МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет аеронавігації, електроніки та телекомунікацій

Кафедра аеронавігаційних систем

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедриАНС
д-р техн. наук, проф.

______________ Ларін В.Ю.

«____» ____________ 2020р.

ДИПЛОМНАРОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ«МАГІСТР»
за освітньо-професійною програмою
«ОБСЛУГОВУВАННЯ ПОВІТРЯНОГО РУХУ»

Тема:

Діяльність авіадиспетчерів в умовах підвищеної виробничої завантаженості

Виконавець: Мельничок Антон Михайлович

Керівник: Аргунов Геннадій Федорович

Нормоконтролер Аргунов Геннадій Федорович

Київ 2020

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL AVIATION UNIVERSITY

FACULTY OF AIR NAVIGATION, ELECTRONICS AND TELECOMMUNICATIONS

AIR NAVIGATION SYSTEMS DEPARTMENT

PERMISSION FOR DEFENCE

Head of the Department

Doctor of Engineering Sciences,prof

_______________V.Yu. Larin

"_____" ____________ 2020.

MASTER'S THESIS

ON THE EDUCATIONAL PROFESSIONAL PROGRAM

"AIR TRAFFIC SERVICE"

(EXPLANOTARY NOTE)

Theme:

"AIR TRAFFIC CONTROLLERS ACTIVITY IN CONDITIONS OF INCREASED WORKLOAD"

Performed by: Melnichok A. M.

Supervisor: Argunov G. F.

Standard inspector Argunov G. F.

Kyiv 2020

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет аеронавігації, електроніки та телекомунікацій

Кафедра аеронавігаційних систем

Спеціальність: 272 «Авіаційний транспорт»

Освітньо-професійна програма: «Обслуговування повітряного руху»

ЗАТВЕРДЖУЮ
Завідувач кафедри АНС

____________ В.Ю. Ларін

«____»______________ 2020 р.

ЗАВДАННЯ

на виконання дипломноїроботи магістра

Мельничка Антона Михайловича

1. Тема дипломної роботи: «Діяльність авіадиспетчерів в умовах підвищеної виробничої завантаженості», затверджена наказом ректора від “29” вересня 2020 № 1815/ст

2. Термін виконання роботи: з 05.10.2020 – 13.12.2020.

3. Вихідні дані до роботи: Методика оцінки та підвищення ефективності діяльності авіадиспетчерів в умовах високої завантаженості.

4. Зміст пояснювальної записки: Аналіз факторів, що впливають на ефективність діяльності авіадиспетчерів, Класифікація та методики оцінювання і контролю завантаженості авіадиспетчерів, Методики попередження помилок під час роботи авіадиспетчерів в умовах підвищеної завантаженості, Дослідження діяльності авіадиспетчерів в стресових умовах.

5. Перелік обов'язкового графічного (ілюстративного) матеріалу: графіки, таблиці, формули

6. Календарний план-графік

№ пор.	Завдання	Термін виконання	Відмітка про виконання
1.	Підготовка та написання 1 розділу. АНАЛІЗ ФАКТОРІВ, ЩО ВПЛИВАЮТЬ НА ЕФЕКТИВНІСТЬ ДІЯЛЬНОСТІ АВІАДИСПЕТЧЕРІВ	05.10.2020 – 25.10.2020	Виконано
2.	Підготовка та написання 2 розділу. КЛАСИФІКАЦІЯ ТА МЕТОДИКИ ОЦІНЮВАННЯ І КОНТРОЛЮ ЗАВАНТАЖЕНОСТІ АВІАДИСПЕТЧЕРА	15.10.2020 – 28.10.2020	Виконано
3.	Підготовка та написання 3 розділу. МЕТОДИКИ ПОПЕРЕДЖЕННЯ ПОМИЛОК ПІД ЧАС РОБОТИ АВІАДИСПЕТЧЕРІВ В УМОВАХ ПІДВИЩЕНОЇ ЗАВАНТАЖЕНОСТІ	25.10.2020 – 8.11.2020	Виконано
4.	Підготовка та написання 4 розділу. ДОСЛІДЖЕННЯ ДІЯЛЬНОСТІ АВІАДИСПЕТЧЕРІВ В СТРЕСОВИХ УМОВАХ	05.11.2020 – 28.11.2020	Виконано
5.	Оформлення дипломної роботи	05.11.2020 – 13.12.2020	Виконано
6.	Підготовка презентації та доповіді	15.10.2020 – 13.12.2020	Виконано

7. Дата видачі завдання: «10» жовтня 2020р.

Керівник дипломної роботи Аргунов Г.Ф.

Завдання прийняла до виконання Мельничок А. М.

NATIONAL AVIATION UNIVERSITY
Faculty of Air Navigation, Electronics and Telecommunications

Air navigation Systems Department
Specialty: 272 «Aviation Transport»
EPP: «Air Traffic Services»

Approved:

Head of the Department

____________V.Yu.Larin

«____»_______________

Graduate Student's Degree Thesis Assignment

Anton Melnichok

1. The Master's degree thesis topic: "Activity of air traffic controllers in the conditions of the increased production load", approved by the Rector's order from of 29.09.20 № 1815/st.

2. The Master's degree thesis to be completed between: with 05.10.20 – 13.12.20.

3. Initial data to the thesis: Methods for evaluating and improving the efficiency of air traffic controllers in conditions of high traffic.

4. The content of the explanatory note: Analysis of the factors influencing the efficiency of air traffic controllers, Classification and methods of assessment and control of air traffic controllers' workload, Methods of error prevention during air traffic controllers' work in conditions of high workload, Research of air traffic controllers' activities in stressful conditions.

5. The list of mandatory graphical (illustrated) materials: graphs, tables, formulas

6. Calendar time-table

№	Completion stages of master's thesis	Stage completion dates	Remarks
1.	Preparation and writing of chapter 1. ANALYSIS OF FACTORS AFFECTING THE EFFICIENCY OF THE ACTIVITY AIR DISPATCHERS	05.10.2020 – 25.10.2020	Done
2.	Preparation and writing of chapter 2 CLASSIFICATION AND METHODS EVALUATION AND CONTROL LOAD OF THE AIR DISPATCHER	15.10.2020 – 28.10.2020	Done
3.	Preparation and writing of chapter 3 PREVENTION METHODS ERRORS DURING WORK AIR DISPATCHERS IN CONDITIONS INCREASED LOAD	25.10.2020 – 8.11.2020	Done
4.	Preparation and writing section 4. RESEARCH OF AIR TRAFFIC OPERATORS 'ACTIVITY UNDER STRESS CONDITIONS	05.11.2020 – 28.11.2020	Done
5.	Registration of the diploma work	05.11.2020 – 13.12.2020	Done
6.	Preparation of presentation and report	15.10.2020 – 13.12.2020	Done

7. Assignement of issue date: "10" October 2020

Supervisor of graduate work ___________ G.F. Argunov
(supervisor's signature) (name, surname)

The task is obtained for fulfillment by ____________ A.M. Melnychok
(student's sgnature) (name, surname)

РЕФЕРАТ

Пояснювальна записка до дипломного проекту «Діяльність авіадиспетчерів в умовах підвищеної виробничої завантаженості»: 91 сторінка, 23 рисунка, 11 таблиць, 22 використаних джерела, 1 додаток.

ВИКОРИСТАННЯ ПОВІТРЯНОГО ПРОСТОРУ, ЛЮДСЬКИЙ ФАКТОР, ЕРГОНОМІЧНІ ФАКТОРИ, СТРЕС, ОБСЛУГОВУВАННЯ ПОВІТРЯНОГО РУХУ, ВИРОБНИЧЕ НАВАНТАЖЕННЯ, ІНТЕНСИВНІСТЬ ПОВІТРЯНОГО РУХУ, ЕФЕКТИВНІСТЬ ДІЯЛЬНОСТІ, РИЗИК, ПРОФЕСІЙНА НАДІЙНІСТЬ, ПОДОЛАННЯ ПОМИЛОК

Мета дипломної роботи – підвищення ефективності та зменшення помилок авіадиспетчерів під час управління повітряним рухом в умовах надмірної виробничої завантаженості.

Засоби досягнення – застосування методів і алгоритмів запобігання помилок авіадиспетчерів в умовах ускладненої повітряної обстановки, методики нейтралізації стресу, що спричиняється підвищеною виробничою завантаженістю, вдосконалення процесу підготовки фахівців.

Об’єкт удосконалення – професійна діяльність фахівців при обслуговуванні повітряного руху.

Прогнозні припущення щодо розвитку об’єкта дослідження – за допомогою застосованих методів очікується покращення умов діяльності авіадиспетчерів, підвищення рівня безпеки повітряного руху за рахунок контролю можливих помилок.

ABSTRACT

Explanatory note to master’s degree thesis "Activities of air traffic controllers in conditions of increased production load": 90 pages, 23 figures, 11 tables, 22 sources used, 1 appendix.

Purpose of the work - increase the efficiency and reduce the errors of air traffic controllers during air traffic control in conditions of excessive production load.

The object of research - application of methods and algorithДЩ to prevent errors of air traffic controllers in difficult air conditions, methods of neutralization of stress caused by increased workload, improvement of the training process.

Object of improvement - professional activity of specialists in air traffic services.

Assumptions about the development of the object of study - with the help of the applied methods it is expected to improve the conditions of air traffic controllers, increase the level of air traffic safety by controlling possible errors.

USE OF AIRSPACE, HUMAN FACTORS, ERGONOMIC FACTORS, STRESS, AIR TRAFFIC SERVICES, PRODUCTION LOAD, INTENSITY OF AIR TRAFFIC PERFORMANCE, RISK PROFESSIONAL RELIABILITY, REDUCE ERRORS

PAGE OF REMARKS

CONTENT

LIST OF ABBREVIATIONS

APW (Area Proximity Warning Function) - a function to warn of approaching restricted areas

ICAO (International Civil Aviation Organization) - International Civil Aviation Organization

STCA (Short Term Conflict Alert) - short-term conflict warning

STAR (Standard Instrument Arrival) - standard route of arrival by instruments

SDPS (Standard Data Processing System) - surveillance data processing system

SID (Standard Instrument Departure) - standard route of departure by devices

OLDI (On Line Data Interchange) - air traffic control data exchange protocol

MSAW (Minimum Safe Altitude Warning Function) - function to warn of violation of the minimum safe altitude

EDPS (Electronic Data Processing System) - an external data processing system

RVSM (Reduced Vertical Separation Minimum) - reduced minimum vertical separation

FDPS (Flight Data Processing System) - flight data processing system

GPWS (Ground Proximity Warning System) - a system to prevent dangerous approach to the ground

MRVA (Minimum Radar Vertical Altitude)- minimum height of radar guidance

MTCD (Medium Term Conflict Detection) - medium-term conflict detection and resolution

TERMS AND DEFINITIONS

Anthropometry - measurement of basic physical indicators of the person.

Dynamic density - a measure of the load on the air traffic control system, which is characterized by the function of both the number of aircraft in the sector and the complexity of air traffic in its volume.

Ergonomics - a scientific discipline that comprehensively studies man in the specific conditions of its activities in modern production.

Efficiency of activity -the relationship between productivity and the amount of costs (including the degree of rational use of resources), which is expressed in achieving the maximum effect at minimum cost. There is an inverse relationship between labor costs per unit of output and labor efficiency. Labor efficiency is a multifaceted economic category, each of the aspects of which reveals some of its essential aspects and is expressed in a less capacious category. Such categories are labor productivity, productive labor force, labor quality, labor productivity, labor stability, labor intensity, and so on.

Intensity of air traffic - the number of aircraft that fall within the area of responsibility of the dispatcher for a certain period of time.

Short-term conflict warning - a system that provides the air traffic controller with a warning whenever it predicts a breach of established vertical or horizontal intervals between aircraft.

Conflict situation - projected convergence of aircraft in space and time, which violates the established minimuДЩ of separation.

Convergence of aircraft.A situation in which, in the opinion of the pilot or air traffic service personnel, the distance between aircraft, as well as their relative location and speed, are such that the safety of those aircraft may be compromised. Has the following classification:

Risk of collision. Category of situations when as a result of approach of aircraft there was a serious danger of collision.

Flight safety was not guaranteed. The category of situations where, as a result of the convergence of aircraft, their safety could be endangered.

There was no risk of a collision. Category of situations when there was no danger of a collision as a result of the approach of aircraft.

The risk is not defined. The category of situations with aircraft convergence, when the lack of sufficiently complete information does not allow to determine the existing risk of collision, whether the data are not convincing enough or the available data are contradictory and it does not allow to determine the degree of risk.

The human factor - a stable expression that meAHC a person's mental abilities, as a potential and relevant source of information probleДЩ when using this person modern technology.

Air traffic service - a general term meaning, where appropriate, the provision of the following services: flight information service, emergency service, advisory service, air traffic control service (district control service, approach control service or aerodrome control service).

Aircraft Is an aircraft that is kept in the atmosphere due to its interaction with air, different from the interaction with air reflected from the earth's surface, and is able to maneuver in three-dimensional space.

Air traffic - all aircraft in flight or moving in the aerodrome maneuvering area.

Capacity of air traffic services - the ability of air traffic services or any operating subsysteДЩ to service aircraft in normal operation is determined by the number of aircraft entering a defined part of the airspace during the relevant period of time.

Regularity of flights - the concept that characterizes the work of airports, operators and the industry as a whole in relation to the delivery of passengers, luggage and cargo in accordance with contracts of carriage, includes the concept of regularity and regularity of departures, defined as a percentage of regular flights to total flights.

Frustration - a mental state that arises in a situation of frustration, failure to achieve any significant goal or need.

Warning function for aППroaching restricted areas - a function of the system that provides the controller with a warning whenever it predicts a breach (within 2 minutes) or in the event of a breach (in the horizontal or vertical plane) of a permanent or temporary flight restriction zone.

Warning function for violation of the minimum safe absolute height -a function of the system that provides the air traffic controller with a warning whenever the aircraft falls below the minimum safe absolute altitude, which is set to avoid the collision of the aircraft with the ground. The system generates a warning only up to the absolute flight altitude of the fixed landing end point.

Target installation - a component of the executive mechanisДЩ of activity, which reflects the vital importance of objects and phenomena of reality, to which this activity is directed.

INTRODUCTION

Every person who for the first time somehow finds hiДЩelf in the hall where air traffic controllers work, has the impression of a very calm atmosphere. But it is deceptive. Outside this calm hides a huge internal tension. The tension of responsibility that each of the employees in the control room bears personally and cannot be transferred to someone else. And the point here is neither in clearly described procedures and rules, nor in the desire to prove that they can cope with the situation, but in the unusual nature of these people. Each of them throughout the nervous system feels that the dots that glow on the indicator are hundreds of human hearts, which they have no right to stop because of, sometimes, nonsensical errors. Therefore, no matter how difficult the situation, no matter how strong the tension, the most important task of the dispatcher is the obligation to remember,

On average, about 3,000 people die each year in plane crashes worldwide. In comparison with these data we will give the same statistics of road accidents, and we will see that the indicator of victiДЩ is much bigger. This type of transport takes more than 30,000 lives, and only in Ukraine. That is, according to statistics, civil aviation is the safest mode of trAHCport.

However, gradually the intensity of air traffic increases, the number of airlines and, accordingly, the transportation of both passengers and cargo. According to Eurocontrol statistics for the next 3 years in the European region is projected to increase air traffic by an average of 3.7% annually [10].

Despite the introduction of the concept of flexible use of airspace, the activities of air traffic controllers are becoming more complex every year. They have to work in conditions of constant increased workload and stress.

It is known that at relatively low levels of functional stress, performance is restored fairly quickly, and no harmful effects on the human body do not occur. However, in cases where the functional stress reaches levels at which the restoration of the spent functional potential during the work shift is impossible, conditions are created to reduce the efficiency of the employee. Usually short-term rest and change of activity promote restoration of the spent resources of an organism.

In cases where the level of functional stress is excessive and overload lasts a long time, short rest no longer leads to a full recovery of spent resources. Continuation of work with the former intensity can lead to the fact that all the reserve resources of the body will be spent on recovery, and this, in turn, can cause the emergence and development of various occupational diseases.

In the course of work of the air traffic controller it is important to understand that professional overstrain - a borderline condition between normal functioning of an organism and emergence of pathological states which are characterized by these or those functional disturbances of separate bodies and systeДЩ. Overexertion can be a risk factor for the emergence and development of occupational diseases of the nervous and cardiovascular systeДЩ, metabolism, digestive orgАНС, etc.

In addition to harming one's own health, an overstrain by an air traffic controller can reduce the level of flight safety. What can not be allowed.

The purpose of the thesis- increase the efficiency and reduce the errors of air traffic controllers during air traffic control in conditions of excessive production load. In other words, the purpose of this thesis is to consider existing and develop new techniques that are needed to ensure that increased workload has as little impact on the efficiency of air traffic controllers, while maintaining a high level of safety in air traffic services.

To achieve this goal it is necessary to solve the following tasks:

1. Perform an analysis of the factors influencing the efficiency of air traffic controllers.

2. Analyze the concept of congestion of air traffic controllers, determine its allowable level.

3. Investigate the peculiarities of dispatchers in stressful conditions and highlight the possible consequences.

4. Highlight existing methods of preventing the occurrence of danger due to overcrowding of air traffic controllers and suggest ways to improve them.

CHAPTER 1

ANALYSIS OF FACTORS AFFECTING THE EFFICIENCY OF AIR TRAFFIC OPERATORS

The process of air traffic control is a complex algorithmic and time-continuous activity of the dispatcher. This process is characterized by a rather complex set of air conditions, established clear rules and procedures, radiotelephone communication, meteorological information and other similar conditions that require air traffic controllers to perform many technological operations and make many decisions in a relatively short period of time. That is, the main feature of this profession is that in addition to performing mandatory routine tasks and processes that must be transferred to the level of skills with experience, there are also situations of a random nature that never recur and require a creative approach.

The main tasks of the air traffic controller [4] are:

1. Prevention of collisions between aircraft (ACs) in the air.
2. Prevention of collisions of aircraft in the maneuvering area, as well as with obstacles in this plane.
3. Accelerate and maintain an orderly flow of air traffic.

The air traffic controller must be able to plan the air traffic control (ATC) process, implement plans, make decisions, solve problems and prepare forecasts. Thus, this type of activity is very complex and responsible.

An important task in the air navigation system is to optimize the work of air traffic services (ATS), reduce their workload and increase efficiency.

1.1. General aspects of airspace efficiency

With the current distribution and use of airspace of Ukraine, the needs of not all its users are fully met. Therefore, the distribution of airspace should be carried out with maximum regard to the objective needs of all users.

When analyzing the effectiveness of the runway, criteria should be provided that allow to predict and quantify the effectiveness of measures that increase the effectiveness of the runway process.

In such circumstances, the airspace allocated to each user should be used with the greatest efficiency, the requirements for which are determined by the existing needs of practice, and the actual level - the existing opportunities to ensure the required level of efficiency.

The airspace used for flights can be considered as a complex system of a certain level of organization. Such airspace is the operating environment of the ATM system, ie one of its components. The level of traffic organization in the airfield depends on the characteristics of aircraft operating in this airfield, flight rules, procedures and air traffic control technology, the human factor associated with the activities of crews and air traffic controllers, the perfection of technical means, meteorological condition and more.

