on complex simulators should not be operational, but process, ie based on the widespread use of methods and means of anti-stress training. At the initial stage of aircraft operation, situations may arise that lead to a significant increase in the psychophysiological load of operators, and as a consequence - to their premature fatigue and overfatigue. This important factor in most cases is not taken into account when summarizing data and analyzing the work process of aviation professionals. Labor processes, if designed, only taking into account the functioning of technical means, their characteristics, and psychophysiological properties of the human operator, unfortunately, are not taken into account, although the processes of flight operation and maintenance are processes of human interaction with technology. complex and have their own specifics. The effective commissioning of new aircraft, which are equipped with more advanced avionics, requires a significant restructuring of civil aviation enterprises and the transition from the methods of information operation, which is characterized by a certain steady flow of equipment failures and erroneous actions of service personnel, to the methods of initial operation, which take into account the dynamic changes in the structure of processes that characterize the quality of operation of the onboard equipment with the participation of the human operator. Experience in the development of aircraft shows that the maintenance of new types of aircraft for all types and forms of scheduled work, especially in the initial period, it is advisable to carry out with the help of a specialized unit. Specialization allows aviation personnel to quickly master a certain type of aircraft and achieve the highest quality of work during its maintenance. Moreover, the preparation of the aviation technical base or the center of maintenance and repair of aircraft for the operation of new types of aircraft should begin 1-3 years before the scheduled date of their receipt. The training period largely depends on the type of aircraft, the complexity of the onboard equipment, operating conditions and specific features of the structure and production activities of a particular aviation base. In preparation for the operation of new aircraft it is necessary:

calculate the total number of engineering and technical staff that will deal with the maintenance process in the main areas of work, based on the volume and specifics of maintenance work;

correctly determine the need for different specialists, their level of qualification and specialization;

determine the optimal load, rhythm and mode of operation.

These indicators should be determined taking into account the annual volume of maintenance work, the schedule of scheduled flights of aircraft (for operational changes) with the obligatory consideration of slightly higher labor costs at the initial stage of development of new aircraft. One of the important tasks to be solved in preparation for the base of a new type of aircraft is to equip the production base of the operating enterprise with the necessary equipment, control and testing equipment, laboratory stands, mechanization and automation. The required additional production space is calculated in accordance with the expected maintenance and repair facility. Timely equipping of the production base will avoid a significant increase in labor costs during the development of new aircraft, reduce downtime for maintenance and repair. Of great importance is the modern organization of material and technical supply, technological preparation of production. Attestation of aviation personnel jobs is of great importance for the initial stage of aircraft operation. At this stage, it is necessary to create all the conditions for the effective conduct of the next period - the normal operation of the aircraft and its functional systems. And, first of all, it is necessary that the design of the workplace provides speed, safety, simplicity and cost-effectiveness of management, control and maintenance processes in both normal and emergency situations; would fully meet the functional requirements in the conditions of technical operation of aircraft, taking into account the activation of the human factor in civil aviation. Thus, a comprehensive consideration of various factors that affect both the ergatic system as a whole and its components, already at the initial stage of flight operation of aircraft will create the necessary conditions for the effective implementation of the next longest period - the period of normal operation. Its duration is commensurate with the service life of aircraft products and systems, as the period of operation is relatively short, and the operation at the stage of wear (aging) of particularly important avionics equipment (eg aerobatic navigation system) is unacceptable: elements, components, units and systems renewed or replaced with new (serviceable) before the beginning of this period.

2.2. Dynamic stereotype.

Considering the material of the Collection of materials "Human factor №5. The operational implications of automation in advanced cockpit equipment (Cir 234) ”one cannot but agree that the training of pilots to operate automated aircraft is given great attention. Accordingly, in the process of training pilots should develop a dynamic stereotype (DS) of piloting a modern aircraft, which will facilitate the process of performing the flight task.

Dynamic stereotype (from the Greek dinamikos-strong, mobile, stereos-solid, typos-imprint) - an integrated system of habitual conditioned-reflex responses, which corresponds to the signal, ordinal and temporal characteristics of the stimulus. The concept was introduced by IP 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 reinforced stereotype, this sequence of nervous processes is fixed, all responses can be reproduced while maintaining the sign, intensity and sequence - even with the presentation of 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.

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

Automation provides ample opportunities and comfort for flight.

It should be borne in mind that such aircraft have a fixed DS piloting in the steering mode.

However, it should be noted that there is no tendency to reduce the share of the human factor (HR) in aviation events. It is 70-90%. Experts on the human factor have repeatedly pointed out that the cause of these unlikely events is the inability of pilots to counteract the overlays of factors (LF).

Overlay factors 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 order to teach the pilot to counter LF, 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 psychologist IM Sechenov "Reflexes of the brain" and in the scientific developments of EM Хохлова, C.B. Korneeva, Yu.A. Khalafa et al.

The essence of the problem is that, despite the importance of pilot training, the correct actions need to be given knowledge about the mechanism of retention of enhanced reflected movements leading to inappropriate control action on the aircraft controls and erroneous action of the pilot. 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 (LF). 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. As statistics show, changes in flight parameters in the process of steering mainly have the form of a sinusoid (increasing, decaying, etc.)

It should be noted that each pilot has his own handwriting 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, when compared with flights under normal conditions.

2.3. Experimental data proving the phenomenon of increasing stereotype and "flying handwriting" under the action of complex failures.

During the flight, pilots can not always avoid the appearance of erroneous actions. Moreover, as shown by static data collected on KTL-154, the duration

improper piloting of the aircraft increases with increasing number of concurrent factors (in this case, failures).

The most characteristic errors in technology are: not maintaining the glide path and not maintaining the speed on the planning glide path, the approach of the course on the turn, not maintaining the course, correcting it in the wrong direction, not maintaining the vertical speed and. etc. Moreover, after the pilot begins to correct the error, there is an increase in the dynamic stereotype in amplitude and frequency, we fix the means of flight registration. In the existing literature sources there is a diametrically opposite opinion - the actions of factor loads are not amplification, but the so-called "breaking" of the dynamic stereotype of action. Experiments on KTL and statistics do not confirm this. Especially good discrepancy is visible on the oscillograms on the parameter "roll angle". Verification of this provision is of great practical importance for the development of new training programs, as well as for the issuance of practical recommendations to the pilot to improve his piloting skills. The pilot begins to swing the plane around the desired parameter, indicating the pilot's impact in the area of reflected movements, ie we see muscular (qualitative) or temporary (quantitative) oscillation of the pilot, starting with spatial, derived from visual and purely tactile receptors. Moreover, visual sensations are objective, and muscular - subjective.

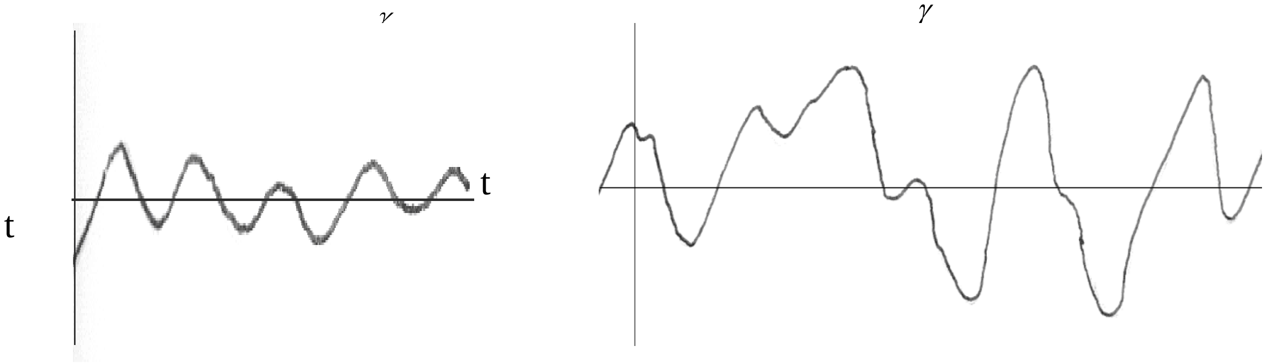
Erroneous and illogical actions in the course of flight are connected first of all, with changes in mental processes spatial signals from action of factor loadings. Receiving spatial signals from the action of factor loads with a sufficient number of them, the pilot can get into the zone of reflected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

Strengthening of a dynamic stereotype without changes of "physiognomy" of movements is observed in the majority of crews at trainings (fig. 2.1)

Suppression of temporary reflections of movements in pilots is a good indicator.

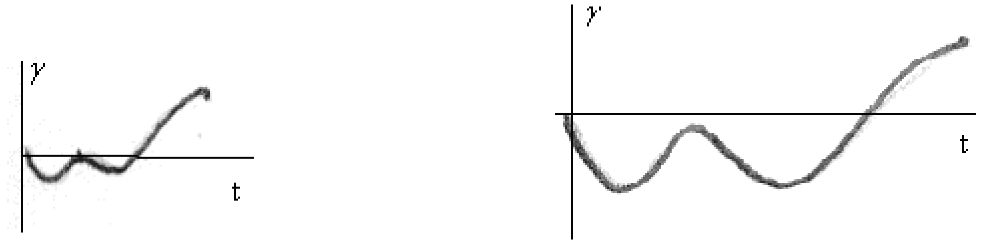
From such data of influence we can judge degree of counteraction to factor loading (fig. 2.2.)

Strengthening the dynamic stereotype



without failures
(after the 4th turn)

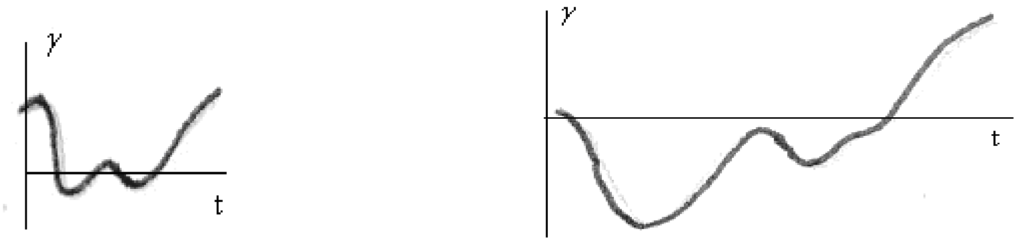
failure of 2 engines and 2 air horizons
(data on a roll of 1 mm = 1,250)



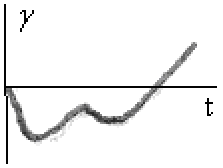
jamming of flaps failure of air horizons

Fig. 2.1.