The efficiency of using air transport by air transport is characterized by many criteria: productivity of transportation in it, quality of these transportations - safety, regularity, economy, accessibility of software to users, negative impact of transportation on the ecological condition of air transport, etc.

The efficiency of airspace use is a productivity characterized by the volume of traffic and economic effect. But in a broader sense - efficiency is efficiency, ie the consequences (positive and negative) of the implementation of the process of using airspace for air transport.

Qualitative and quantitative indicators characterize the use of airspace. Qualitative indicators include, for example, air quality, which is necessary for the existence of all living things on the planet, the presence or absence of violations of the use of state airspace from outside and within the state, regularity or random use of airspace, priority or equivalence of airspace use by users and others. Quantitative expression of the level of airspace use, necessary to determine the completeness of its use, planning measures to improve the efficiency of airspace use from production and environmental points of view, etc. [3]

Performance criteria can be generalized to all users and specific to each of them.

The generalized include:

- meeting the needs for the use of software by each user;
- availability of software to a specific user;
- availability of software to a certain user during a certain time interval;
- predictability of the state of airspace;
- compliance of the state of the airspace with the established requirements;
- completeness of airspace use;
- the impact of the user on the environmental condition of the PE, etc.

Efficiency of airspace usecharacterized by efficiency (productivity) that the user can get in the process of using software. For different users of the software, different indicators or their different values can determine it.

The complexity of air traffic and methods of its assessment

In the process of ATC, the tasks of ensuring flight safety and increasing the capacity of the route network are solved. Heavy traffic puts a heavy strain on the air traffic control system, so the airspace is divided into sectors that are controlled by individual air traffic controllers. Two strategies are usually used to reduce aircraft congestion in sectors. The first of them is reduced to the adaptation of air traffic to the existing capacity of airspace, and the second, on the contrary, to the adaptation of capacity to traffic requirements. For both approaches, the number of aircraft in the sector under control measures the capacity of the sector.

Observations of the management process in the sectors show that sometimes controllers in simple situations take control of the number of aircraft exceeding the sector capacity threshold, while in other situations they avoid servicing the boards until the airspace capacity increases. This fact clearly indicates that, using a metric that contains only operational indicators, it is not possible to estimate the load on controllers.

A group of researchers from NASA has developed a metric called "dynamic density", which provides an adequate quantitative assessment of the complexity of ATC [3]. Studies to determine the dynamic density (DS) have revealed the potential importance for the purposes of its description of the use of various complex (group) factors, taking into account, in particular, the structure of the airspace.

In essence, HF is a measure of the load on the ATC system and is a function of both the number of aircraft in the sector and the complexity of the traffic picture in its volume. The review of traffic complexity in the sector shows that the number of ACs, sector geometry, separation standards, AC flight characteristics, weather conditions are the most common factors influencing the complexity of traffic in the sector.

The following is a list of factors that determine the complexity of air traffic in the sector:

- number of ACs;
- AC density or traffic capacity;
- the number of processed ACs for the previous period of time (for the last hour);
- number of AC arrivals;
- number of AC shipments;
- number of critical situations;
- number of special flights;
- coordination;
- mixed traffic structure (arrivals, departures, flights);
- number of airports;
- traffic distribution;
- staff;
- weather conditions;
- condition of equipment;
- the number of communication channels with the AC;
- number of communication channels with other sectors;
- the presence of conflicts;
- the number of changes in the trajectories of the AC;
- conflict prevention (on intersecting and longitudinal routes);
- number of crew requests;
- air traffic structure;
- types of ACs that are serviced simultaneously;

- recruitment and reduction of AC;
- the number of trajectories of the intersecting AC;
- the number of required procedures;
- the number of flights of military aircraft;
- degree of weather deterioration;
- airspace for special flights;
- geometric dimensions of the sector;
- standards of longitudinal and lateral separation;
- radar coverage;
- overload of the frequency range of communication;
- the number of echelons in height.

It is simply impossible to take into account all these factors, so the metrics are carried out by different organizations for different sets of factors. Among them there are 4 metrics: WJHTC / Titan Systems, metric 1 NASA, metric 2 NASA, metric Metron Aviation [3].

Dynamic density is a complex quantitative characteristic of the complexity of ATC in the sector. The functional dependence of this characteristic on the above parameters is calculated using the apparatus of regression analysis and the method of expert estimates based on retrospective data describing air traffic in the sector.

At the first stage of construction of metrics the order and the maintenance of experimental procedures of definition of estimations of complexity of traffic on the basis of judgments of dispatchers and inspectors should be defined. For example, the values of variables for HF metrics researchers can extract from the data of navigation information monitoring in an improved air traffic control system.

In the second stage, data on air traffic control in the sector should be collected. You need to get a few dozen samples of traffic, lasting at least half an hour each. Each sample of traffic is divided into two-minute intervals. Experts (inspectors and dispatchers) provide an individual assessment of the complexity of the CRC for each two-minute interval on all traffic samples. Thus, an appropriate group expert assessment is formed.

At the third stage of research the following tasks are solved:

- construction of a regression equation for the dynamic density of motion;
- analysis of the accuracy of compliance of regression results with expert estimates;
- analysis of the probability and stability of the forecast of the complexity of air traffic for a period of time of several hours on the basis of the obtained regression equation.

Criteria for assessing the efficiency of airspace use by air transport

Airspace is used to different degrees in different regions of the planet and the state. It is mostly used in North America and Western Europe. In Ukraine, the highest flight intensity is observed in the zones of Kyiv and Simferopol districts. The effectiveness of the use of airspace over the years is of growing interest. Over the last decade, there has been a problem of evaluating and improving the efficiency of airspace use. A number of factors, as shown in Fig. 1.1 limits it.

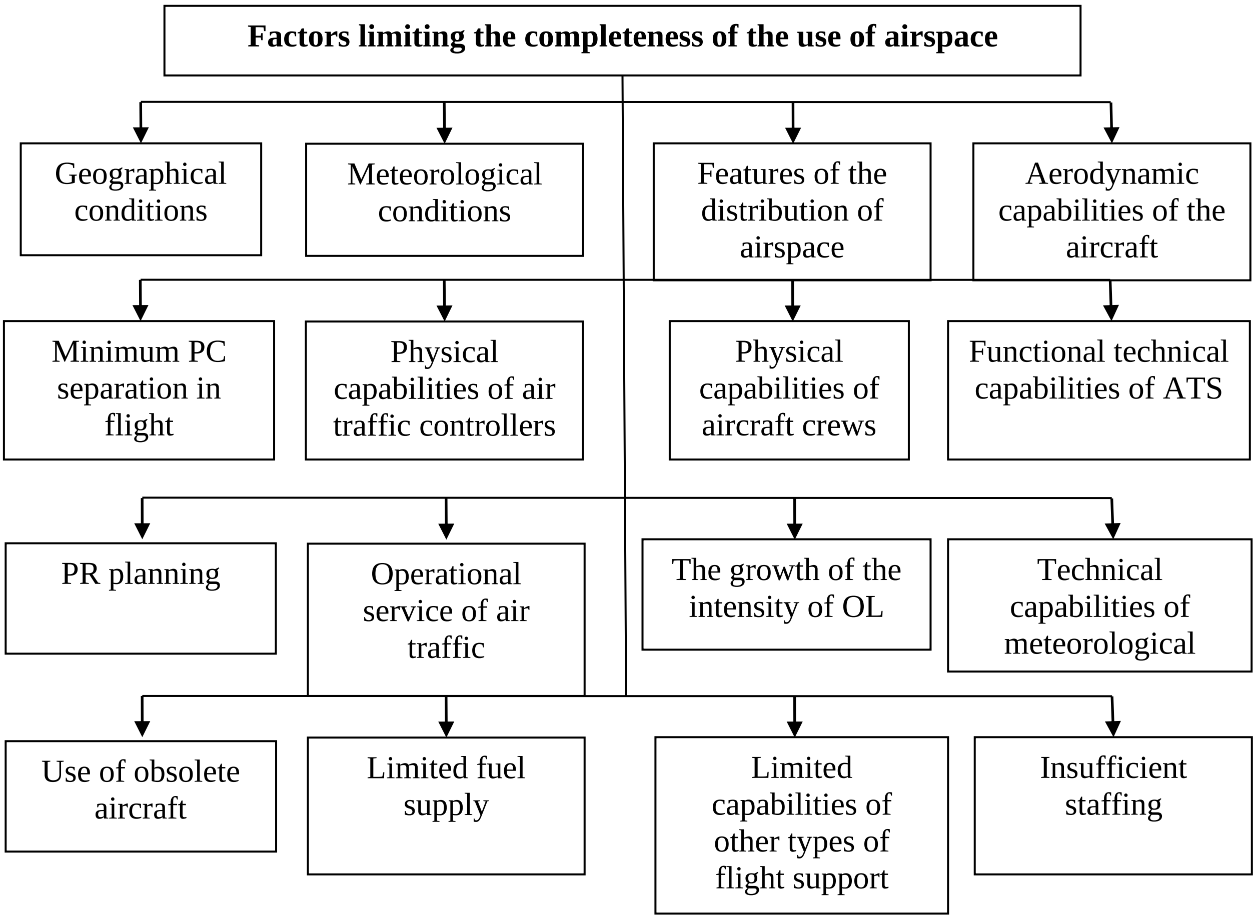

Figure 1.1 - Factors that limit the completeness of the use of airspace

Improving the efficiency of airspace can be achieved in the presence of a methodology for assessing its level. It is necessary to determine the actual quantity and quality of the use of airspace.

The efficiency of the use of airspace by air transport is determined by changing (increasing) the level of air traffic in it in absolute and relative terms:

- volume of traffic;
- duration of flights in the zone of airspace;
- flight safety;
- the level of satisfaction of transportation needs;
- capacity of the airspace zone;
- reducing the complexity of air traffic in the area of the PP;
- availability of PE resources for flights;
- availability of resources of ATS technical means in the airspace zone;
- regularity of flights (reduction of aircraft delays in flight);
- cost-effectiveness of flights;
- impartiality of air traffic services;
- predictability of aircraft flight;
- environmental safety.

It is clear that the most important indicators of the effectiveness of the use of airspace are to increase flight safety and productivity.

Criteria for the effectiveness of the use of airspace may be different depending on which airspace is in question: the airspace of the planet, the airspace of the state or the airspace of the industry.

If it is a question of airspace of Ukraine, the following criteria of efficiency of use of airspace should be used:

- the share of airspace, which is allocated to each of the industries;
- coefficient (completeness) of airspace use by each of the industries in general and by regions;
- maps, schemes of use of state software;

- meteorological and climatic conditions of flights in different regions of the airspace;

- productivity of using the planet's airspace, etc.

Here is a list of appropriate criteria for the effectiveness of the use of airspace:

- the absolute number of aircraft that have flown in the area of the aircraft for a certain period of time;

- the absolute number of traffic in the area of the airspace for a certain period of time;

- the absolute duration of the time of use of the airspace zone for a certain time interval (completeness of the use of airspace);

- flight safety in absolute terms for a certain period of time;

- the probability that the state of the state on a particular flight route at the right time there are the necessary conditions to perform the declared flight;

- the probability that in the selected for a particular route airspace at a certain time there are the necessary weather conditions for flights;

- the probability that in a particular state of the state a certain flight (flights in general) is performed (performed) regularly at a certain period of observation;

- the probability that the declared flights in the state of the state will be performed regularly (seasonally and annually);

- the average unit cost of a particular type of aircraft of a particular flight in certain weather conditions;

- income of the state from the implementation of flights in its PE for a certain period of time (season, year) when performing: domestic flights, flights of foreign airlines;

- income from air navigation services of flights in the state of the state for a certain period of time (season, year) when performing domestic flights, flights of foreign airlines;

- estimated and actual capacity of specific areas of the airspace;

- the average duration of flight delays on a particular route (due to weather conditions, due to the air traffic management system, for all possible reasons).

1.2. Study of the components of the workload of the air traffic controller

For general coverage of the issue, we provide an expanded classification of workload, taking into account the main criteria and characteristics of a particular profession (Table 1.1) [16].

Table 1.1 - Classification of workload

Download criteria	Activity groups by workload			
	unloaded	lightly loaded	loaded	very busy
Warning: ○ Number of objects of simultaneous observation	to 6	to 10	to 25	more than 25
○ Duration of concentrated attention in% to working time	to 25	up to 50	up to 75	more than 75
○ Density of messages (signals per hour)	up to 75	to 175	up to 300	more than 300
Emotional tension	Work on an individual plan	Work according to the established plan with a possibility of adjustment in the course of activity	Working in a shortage of time with increased responsibility	Personal risk and responsibility for the safety of others
Variability	Morning 7-8 hours	2 changes without night	3 changes with night	Irregular variability with night work
Intellectual tension	No need to make decisions	Solve easy alternative probleДЩ according to the instructions	Solving complex probleДЩ by algorithm	Creativity

Attention is three separate criteria. The first of them is the number of objects of simultaneous observation. From 1 to 20 aircraft can be under the control of one air traffic controller at the same time, depending on the volume of airspace of the area of his responsibility. Regarding the duration of concentrated attention, we know that during the entire shift, from the reception to the delivery of duty, the dispatcher must constantly monitor the state of the air. That is, all 100% of their working time attention should be focused only on ensuring the safe movement of the aircraft. Consider the following criterion of attention - the number of messages per hour. We take into account that on average about 40 aircraft pass through the area of responsibility per hour. The crew of each of them airs at least twice. At high intensity of OL, in difficult meteorological conditions or in case of special cases in flight, the number of messages received from crews increases approximately 3-7 times. Coordination between related sectors should also be considered. Thus, we get that in a complex situation, the number of messages received by one manager is approximately 200.

Air traffic controllers work on shifts according to the scheme day - morning - night (DRN). This means that the first working day takes place in the day shift, the second - in the morning, the third - at night. Such variability, although it is systematic and consistent, cannot be called regular. The concept of regular variability includes a person's habituation to a personal schedule, which includes waking up every morning at the same time. This has a good effect on human health. Given the three different start of work air traffic control and night work can not be attributed to such a change to regular.

The last criterion is intellectual tension. In the process of aor traffic management, all decisions are responsible, the tasks are complex and are solved sequentially according to certain algorithms. You need to act correctly, quickly, do not deviate from the established documents and work instructions. But note that in the event of, for example, a potential conflict situation, the dispatcher chooses the method of its resolution. In such a situation, the challenge is to ensure a safe interval between potentially conflicting aircraft. But how to do it - by changing the flight level, speed control or radar guidance, decides directly to the dispatcher, guided by the state of the PR and personal experience. That is, the conclusion of this simple example is that the activities of the dispatcher relate to creative work.

After analyzing each of the criteria of workload, we conclude that the activities of the air traffic controller belong to the third and fourth groups according to table 1.1. That is, it is busy, and by some criteria and in some situations - very busy. It is clear that given this workload, the specialist must be endowed with many abilities and character traits from birth. To ensure professional skills in the field of ATS, professional selection is carried out before training.

To determine a large number of human qualities that affect his ability to work and determine the success of work, a detailed analysis of professional tasks. After that, all candidates are tested to assess such qualities. Tests should be standardized and results objective. All the qualities measured by certain tests have different values for the CRC and therefore the results of some tests are given more importance than others. Some of them allow you to assess the general abilities of man, which are relevant to many aspects of CRC.

It is believed that the numerous human abilities, which are assessed by standardized tests, are of great importance in the implementation of the forecast of the selection of dispatchers. Among them - general intelligence, the ability to spatial perception, abstract mathematical thinking, the ability to solve problems together, good command of speech and coordination of hand movements.

Other non-testing procedures and data also play an important role in the selection process. Age, medical history, vision, hearing, emotional stability and previous education are important for the future specialist.

1.3. Analysis of factors that directly affect the complexity of air traffic control

Consider in more detail the factors that significantly affect the complexity of air traffic control. Such factors are divided into permanent and temporary. Positive permanent factors are given in table. 1.2. They concern the technical equipment of CRC points and the number of dispatchers in the sector [3].

Table 1.2. - Positive permanent factors

Factor	Clarifying characteristics of the factor
Technical equipment of CRC points	The CRC speaker is used
	Secondary radar
Number of dispatchers at a particular point	2 dispatchers

In the table. 1.3. negative permanent factors are taken into account, taking into account which increases the workload. Note that the influence of the factor may extend to the maintenance of the entire flow of aircraft or to the maintenance of a certain part of it.

But quite often there is a need to take into account additional factors that can significantly affect the load factor (meteorological complications, emergencies, etc.). Such factors are temporary and their consideration is necessary for the organization of the CRC for the period of validity of these factors. In the table. 1.4. shows which temporary factors can significantly change the load rate.

Dependence of the load indicator on the capacity of the air traffic controller's area of responsibility

The activity of the air traffic controller also depends on the intensity of the air traffic. In order to maintain the production load within the established safety limits and reduce its impact on efficiency, the concept of capacity of the area of responsibility is used.

Table 1.3. - Negative permanent factors

Factor	Clarifying characteristics of the factor
Technical equipment of CRC points	There is no secondary radar
Flights in the air zone	Availability of flights, the management of which requires additional coordination with the control points of adjacent aerodrome zones
Terrain	Flights in mountainous terrain (on mountain a / d)
Flights at joint airfields (use)	At the time of joint flights
The presence of a state border	The influence of the factor extends to the maintenance of all aircraft or a separate part
Flights with a variable profile (for RDC control points)	The influence of the factor extends to the maintenance of part of the aircraft or all aircraft for undiluted air routes
The presence of direct communication with adjacent points of the CRC	There is no direct connection with the adjacent points of the CRC
Radio communication in English	The influence of the factor extends to the maintenance of all aircraft or a separate part

Table 1.4 - Temporary factors

Factor	Clarifying characteristics of the factor
Restrictions imposed by state aviation flights (for control points in the area of responsibility of which restrictions are imposed, and adjacent to them)	Restriction of levels, closing of air routes
RTZ refusal	Scheduled shutdown or failure of radio equipment
Dangerous meteorological phenomena	Meteor phenomena in the area of the aerodrome and at the aerodrome

The load indicator is the ratio of the time spent on direct air traffic control to the time interval at which the load of the controller is estimated.

Theoretically, it is believed that if the direct control of air traffic to spend the entire working time interval, the load index will be equal to 1. Although in practice this is not possible. The average value of the load index is taken equal to 0.55, with the activities of the air traffic controller is in the most comfortable in terДЩ of psychophysiology conditions. The maximum allowable value of the load index is taken equal to 0.7.

Depending on the value of the load indicator, the time of continuous operation of the remote control is limited. If the coefficient is greater than the value of 0.7, a regulated break is provided.

The capacity of the area of responsibility is the ability of the air traffic controller to service the aircraft in the normal safe mode of operation, which is determined by the number of aircraft included in the area of responsibility of this controller per hour of working time. If in several adjacent areas of responsibility the values of throughput differ, in such cases the least of all is taken (Fig. 1.2).

Consider the factors that affect the value of bandwidth:

1. **Procedures used by the dispatcher in his activity.** It is clear that the bandwidth will increase when setting for example the standard departure and arrival procedures of SID and STAR, because it will reduce the load on the manager.

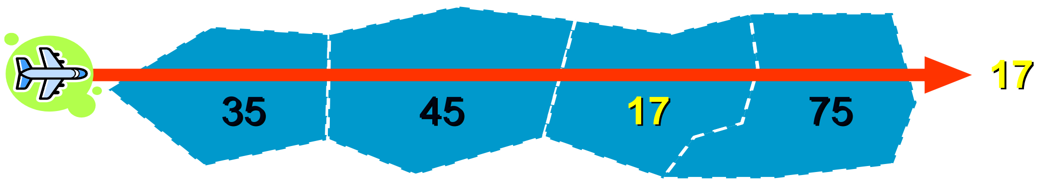

Figure 1.2 - Capacity of several areas of responsibility

2. **Minimum separation, which are set in this sector.** It is much easier to provide safe intervals between ACs flying in an RVSM airspace.

3. **Air navigation maПС.** The presence of restricted, restricted, dangerous and training areas in the sector of responsibility complicates the air traffic management process, reducing the value of capacity, respectively.

4. **Ground and onboard equipment.**At present, CPDLC equipment is being introduced in many countries around the world due to the increasing intensity. It allows you to transmit information to the crew through digital communication channels, instead of radiotelephone communication, which significantly saves the time of the dispatcher and increases bandwidth.

5. **Professionalism of an air traffic controller.** Work experience also has a direct proportional effect on throughput.

6. **Organizational factors.** The capacity will be higher if a lot of attention is paid to the ergonomics of the dispatcher's workplace and the conditions in which the activity is conducted.

According to the method of determining the capacity we have a graph of the load factor on the ratio of the intensity of the air traffic and the normative value of the capacity (Fig. 1.3).

The value of the load indicator is determined according to the schedule *Kz* = *f* (ІПР / NPrS). This dependence determines the load level on the dispatcher in a sector with known regulatory capacity. The load level of the dispatcher, in turn, determines the mode of its operation.

Note the significantly nonlinear nature of the dependence of the load of the dispatcher on the intensity of the external flow of the aircraft. It is seen that there is an area of low sensitivity of the dispatcher to changes in the flow of the aircraft (at a load close to the norm). It is clear that this area can be considered a range of comfortable work of the air traffic controller.

That is, bandwidth is a kind of protective barrier to maintain the proper level of efficiency of the dispatcher.

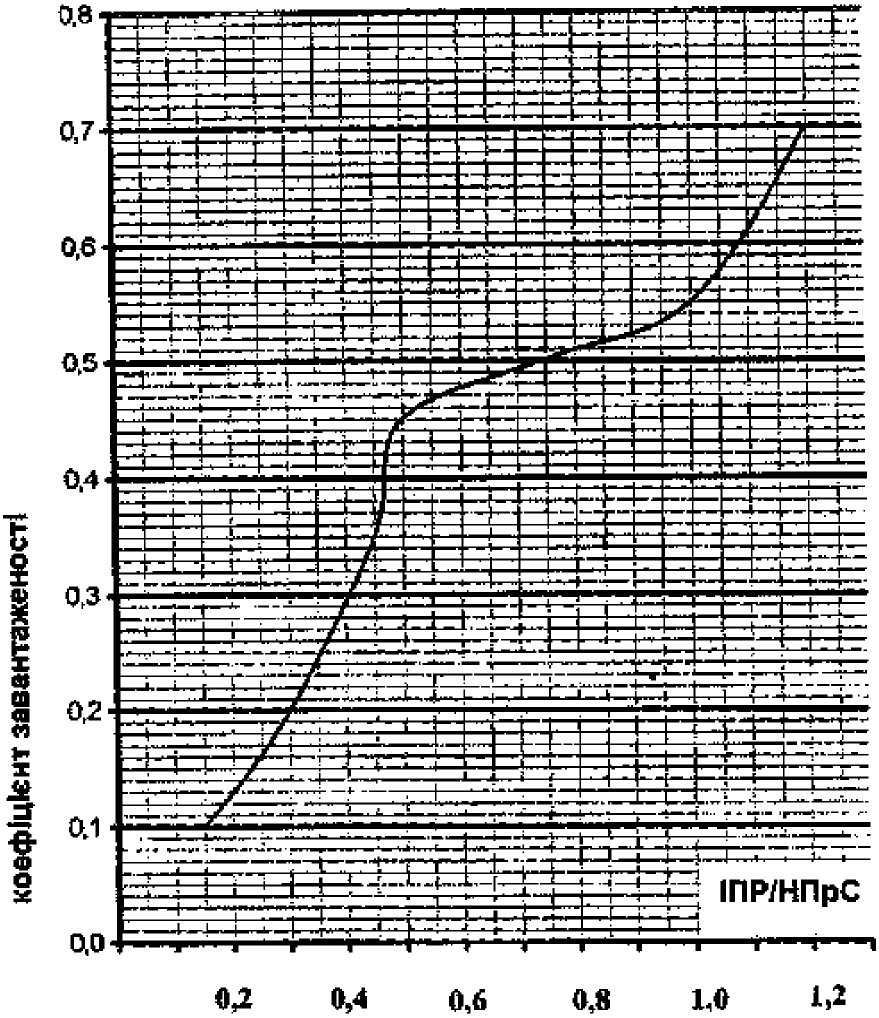

Figure 1.3 - Graph of the dependence of the load factor on the ratio of the intensity of the air traffic and the normative value of throughput

Anthropometry and ergonomics of the workplace as factors influencing the efficiency of air traffic controllers

The performance of the CRC tasks by the air traffic controller depends on the characteristics and planning of the workspace, as well as on the compliance of the PR needs with the equipment and means at his disposal.

Anthropometry deals with the measurement and description of the physical dimensions of the body of an ordinary person, and studies the totality of all the characteristic features of the interaction of man and the environment. Since people's bodies differ in size, it is necessary to be able to adapt the relevant elements of the workplace. This should be ensured by adjusting the horizontal surface of the control panel, or by adjusting the height of the chair, or by adjusting both. The thickness of the front part of the horizontal surface of the remote control should be small so as not to impede the movement of anyone sitting behind the remote control. In addition, there should be enough legroom for the person sitting at the workplace.

The chair should be adjustable taking into account the predetermined anthropometric dimensions of the body of the dispatcher, have good resistance for the back, as well as pillows or soft upholstery, which is convenient for prolonged work in a sitting position. In addition, the chair should be easy to move, preferably on large swivel wheels that do not brake when moving on the floor. It is also recommended to use adjustable armrests. The distance between the centers of the seats of adjacent controllers must be at least 650 mm.

The layout of the equipment in the workplace should ensure the performance of functional responsibilities through effective human-to-human interaction. For example, the air traffic controller's workplace should be equipped with meAHC of effective control in a convenient and rational manner. Otherwise, the control will not be performed, because the CP will not be able to do anything without the mentioned meAHC of control.

The equipment in the workspace should be placed in such a way that nothing distracts the dispatcher from work, and that he is able to concentrate as much as possible on the main activity, and also to minimize the number and amplitude of movements necessary to solve head movements. There should be no noticeable disparity in the brightness of different information displays on the indicators of one workplace.

If all anthropological and ergonomic standards and recommendations are followed, this will allow the air traffic controller to be more focused on the smooth performance of work, even in conditions of increased workload.

Influence of physical environment factors on the efficiency of ATC

Interiorin the working room is not chosen arbitrarily, but is developed from real needs. This is necessary to ensure optimal conditions for visual perception. It is better if the surfaces are matte and not shiny, in addition, they should not become so over time. Painting walls, floors and furniture should be pastel tones, as saturated colors can have too strong an effect on the perception of colors that encode the information on the displays. Pastel colors such as light brown and light gray often meet the requirements, while white may be too bright.

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Any large room should be high enough. Low ceilings in large rooms create a depressed impression and significantly prevent the provision of uniform lighting of all workplaces.

One of the most important conditions of the physical environment is **ambient lighting**. There are two different types of workspaces in ATC. In ADP rooms, ambient lighting can range from direct sunlight to artificial lighting in the dark. However, under all lighting conditions, all displays and controls must remain usable. It must be possible to adjust the light intensity automatically or manually. On sunny days, when the light is very bright on the ADP, there can be very serious problems with blindness. Therefore, ADPs should be positioned so that controllers do not sit facing the sun under normal operating conditions when observing major runways. Blinding glare and reflection of light from any source within the working space should be avoided.

There are no external inspection approaches in the work rooms of the RDC or control rooms or there should be blinds on the windows to control the lighting. In such cases, you can choose the optimal lighting to work with all visual displays, controls and printed texts.

Thermal factors include temperature, humidity and air velocity. The profession of air traffic controller is associated with work indoors. During the work process, dispatchers move very little, and therefore in terms of thermal comfort, they fall under the classification of people with a sedentary lifestyle.

Relative humidity should be 50% or slightly higher. Some fluctuations are assumed, but too high humidity makes the air heavy and suffocating and the clothes become uncomfortable. Low humidity can lead to dry throat, which is undesirable, because dispatchers usually have to talk a lot.

Another important component of providing comfortable conditions for the professional activities of air traffic controllers is the speed of air movement. The movement of air at a speed of about ten meters per minute is felt by a person, and he has the impression of an influx of fresh air, and there is no draft. The placement of furniture should be planned so that it does not interfere with the movement of air flows. The mentioned air flow rate should not be reached through the use of fans or other similar devices, as they create significant background noise.

Consider the **noise factor**. High noise levels reduce the efficiency of CRC, especially in the process of coordinating the actions of air traffic controllers and their interaction with pilots. It is not recommended to use the speakers regularly during CRC. Silent ventilation, carpeting, sound-absorbing panels, as well as providing rapid damping of sound waves in the workplace - all this is necessary to reduce noise from aircraft and other external sources. These tools reduce the external noise level to 55 decibels and are the main ones used in practice. This level of noise is of great benefit, because all dispatchers will be able to talk to each other without straining and conduct radiotelephone communication. In cases where dispatchers are forced to shout to be heard, very important messages are often lost and the likelihood of erroneous actions increases.

From this we conclude that it is necessary to take all possible measures to withstand the recommended thermal and noise factors (Table 1.5) in all workplaces associated with CRC.

Display of air condition

Electronic air condition indicators used by CRC bodies display information of two types. Static background information, such as air routes, coastlines, restricted areas, range ranges, should be displayed on the screen in a way that is not conspicuous. In color display, this is achieved by using unsaturated colors and low contrast ratios.

Elements of dynamic information in the foreground of the display can change their position or move. Such information, including support forms, relates to the specific aircraft. The brightness ratio of the contrast between the dynamic and background data should be approximately 8:1.

Table 1.5. - Sanitary and microclimatic standards

Microclimate parameter	Optimal value parameter	Human reaction to a change in the value of a parameter	
		LESS than optimal	MORE than optimal
Air temperature, t ° C	22-24	Inhibition of reaction, slow movements, flexibility and agility worsens, stress is possible	Excessive sweating, thirst, discomfort, decreased efficiency, possible stress
Relative humidity, %	40-60	Dry throat, pronunciation problems, dehydration, thirst, discomfort	Excessive sweating, clothing becomes uncomfortable, thirst, discomfort, poor performance
Air velocity, m / sec	Not more than 0.1	Lack of fresh air, discomfort	Draft, irritability, the possibility of catching a cold, discomfort
Noise level, dB	Not more than 55	Normal conditions	Negative psychological and physiological effects on the human body, loss of the air traffic controller's ability to hear well, increased blood pressure, headache, fatigue, irritability, stress, impaired performance

Symbols and alphanumeric signs

Much of the dynamic information about the air condition is displayed in the form of symbols or alphanumeric characters, the readability of which depends on how they are generated. When using modern equipment, the minimum height of the mark, which is approximately 3 mm, is considered satisfactory for the symbols and data included in the form. The size of the signs should be increased if old equipment is used or there are unfavorable visual perception conditions, such as bright ambient lighting. The minimum vertical distance between the lines of alphanumeric characters in one form should be approximately 30% of the height of the sign, and a similar distance between the lines of continuous text on the displays should be at least 60% of the height of the sign.

1.4. Study of the influence of the human factor on efficiency professional activities of the air traffic controller

Analyzing the process of PR management, it becomes clear that it is almost impossible to completely exclude the human factor from it. The computer quickly completes mathematical tasks, but it cannot perform creative tasks such as decision making. And decision making is a key element of the PR management process. A person has the ability to make mistakes, depending on their emotional state. Human behavior and performance of professional tasks are the cause of most plane crashes (Fig. 1.4).

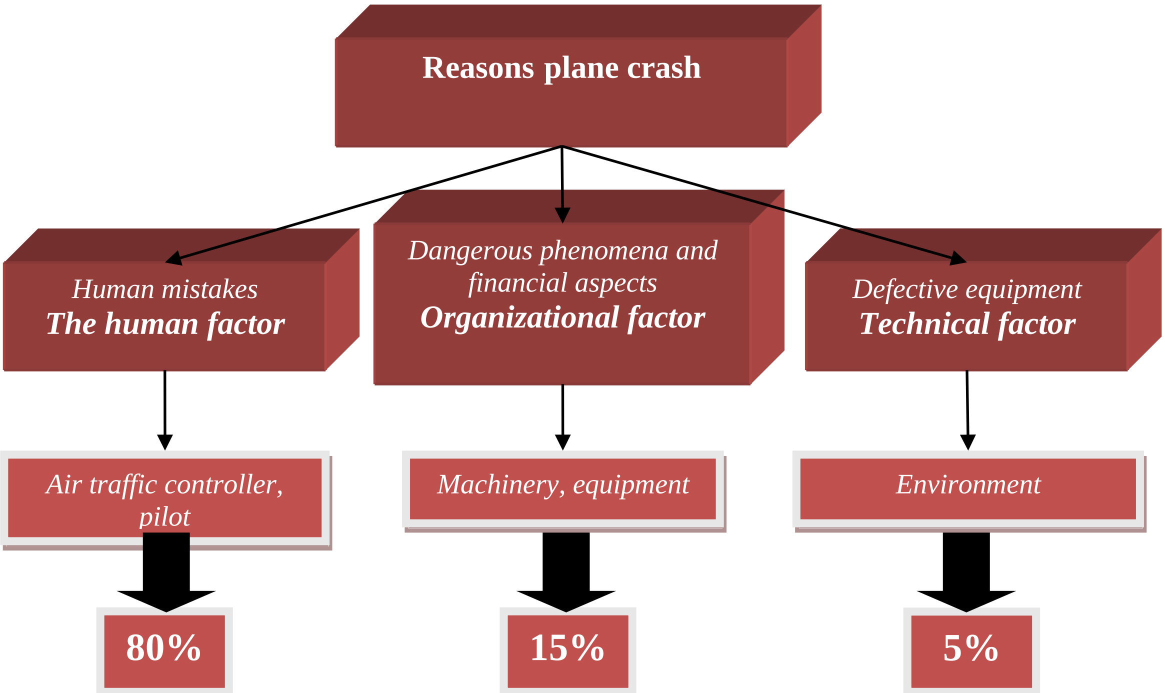


Figure 1.4 - Causes of plane crashes

For the most part, the problems associated with the human factor in CRC are not new, but stem from the same basic human capabilities and limitations. However, these problems need to be addressed, taking into account changes in other areas, such as the growth of PR or the emergence of new technical means. To fully realize all the benefits of using new, more advanced technology, it is necessary to coordinate the capabilities of man and machine so that people do not interfere with the development of technology in cases where it is necessary to perform tasks beyond their capabilities. The solution to the problems associated with the human factor in CRC, is primarily to reconcile the capabilities and limitations of man with the technical characteristics and structure of CRC. The coordination of human and system capabilities is a dynamic process.

The human factor- is primarily knowledge of how a person feels and perceives information, how the process of assimilation, understanding, interpretation, processing, memorization and use. In addition, it is knowledge of methods for measuring the characteristics of human performance and the impact it has on the functioning of the system.

Knowledge in the field of the human factor is used to understand the qualitative assessment of the interaction of the CRC system and man. This is necessary to ensure that the efficiency of the CRC and flight safety are at an optimal level, without compromising the health of the controller. The CRC manager must have an idea of the structure and functioning of the PR management system in order to interact with it. The main purpose of the application of knowledge in the field of the human factor in CRC is to increase the level of flight safety and to assist in the prevention of aviation accidents.

Characteristic features of a person from the first category are related to the impact that the CRC system has on people working in this system. In this regard, this category includes such features that are affected by changes in CRC procedures, environment or conditions. These include stress, boredom, complacency, and human error, which are considered to be the result of influencing the dispatcher of the factors operating in the CRC system, and therefore can be eliminated by refining the system.

The second category includes fundamental and general features of man, which are relatively independent of specific aspects of the conditions of ATC and which in this regard should be taken into account in the organization of ATC systems. This category includes the individual needs of people in the organization of work, psychophysical differences, and competence in solving specific tasks, such as control, as well as human characteristics in relation to information processing, thinking, decision-making and memorization ATC system can not change such human abilities, so it must be adapted through the use of benefits and taking into account the limitations.

1.5. Analysis of changes in the psychological and physical condition of a person under stress

Stress is a term used to describe a wide range of human states and actions that occur in response to a variety of extreme actions called stressors. Stressors are divided into physiological, such as pain, thirst, excessive exercise, and psychological, such as danger, threat, deception, resentment, information overload. Depending on the types of stressors and the nature of their impact, there are different types of stress, in the most general classification **- physiological and psychological**. The latter in turn are divided into informational and emotional.

Information stress occurs in situations of information overload, when a person who bears great responsibility for the consequences of decisions made by him, can not cope with finding the right algorithm, does not have time to make the right decisions at the right pace. A striking example of such stress is the increased workload on air traffic controllers.

Regardless of the type of stressors, psychologists study the consequences that occur at the physiological, psychological and behavioral levels. With rare exceptions, these consequences are negative. There are emotional shifts, the motivational sphere is deformed, the course of processes of perception and thinking changes, motor and speech behavior is broken. Sometimes, the power of affect is such that it is able to inhibit any other psychological processes. Moreover, affects impose on a person the outlined ways of "emergency exit" from an extreme situation. In typical biological conditions it can be escape, numbness, uncontrolled aggression. In our case, namely in social conditions, during information stress there is an increase in mental activity, increase the speed of thought, increase efficiency. It's possible,

Consider how the human body responds to stress. Experiments have shown that in response to any aggressive influence of the external environment during physiological processes, there are three types of characteristic changes. First, there is a sharp release into the blood of catecholamines - adrenaline, norepinephrine and their derivatives. This leads to an acceleration of heart rate and increased tone of blood vessels, muscles, increased respiration, enrichment of blood with oxygen and glucose. That is, the readiness for emergency actions in a difficult situation automatically increases.

The second characteristic sign of stress - spot detection of the gastric and intestinal mucosa. This is due to the fact that in the period of acute response to danger, the body's work is adjusted to the mode of expenditure of forces, and the processes of recovery and accumulation of resources are blocked. Secretion in many organs is suspended.

The third component is the shrinkage of the lymph nodes and thymus gland - the organs involved in maintaining immunity. However, it cannot be said that when a stressful situation arises, immunity decreases sharply. On the contrary, this sign indicates a sharp increase in immune activity, but only in the early stages of response to danger [22].

However, if stress occurs too often due to information overload, it can lead to poor health.