Suppression of temporary repulsed movements in pilots



normal flight (without failures) failure of the second engine between 2 and 3 reversals



the same failure between the 4th turn and the runway

Fig. 2.2.

Increasing the "swing"

jamming of flaps failure of air horizons

takeoff landing

Fig. 2.3. Formed alogisms

γ

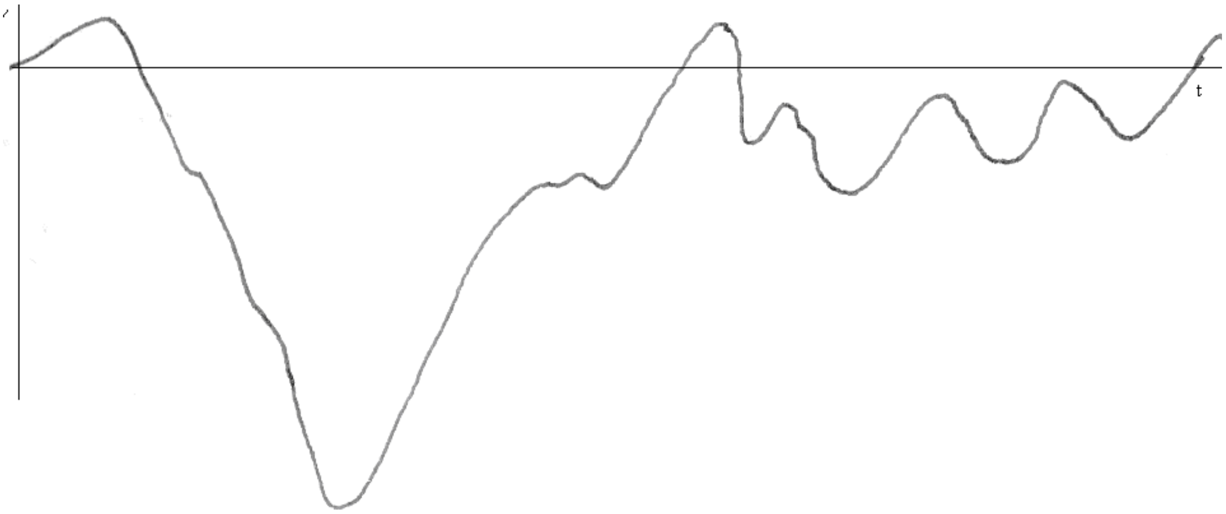
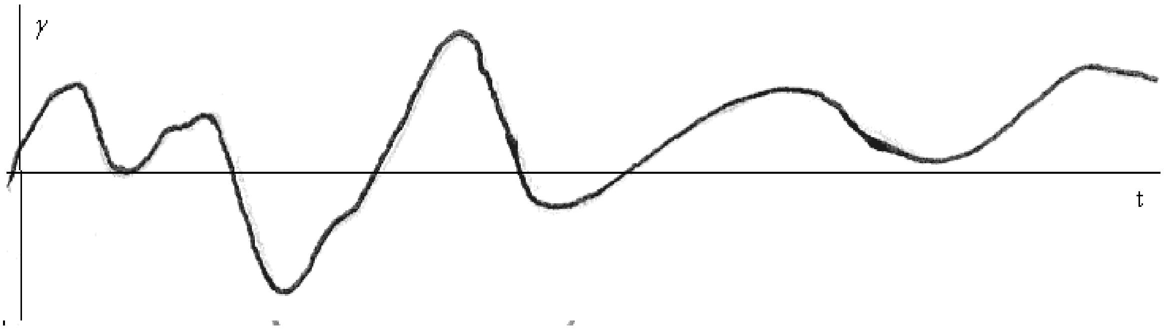


Fig. 2.4. Failure of the airline

Spatial algorithms



Co-piloting under normal conditions

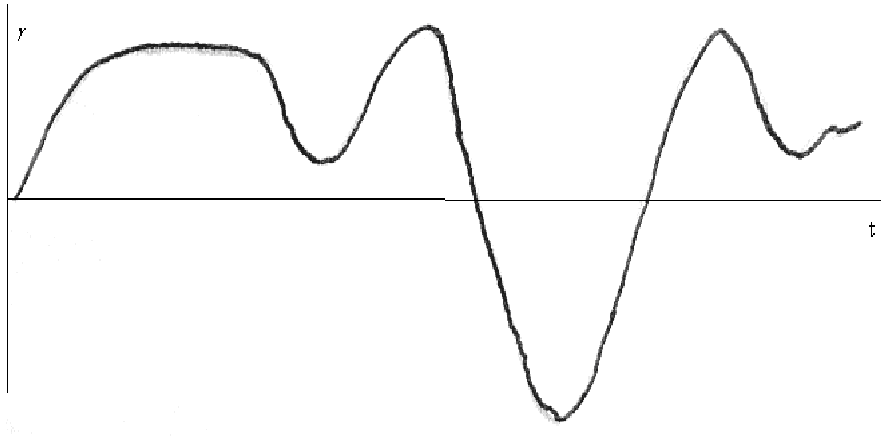


Fig. 2.5. Alogism before the second turn

According to the curves, we see that this is an experienced pilot who managed to suppress the strengthening of the oscillation under the action of factor loads.

However, in most cases, we have the opposite picture (Fig. 2.3.).

In addition to the temporal distribution of the dynamic stereotype, there are also spatial alogisms, accompanied by a temporary oscillation, which indicates the impact in the area of temporary reflected movements (Fig. 2.4).

After performing alogisms, some of the pilots fall into the zone of temporary reflections, which shows their inability to delay temporary reflected movements.

Guided by the theory of counteraction Sechenov IM, who proved that all conscious movements are usually called arbitrary, but they can be reflected.

From this we conclude that the temporal reflected movements of the pilots must be suppressed with the advent of spatial reflected movements, leading to or alogisms to their complete prevention.

2.4. Experimental data on the effectiveness of the assessment of pilot training on the CCC on the criterion of counteraction.

Under the action of the woofer, according to Sechenov's training, the human operator performs inappropriate movements and erroneous actions. This is especially true for those types of operator activities when a person has a well-established DS. Incl. increase in the flow of remarks indicate the pilot's hit in the area of enhanced reflected movements.

1. Action indicator:

$$O_{\text{Д}} = \frac{N_{"5"}}{N_{O_{\text{Б}}}};$$

2. Counter-indicator:

$$O_{\text{ПД}} = \frac{N_{3\gamma}}{N_{O_3}},$$

where $O_{\text{Д}}$ - evaluation on a five-point scale, $O_{\text{ПД}}$ - assessment of the flow of the instructor's remarks, $N_{"5"}$ - the number of excellent ratings of pilots by the instructor, $N_{3\gamma}$ - the number of comments of the instructor on the roll, $N_{O\text{Б}}$ - total number of estimates, N_{O3} - the total number of comments of the instructor.

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

Chapter 3. JUSTIFICATION AND DEVELOPMENT OF DEVICES NECESSARY FOR DETECTION OF AMPLITUDE AMPLIFICATION OF DYNAMIC STE-REOTYPE IN PILOLTS

3.1. APDS detection device using analysis of cross-correlation functions.

Currently, there are no methods for measuring the gain of the dynamic stereotype of the pilot under the action of factor loads relative to the normal dynamic stereotype (without the action of factor loads). Such a device can be installed on an airplane, simulator, with the help of our device it is possible to analyze flight information from the recording of the magnetic system for recording flight parameters.

Because such a device can be implemented most quickly on the simulator, where we have already conducted a number of studies (on KTL-154), and in the future we will offer our development to work on the simulator.

The prototype in the device is a correlator, which allows to obtain the curves of the dynamic stereotype of the pilot on the given parameters in the form of a correlation function (Fig. 3.1. And 3.2.).

Signal information from the complex simulator is launched on two channels:

- channel of flight parameters without failures;
- channel of flight parameters with failures.

Failure of air horizons

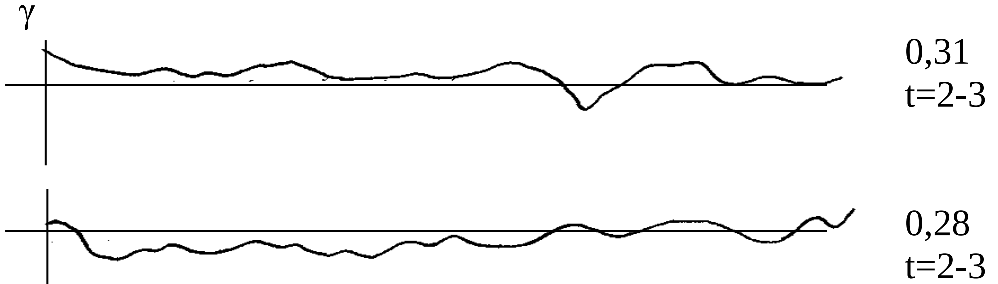


Fig. 3.1.

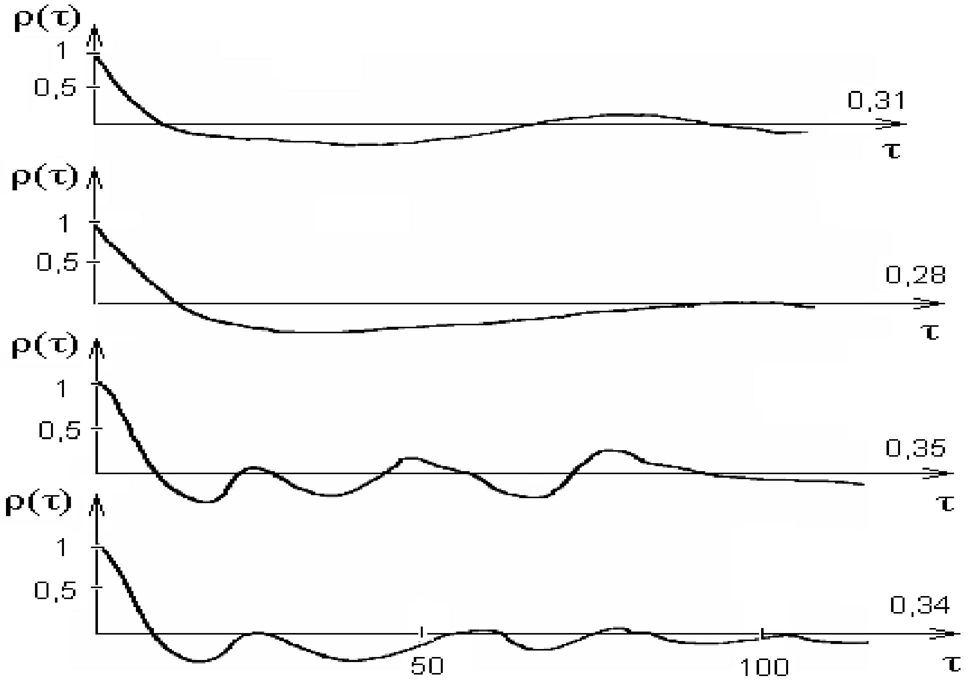


Fig. 3.2.