Physical signs of stress are [22]:

- inability to focus on anything;
- too many mistakes in work;
- memory deteriorates;
- too often there is a feeling of fatigue;
- very fast speech;
- thoughts often disappear;
- often there is pain in the head, back or stomach;
- increased excitement;
- loss of appetite.

CONCLUSIONS TO CHAPTER 1

The general questions concerning efficiency of use of PP and criteria of its estimation on air transport are considered.

The concept of air traffic complexity is analyzed and perspective methods of its quantitative assessment are considered.

The general classification of factors of production load on an example of production load of air traffic controllers is resulted.

The analysis is made and the classification of the factors influencing complexity of air traffic control is resulted.

The dependence of the load indicator on the capacity of the area of responsibility of the air traffic controller is analyzed.

A thorough analysis of the impact of ergonomic, anthropometric and physical factors on the effectiveness of the professional activities of the air traffic controller:

- interior;
- lighting;
- thermal and noise factors;
- reflection of the air situation.

The relevance of the diploma project on paying great attention to the problem of congestion of air traffic controllers at production is substantiated.

CHAPTER 2

CLASSIFICATION AND METHODS OF EVALUATION AND CONTROL OF CARRIAGE

2.1. Characteristics of air traffic controller workload

Congestion- the amount of effort, both physical and physiological, that is spent due to the needs of the ATS system and compliance with the established standards for implementation. The degree of workload is higher, the more difficult the task and, accordingly, the more intensively used mental or physical abilities. Consider in detail the aspects of congestion in Fig. 2.1. [9]

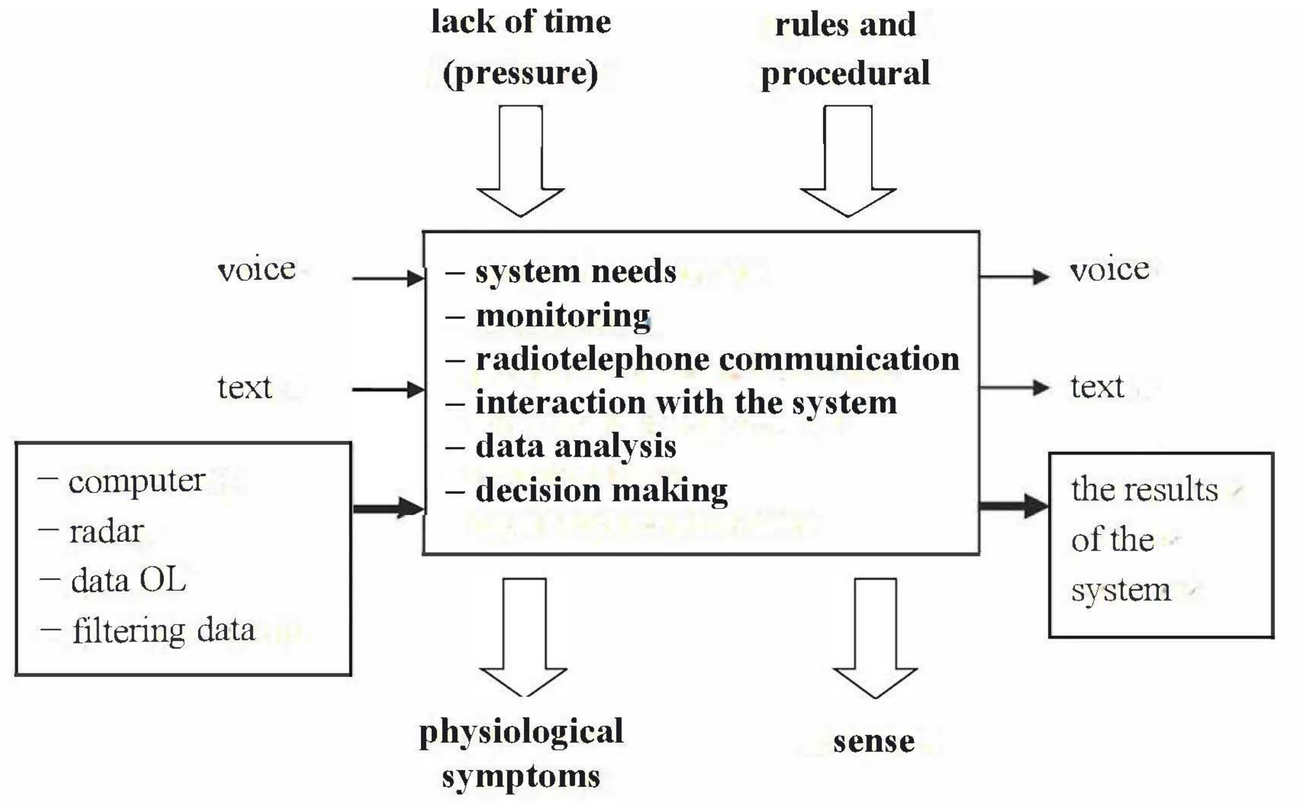


Figure 2.1 - Aspects of congestion

Depending on the obtained value of the coefficient, the workload of the air traffic controller is divided into different categories (Table 2.1).

Note that the most optimal for the activities of air traffic controllers is the value of the load factor, which is equal to 0.55.

Overload and monotony have equally dangerous consequences. And if the consequences of overload are obvious and are shown in Table 2.1, the consequences of monotony are at first glance hidden. In some cases, monotony is even more dangerous.

Consider two cases. In the first, the intensity of the PR increases gradually, the air traffic controller gradually concentrates, and even in overload conditions can work quite comfortably. The second case - air traffic from weak immediately becomes very intense. The monotony changes to overload, and due to the still scattered state, the air traffic controller can make a very dangerous mistake. Another case of danger of monotony is the first 15 minutes after taking turns, when the air traffic controller does not have time to concentrate after rest.

Table 2.1 - Download categories

Category	The value of the load factor	Possible consequences
Monotony	up to 0.20	Occurrence of boredom, switching of attention, dispersion
Comfort	0.2 –0.75	Favorable conditions for mental activity
Overload	more than 0.75	Fatigue, decreased concentration, loss of "picture" of air traffic, lack of time to make the right decisions, a high probability of error

The workload of the air traffic controller when performing technological operations with ATS is characterized by the load factor:

$$К_з = \frac{Т_з}{Т}, \qquad (2.1)$$

where: $К_з$ - employment (load) ratio of the air traffic controller; - $Т_з$ - the total time that the air traffic controller spends on the maintenance of the entire set of aircraft in the area during its operation $Т$.

During the work, the air traffic controller is engaged in the process of collecting the necessary information about the flight of each aircraft in the area, coordinating ATS issues with the controllers of adjacent zones and services, understanding the information and decisions, transmitting decisions or information to aircraft crews.

At a time when the operations of collecting and transmitting information through air and terrestrial voice channels are timed, the duration of decision-making operations by the air traffic controller and crew is difficult to register.

Therefore, the total workload of the air traffic controller is slightly greater than the total duration of communication operations [3]:

$$T_з = \sum_{i=1}^{N} \sum_{j=1}^{Mi} \alpha ij \times Tзв ij \text{ ,} \tag{2.2}$$

where: αij -coefficient that takes into account the increase in the workload of the air traffic controller in connection with the decision on the duration of the j's session of the I's aircraft, , i is n; j is m; $Tзв ij$ - the duration of the j's session with i's PS; Mi-number of air and ground communication sessions during ATS i-th PS; N- the number of aircraft serviced by the dispatcher in the control area during its operation T.

At non-automated management the dispatcher spends:

- to obtain information on average 36% of working time;
- to record information - 6%;
- for the analysis of the air situation and decision-making - 35%;
- for the transfer of control commands - 23% of the total time.

CRC automation reduces the time spent on obtaining and submitting to the dispatcher the necessary information about the state of air traffic, meteorological conditions, which increases the time budget of the air traffic controller to analyze the air situation and make decisions, increases their efficiency and quality by automating information processing. This helps to increase air safety.

It is believed that approximately the same.$\alpha ij = \alpha = const \alpha = 1{,}7$

Then

$$T_з = 1{,}7 \sum_{i=1}^{N} \sum_{j=1}^{Mi} Tзв ij \tag{2.3}$$

The duration of the air traffic controller's employment is determined by the time spent on operations that are subject to direct control and timing, taking into account the coefficient that takes into account the time spent on the analysis of the air situation and decision-making.

The work of the air traffic controller for a long time (duration of the shift) at maximum load can lead to unwanted failures and errors in assessing situations and making management decisions. Therefore it is considered expedient a little facilitated mode of work of the air traffic controller when the factor of its loading makesКз.норм. = 0.55.

Load factor $К_{з.норм}$ = 0.55 was recommended in the seventies of last century. Since then, the level of automation of air traffic control has changed significantly, the quality of flight information support, which raises the question of the possibility of reviewing this level, to slightly increase the allowable level of workload of the air traffic controller.

Load factor has several components, each of which is a function of the intensity of flights in the area:φ

$$Кз = Кпз(\varphi) + Ккс(\varphi) + Киз(\varphi) \tag{2.4}$$

where:Кпз(φ) - component of the load factor, which characterizes the degree of employment of the air traffic controller in air communication operations in the maintenance of conflict-free air traffic and depends on the intensity of flights:

$$Кпз = \frac{1{,}7}{Т}\left[\sum_{i=1}^{N1}\sum_{j=1}^{Mi} tзвij\right]_{пз}; \tag{2.5}$$

- Ккс(φ) - component of the load factor, which characterizes the degree of employment of the air traffic controller in air communication operations and other operations for the detection and resolution of conflict situations in ATS in the event of their occurrence:

$$Ккс = \frac{1{,}7}{Т}\left[\sum_{i=1}^{N2}\sum_{j=1}^{Mi} tзвij\right]_{кс} \tag{2.6}$$

- Киз(φ) - component of the load factor, which characterizes the degree of employment of the air traffic controller in terrestrial radio operations and work with strips:

$$Киз = \frac{1{,}7}{Т}\left[\sum_{i=1}^{N3}\sum_{j=1}^{Mi} tзвij\right]_{из}; \tag{2.7}$$

- N1, N2, N3 - respectively, the number of aircraft in respect of which it is necessary to conduct air radio communication, to identify conflict situations, to conduct ground communication;

- φ - the intensity of air traffic, which is determined by the number of aircraft serviced by the controller per unit time during the interval of its operation.

The allowable number of aircraft that can be simultaneously served by the air traffic controller at all levels in the sector is:

$$N = nT_{0сер}, \tag{2.8}$$

where: T0ser - the average residence time of the aircraft in the ATS sector, T0ser = L / V (L - the length of the route within the sector, V - the flight speed of the aircraft in the sector).

The normative capacity of the airspace zone (sector) is numerically equal to the maximum intensity of the aircraft flow, the service of which in this zone can be provided in compliance with the established flight safety requirements without creating a queue for service Nmaxnorm = maxnorm.φ

In order to ensure air traffic safety requirements, the values of the load factor are used in determining the regulatory capacity.Кз.норм. = 0.55

Taking into account expression (2.3), expression (2.1) will look like:

$$Кз = \frac{1{,}7}{Т} \sum_{i=1}^{N1} \sum_{j=1}^{Mi} tзвij. \tag{2.9}$$

If we are talking about the normative load factor, then from expressions (2.5) and (2.6) we obtain

$$Кз = \frac{1{,}7}{Т} \sum_{i=1}^{n\text{maxнорм}} \sum_{j=1}^{Mi} tзвij. \tag{2.10}$$

The maximum standard number of aircraft that can be in the control area at the same time is:

$$N_{махнорм} = n_{махнорм} \times T_{0сер}. \tag{2.11}$$

If the intensity of the aircraft flow at the entrance of the zone exceeds> maxnorm = nmaxnorm, then there may be incidents and queues at the ATS due to congestion of the air traffic controller. If $\varphi < \varphi_{maxнорм} = n_{maxнорм}$ there will be insufficient load of the air traffic controller.

2.2. Calculation of the load factor of the air traffic controller

As an indicator of the air traffic controller's workload, the ratio of time spent on direct ATS and related technological operations to the total working time interval at which the air traffic controller's workload is estimated is used [9]:

$$К_{зав.} = \frac{Тзайн.\times 1,35}{Троб.}, \qquad (2.12)$$

where - $К_{зав}$ - load indicator of the air traffic controller (load factor); Тзайн - the total time of employment of the air traffic controller, which is spent on direct ATS and related technological operations; T - the interval of working time, which estimates the workload of the air traffic controller; 1.35 - a value that takes into account the time spent by the air traffic controller on the analysis of the air situation and decision-making.

The time of employment of the dispatcher is determined by the time spent on operations that are subject to direct control and timing.

The normative indicator of air traffic controller workload is the value of air traffic controller workload coefficient equal to 0.55. The value of the load factor of the air traffic controller, equal to 0.7, is taken as the maximum allowable indicator of the air traffic controller's workload.

The relationship between the load factor of the air traffic controller and the main components of this factor is established by the following formulas:

$$К_{зав.} = (К_0 + К_{кс} + К_{нк}), \qquad (2.13)$$

$$К_0, К_{кс}, К_{нк} = f(\lambda);\ N = \lambda\ T_{сер.} \qquad (2.14)$$

$К_0$ - is determined by the ratio of time spent in the average ATS sector for maintenance by the air traffic controller due to the absence of conflict situations to the total working time interval at which the air traffic controller's workload is estimated:

$$К_0 = \frac{\sum Тбез\ кс}{Троб.}, \quad (2.15)$$

where: $\sum Тбез\ кс$ - the amount of time spent by the air traffic controller on the operation of all aircraft in the absence of conflict situations for a certain period of working time; KCS - is determined by the ratio of time spent on average in the ATS sector for maintenance by the air traffic controller in the presence of the COP, to the total working time interval at which the workload of the air traffic controller is estimated:$\sum Тбез\ кс$

$$К_{кс} = \frac{\sum Ткс}{Троб.}, \quad (2.16)$$

where: : $\sum Ткс$ - the amount of time spent by the dispatcher on aircraft maintenance operations in the presence of conflict situations in a certain period of working time; $К_{нк}$ - is determined by the ratio of time spent by the air traffic controller on average in this sector of ATS for radio communication by land communication channels, to work with strips, etc., to the total working time interval at which the workload of the air traffic controller is estimated:

$$К_{нк} = \frac{\sum Тнк}{Троб.}, \quad (2.17)$$

where: $\sum Тнк$ - the amount of time spent by the air traffic controller on operations for maintenance of all aircraft related to radio communication by terrestrial communication channels, to work with strips, etc., for a certain interval of working time; 1.35 - a value that takes into account the time spent by the air traffic controller to perform analysis of the air situation and decision-making;λ - air traffic intensity, measured by the number of aircraft serviced by the air traffic controller, for the working time interval at which the air traffic controller's workload is estimated; N is the allowable number of aircraft that can be simultaneously serviced by the air traffic controller in the ATS sector; $T_{сер.}$. - average time spent by the aircraft in the sector.

Expressions (2.12) and (2.13) allow to determine the allowable characteristics of the flow of the aircraft - intensity (λ) and the number of aircraft (N) that are simultaneously serviced by the air traffic controller.

Estimation of the value of K_0 is performed by measuring the actual time spent on all operations related to the maintenance of each aircraft operating through the ATS sector. This is the time spent on radio communication when crossing the reception-transmission boundary, the point of mandatory reporting, when gaining height and descent, and so on.

Estimation of the value of $K_{кс}$ is to measure the actual time spent by the aviation dispatcher to perform all operations related to the management of the aircraft, in order to eliminate the COP. This is the time spent on radio communication with PC crews, in order to transmit instructions on changing the flight level, flight direction, warnings about the COP, requests to obtain information about the flight conditions, and so on.

Estimation of the value of $K_{нк}$ is performed on the basis of measuring the time spent on technological operations not related to radio exchange with aircraft. These are information exchange with air traffic controllers of related sectors of ATS, coordination and coordination of air traffic, work with comics, interaction with technical means at the workplace, etc.

Since K_0, $K_{кс}$ and $K_{нк} = f(\lambda)$, ie K_0, $K_{кс}$ and $K_{нк}$ change when changingλ, then λ determined by successive approximations to the normative (maximum allowable) load indicator of the air traffic controller.

Accounting for the nature of technical equipment of air traffic controllers' workplaces should be performed when assessing the post-operational load of the air traffic controller, ie when determining the composition of technological operations for timing and when estimating the values of K_0, $K_{кс}$ та $K_{нк}$.

Taking into account the features and technology of ATS in assessing the workload of the air traffic controller can be done, as well as taking into account the technical equipment of workplaces of air traffic controllers, by determining the list of operations to be timed in each sector of ATS.

Here is a more general formula, which we can directly use to calculate the load factor of the air traffic controller during the simulation of the real air condition on the control simulators:

$$Кзав = \frac{Nузг.\times Tузг. + (Nсер.под \times \varphi) \times Tпод + Nнаб.зниж. \times Tнаб.зниж.}{Tроб.} \times 0{,}65, \quad (2.18)$$

$$Nсер.под = \frac{Nпод}{Nмаршрутів}, \quad (2.19)$$

where: $N_{узг.}$- the number of approvals for the entry of PCs into the sector and the exit of aircraft from the ATS sector; $T_{узг.}$ - the time spent by the air traffic controller in one coordination with the adjacent ATS unit on entering the sector (leaving the ATS sector); $N_{сер.под}$ – - the average number of items of mandatory reporting in the ATS sector; $T_{узг}$ - the intensity of air traffic, measured by the number of aircraft serviced per unit time, for which the load of the air traffic controller is estimated; $T_{под}$ - time spent by the air traffic controller on radio communication with the aircraft crew during the passage of the mandatory reporting point; $N_{наб.зниж}$ - number of approvals between the aircraft crew and the air traffic controller regarding gaining or lowering the aircraft; $T_{наб.зниж.}$ - time spent by the air traffic controller on radio communication with the PC crew when gaining altitude or lowering the aircraft; $T_{роб.}$ - time interval for which the workload of the air traffic controller is estimated; 0, 65 - value that takes into account the work of two air traffic controllers at the workplace, in the presence of the AU CRC. In the absence of AS CRC instead of the value of 0.65 in the formula is substituted for a value equal to 0.85. When working with one air traffic controller at the workplace in the presence of the CRC AS instead of 0.65 is substituted 0.80. In the absence of the CRC AS (when operating one air traffic controller), instead of 0.65, a value equal to 1 is substituted; Npod - the number of items of mandatory reporting; Nroutes - the number of ATS routes in the sector. instead of 0.65, a value equal to 1 is substituted; $N_{под}$ - the number of items of mandatory reporting; Nroutes - the number of ATS routes in the sector. instead of 0.65, a value equal to 1 is substituted; $N_{под}$ - the number of items of mandatory reporting; $N_{маршрутів}$ - the number of ATS routes in the sector.φ

2.3. Analysis and control of the load level

The DORA method, developed in the United Kingdom, is used to externally assess the workload of air traffic controllers. To do this, the expert monitors the air traffic controller in a particular sector, noting such actions as radiotelephony, work with comics, coordination with colleagues and more. The expert determines the time spent on all these actions and evaluates it as a percentage of total time. That is, every two minutes he records the percentage of employment of the air traffic controller. At the end of this procedure, the obtained data are entered into the system and compared with the levels of PR intensity that correspond to the same picture on the display during the measurements. The DORA method uses the load classification given in table 2.2.

Table 2.2 - Classification of DORA workload

Download category	Interpretation
1	Full load, no aircraft can be taken under control other than those already available
2	Very heavy workload, but with some breaks
3	Normal load without much difficulty
4	Load less than 3 (low load)

After the two-minute estimates of the load indicators are compared by the system with the air traffic flow, it gives the actual value of the air traffic controller load per hour, a value that would meet the needs of all aircraft under control, as well as a graph of the actual load (Fig. 2.2). the number of aircraft in the sector and the established procedures performed by the air traffic controller at a separate workplace.

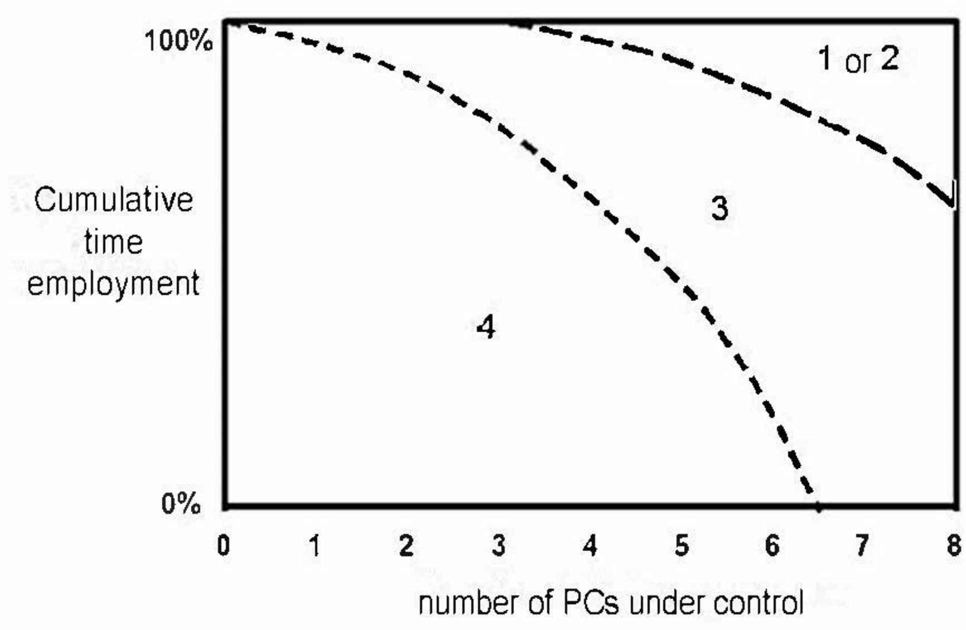


Figure 2.2 - Graph of the dependence of the air traffic controller's workload on established procedures and the number of PCs in the sector

This schedule is made separately for each sector, taking into account the features of the equipment and established procedures.

Looking at the horizontal axis, we see the maximum number of PCs. This value cannot be exceeded in this sector. The vertical axis shows the percentage of time from 0% to 100%, during which the air traffic controller is occupied directly by the ATC.

By analyzing this schedule, you can control the workload of the air traffic controller. Depending on the goal, it is necessary to choose how the workload will change - by adjusting the intensity of the PR by setting less or more bandwidth or improving the system and automating procedures to reduce the percentage of time spent by the air traffic controller.

2.4. Consequences of increased workload

It is necessary to control the workload of air traffic controllers, because one of the features of a person is the tendency to fatigue. The effectiveness of any activity is limited by fatigue.**Fatigue - a decrease in working capacity of a temporary nature caused by previous work.**

The state of fatigue is manifested in significant changes in the activities of various organs and systems, namely - changes in heart rate (or increases or decreases significantly), increases the time of visual-motor reactions, ie the time required for analysis, processing and response to information increases. duration of operations, the number of erroneous movements.

There are the following **stages of fatigue: [8]**

- Manifestation of fatigue is insignificant, labor productivity is not reduced;
- Significant decrease in productivity and severe mental changes;
- Fatigue.

Fatigue impairs mental ability, which can negatively affect the safety and effectiveness of ATC. This is unacceptable from the point of view of flight safety and the efficiency of air traffic controllers, as well as their health. Air traffic controllers should not be overtired by excessive hours of work or unreasonably high requirements, and therefore aspects related to the prevention of fatigue in air traffic controllers should seriously influence decisions in the field of work organization.

This can be achieved by rational distribution of responsibilities, staffing, reducing the duration of work shifts, as well as optimally organizing cycles of work and rest, providing additional training of staff and installation of modern equipment.

Staffing should be such as to provide sufficiently long breaks for rest during each shift. The recommended maximum duration of continuous operation is 2 hours, especially in conditions of intensive PR. Air traffic controllers should not rest at work, because in this case they continue to be on duty and at any time must be ready to quickly return to work. The air traffic controller should not be responsible for the ATC during rest breaks. Even in the conditions of the lowered requirements and small loading the air traffic controller needs to have breaks for rest.

The activities of the air traffic controller are associated with night shifts. Despite the existing differences, rotation of work shifts is generally preferred. It is best to rotate so that the morning shift the next day is followed by the day. It is very bad if the morning shift follows the day shift. It is necessary to take into account the age of air traffic controllers, because when working in shifts, older people get tired faster. It would be expedient to transfer air traffic controllers to other places where the work is more in line with their capabilities with age and as needed. Extensive experience of such people can to some extent compensate for the deterioration of working capacity due to age, but constant efforts to maintain high performance can cause even more fatigue.

Air traffic controllers are exposed to strong **stress** caused by the conditions of their activities. This is due to aspects of the job, such as strict requirements for tasks, lack of time, responsibility, or equipment that does not meet the established requirements. Sometimes stress occurs under the influence of environmental factors, or interaction "person - person", including activities in conditions of bad relationships with management and colleagues, poor assessment of skills of the manager, insufficient training, unfulfilled career expectations, the wrong attitude to society , ATC or its unfair assessment.

Any air traffic controller who has signs of stress should be removed from duty. This is a valuable but necessary tool, as flight safety and the effectiveness of ATC cannot be compromised (Fig. 2.3).

It is much better to prevent stressful situations by well-organized workplace, rational schedule and change. Management support and understanding are important. Because stress can occur for many reasons, their successful prevention in any particular circumstance depends on the correct diagnosis of these causes.

Consider the following possibilities. If the requirements of the ATS in relation to any particular job are significantly inflated for everyone who performs this work, it is necessary to revise these requirements by changing the structure of tasks and redistribution of responsibilities. If the requirements are excessive for only a few or one dispatcher, he should be transferred to another easier position. In cases where the constant stress in individual managers is due to factors such as working hours or cycles, and not the process of ATC, the solution is to adjust the working hours, cycles "work - rest" and so on.

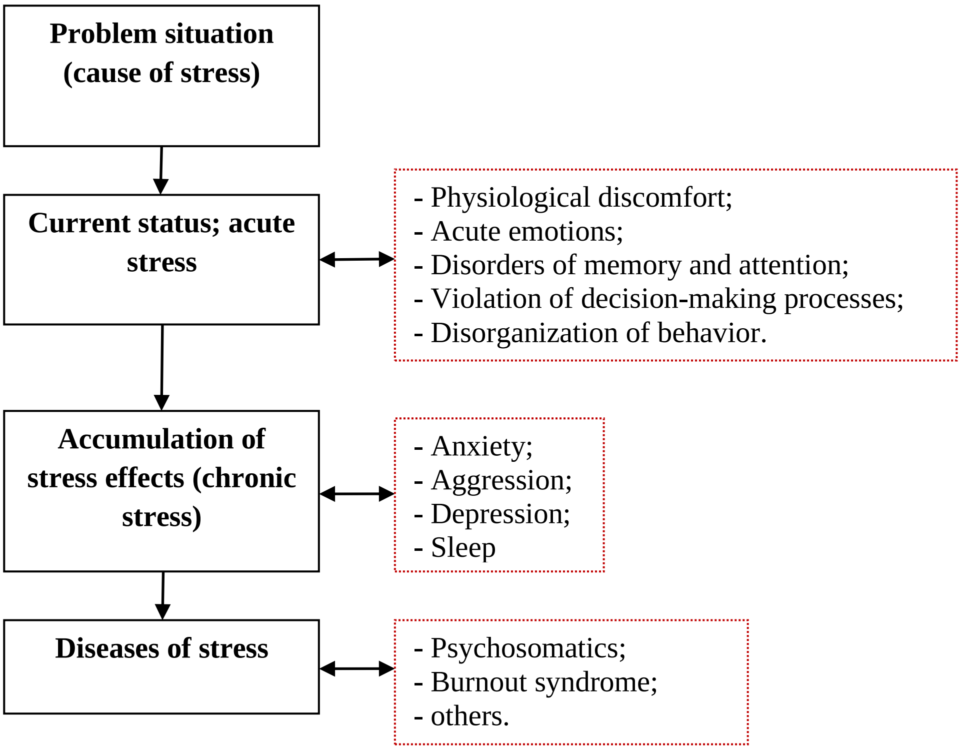


Figure 2.3 - Stress as a dynamic of human conditions

Confidence and complacency sometimes play a big negative role. When doing work that requires quick problem solving and decision making, self-confidence is important. Indecisive people have no place in the UPR. But confidence can lead to overconfidence and complacency. If in the process of activity the restrictions of a particular air traffic controller are never checked, then any difficulties begin to seem familiar to him, each problem is previously foreseen, and as a result he has complacency.

When designing systems, workspace, defining tasks, forecasting requirements for tasks, defining operating conditions, all possible measures are taken to ensure that the dispatcher is constantly responsible for their responsibilities and make as few mistakes as possible. The degree of success depends on the appropriate consideration of the human factor in the initial stages of planning and designing the system. With this approach, potential sources of errors and inattention can be identified in advance and measures taken to prevent them. Most human errors are determined by the design features of the system, which makes it possible to determine in advance their nature. However, the immediate causes of each error are usually due to subjective factors. It is human nature to make mistakes, and air traffic controllers make mistakes regardless of experience and skill level. Regardless of the efforts made to prevent human error, it cannot be said that the ATC system provides complete security, assuming that every human error can be prevented. Errors will occur in any case, so you need to ensure the security of the system by designing it on the principle of permissible errors.

Many types of errors can be predicted by analyzing the tasks and process, the characteristics of display devices, command input devices, means of communication, as well as on the basis of the requirements for ATC. Air traffic controllers can detect their errors and correct them immediately. In other cases, in the conditions of team work, colleagues may detect errors of the dispatcher and point them to them. The system also introduces programs aimed at identifying and preventing human error in such a way that they do not accept or execute erroneous commands, or automatically take measures to eliminate adverse effects.

During the exchange of material information, the main sources of errors are phonetic confusion, omission of information, misperception and non-standard sequence of message elements. When using tabular information, one row or block may be mistaken for another, and characters and symbols that are similar to each other may be confused.

There are several classifications of air traffic controller errors. Once they are categorized by class, appropriate procedures are formulated to eliminate them or prevent more serious consequences.

CONCLUSIONS TO CHAPTER 2

The main aspects and constituent factors of air traffic controller workload are considered.

The influence of the availability of certain equipment at the workplace, procedures and technologies for performing operations during the activities of the air traffic controller on their workload is analyzed.

Modern methods of calculating the load factor are considered, the formulas and characteristics of their components required for calculation are given in detail.

The classification of air traffic controller workload is given:

- according to the calculated value of the load factor;
- according to the DORA method.

The method of estimating the load of the air traffic controller in a certain working sector of ATS by applying the basic principles of the DORA method is presented and the general principles of load control are proposed.

The consequences of increased workload are considered.

CHAPTER 3

SUPPORT FOR THE ACTIVITIES OF AIR DIRECTORS IN CONDITIONS OF INCREASED WORK LOAD

3.1. Errors of air traffic controllers, their causes and classification

Errors should be taken as a normal component of any system. Awareness of the fact that air traffic controllers, like everyone else, make mistakes plays a key role in safety management. Only in this case can effective measures be implemented to minimize the consequences of air traffic controllers' errors for flight safety.

Even if human errors cannot be completely avoided, they can be controlled through the use of advanced techniques, appropriate training, rules and procedures (Fig. 3.1). The results of the work of air traffic controllers can be significantly influenced by organizational, regulatory, cultural factors and factors of the production environment that arise during the production process. For example, many unforeseen errors are caused by organizational processes, including inadequate communications, unclear procedures, insufficient resources, and unrealistic budget planning — virtually all processes that an organization can control.

The work of a dispatcher is a complex mental process, and complex actions require the participation of consciousness. When solving standard tasks, we use a set of life or professional rules that save both effort and time. When solving the same type of tasks, a stereotype of actions is formed (consciously or unconsciously), which on the one hand facilitates the task, on the other hand reduces the level of awareness. There is something like automation of procedural activities.

Air traffic controller errors are classified as follows:

- planning errors;
- execution errors.

Mistakes can be made at the planning stage or during the implementation of this plan. **Planning errors** lead to errors. The person either goes to the wrong procedure when solving a standard problem, or plans the wrong course of action to solve any new situation. Even with proper planning, mistakes can be made when executing a plan. When solving problems, air traffic controllers intuitively look for a set of rules that are known, applied before and are suitable for this problem. Mistakes can be made in two ways, namely by applying a rule that is inappropriate to the situation and by applying a correct rule that has shortcomings.

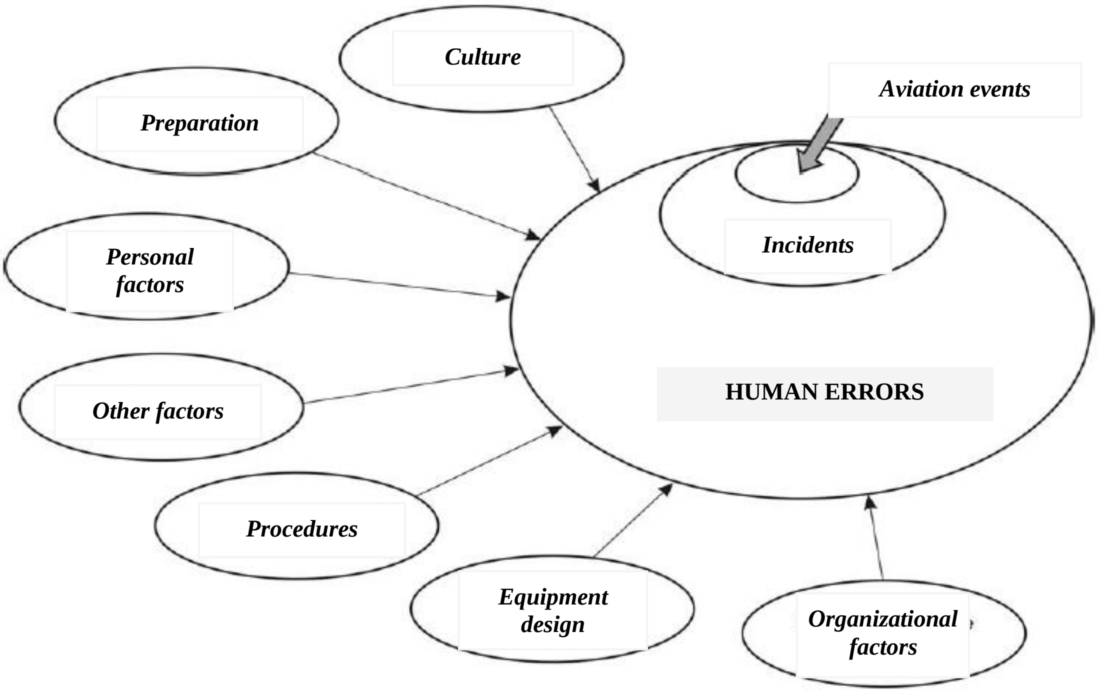


Figure 3.1 - Factors influencing air traffic controller errors

Factors that contribute to planning errors of air traffic controllers:

- **Wrong application of correct rules**. This is the case if the air traffic controller encounters a situation where a number of its features are similar to the circumstances for which the rule was intended, but with some serious differences. If the dispatcher does not recognize important differences, he may apply an inappropriate rule.

- **Application of imperfect rules**. This happens when using a procedure that has given positive results in the past, but now has some drawbacks. If such a solution is applied in the circumstances in which it was first tested, it may become part of that person's standard approach to solving such problems.

- **Lack of knowledge and incorrect judgments**. In cases where the dispatcher does not have a ready-made solution, which is based on previous experience, he turns to his personal knowledge and experience. The process of deciding a problem using such a method will inevitably take more time than a decision based on rules, because in the first case requires logical reasoning based on knowledge of basic principles. Mistakes can be made due to lack of knowledge or due to incorrect reasoning. The use of reasoning based on personal knowledge in solving any problem will be particularly difficult in a busy environment, as the manager is likely to be distracted from the process of logical reasoning to other problems. In this situation, the probability of error increases.

Execution errors misses and omissions are considered. **A mistake is** an action that is not performed as planned, and therefore it will always be noticeable. **The omission** is a memory failure, and it will not necessarily be obvious to anyone but the person in whom it occurred. As a rule, the actions of experienced and qualified staff are well-established and skillful. They are performed mainly in automatic mode, except for periodic checks of the process.

Misses and omissions can occur for the following reasons:

- **Misses due to carelessness**. They are the result of not checking the progress of a standard operation at any critical point. The probability of such a situation is especially high when the planned procedure is similar to the procedure used by default, but is not identical to it. If the attention is distracted and the dispatcher is distracted at a critical point where the action differs from the normal procedure, the result may be a situation where the dispatcher goes to the normal procedure, rather than the one that needed to be performed in this case.

- **Memory loss**. They occur when the dispatcher forgets what he planned to do, or miss any link in the planned sequence of actions.

- **Errors of perception**. These are recognition errors. They occur when the dispatcher considers that he has seen or heard something that differs from the information actually presented.

There is another classification of air traffic controller errors. Consider it:

- procedural error - an unintentional error or omission in the implementation of regulations. For example, an action or phrase was omitted in the procedure, according to the document, but in general the procedure did not change;

- communicative error - an unintentional error, namely, misunderstanding or use of phraseology;

- professional error - an unintentional mistake that is made as a result of lack of professional knowledge, skills and abilities;

- operational error - unintentional erroneous decision-making;

- intentional violation - non-fulfillment of the established control documents at one's own will.

3.2. Prevention and overcoming of errors of air traffic controllers

Typically, errors are detected and corrected without undesirable results, such as selecting the wrong radio frequency or setting the altimeter index to the wrong altitude. Thus, the problem is not only how to prevent mistakes, but also that you need to be able to safely overcome the inevitable mistakes. Below we see the Rison model (Fig. 3.2), the principle of which is that the errors and violations that are allowed at different levels of the air traffic control system, a lot. But it is necessary not only to have certain means of protection, but to constantly look for ways to improve them, in order to significantly reduce the number of errors and the safety of their consequences, if these errors are made.