Signals of flight information during the flight with failures and without failures are given to the corresponding outputs of the correlator. The signals coming from the flight parameters channel are sent to output X without failures and then we send the information to the RAM of the correlator (there is one RAM in the correlator). The signal coming from the channel of flight parameters with failures is sent to the output of the correlator B, from where the information in the form of a correlation function is sent to additional RAM, because the serial correlator has only one RAM.

Flight parameter channels are used to record flight information. As control and recording equipment we use MSRP-64. The analog flight information we need, converted into an ADC (analog-to-digital converter) into digital, is recorded on a magnetic tape. When processing the information received in real flight, or non-operational information from the simulator, we use the information processing system and the amplifier-shaper digital-to-analog converter, including (DAC) for feeding to the correlator.

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

However, to commission a more complete 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 characterization of the APDS by an integrated assessment of the negative effect. To do this, we do. In this device, we must 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.3.3).

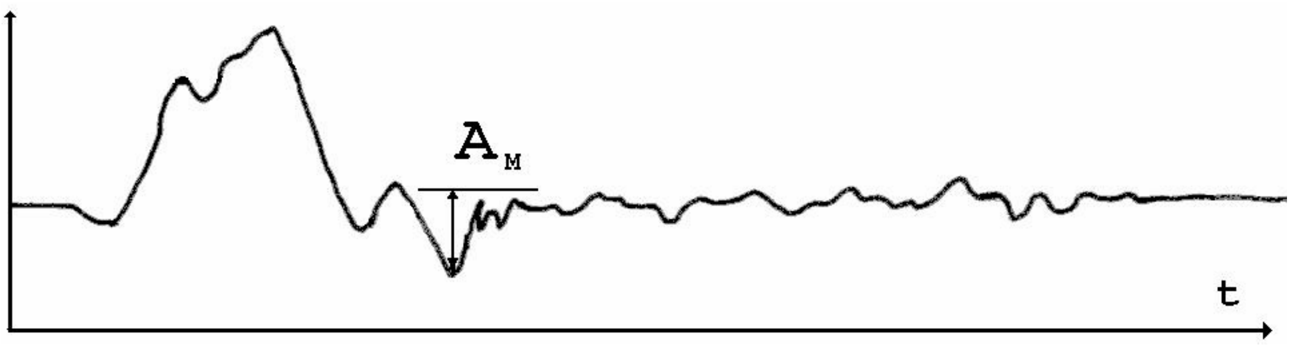


Fig. 3.3.

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. 3.4).

Fig. 3.4

In the differential circuit at the beginning of the signal is formed a sharp pulse, which serves to trigger (Fig.3.5).

Fig. 3.5

When a signal is applied to the trigger, a gate pulse signal with τc = 10-15 seconds is formed in it (Fig. 3.6).

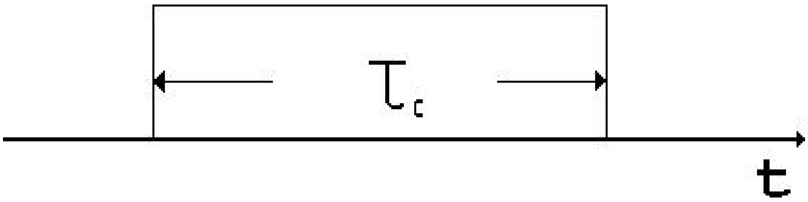


Fig. 3.6

After applying to the scheme of equalization of the gate pulse and the roll parameter, the output we will have the real roll of the aircraft limited by the boundaries of the gate (Fig. 3.7).

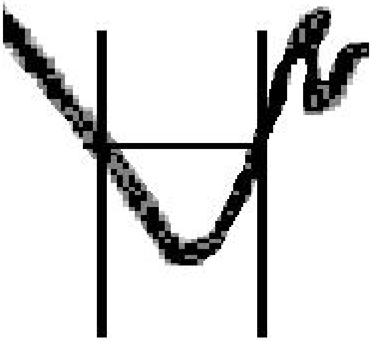


Fig. 3.7.

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 that most characterize the quality of piloting: vertical load, aircraft roll, instrument speed, deviation of the left rudder, aircraft pitch, course, rotor speed on the engine (Fig. 3.8, 3.9).

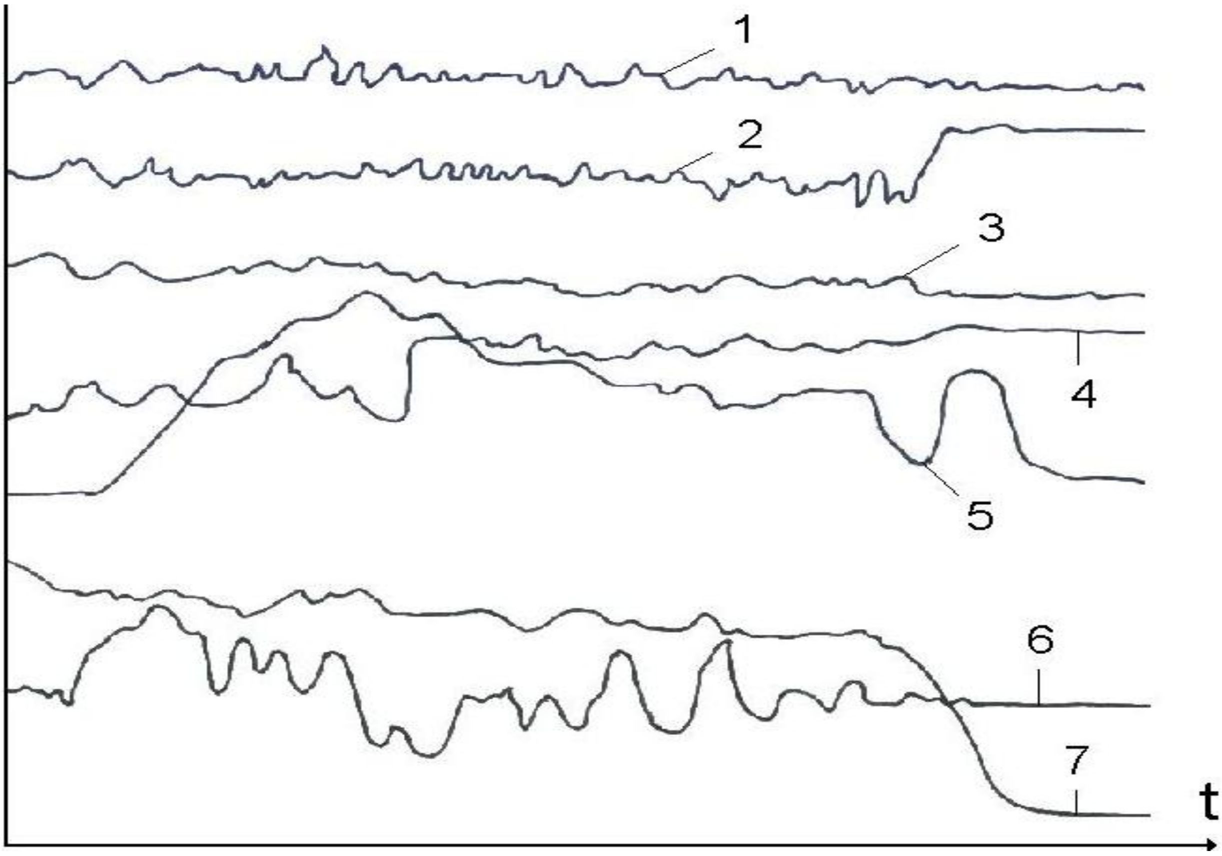


Fig. 3.9

1 - vertical load; 2 - deviation of the left steering wheel height; 3 - aircraft pitch; 4 - engine rotor speed; 5 - the course of the aircraft; 6 - the roll of the aircraft; 7 - instrument speed

These are oscillograms of real flights - normal (without factor overlay) (Fig. 3.8) and factor (in mountainous conditions) (Fig. 3.9) serve as an illustration of how factor overlays operate in real flights. The example shows that in mountainous conditions, difficult weather conditions, in polar nights, in winter, etc. 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-pilot changes of the following parameters: vertical load, aircraft roll, instrument speed, deviation of the left rudder, aircraft pitch, course, rotor speed on the engine.

The presence of these qualitative factor changes of deviations allows us to develop a special device for their registration on the simulator, when we simulate such situations on the KTL.

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

The calculation of the standard deviation is performed by formula (2.1).

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

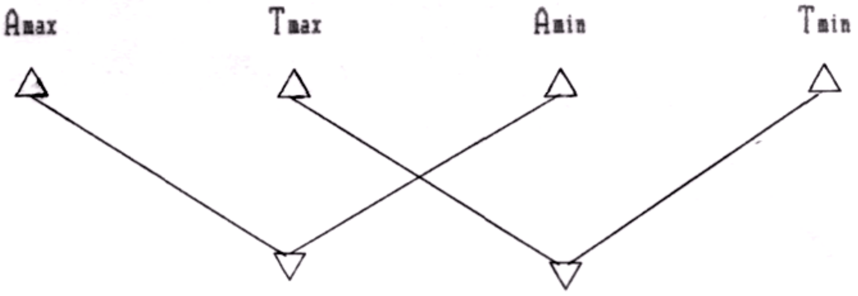
Where V- vertical speed, G-overload, γ - roll, ψ - course.

$$\Delta G = \frac{G_{A_{\max}} - G_{A_{\min}}}{G_{A_{\max}}};\ \ \Delta\gamma = \frac{\gamma_{A_{\max}} - \gamma_{A_{\min}}}{\gamma_{A_{\max}}};\ \ \Delta\psi = \frac{\psi_{A_{\max}} - \psi_{A_{\min}}}{\psi_{A_{\max}}};\ \ \Delta V = \frac{V_{A_{\max}} - V_{A_{\min}}}{V_{A_{\max}}}$$

Depending on the result we see on the scoreboard, we can judge the difficulty of the flight.