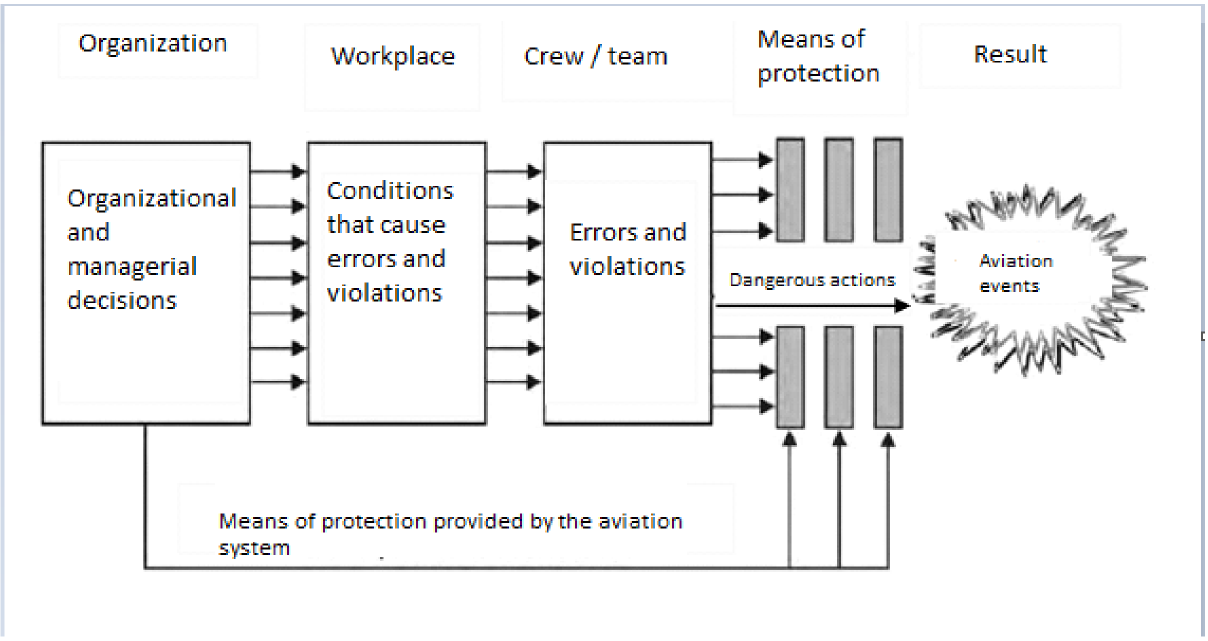


Figure 3.2 - Model Reason

There are two methods for controlling the errors of air traffic controllers (Fig. 3.3):

- minimization of the frequency of errors;
- reducing the risk of consequences, after making mistakes.

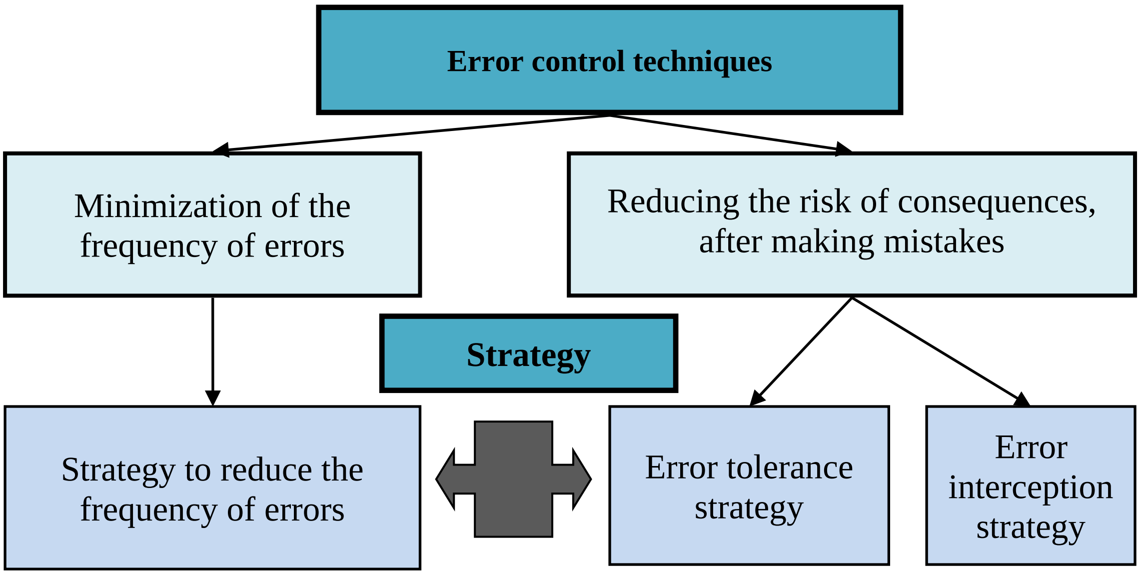


Figure 3.3 – Error control techniques

Minimizing the frequency of errors is a technique that, using a **strategy to reduce the frequency of errors**, directly affects the source of the error itself by reducing the number of factors that contribute to the error, or by eliminating them. An example of this strategy is to improve ergonomic factors in the area of activity, reduce the number of distractions in the environment and increase the level of staff training . Most of the error control methods used in aircraft maintenance also apply to this strategy.

The methodology for ***reducing the risk of consequences*** consists of two strategies: interception of errors and tolerance to errors.

Error interception strategy - assumes that the error has already been made. The goal is to intercept the error before its adverse effects manifest themselves. The strategy of error interception differs from the strategy of reducing the frequency of errors in that it is not intended directly to reduce the number of errors and eliminate them. Examples of such strategies are cross-checks on the correctness of any task and test flights to verify the operation of the equipment.

An error tolerance strategy involves the system's ability to respond to an error without serious consequences. An example of how to increase error tolerance is the installation of air traffic controllers in the workplace of functions such as MTCD . MTCD - a function of detecting possible conflict situations, which in turn consists of such functions as: STCA - a function of short-term warning of a conflict situation; MSAW - function of warning about the minimum safe height in the sector; APW - a function to warn of the possibility of entering the danger zone.

Other examples of elements of this strategy are standard operating rules (EPS), instruction, training.

Other methods of counteraction are to a greater extent directly related to the contribution of air traffic controllers to flight safety during ATC. These include individual strategic and tactical techniques, individual and collective countermeasures, which usually include general skills, knowledge and attitudes to work, formed as a result of special training.

3.3. Function of detection of possible conflict situations

Today, the air traffic controller analyzes strips or electronic lists and the situation on the radar display to analyze the future air situation. At the same time, the air traffic controller analyzes one aircraft in relation to the entire air situation in the area of responsibility in the near future. At the same time, he is responsible for resolving all emerging conflict situations.

As air traffic increases, so does the load on the air traffic controller and the capacity of the sectors decreases, leading to delays and the use of detours.

The Medium Term Conflict Detection (MTCD) function helps the air traffic controller to continuously monitor the air condition and displays information about anticipated conflict situations on the monitor. Moreover, the MTCD gives the air traffic controller more time to identify and, if necessary, to take well-thought-out actions to resolve conflict situations (Figure 3.4).

Figure 3.4 - The function of identifying possible conflict situations MTCD

Based on the definition of the MTCD function, here is a list of tasks that solve this function:

- conflicts between aircraft: determining the reduction of intervals between the assumed positions of two aircraft, based on system trajectories;

- entrance to the PP of special use: reduction of the required distance between the intended location of the aircraft and the airspace of special use;

- descent below the lower echelon: the assumed position of the aircraft below the lower echelon in this airspace.

The MTCD is an airspace planning tool with a conflict detection range between aircraft of 0 - 20 minutes and 0 - 60 minutes of detection of the possibility of entering the airspace of special use, as well as when descending below the lower echelon.

Conflict warning in the range of 0 - 2 minutes is provided by Safety Nets functions , namely: STCA , APW , MSAW. Conflict situation is declared in cases when there is a violation of both horizontal and vertical intervals (Fig. 3.5).

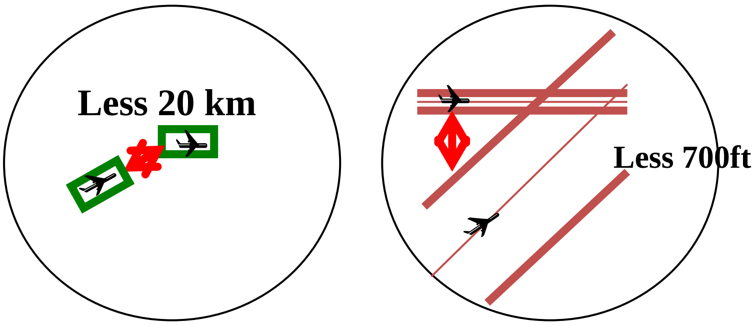


Figure 3.5 - Conditions for declaring a conflict with the MTCD function

The MTCD function interacts with other components of the automated ATS system (Fig. 3.6) .

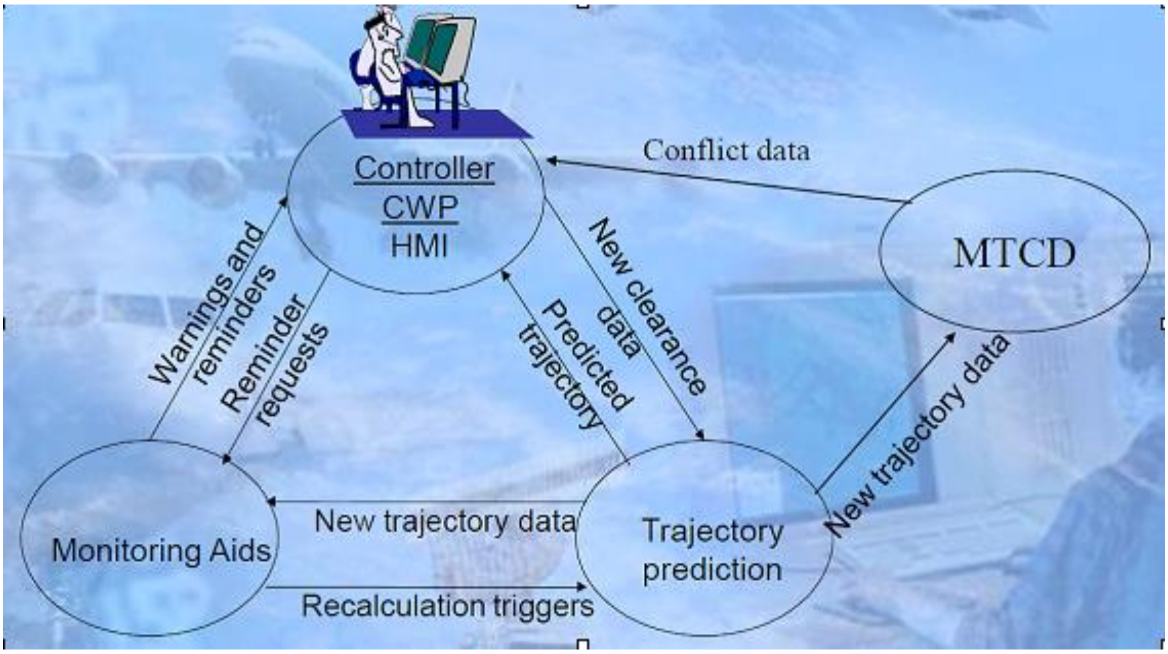


Figure 3.6 - Relationship between MTCD and CRC AS components

Information received from MTCD is displayed on:

- PPD - potential problem display . A window that is primarily intended for the scheduling manager, who may not always be able to see the aircraft conflict due to the radar display.

- VAW - vertical aid window . A window that is a vertical profile of all flights passing through the sector.

- Directly on the radar display.

The function of short-term warning about a conflict situation

The STCA is a system that provides the air traffic controller with warnings whenever it predicts a breach of the established minimums of the vertical or horizontal interval between aircraft. The STCA function provides a high level of detection of errors that have been made by the air traffic controller in ensuring the established separation intervals.

The conflict detection tool in the STCA system is based on geometric algorithms that work by determining the minimum predicted distance between the aircraft. The input data for the algorithm comes from the FDPS flight data processing system .

The main mechanism for detecting conflict situations, which uses the STCA function , is **a linear prediction filter** . The purpose of this filter is to determine the probability of convergence of tracks of the aircraft pair, in which the horizontal, lateral and vertical intervals will be violated at the same time. Prediction is performed using a three-dimensional vector of linear extrapolation of each of the aircraft.

There are two approaches to identifying conflict situations. The first and more general is the arithmetic approach, in which the equations of the aircraft tracks are solved to determine the beginning and end of the interval violation. The second approach is to make a step-by-step forecast of the future location of each aircraft . Locations are extrapolated in increments of a few seconds. During each step, the horizontal and vertical approximation of the aircraft is tested by the set parameters of the minimum allowable intervals. [14]

As a rule, the arithmetic approach is adapted to the vertical measurement, and the step-by-step forecast method is adapted to the horizontal one.

After passing the information through all the filters of the system, comes the last stage of processing - the stage of alarm confirmation (Figure 3.7). It has several purposes:

- test whether a conflict situation is imminent and an alarm is required immediately;

- withhold an alarm that may be caused by false flight information;

- test whether an alarm is needed now or whether it should be delayed, hoping that the situation will improve before the alarm is needed.

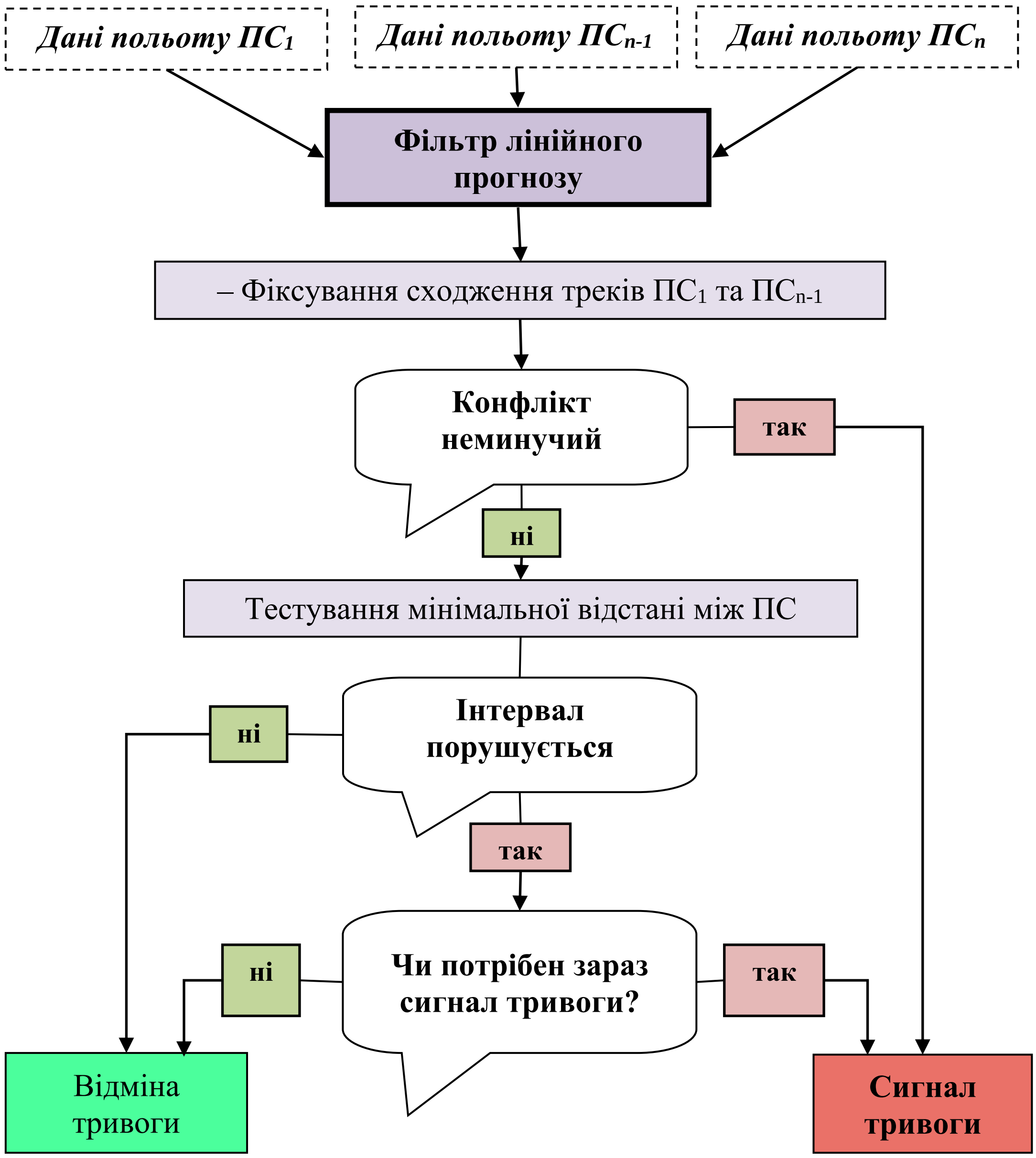


Figure 3.7 - Algorithm of data processing in STCA

Minimum safe height warning function in the sector

The minimum safe altitude warning function in the MSAW sector is designed to prevent collisions of controlled aircraft with ground obstacles by generating alarms in cases of potential or actual violation of the minimum safe altitude.

The MSAW system can operate in two configurations: using **bulk polygons** or using **digital data on the earth's surface** . [12]

Most systems use MSAW **about ' succinct grounds** for determining surface MSAW. This surface can be determined by the dispatcher himself, and may, if desired, be set below the minimum safe height used in the sector or even closer to the ground. The dispatcher must choose what he wants from the insured - from violation of the minimum safe height, or from the collision of the aircraft with the ground.

However, in most MSAW systems, the surface is defined as the set of minimum safe heights defined by the controller as a series of three-dimensional polygons, each of which has a specific height limit. This restriction is the necessary safe height to detect conflict situations. In this case, the surface of the MSAW system is usually set slightly below the minimum guidance height MRVA .

If the dispatcher chooses protection against violating the minimum safe heights, there should be a small margin of a few hundred feet to account for the extrapolation lead. That is why the surface of the MSAW system must be installed slightly below the actual safe height. Otherwise, almost all aircraft traveling in horizontal flight at an altitude bordering the MBV will be subject to the MSAW alarm system.

Figure 3.8 shows a profile of how the MSAW surface can be installed using polygons to determine the minimum safe height in the sector.

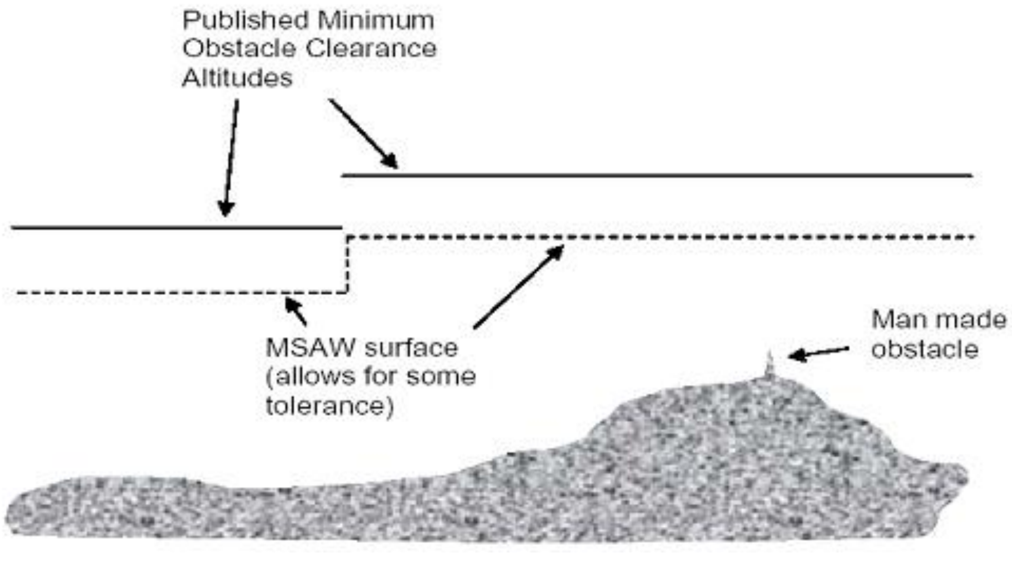


Figure 3.8 - Profile surface MSAW using three-dimensional polygons

Digital data on the earth's surface obtained from satellite observation have a more accurate determination of the surface for the MSAW system, and are therefore more suitable for preventing the collision of aircraft with the earth's surface. Using this system configuration, a vertical margin is added to the digital data, taking into account vegetation and temporary obstacles. These data can also be supplemented by a number of polygons installed by the dispatcher, which depict constant obstacles (Fig. 3.9). Function n warning about the possibility of getting into the danger zone.

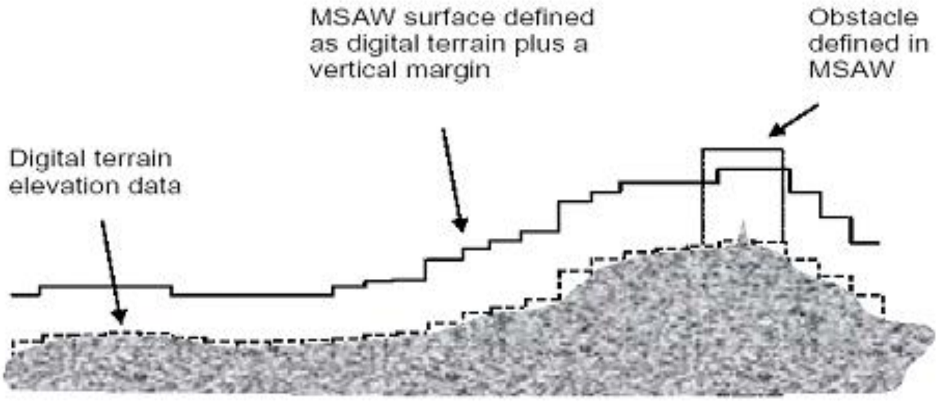


Figure 3.9 - Profile surface MSAW using digital data and three-dimensional polygons

Area Proximity Warning

The APW flight restriction warning function provides the air traffic controller with a warning whenever it predicts a breach within two minutes, or in the event of a breach in the horizontal or vertical plane of the permanent or temporary flight restriction zone.

APW systems tend to fall into one of two categories as given below:

1. Those that produce an alert when a civil aircraft is about to enter a restricted area, military aerobatic area or danger area.

2. Those that produce an alert when an aircraft not under ATC has entered controlled airspace.

In principle, APW could be adapted to allow both types of functionality (protection of controlled airspace and restricted areas) to be combined in the same implementation.

System APW, to carry warning signals should be informed by the data processing system of observation SDPS , external data processing systems EDPS and flight data processing system FDPS (Fig. 3.10).

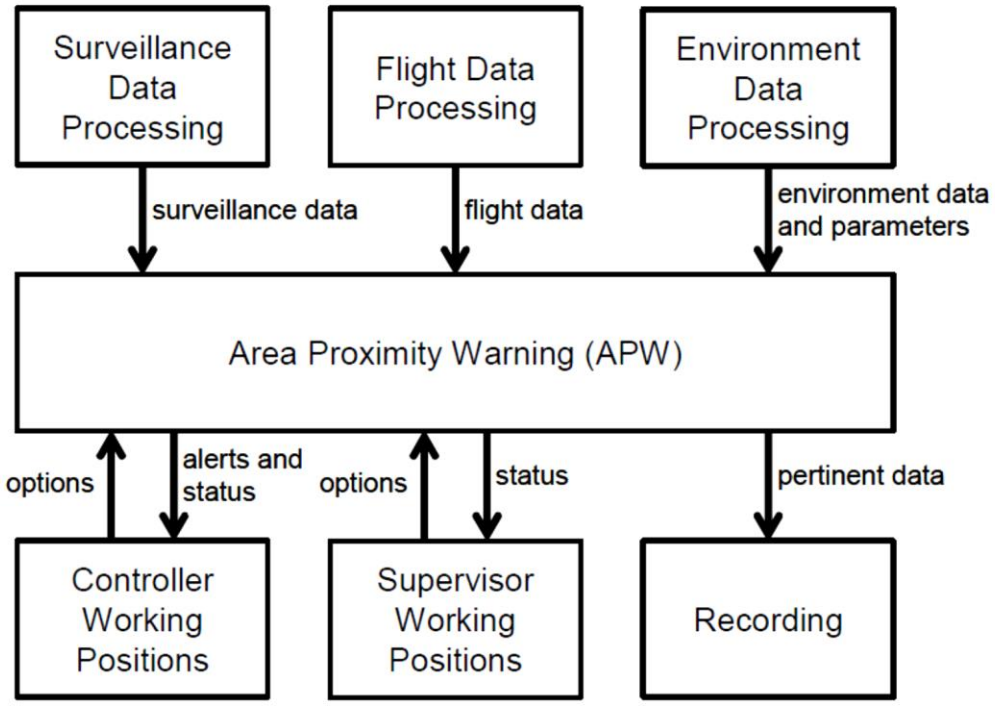


Figure 3.9 - APW Context Diagram

Observation data include the actual pressure to determine height information, without which conflicts cannot be predicted.

Flight information data includes:

- flight category required to determine the type of signal;
- sector to which the signal will be sent;
- the level that the aircraft was allowed to occupy so that the signal was appropriate.

The APW uses the external data parameters to determine the parts of the airspace where the warning signals should be applied.

Warning signals shall be generated at the air traffic controllers' workstations. Also, all the information that caused the signal should be recorded on film for further analysis and research.

3.4. Electronic data transmission protocols

Koordynatsiya - a process that execu etsya between adjacent ATC authorities, which aims to transfer the data of the flight plan of the aircraft on which control is transferred to another odnm sector.

With the introduction of electronic data transmission protocols OLDI, this process becomes much easier. In addition, after the implementation of OLDI with appeared many achievements, including such as:

- increasing the flow of PR over the territory of Ukraine;
- improving the structure of the PP;
- reducing the likelihood of errors in flight data.

But the main achievement of OLDI is to reduce the workload of air traffic controllers.

The purpose of OLDI is: [13]

- recovery of lost flight plan data (ABI);
- replacement of voice data transmission with automatic sending of flight details from one ATC unit to the next, to which the control of the aircraft will be transferred;
- improving the display of flight plan master data;
- the possibility of early correlation of the route. Even before entering the area of responsibility, the dispatcher receives the point, time, level and other conditions of entry of the aircraft. This significantly reduces the workload of the manager and increases the bandwidth of the sector.

OLDI message categories :

- category 1: data transmission;
- category 2: coordination;
- category 3: notification.

The transmission time of messages (Table 3.1) depends on their category:

Table 3.1. – Message transmission time

Message category	Message transmission time
1	4 - 10 sec
2	10 - 25 sec
3	15 - 45 sec

Categorization of OLDI messages :

- basic procedural messages (Table 3.2);
- notification on coordination (Table 3.3);

- data transmission messages (Table 3.4).

Table 3.2. – Basic procedural messages

Message type	Abbreviation	Category
Advance Boundary Information	ABI	3
Activate	ATC	2
Revision	REV	2
Preliminary Activate	PAC	2
Abrogation of Co-ordination	MAC	2
SSR Code Assignment	COD	2
Information	INF	3
Logical Acknowledgment	LAM	3

Table 3.3. – Basic procedural messages

Message type	Abbreviation	Category
Referred Activate Proposal	RAP	2
Referred Revision	RRV	2
Co-ordination	CDN	2
Stand-by	SBY	2
Accept	ACP	2
Reject Co-ordination	RJK	2

Table 3.4. – Data transmission messages

Message type	Abbreviation	Category
Transfer Initiation	TEAM	1
Supplementary Data	SDM	1
Handover Proposal	HOP	1
Change of Frequency	COF	1
Request on Frequency	ROF	1
Manual Assumption	MAS	1

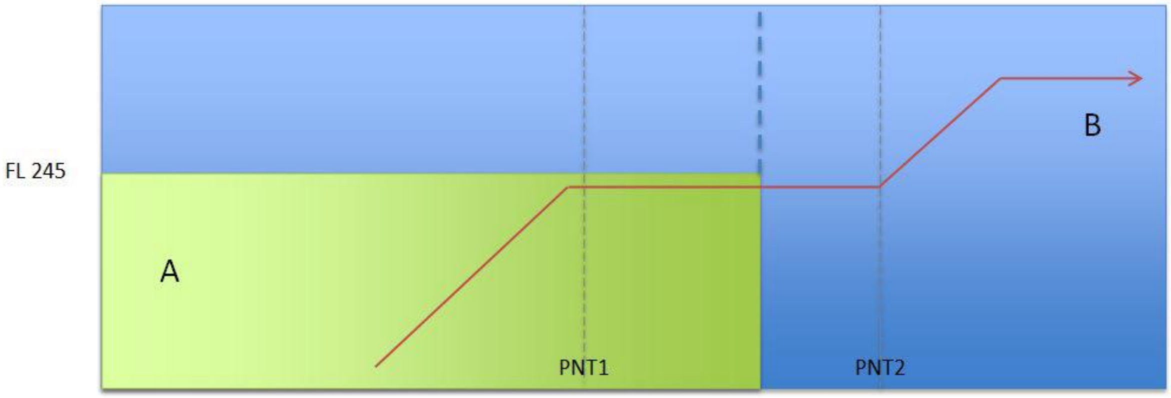
Not all types of OLDI messages are used in Ukraine , namely, such as ABI, ACT , LAM , PAC , MAC , REV , COD , INF. Messages of the first category are not used at all in our country, but their use is planned in the future.

The main messages are ABI , ACT and LAM . ABI and ACT contain the same information, such as:

- type of message;
- message number;

- aircraft identification;
- code of the defendant PS;
- departure aerodrome;
- arrival time;
- destination aerodrome;
- registration number and type of aircraft;
- type of flight;
- aircraft equipment;
- flight route;
- other flight data.

Scenarios for ECL field (Simple configuration)



The airspace and flight elements used for this scenario are fictitious.

The airspace data is depicted as:

•ATS A in green

•ATS B in blue

ATS B is divided into two sectors as:

•SC1 on top of ATS A (FL 245-660)

•SC2 on the side of ATS A (FL 000-660)

The boundary between these sectors is depicted in dotted blue. The flight trajectories are depicted in red.

The IFPS distributed the original FPL (FPL –FPL0001-IS –B737/M-SRWY/C –ADEP1010 - N0420F240 PNT1 DTC PNT2/N0420F300 AIRWAY PNTX –ADES0120) to ATS A and ATS B.

The transition between ATS A and ATS B is initially through a wall, at level F240, toward SC2.

10:35: ATS A sends an ABI to ATS B. The ECL is not present as the transition is through the wall

10:40: Following coordination between ATS A and ATS B, it is decided that the flight will be sent to B through the ceiling, toward another sector (SC 2). During the coordination, it is also decided that the flight will directly climb toward its next RFL.

10:43: Following a verbal coordination, ATCO from B SC 1 informs ATCO from ATS A that finally, the flight will not climb directly toward its next RFL, but toward FL 260.

-TITLE **ABI**	-TITLE **ACT**	-TITLE **REV**
-REFDATA	-REFDATA	-REFDATA
-SENDER -FAC **ATSA**	-SENDER -FAC **ATSA**	-SENDER -FAC **ATSA**
-RECVR -FAC **ATSB**	-RECVR -FAC **ATSB**	-RECVR -FAC **ATSB**
-SEQNUM **001**	-SEQNUM **002**	-SEQNUM **003**
-ARCID **FPL0001**	-ARCID **FPL0001**	-ARCID **FPL0001**
-SSRCODE **A1234**	-SSRCODE **A1234**	-SSRCODE **A1234**
-ADEP **ADEP**	-ADEP **ADEP**	-ADEP **ADEP**
-COORDATA	-COORDATA	-COORDATA
-PTID **PNT1**	-PTID **PNT1**	-PTID **PNT1**
-TO **1058**	-TO **1054**	-TO **1054**
-TFL **F240**	-TFL **F240**	-TFL **F240**
-ADES **ADES**	-ADES **ADES**	-ADES **ADES**
-ARCTYP **B737**	-ARCTYP **B737**	-ARCTYP **B737**
	- EFL **F300**	-EFL **F260**

3.5. Redistribution required bonds controllers artist and planner

During the analysis of the activity of air traffic controllers in the conditions of increased production load, it was found that in most cases the load factor above the acceptable one is fixed only for air traffic controllers - executors. Therefore, in addition to the above methods, it is proposed to redistribute the responsibilities of the dispatchers of the executor and the scheduler, and to transfer part of the responsibilities of the executor to the scheduler. That is, in addition to their direct responsibilities to reconcile information, the dispatcher-planner is invited to assist the dispatcher-executor to resolve potentially conflict situations with minimal interference in this process by the executor.

The following new scheduling manager features are available:

- to help the dispatcher - the executor;
- reduce and control the workload on the dispatcher - the executor;
- strategically solve emerging problems;
- perform coordination;
- update data in the system

CONCLUSIONS TO CHAPTER 3

The possible causes of errors of air traffic controllers are considered and their classification is given.

The Rison model and other methods of error prevention and overcoming are presented.

An analysis of how MTCD system features such as:

- STCA ;
- MSAW ;
- APW .

The principle of using electronic OLDI data transmission protocols is considered. The results showed that the use of OLDI significantly reduces the workload of the air traffic controller . This encourages ATS units that do not currently use electronic data transmission protocols to reconsider their position on this issue and install OLDI. It should also be noted that the possibility of reducing the workload depends not only on the dispatchers of ATS data bodies, but also on the dispatchers of adjacent ATS units .

The redistribution of responsibilities of planner and executor dispatchers is proposed.

CHAPTER 4

INCREASING THE LEVEL OF ACTIVITY OF AIR DISPATCHERS IN THE CONDITIONS OF INTENSIVE WORK

4.1. Recommendations for improving the efficiency of activities during the training of specialists in ATS

And viadispatchers are constantly under the influence of increased workload. The need for a holistic approach to research on peo - Dinky controllers in such conditions dictated by the need to address the problem of human adaptation to critical factors and increase its professional reliability in difficult conditions. When the normal pace of activity is disrupted, dispatchers experience stress, which in turn causes changes in the course of various mental and sometimes physical functions. All this leads primarily to reduced efficiency, the emergence of negative emotional experiences and conflicts.

A fairly clear classification of human mental states in complex production conditions has not yet been developed. In the analysis of the state of dispatchers in such conditions, the subjective side of everyone plays a particularly important role. The dynamics and nature of the emotional stress that arises are quite different from those observed in normal working conditions. Such specifics must be studied and taken into account when deciding on the modes of work and rest of air traffic controllers, as well as the implementation of methods of professional selection and in the preparation of training programs for professional skills.

Traditionally, to develop training simulators dispatching tasks to vrahovu zhenie factors such congestion:

- number of aircraft;
- use of the vertical flight performance profile;
- the presence of conflict situations;
- mandatory use of radar guidance procedure;
- occurrence of emergency situations in flight.

Recommended use for these factors as minimum necessity tion to which you want to add a few more:

- use of all equipment required in the workplace;
- coordination between adjacent dispatchers;
- performance of local procedures;
- use of PP restrictions.

The above factors cannot be ignored in the training and training of air traffic controllers. In îîè play a very important role in professional activities.

We recommend implementing the following training **phases** :

- **basic** (Fig. 4.1): training of identification procedures, introduction of conflict-free flights on arrival and several transit flights;

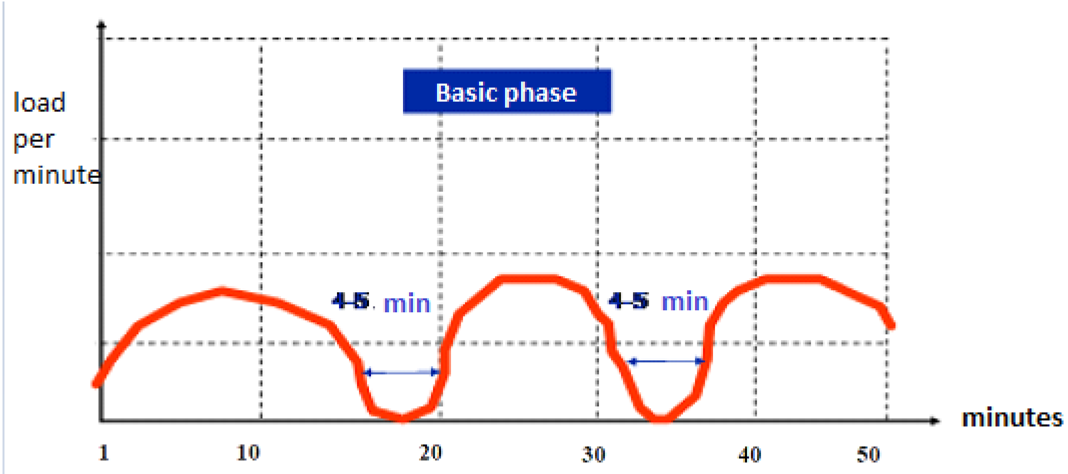


Figure 4.1 - The load of the base phase

- **average** (Fig. 4.2): presentation of several basic conflict situations;

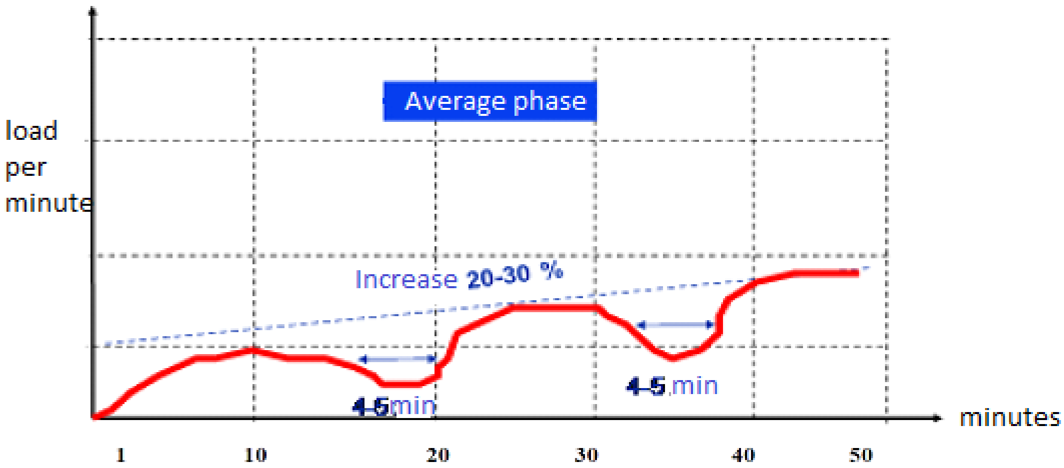


Figure 4.2 - The load of the middle phase

- **improving** (Fig. 4.3): taking into account all load factors except for special conditions and emergencies;

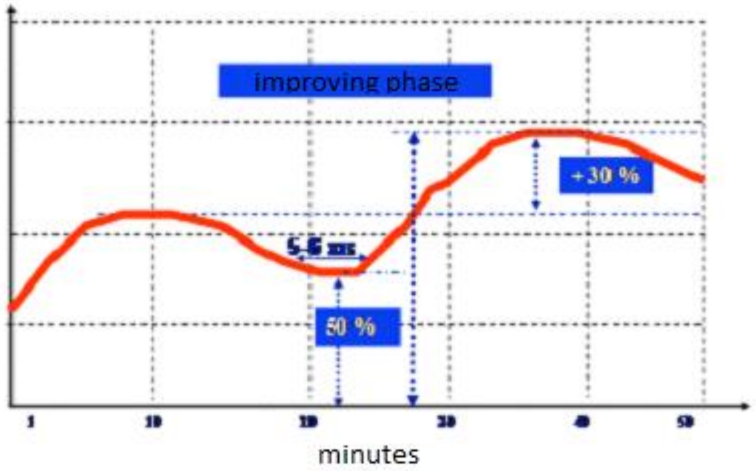


Figure 4.3 - The load of the improvement phase

- the **emergence of special conditions and emergencies** : the use of tasks of the improvement phase, but with the introduction of specific special conditions and emergencies;

- **strengthening** (Fig. 4.4): presentation of the maximum possible factors for training all acquired skills and abilities before the examination period;

- **examination** (Fig. 4.4): the content of exercises is the same as in examination tasks.