3.3. Application of trend algorithms for the analysis of the phenomenon of strengthening of a dynamic stereotype

Special trend algorithms have been developed for the analysis of NPS, which estimate the resistance of LF pilots (Fig. 3.11.). The comparison of the maximum amplitude and the corresponding period with the minimum amplitude and the corresponding period is performed as follows:

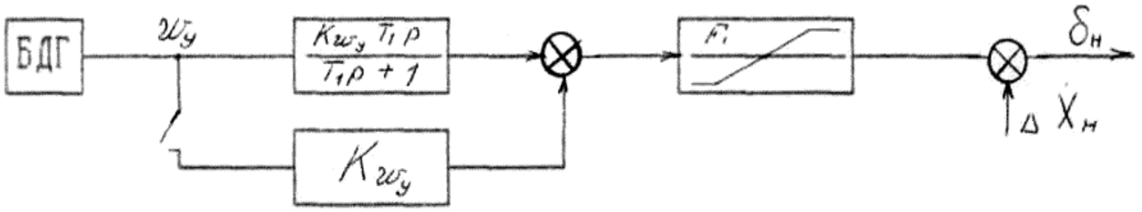


The account of counteraction on A and T allows to remove the errors connected with resolution of perception by the pilot of aerobatic and navigational devices and to consider boundary conditions on counteraction not only on the maximum, but also the minimum values. Taking into account the trend part of changes in a parameter also allows to exclude in the analysis process possible "emissions" and "bursts" associated with aerodynamic oscillations, especially short-periodic species.

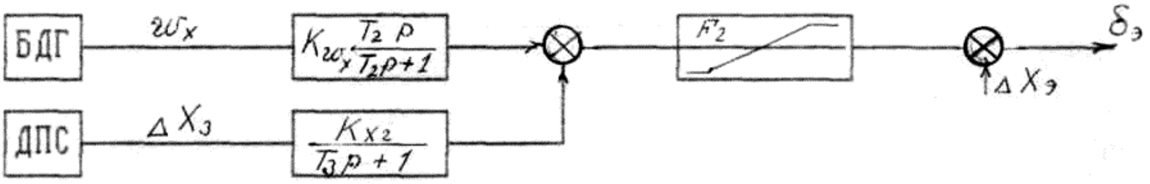
Modeling the flight process based on trend algorithms expands the possibilities of analyzing the activities of pilots in extreme situations and allows the CCC to more adequately create models of emergencies, to identify general trends in the development of positive or negative phenomena in flight activities.

To analyze the dynamic stereotype of the pilot when flying on the Tu-154, consider the work of ABSU-154 during manual piloting in the entire range of operating speeds and flight altitudes (Fig. 3.12.).

Course channel



Channel roll



Pitch channel

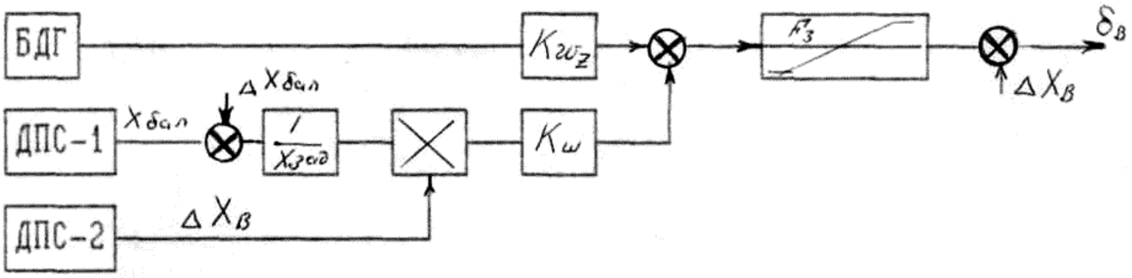


Fig. 3.12. Block diagram of ABSU-154 steering control.

BDG - block of damping gyroscopes; DPS - aileron position sensor; DPS-1, DPS-2 - sensors of position of a column of a rudder ;, - angular speeds of the plane on a course, a roll, a pitch accordingly; $\Delta X_{\text{В}}$ - values of column displacements from the balancing position (in the steering mode);, $\delta_{\text{В}}$ - angles of deviation of a steering wheel, ailerons and a steering wheel of height accordingly; $X_{бал}$ - відхилення балансування штурвалу;, k_{ω_X} - gear ratios; B - the switch (is included in the modes of approach on landing and the set course);, - transfer functions $\frac{k_{\omega_Y} T_1 p}{T_1 p + 1}$;, $\frac{k_{\omega_X} T_2 p}{T_2 p + 1}$

The equation of the steering system ABSU-154 has the form::

on the course $$\Delta\delta_{\text{Н}} = F_1 k_{\omega_Y} \frac{T_1 p}{T_1 p + 1} \omega_Y + \Delta X_{\text{Н}};$$

on the roll $$\Delta\delta_{\text{Э}} = F_2 (k_{\omega_X} \frac{T_2 p}{T_2 p + 1} \omega_X + k_{X\psi} \frac{1}{T_\psi p + 1} \Delta X_\psi) + \Delta X_\psi$$

on pitch $$\Delta\delta_{\text{В}} = F_3 (k_{\omega_Z} \omega_Z - k k_{X_3} \Delta X_\vartheta) + \Delta X_\vartheta$$

To obtain quantitative data for measuring DS, we use the law of trend management:

$$\Delta\delta_{(\text{Н,Э,В})} = \frac{\delta_{\max} - \delta_{\min}}{\min \Delta\delta};$$

$y = \lim\limits_{\delta \to 0} \min(\max \delta - \min \delta)$ - double delta law.

Thus, trend algorithms are an additional development of algorithms for selective limit spectral density and are designed to solve a number of practical problems that arise when teaching a pilot anti-stress training and the formation of resistance and anti-skills.

Let's consider one of the variants of the order of application of trend algorithms for the analysis of counteraction of pilots to overlays of factors. Having data numerical or graphs of change of a course, a roll (γ) and a pitch from the end of the fourth turn before landing it is necessary to define distances from extremes to zero. Calculate the difference between subsequent extremes (without module) of the change of each parameter. Results A are taken modulo. Identify the maximum and minimum A of each parameter (provided A> 1 '). Calculate the half-periods corresponding to the maximum and minimum values of each parameter. Next, calculations are performed according to the following formulas for each parameter:

$$\Delta A = \frac{A_{\max} - A_{\min}}{A_{\min}}; \Delta T = \frac{\mathrm{T}_{\max} - \mathrm{T}_{\min}}{\mathrm{T}_{\min}}.$$

After that we will make the general picture of polychannel change of parameters:

$$\Delta\Delta A_{\gamma,\psi,\vartheta} = \sqrt{\Delta A_{\gamma}^2 + \Delta A_{\psi}^2 + \Delta A_{\vartheta}^2};$$

$$\Delta\Delta \mathrm{T}_{\gamma,\psi,\vartheta} = \sqrt{\Delta \mathrm{T}_{\gamma}^2 + \Delta \mathrm{T}_{\psi}^2 + \Delta \mathrm{T}_{\vartheta}^2}$$

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, it is advisable to compare ($\Delta\Delta\delta_{\text{Э,Н,В}}$)the deviation of the ailerons, steering wheel direction and altitude with ($\Delta\Delta A_{\gamma,\psi,\vartheta}$)hanges in the parameters:

$$\Delta\Delta\delta_{\text{Э,Н,В}} = \sqrt{\Delta\delta_{\text{Э}}^2 + \Delta\delta_{\text{Н}}^2 + \Delta\delta_{\text{В}}^2};$$

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

For example, during the "mumble" on the discrepancy and can be judged on the quality of piloting techniques, because with a strong mumble experienced pilot does not allow strong deviations of the parameters, although the consumption of rudder and ailerons is high. In the presence of JUICE on KTS it is possible not to consider as "chatter" can be excluded from the instructor's panel.

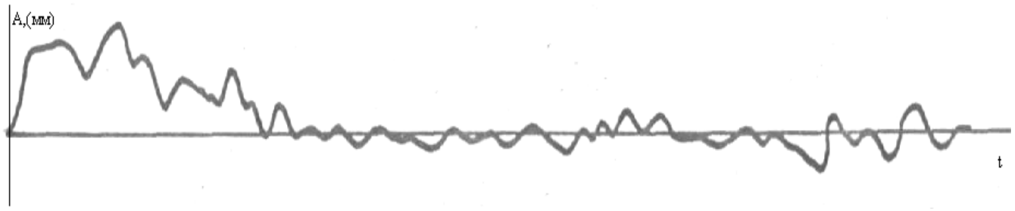
Using trend algorithms and computer processing program, according to the number of printing, we can obtain specific comparison data for flights with $\Delta\Delta A_{\gamma,\psi,\vartheta} = \sqrt{\Delta A_{\gamma}^{2} + \Delta A_{\psi}^{2} + \Delta A_{\vartheta}^{2}}$. woofer (complex failures on the CCC) and without them. The algorithm and the program of training 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 MGA the author of this work. The difference between and norms can be judged on the degree of resistance of LF pilots, the smaller the difference, the greater the degree of resistance, qualitative changes can be quantified.

3. Experiment to test the effectiveness of trend algorithms.

Using data on KTS Tu-154B2, we compare paired flights (flights with failures and without failures), on a roll and vertical speed. We can observe that in some pilots the amplitude gain of the DS when compared with flights with failures and without failures is much higher than in others.

It is also possible to quantify the degree of resistance of each pilot and quickly train him to counteract the woofer. This is achieved by a theoretical explanation of the nature of the occurrence of enhanced reflected movements and practical mechanization of counteraction by introducing complex failures.

Pilot №1.
Angle roll
Landing without failures



Landing with three failed engines

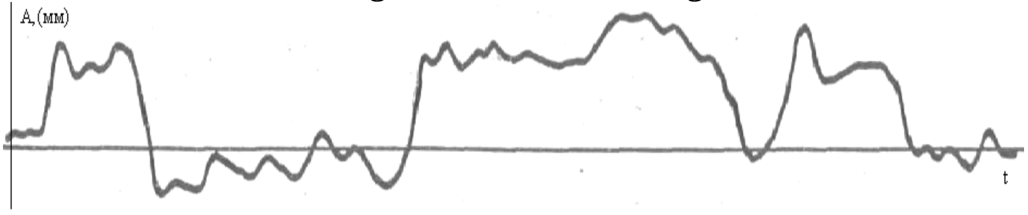


Fig. 3.13.
Vertical speed
Landing without failures

Landing with three failed engines

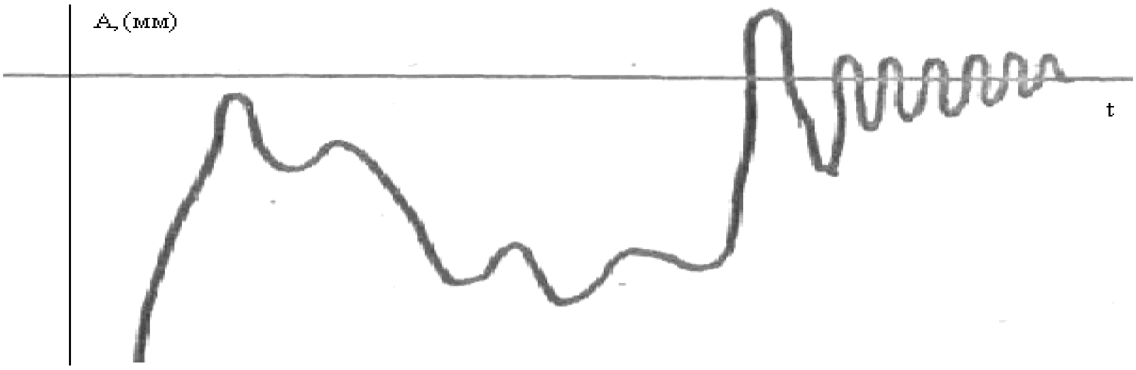


Fig. 3.14.

1. Calculation of algorithms of relative difference at a minimum:

$$\Delta\gamma_{БВ} = \frac{\gamma_{A\max} - \gamma_{A\min}}{\gamma_{A\min}} = \frac{5-1}{1} = 4; \qquad \Delta\gamma_{В} = \frac{\gamma_{A\max} - \gamma_{A\min}}{\gamma_{A\min}} = \frac{13-0.5}{0.5} = 25;$$

$$\Delta V_{БВ} = \frac{V_{A\max} - V_{A\min}}{V_{A\min}} = \frac{8-2}{2} = 3; \qquad \Delta V_{В} = \frac{V_{A\max} - V_{A\min}}{V_{A\min}} = \frac{15-2}{2} = 6.5;$$

2. Calculation of standard deviation:

$$\Delta A_{БВ} = \sqrt{\Delta\gamma_{БВ}{}^2 + \Delta V_{БВ}{}^2} = \sqrt{4^2 + 3^2} = 5; \qquad \Delta A_{В} = \sqrt{\Delta\gamma_{В}{}^2 + \Delta V_{В}{}^2} = \sqrt{25^2 + 6.5^2} = 26;$$

3. Calculation of the trend algorithm:

$$\Delta\Delta A_1 = \sqrt{\Delta A_{БВ}^2 + \Delta A_{В}^2} = \sqrt{5^2 + 26^2} = 27;$$

4. Calculation of the gain:

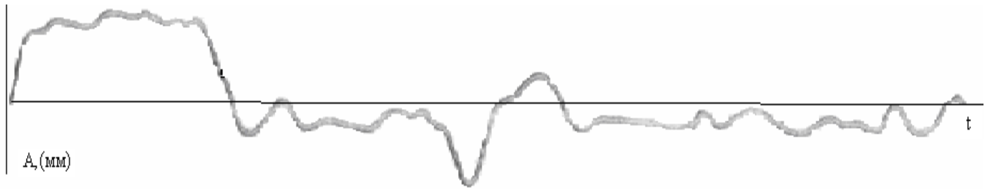
$$K_{y1} = \Delta A_{В} - \Delta A_{БВ} = 26 - 5 = 21,$$

where $\Delta\gamma_{БВ}$ - algorithm for comparing the minimum on the roll of landing without failures; $\Delta\gamma_{В}$ - algorithm for comparing the minimum on the roll of landing with the three failed engines; $\Delta V_{БВ}$ - algorithm for comparing the minimum on the vertical landing speed without failures; $\Delta V_{В}$ - algorithm for comparing the minimum vertical landing speed with three failed engines; $\Delta A_{БВ}$ - standard deviation of landing without failures; $\Delta A_{В}$ - standard deviation of landing with three failed engines; $\Delta\Delta A_{n}$ - trend algorithm, $K_{уп}$ - gain.

Pilot №2.

Angle roll

Landing without failures



Landing with three failed engines

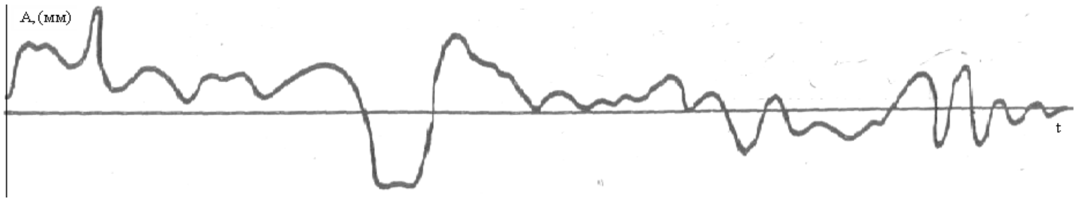
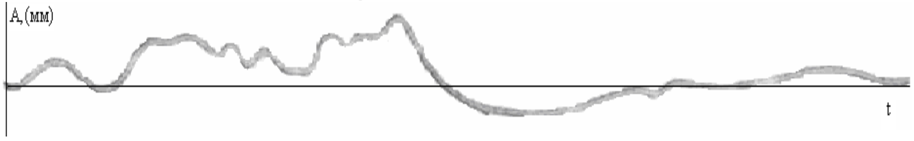


Fig. 3.15.

Vertical speed

Landing without failures



Landing with three failed engines

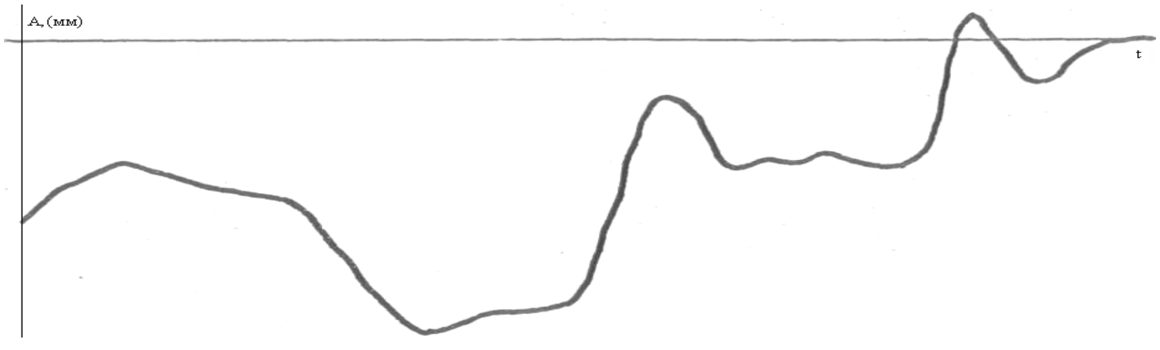


Fig.3.16.

1. Calculation of algorithms of relative difference at a minimum:

$$\Delta\gamma_{БВ} = \frac{\gamma_{A\max} - \gamma_{A\min}}{\gamma_{A\min}} = \frac{8-1.5}{1.5} = 4.3; \qquad \Delta\gamma_{B} = \frac{\gamma_{A\max} - \gamma_{A\min}}{\gamma_{A\min}} = \frac{10-1}{1} = 9;$$

$$\Delta V_{БВ} = \frac{V_{A\max} - V_{A\min}}{V_{A\min}} = \frac{5.5-0.5}{0.5} = 10; \qquad \Delta V_{B} = \frac{V_{A\max} - V_{A\min}}{V_{A\min}} = \frac{13-5}{5} = 12;$$

2. Calculation of standard deviation:

$$\Delta A_{БВ} = \sqrt{\Delta\gamma_{БВ}{}^{2} + \Delta V_{БВ}{}^{2}} = \sqrt{4.3^2 + 10^2} = 10.9; \qquad \Delta A_{B} = \sqrt{\Delta\gamma_{B}{}^{2} + \Delta V_{B}{}^{2}} = \sqrt{9^2 + 12^2} = 15;$$

3. Calculation of the trend algorithm:

$$\Delta\Delta A_2 = \sqrt{\Delta A_{БВ}^2 + \Delta A_B^2} = \sqrt{10.9^2 + 15^2} = 18.5;$$

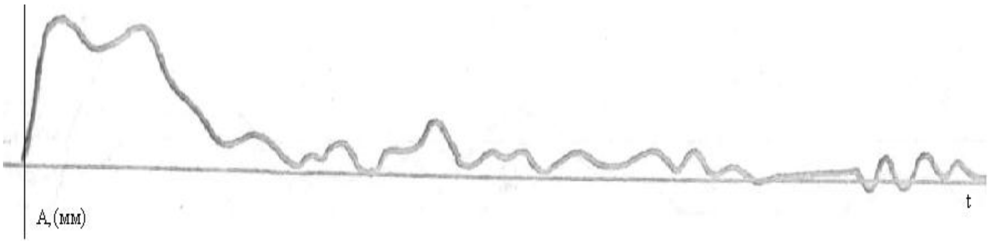
4. Calculation of the gain:

$$K_{y2} = \Delta A_B - \Delta A_{БВ} = 15 - 10.9 = 4.1.$$

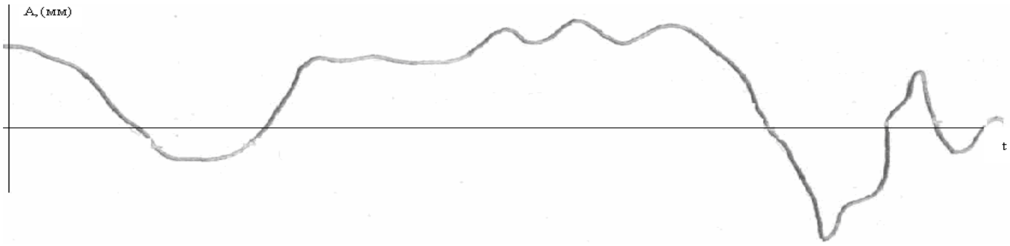
Pilot №3.