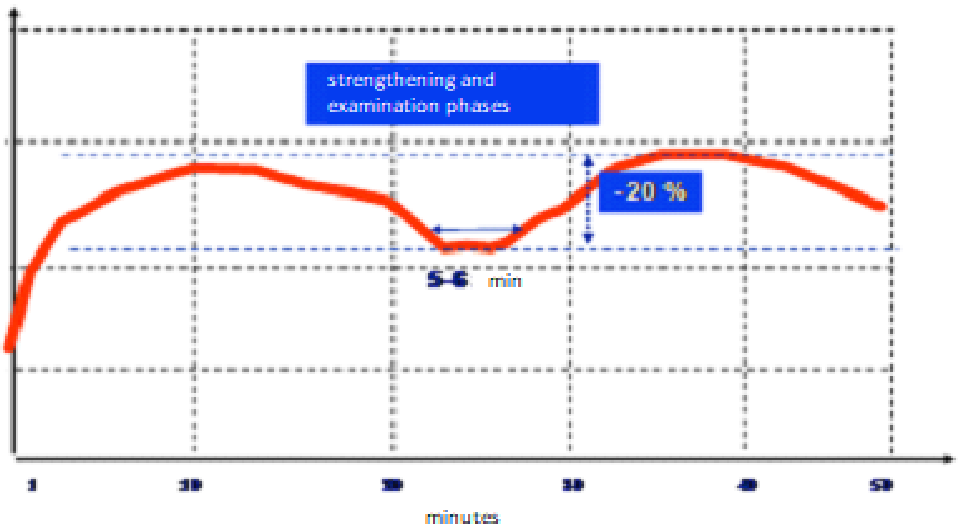


Figure 4.4 - The load of the strengthening and examination phases

The duration of the above phases of training is shown in Fig. 4.5.

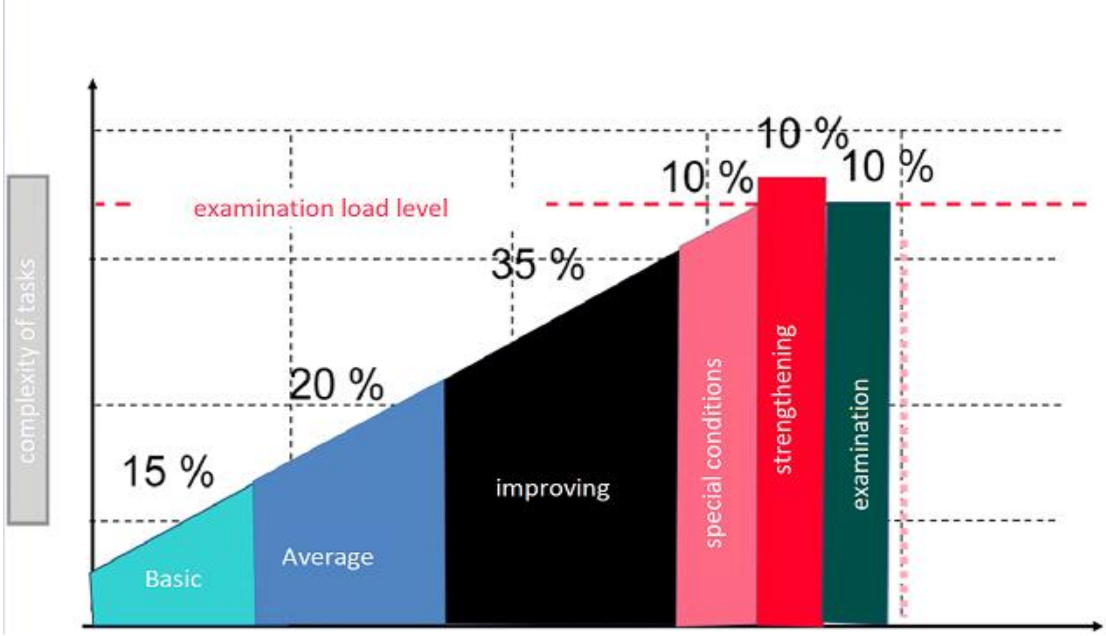


Figure 4.5 - Duration of the phases of training specialists in ATC

4.2. Experimental study of air traffic controllers in conditions of high traffic

The lack of clarity on the issue of controlling the psychological aspects of dispatching activities prompted a comparative study of the importance of emotional - volitional traits and operational thinking skills in ensuring the effectiveness of professional work of air traffic controllers. Assume that character traits associated with behavior in stressful situations are the guiding point in determining dispatching activities. That is, the hypothesis is that the effectiveness of air traffic controllers depends largely on the emotional - volitional traits of human nature, regardless of the level of workload. And the impact of increased workload on efficiency is minimal and should not threaten flight safety.

Initially, a **professional study of the** peculiarities of air traffic controllers during high workload. It turned out that in terms of moral and legal responsibility for flight safety, the air traffic controller needs to make more than 5 decisions and perform approximately 23 work actions per minute. This is three times higher than similar indicators of railway managers and seven times - construction managers. The number of aircraft flying through the air traffic controller sector is 1.7 times higher than the normal level of load on its memory. This nature of the activity makes strict demands on the system of its mental regulation, especially in the event of sharp, difficult situations.

Experimental testing of the hypothesis was to determine the effectiveness of activities by obtaining external assessments and self-assessments, as well as to determine emotional - volitional traits, determine the level of operational thinking, success in solving complex situations and the relationship of these psychological indicators with performance.

Professional performance was determined through interviews with air traffic controllers and senior air traffic controllers, who provided an external assessment of air traffic controllers . Each of the 12 air traffic controllers selected for the experiment was thus evaluated directly by the effectiveness of the ATS (Appendix A) . In addition, the definition of self - assessment of emotional - volitional traits of air traffic controllers was introduced by analyzing questionnaires filled out directly by air traffic controllers. Other characteristics that were investigated were determined using methods stre sohennoyi game "five." The meaning of the game is to provide managers with five tasks (Appendix B) , which they must consistently solve. Tasks are not related to professional activities, designed only for logical thinking and mathematical operations that do not require special training.

The peculiarity of the technique is that after easy tasks the most difficult one is offered immediately. In conventional units, the complexity of the problems is expressed by the ratio 1:1: 1: 1: 4. This organization of a series of tasks provokes great stress. The level of development of operational thinking is checked by analyzing the process of solving easy problems. And the transition from easy to complex tasks indicates the development of intellectual and emotional - volitional traits.

There are three main types of orientation of emotional - volitional traits, which are determined by the transition to a complex task:

1. **"I can decide what it costs me"** - people for whom it is important to maintain their intellectual - volitional "prestige", selfishness, high self-esteem in their

own eyes and in the eyes of the experimenter. All members of this group solved a difficult task;

2. **"I can not solve"** - people are insecure, who have a fear of a new failure, a sense of futility of further efforts and a sense that they will not cope with the task. Everyone refused to solve a difficult problem;

3. **"I want to solve immediately, and if it is difficult - I do not want"** - people who go to the easy, quick solution of all problems and avoid systematic and long-term efforts. Everyone also refused to solve, after the first attempt to solve as well as easy tasks.

The leading character traits of persons of group 1 are initiative, optimism, desire to achieve the goal, ignoring failures, risk-taking, impulsiveness and some adventurism. They strive for self-affirmation by achieving real success in business. For persons of group 2, the characteristic features are the predominance of doubts, self-doubt, avoidance of failures, a state of active anxiety, fears and worries about their fate. At persons of 3 groups the advantage of depressive states, frustration in life prospects is observed.

As a result of the research, the efficiency indicator turned out to be closely connected with the external assessment and self - assessment of emotional and volitional traits and with the success of solving a difficult task. Such results support the hypothesis.

During the experiment, it turned out that the success of solving easy problems is very great - all participants solved them correctly and quickly. This testifies to the excellent operational thinking of air traffic controllers. But the number of people who refused to solve a difficult problem is quite large - 33%. A comparison of external assessments of emotional and volitional traits obtained from air traffic controllers and senior air traffic controllers indicates the truth of the hypothesis. Dispatchers who have solved a difficult task have previously received a higher rating from managers on the effectiveness of activities. That is, it is obvious that the level of development of emotional - volitional traits directly proportionally affects the effectiveness of their activities.

It can be concluded that the most important psychological factor of disproportion in the development of professionally significant personality traits of the air traffic controller is the insufficient development of some of them emotionally - volitional self - regulation of activity.

The results of the study allowed to formulate **recommendations** for the professional selection and organization of training of air traffic controllers on the basis of diagnosis and taking into account primarily emotional - volitional personality traits. It is proposed to include in the system of air traffic controller training a series of professional tasks, in which difficult tasks are unexpectedly followed by complex ones. Such organization of trainings can help to strengthen in the personality of dispatchers traits that provide timely overcoming of conflict, stressful situations, and ultimately lead to an increase in their level of professional activity, even in conditions of increased workload.

D For each existing or future specialist proposed **test** , which indicates the ability to effectively operate even under heavy load. This test is designed for self-assessment, not for management to identify the level of employee training. Each question is answered for 3 seconds, unless otherwise specified in the question. In total, the test takes 2 minutes and 40 seconds, including time to read the questions. The test consists of the following questions:

1. Write the first letter of the name Sergey and the last letter of the name of the first month of the year;
2. Write the word "pairs" so that any one letter is written above the others;
3. Draw two vertical lines and cross them with two horizontal ones (4 sec);
4. Draw a sine wave;
5. Write the symbols "+" and "1" so that the first was exactly above the second;
6. Draw n ' yatykintsevu star (4 sec);
7. If today is not Wednesday, write the penultimate letter of your name;
8. Write the equation and its result: (12 + 4) / 0 = (5 sec);
9. Draw a straight line, put a "+" over it;
10. Draw a triangle, mark the top with the last letter of your city (4 sec);

11. If in the word "synonym" the sixth letter is a vowel, write the number "1";

12. If the numbers 7954238 and 895428 are not the same, write "+";

13. Draw a circle, divide it in half;

14. Draw a triangle, mark the vertices with the letters A, B, C counterclockwise, starting from the top corner (6 sec);

15. If the third letter in the word "gift" is not "and", write the sum of the numbers 3 and 5;

16. Write the difference of these numbers;

17. Write the word "salute", circle the consonant letters and cross out the vowels (6 sec);

18. If the number 54 is divisible by 9, draw a square (4 sec);

19. Write the word "world", circle the first letter in a circle, the second - a square;

20. Draw the arrows pointing up, left, down, right (5 sec);

21. In the number 6823749 cross out the numbers divisible by 3 and underline the rest (5 sec).

During the test, score one point for each unfulfilled, incorrectly or incompletely completed task. Unfortunately, in conditions of increased workload, only those who have earned 0 - 2 points will be able to work flawlessly .

4.3. Analysis of the impact of psychological aspects on the efficiency and professional reliability of air traffic controllers

The main reasons that increase the emotional stress of air traffic controllers in difficult conditions are also mental unpreparedness for work, physical and psychological fatigue of various origins, partly due to the constant expectation of extreme conditions.

Low levels of emotional stress are considered normal for dispatchers. It helps to solve professional problems. In this case, the body's reserves are mobilized. Prolonged state of emotional stress has a negative effect on the work process, sometimes before the onset of nervous - emotional breakdown. This in turn is dangerous not only for health ' I air traffic controllers and even thousands of people whose lives are under their responsibility.

During high workload, namely: when changing stereotypes of actions, a sharp change in working conditions, in the event of a real or imagined threat to flight safety - the stress that arises in air traffic controllers and their behavior depends on emotional - volitional traits they possess, namely :

- the identity of the dispatcher;
- moral and intellectual properties of character;
- risk appetite;
- individual features of the decision-making process;
- formation of skills of self-control and self-regulation;
- feature of individual style of activity;
- frustrating tolerance;
- professional responsibility;
- mental adaptation;
- the formation of motivation to overcome the heavy workload;
- content - life orientation and target (content) settings.

The latter factor can take three forms:

- form that stabilizes the activity;
- form that interferes with activities;
- a form that disorganizes and rejects activities.

We recommend developing the emotional and volitional traits of air traffic controllers during professional training and promoting the correct choice of content - life orientation and target settings.

It is known that under the influence of long-term heavy activity, the indicators of a number of active functions decrease, and the indicators of inactive ones increase. However, this pattern is not universal. During experimental studies conducted under stressful conditions, cases were found to maintain a high level of functional indicators directly related to activities that are critical to safety. At the same time, other indicators of relatively secondary importance decreased. That is, the most important elements of professional performance are preserved even during severe fatigue, but only if you choose the right target setting. In any difficult situation, the effectiveness of the activity is also often reduced not by the fact that it is impossible to achieve something, but by the demobilization of forces due to the loss of motivational readiness to overcome difficulties.

It is the value system of air traffic controllers that determines the motivation of his professional activity. Both the goals themselves and the price a person is willing to pay for achieving them depend on this system. If the student-dispatcher sets a high goal to achieve professionalism, he must already understand that sometimes it is impossible to do without much effort. If, on the contrary, he always expects to do without such sacrifices, then in difficult conditions he will not be able to fully mobilize his forces, show courage, devotion - he is not morally ready for this activity.

An important condition for the success and efficiency of activities in conditions of increased production load is the focus of the air traffic controller on the process of solving problems, rather than on the subjective feeling of the situation as impossible for him. Moreover, professional reliability is very important for flight safety. The concept of professional reliability includes long-term patience, endurance of extreme stress, the ability to concentrate even when distracted, resistance to stress and external factors. The level of professional reliability cannot be adequately determined in situations that do not require high requirements.

Therefore, to identify individual indicators of professional reliability, the air traffic controller must be placed in an extreme situation. Training should also take place in a busy environment.

CONCLUSIONS TO CHAPTER 4

Proposed recommendations:

- Improving the training process of training specialists in ATC in conditions of high workload ;

- improvement of professional selection of candidates for training .

Conducted:

- experimental study of the peculiarities of the activities of air traffic controllers during increased production load;

- experimental testing of the hypothesis on the influence of psychological indicators on the effectiveness of professional activities of aviation dissectors .

The types of orientation of emotional - volitional features of air traffic controllers are determined .

Improved :

- stressful game "five" to test the working hypothesis of research ;

- test to assess the ability to work effectively in conditions of increased workload.

Psychological factors that are significant during activity in stressful conditions (high density of flights) are analyzed .

GENERAL CONCLUSIONS

The work of a dispatcher is a complex mental process, and complex actions require the participation of consciousness. When solving standard tasks, we use a set of life or professional rules that save both effort and time. When solving the same type of tasks, a stereotype of actions is formed (consciously or unconsciously), which on the one hand facilitates the task, on the other hand reduces the level of awareness. There is something like the automation of procedural activities. A person cannot work without errors, especially in conditions of high workload, but these errors must be minimized. As a result of the thesis the following tasks were performed and the results were obtained:

1. Modern tendencies of change of air traffic intensity and congestion of air traffic controllers are considered.

2. The analysis is made and the classification of the factors influencing complexity of air traffic control is resulted .

3. The influence of ergonomic, anthropometric and physical factors on the efficiency of professional activity of air traffic controllers is thoroughly analyzed.

4. Modern methods of calculating the load factor are considered, the classification of workload of air traffic controllers is given.

5. The consequences of increased workload are analyzed.

6. The possible causes of errors of air traffic controllers are considered, their classification and methods of prevention and overcoming of errors are given.

7. Proposed:

- redistribution of responsibilities of air traffic controllers;
- use of MTCD system functions as an error indicator;
- use of electronic data transmission protocols OLDI to reduce the workload of air traffic controllers.

8. Recommendations for improving the training process of training specialists in ATS and professional selection of candidates are given.

9. A professional study of the peculiarities of the activities of air traffic controllers during increased workload and experimental testing of the hypothesis on the impact of psychological indicators on the efficiency of activities.

10. Developed a stressful game "five" to confirm the hypothesis of the dominant influence of emotional - volitional traits of air traffic controllers, regardless of the level of workload, as well as a test for self-assessment of the ability to work effectively under stress.

11. The psychological factors that are influential during activity in stressful conditions are analyzed.

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Appendix A

The results of the experimental study

The experiment involved 12 air traffic controllers:

- each received an assessment of the effectiveness of professional activities from flight managers from 85 to 100% (Table A1);

- easy tasks solved in full - 12 people - 100%;

- solved a difficult task in full - 4 people - 33%;

- difficult task tried to solve or solved incorrectly - 7 people - 58%;

- refused to solve a difficult task - 1 person - 8%.

Учасники експерименту	Ефективність діяльності згідно з оцінкою КП, %	Результат рішення легких задач	Результат рішення складної задачі	Помилки в тесті	Тип орієнтації емоційно – вольових рис
1	99	+	+	0	«Можу вирішити, чого б мені це не коштувало»
2	85	+	–	4	«Хочу вирішити, а якщо буде складно – не хочу»
3	90	+	–	0	«Хочу вирішити, а якщо буде складно – не хочу»
4	85	+	–	3	«Не можу вирішити»
5	97	+	+	0	«Можу вирішити, чого б мені це не коштувало»
6	95	+	–	0	«Хочу вирішити, а якщо буде складно – не хочу»
7	90	+	–	3	«Хочу вирішити, а якщо буде складно – не хочу»
8	99	+	+	0	«Можу вирішити, чого б мені це не коштувало»
9	95	+	–	0	«Хочу вирішити, а якщо буде складно – не хочу»
10	100	+	+	0	«Можу вирішити, чого б мені це не коштувало»
11	90	+	–	1	«Хочу вирішити, а якщо буде складно – не хочу»
12	98	+	–	0	«Хочу вирішити, а якщо буде складно – не хочу»