Angle roll

Landing without failures



Landing with three failed engines



Vertical speed

Landing without failures

Landing with three failed engines

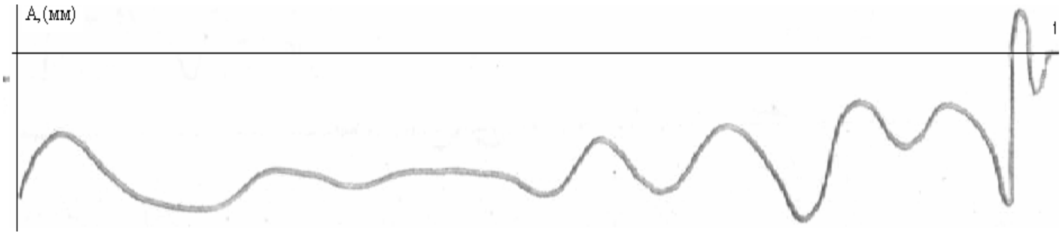


Fig. 3.17.

1. Calculation of algorithms of relative difference at a minimum:

$$\Delta\gamma_{\text{БВ}} = \frac{\gamma_{A\max} - \gamma_{A\min}}{\gamma_{A\min}} = \frac{4.5 - 1.25}{1.25} = 1.8; \qquad \Delta\gamma_{\text{В}} = \frac{\gamma_{A\max} - \gamma_{A\min}}{\gamma_{A\min}} = \frac{16 - 4}{4} = 3;$$

$$\Delta V_{\text{БВ}} = \frac{V_{A\max} - V_{A\min}}{V_{A\min}} = \frac{9 - 7}{7} = 0.28; \qquad \Delta V_{\text{В}} = \frac{V_{A\max} - V_{A\min}}{V_{A\min}} = \frac{10 - 4}{4} = 1.5;$$

2. Calculation of standard deviation:

$$\Delta A_{\text{БВ}} = \sqrt{\Delta\gamma_{\text{БВ}}{}^2 + \Delta V_{\text{БВ}}{}^2} = \sqrt{1.8^2 + 0.28^2} = 1.8; \qquad \Delta A_{\text{В}} = \sqrt{\Delta\gamma_{\text{В}}{}^2 + \Delta V_{\text{В}}{}^2} = \sqrt{3^2 + 1.5^2} = 3.4;$$

3. Calculation of the trend algorithm:

$$\Delta\Delta A_3 = \sqrt{\Delta A_{\text{БВ}}^2 + \Delta A_{\text{В}}^2} = \sqrt{1.8^2 + 3.4^2} = 3.8;$$

4. Calculation of the gain:

$$K_{y3} = \Delta A_{\text{В}} - \Delta A_{\text{БВ}} = 3.4 - 1.8 = 1.6.$$

Table 3.1

№ п/п	$\Delta\gamma_{\text{БВ}}$	$\Delta\gamma_{\text{В}}$	$\Delta V_{\text{БВ}}$	$\Delta V_{\text{В}}$	$\Delta A_{\text{БВ}}$	$\Delta A_{\text{В}}$	$\Delta\Delta A_n$	K_{yn}
1	4	25	3	6,5	5	26	27	2,1
2	4,3	9	10	12	10,9	15	18,5	4,1
3	1,8	3	0,28	1,5	1,8	3,4	3,8	1,6

Preliminary calculations on the roll showed that the flight with a smaller overlay of factors on the pilots differs from the maximum (engine failure, airline, failure of other systems). The data show that 80% of pilots leads to an amplitude amplification of the dynamic stereotype, an increase in the flow of comments on pilot errors.

Now we have checked with the help of trend algorithms that this phenomenon takes the form of polymetric oscillation.

3.4. Instructions for technical operation of the designed device

Persons who have been instructed in safety and those who have passed the test are allowed to work with the device. Before connecting the device to power sources, the cabinet of the simulator in which the device is located must be securely grounded.

3.5. Preparation for work and check of serviceability of the device

Before working with the device, it is necessary to study the technical documentation of the device. Switching on is carried out by switches. Carefully monitor the correct connection of the connectors and the polarity.

3.6. Device maintenance

Maintenance of the device is carried out in order to ensure efficiency. The maintenance also includes carrying out routine work on the set of the device, which includes:

- inspection of the external condition of the device, remote indicators; check of reliability of fastening of the case of devices, tightening and countering of plug sockets and metallization;

- check for external damage every 400 hours;

- check of integrity and durability of fastening and a condition of boards in the case - through

every 1000 hours;

- check for insulation damage - every 800 hours;

- inspection of plug sockets and washing them with alcohol - rectified

to ensure reliable contact - every 800 hours;

- for the purpose of reduction of effort of dismemberment of SHR it is recommended to remove wear products periodically through each 15-30 connections;

- complete setup of the device every 2000 hours.

Daily maintenance includes cleaning the working surfaces of the device from dust and dirt.

Periodic maintenance of the device is carried out once every 6 months. One of the maintenance carried out during the year must coincide with the periodic metrological inspection of the device, and in this case, must precede it.

When carrying out maintenance the following works are carried out:

- check the technical documentation, compare the form numbers with the unit numbers of the device.

CONCLUSION

In terms of scientific and technological progress, there is a continuous improvement of the basic flight characteristics of aircraft: increasing speed, range and passenger capacity. The solution of these issues is due to the complexity of the design of aircraft, which, in turn, is reflected in the management of aircraft.
Analysis of the training of civil aviation pilots in the certification centers shows that the structure of crew training has many tasks related to the need for anti-stress training. To solve these problems have to use flight simulators.

Today, with a sufficient degree of accuracy, experts have learned to assess the reliability of technical systems, which allows with high probability to predict their failures. The reliability of the human link in the system "pilot aircraft" depends on many components, which are difficult to take into account. Reliability in the broadest sense of the word should be understood as the probability that the operator will perform its assigned functions in a certain period of time under certain environmental conditions. However, the concept of psychophysiological reliability is much broader. It must take into account the level of training, on the one hand, the level of psycho-physiological reactions of the body that occur, on the other hand. At the same time, the level of professional training significantly affects the "cost" of activities. The level of psychophysiological reactions, in turn, in many cases affect the quality of professional activity.

Another important point of psychophysiological reliability of the operator - is the backup opportunities for the perception and processing of additional information on the background of the main (professional) activities.

Quantitative characteristic of the degree of objectivity of the display of the results of control of the state of the object is the reliability of control. In a number of different works in detail the influence of exact and reliable characteristics of control means on reliability is investigated. The influence of the operator's activity is less studied. It is especially important to evaluate this impact when moving from manual to automated control. The most characteristic errors of the operator included in the general circuit of the control system include errors in performing basic operations due to deviations of parameters of sensory and motor acts, errors of non-execution or late execution of actions, gross errors such as mistakes with replacement of some actions by others, one way to solve problems .e. Finally, the qualification and honesty of the operator is significantly revealed.

Statistics show that often the failure of complex control systems of aircraft equipment is due to human factors. The dismissal of the KTL instructor of the detachment of performed functions and the transfer of these functions to the automated means of control should significantly increase the reliability of control. With automated control, the instructor is freed from a significant number of performed communications, from the task of identifying and assessing the situation. Detection and cognition are facilitated by a convenient way of displaying information.

We believe that the device developed by us is designed to help the instructor to understand certain situations, in the anti-stress training of the crew and to determine the degree of training of pilots.

CHAPTER 4
OCCUPATION SAFETY

Introduction

The protection of workers' labor is now becoming increasingly important. This is expressed by the need to increase production efficiency due to productivity.

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

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

Protecting and promoting human health is paramount. We need to look at health issues from a broad social perspective. It is determined primarily by living and working conditions, the level of well-being.

This section is designed to make independent decisions on socio-economic, organizational, hygienic, treatment and prevention measures and tools aimed at preserving life, health and ability to work in the process of work.

4.1. Classification of dangerous and harmful production factors

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

Occupational safety at work is determined by the degree of safety of individual technological processes.

Dangerous and harmful production factors according to ГОСТ 12.0.003-74 are divided into physical, chemical, biological and psychophysiological. The latter by the nature of the impact on humans are divided into physical and neuro - mental overload, others on specific dangerous and harmful production factors.

In the process of working at the airline, the employee may be affected by such dangerous and harmful production factors:

- moving aircraft, special vehicles and self-propelled mechanisms;
- moving unprotected elements of aircraft (ailerons, shields, interceptors, trimmers, chassis, rotating propellers, turbines, ladders, etc.), special. motor vehicles (lowering and rising cabins, cradles, bodies, stairs, turntables), mechanisms (loading and unloading winches of aircraft, cranes) and production equipment;
- gases of gases of the cars of the working engines and the objects which got to these streams;

- collapsing structures (side stairs, ladders and other production equipment);
- parts of the aircraft located at altitude;
- increased or decreased temperature, humidity and air mobility in the aircraft maintenance area;
- increased noise, vibration, ultrasound and infrasound;
- increased voltage in the electrical circuit, the short circuit of which can occur through the human body;
- increased level of static electricity;
- increased level of laser radiation in the work area;
- increased level of electromagnetic radiation;
- increased level of ionizing radiation in the work area;
- location of the workplace at a significant height relative to the ground (floor);
- sharp edges, burrs and roughness on the surfaces of aircraft, equipment and tools;
- absence or lack of natural light;
- insufficient lighting of the work area;
- increased air brightness;
- increased pulsation of light flux;
- increased levels of ultraviolet and infrared radiation;
- chemicals (toxic, irritating. Sensitizing, carcinogenic, mutagenic, affecting human reproductive function), which are part of the materials used, fuel, special liquids and pesticides that enter the body through the respiratory tract, gastrointestinal tract , skin and mucous membranes;
- pathogenic microorganisms (bacteria, viruses, rickettsiae, spirotechs, fungi, protozoa) and products of their activity;
- physical overload (static and dynamic) and neuro-mental (emotional, overvoltage analyzers).

Levels of dangerous and harmful production factors should not exceed the maximum allowable values established in sanitary norms, rules and normative - technical documentation.

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

4.2.1. Workplace organization and equipment.

Workplace - is equipped with technical means (means of displaying information, controls, ancillary equipment) space, where the activities of the performer.

The organization of the user's workplace with a video display terminal (VDT) must ensure compliance of all elements of the workplace and their location with the ergonomic requirements of ГОСТ 12.2.032 ССБТ. “Workplace when performing work while sitting. General ergonomic requirements ", the nature and features of work. The area allocated for one workplace with VDT or personal computer should be not less than 6 m^2, and volume - not less than 20 m. Workplaces with VDT concerning light apertures it is expedient to arrange so that natural light fell on it from the side, mostly on the left. Workplaces with VDT must be located at a distance of at least 1 m from the walls with light slots; the distance between the side surfaces of the VDT must be at least 1.2 m; the distance between the rear surface of one video terminal and the screen of another should not be less than 2.5 m. The passage between the rows of jobs should not be less than 1 m.

The design of the workplace of the user VDT (while working sitting) should provide maintenance of an optimum working pose with such ergonomic characteristics:

- feet - on the floor or on a footrest;
- thighs - in the horizontal plane;
- forearms - vertically;
- elbows - at an angle of 70-90 ° to the vertical plane;

- wrists - bent at an angle of not more than 20 ° relative to the horizontal plane;
- tilt of the head - 15-20 ° relative to the vertical plane.

The height of the working surface of the table should be in the range of 680-800 mm, on average it should be 725 mm, width 600-1400 mm, depth 800-1000 mm. The desktop for VDT must have a legroom of at least 600 mm in height, width - not less than 500 mm, depth at the knee - not less than 450 m, at the level of the outstretched leg - not less than 650 mm. The desk for VDT, as a rule, should be equipped with a footrest not less than 300 mm wide and not less than 400 mm deep, adjustable in in height within 150 mm and the angle of inclination of the support surface - within 20 °. The stand should have a corrugated surface and a side on the previous edge 10 mm high.

The working seat (seat, chair, armchair) of the VDT user must have the following basic elements: seat, back and stationary or replaceable armrests.

The type of work chair should be chosen depending on the nature and duration of work. It must be lift-and-turn and adjustable in height at the angles of the seat and back, as well as the distance of the back from the front edge of the seat.

The height of the seat surface should be adjustable within 400-500 mm. The width and depth of its surface must be at least 400 mm, and the angle of inclination of the surface - from 15 ° forward to 5 ° backward. The surface of the seat should be flat, the front edges - rounded.

The supporting surface of the back of the chair should have a height of 250-320 mm, width - not less than 380 mm, radius of curvature of the horizontal plane - 400 mm. The angle of the backrest in the vertical plane must be adjustable within -30 ° ÷ + 30 ° from the vertical position. In order to reduce the static tension of the arm muscles, it is advisable to use stationary and removable armrests with a length of at least 250 mm and a width of 50-70 mm, which should be adjusted by the parameter of the internal distance between the armrests. Adjustment should be performed in the range of 350-

400 mm. The surface of the seat, back and armrests should be semi-soft, with a non-slip, airtight, non-electrifying coating and clean from dirt.

It is necessary to place VDT on a workplace so that the screen surface was at distance of 400-700 mm from eyes of the user. If computer use is your primary activity, it is usually located on the main desktop, usually on the left side. If the use of a personal computer is intermittent, it is usually placed on a docking table, preferably to the left of the main desktop.

The work of computer users is characterized by a significant voltage of the visual analyzer, so it is important to ensure rational lighting of workplaces. Visual discomfort can be caused by incorrect orientation of workplaces relative to light openings (windows); inadequate lighting characteristics of lamps or their incorrect spatial location relative to the workplace; the dazzling effect of bright objects in the user's field of vision (close proximity); mirror reflection on the screen of objects with high brightness, located behind the user (reflected proximity); certification of the screen by direct or diffused light of lamps.

According to the "Rules of labor protection during the operation of electronic computers", lighting in rooms with VDT must be mixed (natural and artificial). Natural light should penetrate through side apertures, usually oriented to the north or northeast. Windows of rooms with video terminals must have adjustable opening devices, as well as blinds, external curtains, external visors, etc.

Artificial lighting of workplaces must be equipped with a system of general uniform lighting. In rooms where work with documents prevails, the use of combined lighting is allowed, when local lighting fixtures are installed at the workplaces, which complement the general lighting. The use of luminaires without diffusers and screen grids is prohibited.

LB-type fluorescent lamps are used as artificial light sources. This reduces the possibility of blinding light reflected by the screen. Incandescent lamps may be used in local lighting fixtures.

The level of illumination on the desktop in the area of the documents should be in the range of 300-500 lux. If it is impossible to provide this level of illumination, the general lighting system allows the use of local lighting fixtures, but there should be no glare on the screen surface and increase the brightness of the screen to more than 300 lux.

The effectiveness of artificial lighting depends on the proper maintenance of lighting fixtures. Contamination of lamps, lamps, glass light openings can reduce the illumination of the premises by 1.5-2 times. Therefore, lamps and window glass must be cleaned at least 2 times a year and timely replaced burnt out lamps.

Computer workstations can generate noise from system unit fans, drives, and printers. They are sources not only of sounds that can be heard, but also oscillations of the ultrasonic range (frequency above 20 kHz). In addition, sources of noise can be the street, adjacent premises. Noise adversely affects the functional state of users, especially during prolonged use. For the user, whose activity is related to the processing of information, which is often accompanied by elements of creativity, this is expressed in reduced mental capacity, headaches, insomnia, impaired attention, etc. According to ГОСТ 12.1.003-83 ССБТ "Noise. General safety requirements ", ТР № 2411-81" Hygienic recommendations for setting noise levels in the workplace taking into account the intensity and severity of work ", approved by the Ministry of Health of Ukraine, СНИП 3.3.2.-007-98 noise level in the premises, depending on the type of work, should not exceed - 40÷65 dB

The main measures to combat noise are to eliminate or reduce the causes of noise at its source in the design process, the use of sound absorption, rational planning of production facilities and workplaces, location of printing devices in another room, or enclosing them with sound-absorbing screens.

When performing work with VDT in the premises, the values of the vibration characteristics should not exceed the permissible values specified in СН 3044-84 and ГОСТ 12.1.012-90. To reduce the vibration of equipment, devices, fixtures must be installed on special shock-absorbing gaskets provided by regulations.

4.2.2. Protection against electric shock

The choice, placement, execution and insulation class of used machines, devices and other electrical equipment is made in accordance with the requirements of state standards of occupational safety standards (SSBT) and "Rules for the installation of electrical installations RIEI - 76".

When conducting research activities using a computer, the operator is exposed to the danger of electric shock. To exclude the possible impact of electric current on a person, computer cases must be grounded.

Artificial grounding is constructed of vertical and horizontal grounding. As vertical grounding conductors use steel rods - a bar and angular steel with a length of 2.5 sm, and as independent horizontal grounding conductors and for connection of vertical - strip steel and a steel bar. The smallest sizes of grounding conductors: diameter of rods not galvanized - 10 mm, galvanized - 6 mm; cross section of non-galvanized bar grounding conductors - 48 mm^2; the thickness of rectangular grounding conductors (strip steel) and angle steel shelves is 4 mm.

Vertical grounding conductors are driven by means of mechanisms in pre-dug trenches with a depth of 0.7-0.8 m. Submerged in the ground vertical grounding conductors are connected by strip steel, welding it to the upper end of the rod with the rib up for better contact with the ground.

4.2.3. Protection against static electricity

The sources of the electrostatic field can be any surface or objects that are easily electrified by friction: carpets, linoleum, lacquered coatings, clothing made of synthetic fabrics, shoes. In addition, the source of electrostatic charges are video terminals (VDT) with cathode ray tubes (CRT). Electrostatic charges accumulate on computer and TV screens and create an electromagnetic field that is characterized by intensity. Experiments have shown that the electrostatic field strength instantly increases to a maximum at the time of inclusion of VDT and subsequently decreases to a stable level.

The electrostatic field strength, depending on the type of VDT varies from 8 to 75 kV/m . Accordingly ГОСТ 12.1.045-84 ССБТ. Electrostatic fields. Permissible levels at workplaces and requirements for control electrostatic field strength at the workplace should not exceed 20 kV / m.

The surface electrostatic potential of VDT in accordance with СН №1757-77 "Sanitary and hygienic standards of allowable electrostatic field strength" and СНИП 3.32-007-98 "State sanitary rules and regulations for work with visual display terminals of electronic computers" should not exceed 500V.

Electrostatic charges accumulate not only on the VDT screen, but also on the user of a personal computer by contact or through induction (from the Latin inductio - guidance). The accumulated charges on the user increase its electrical potential.

Prolonged stay of the worker in the electrostatic field can cause bronchopulmonary diseases, disorders of the cardiovascular and nervous systems. In addition, the adverse effects of the electrostatic field are manifested in the fact that it is able to attract dust, dirt and other parts present in the air around the VDT, which leads to dust coating of its screen.

Protection against electrostatic electricity and its dangerous manifestations is achieved by the following measures:

- the use of air ionization by static neutralizers;
- increasing the electrical conductivity of the surface by maintaining in the room with VDT relative humidity at 40-60% (you can use household humidifiers);
- use in a room with VDT floor with antistatic linoleum and wet cleaning;
- treat non-static floor coverings with antistatic substances ;
- ground VDT in accordance with ДНАОП 0.00-1.21-98 "Rules for safe operation of electrical equipment of consumers";
- it is desirable for employees to wear clothes made of natural or combined (natural and artificial) fibers;

- cotton overalls are recommended for workers as overalls;
- to put all polymers of a covering (covers) VDT in the corner of the room furthest from workers;
- Periodically, when the computer is turned off, wipe the dust from the surfaces of the equipment with a cotton cloth slightly moistened with soap solution.
- Wipe the screen and the protective screen with an alcohol swab

4.2.4. Normalization of lighting

Consider the effects of lighting on the human body. Particular attention should be paid to the important issue of workplace lighting in terms of industrial sanitation.

The level of illumination is set depending on the category of visual work. When working with a PC, it is not les E_{min} = 400 lux.

Industrial lighting is regulated by regulatory and technical documents ГОСТ 12.1.046-85, СНИП П-4-79. Workplace lighting should be combined (natural and artificial light). Natural lighting should be lateral. The coefficient of natural light must meet the normative levels of СНИП П-4-79: when performing work in the category of high visual accuracy - not less than 1.5, when visual work of medium accuracy - not less than 1.

Artificial lighting should be carried out in the form of a combined lighting system using fluorescent light sources in general lighting fixtures. They must provide uniform illumination by means of reflected or diffused light distribution.

Calculate the total illumination of the room where the computer is installed, if the norm of illumination when using fluorescent lamps in category 1 is 400 lux. Room dimensions A = 9 m, B = 6 m, H = 3 m.It is supposed to use lamps of the SHOD type with LD lamps of 2x80 lm, suspension height $h_п$ = 2,5 m, the coefficient of luminous flux k is assumed to be equal to 1.5, as for rooms with low emissions of dust, smoke and soot.

The basic calculation formula:

$$\phi := \frac{A \cdot B}{h_{ï} \cdot (A + B)} \qquad \phi = 1.44$$

Take the value of the reflection coefficient of the ceiling ρ_c = 0,1, the luminous flux of the lamp η = 0,51. The correction factor Z is taken to be equal to 1.2. luminous flux of the lamp in the lamp $F_{л}$ = 4070 lm. Find the number of lamps from the formula:

$$n := \frac{E_{í} \cdot S \cdot k \cdot Z}{F_{ë} \cdot \eta} \qquad n = 18.731 \quad n = 20$$

The number of lamps N will be:

$$N := \frac{n}{2} \qquad N = 10$$

Lamps should be arranged in 2 rows of 5 pcs. in a row.

4.3. Instruction on safety, fire and explosion safety.

The instruction on fire and explosion safety should be made in accordance with the requirements of ДНАОП 0.00 - 4.15 - 98 "Regulations on the development of instructions on labor protection".

1. Terms

The most common measures aimed at reducing occupational injuries are:

1. determination of the list of persons admitted to work and control of admission;
2. rational device of the main and auxiliary production buildings and constructions;
3. rational device of machines, machines, devices, tools, devices and other equipment, their placement and maintenance in good condition;
4. rational organization of jobs;
5. isolation of the production process;
6. organizational and mass events.

During the operation of electrical equipment, workers must follow certain electrical safety rules. The following actions are not allowed:

1. use of electrical equipment and devices in conditions that do not meet the instructions (recommendations) of manufacturers;
2. work on faulty electrical appliances and equipment;
3. use of damaged sockets, plug connectors, switches;
4. the use of self-made extenders that do not meet the requirements of PVE "Rules of installation of electrical installations" to portable wiring;
5. operation of cables and wires with damaged insulation or one that has lost its protective properties during operation;
6. use of non-standard (self-made) electric heating equipment or incandescent lamps for space heating;
7. wrapping of electric lamps and fixtures with paper, cloth and other combustible materials, their operation with the removed caps (diffusers).

Compliance with the above requirements significantly increases electrical safety during operation of electrical equipment.

2. Responsibilities of PC workers:

1. Before work:
   - check the voltage in the network,
   - set the voltage switch on the computer to the correct position,
   - connect the computer via a stabilizer,
   - turn on the voltage stabilizer,
   - turn on the printer,
   - turn on the computer,
   - eurn on the computer monitor;
2. While working:
   - use protective equipment;
   - monitor control devices that indicate the presence of voltage on the equipment (voltage indicators), or devices that indicate the presence of current in the electrical circuit;

3. In an emergency:

- quickly turn off the power and provide assistance to the victim;
- release the victim from tight-fitting clothing;
- free the victim's mouth from foreign objects;
- perform artificial respiration.

4. At the end of the work:

- turn off the printer;
- turn off the monitor;
- turn off the computer;
- switch off the voltage regulator

Conclusion

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

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

Chapter 5. ENVIRONMENTAL PROTECTION

Environmental protection is a system of legislative acts and measures aimed at reducing the impact of harmful and industrial factors on:

- soil;
- water;
- atmosphere;
- vegetation;
- fauna.

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

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

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

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

In modern aviation, operator activity is becoming increasingly important. By its nature, many other types of work of specialists in the management, control and maintenance of aircraft are becoming closer to it. Its main feature is that a person engaged in camera work, does not have the opportunity to interact directly with the subject of work. This interaction is mediated by complex technical systems that transmit information to the person about the subject and means of labor, and through which it realizes in this subject a conscious goal.

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

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

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

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

1. ДСТУ 2420-94 Energy saving. Terms and definitions
2. Р 50-081-2000 Energy saving. Methods for assessing the energy status of energy supply systems of industrial enterprises for their certification
3. 3. Ministry of Health of Ukraine from 01.08.96 N 239 STATE SANITARY STANDARDS AND RULES FOR PROTECTION OF HOUSEHOLDS FROM THE INFLUENCE OF ELECTROMAGNETIC RADIATORS
4. ДСТУ Б В.1.1-8:2003 - Fire protection CABLE PENETRATIONS. FIRE RESISTANCE TEST METHOD

5.1. Influences of an electromagnetic field

The effect of electromagnetic radiation on human

Electromagnetic field (electromagnetic radiation) occurs when free electrons move in a conductor - the transfer of electrical energy is accompanied by intense electromagnetic radiation. It has been scientifically proven that electromagnetic radiation has a more detrimental effect on the body of living beings than radiation. The fact is that the radiation background has always been on our planet and at certain times its level was higher than in the Hernozone "Chernobyl", and the level of the earth's electromagnetic field increases every year, which is due to human activities. In the CIS, the total length of only 500-kV transmission line exceeds 20,000 km. (except for the transmission line-150 transmission line-300 transmission line-750). Power lines and some other power plants create electromagnetic fields of industrial frequencies (50 Hz) hundreds of times higher than the average level of natural fields. The field strength under the transmission line can reach tens of thousands of V / M. The greatest field strength is observed at the place of maximum sagging of wires, at the point of projection of extreme wires on the ground and five meters from it around the longitudinal axis of the route: for 330 kV transmission line - 3.5 - 5.0 kV / m, for transmission line 500 kV - 7.6 - 8 kV / m, for transmission line-750 kV - 10.0 - 15.0 kV / m. The negative effects of electromagnetic fields on humans or other components of ecosystems are directly proportional to the field strength and irradiation time. The adverse effect of the electromagnetic field generated by the transmission line is detected already at a field strength of 1000 V / m. In humans, the endocrine system, metabolic processes, functions of the brain and spinal cord, and others are disturbed.

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

Possible mechanisms of biological action of the electromagnetic field.

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

Influence of electromagnetic field on a cell.

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

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

The electromagnetic field affects charged particles and currents, as a result of which the field energy at the cell level is converted into other types of energy.

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

Influence of electromagnetic field on the nervous system.

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

The effect of electromagnetic radiation on the immune system.

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

Influence of weak electromagnetic fields on living organisms.

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

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

5.2. Calculation of electricity consumption

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

$$\sum_{\text{³}=1}^{n} W_{\text{îá}} = \frac{\sum M_{yi}\hat{O}_{\text{ä}i}K_{\text{ç³}}\hat{E}_{0}}{\eta \hat{E}_{B\tilde{N}}} \qquad (5.1)$$

where M_{yi} – total power of the designed equipment (0.15), in kW; $Ф_{\partial i}$ – actual equipment time fund (5000); $К_{зi}$ – equipment load factor (0,90); $К_0$ – refresh rate (0,85); η – coefficient of performance (0,85); $К_{BC}$ – loss factor in networks (0,95).

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

$$\sum_{i=1}^{n} W_{oy} = \frac{\sum P_y F_{yi} Ф_{Гi} К}{1000} \qquad (5.2)$$

where P_y – specific electricity consumption per 1 m^2 (0.01 kW);

F_{yi} – area of the *i*-th section; $Ф_{гi}$ – number of hours of lighting fixtures at 3-shift mode of operation of the *i*-th shop (3100 hours); $К$ – loss factor:($К$ = 1,05).

The total electricity consumption is determined by the formula:

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

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

$$У_{ел} = W у_{ел}, \qquad (5.4)$$

where by the formula (5.4): $у_{ел}$ – specific environmental damage 24.36 kopecks / kWh.

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

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

$$У_{пр} = \sum_{i=1}^{n} У_{ел} \qquad (5.5)$$

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

Ecological and economic effect obtained as a result of the use of electricity by electrical equipment is calculated by the formulas (5.1 – 5.4):

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

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

$$\sum_{i=1}^{n} У_{ел} = (794{,}118 + 3{,}255) \cdot 0{,}2436 = 194{,}25 \text{ hryvnas}$$

Therefore, the total environmental and economic effect obtained as a result of the project will be $У_{пр}$ = 194,25 hryvnas.

Disposal of the device

After working out the resource, the device of the analysis of influence of complex refusal on a condition and behavior of the pilot is subject to utilization, according to ecological requirements, namely the permission of the enterprise for processing. Precious metals that have a device are subject to accounting and reuse, thanks to Kolorvtormet.

Conclusions

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

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

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

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

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

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

- introduction of new technologies with a lower level of electromagnetic radiation and energy consumption, and with better technical characteristics.

the use of waste-free technologies - which, although they do not completely eliminate environmental pollution, but can significantly reduce it.

REFERENCES

1. Collection of materials "Human factor", «5. Operational consequences of auto-automation in equipped with advanced equipment in the crew cabins (Sir 234) .- ICAO Montreal, 1992.-55 p.
2. Shabatura MN etc. Human Biology: Textbook. For the 9th grade. among. General education. textbook hall / M.N. Shabatura, N.Yu. Матяш, B.O. Rope. - 3rd ed., Revised. - К .: Генеза, 2004.- 176с .: іл.
3. Selected works. Pavlov IP / Under the general editorship. prof. MA. Uslevich. - M .: State Educational and Pedagogical Publishing House of the Ministry of Education of the RSFSR in 1954.- 416p.
4. Isaenko VM, Krivorotko VM, Franchuk GM Ecology and environmental protection. Diploma design: Textbook. way. - K .: Book Publishing House of NAU, 2005.- 192p.
5. Khokhlov EN Process substantiation of programs and methods of anti-stress training of pilots in ensuring the safety of production processes // Problems of labor and environmental protection in the production processes of civil aviation. - Kiev: KIIGA, 1989. - P. 74-81.
6. Sechenov IM Selected works. M .; "Thought" 1947
7. Grishchenko Yu. V. Ways to increase the safety of removing negative phenomena // Problems of labor protection and the environment in the production processes of civil aviation. - Kiev: KIIGA, 1989. - P. 81-84.
8. Khokhlov EN, Burygin NA Priority ideas in the field of management. Kiev: ONPI "ALIBRA" - NMCPA, 1993 - 102 p.