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THE USE OF INFORMATION TECHNOLOGIES IN RISK MANAGEMENT FOR THE FLIGHT SAFETY OF AVIATION

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Анотація. *На даний час дуже актуальною є проблема забезпечення необхідного рівня безпеки польотів державної авіації за людським та організаційним факторами. Не дивлячись на постійне вжиття заходів, спрямованих на поширення та посилення контролю процесів авіаційної діяльності, льотні інциденти, викликані недостатньою надійністю роботи персоналу, організаційними прорахунками, продовжують займати перші позиції. Має місце недостатня ефективність системи управління безпекою польотів щодо виявлення небезпечних факторів у їх латентній стадії, що необхідно для завчасної профілактики подій. Труднощі відносно завчасного виявлення небезпечних станів системи авіаційної діяльності, які пов'язані з визначеними факторами, обумовлені необхідністю врахування, співвіднесення й аналізу даних дуже великої розмірності та різноспрямованості (багатоаспектності). На думку авторів, успішне розв'язання цієї проблеми можливе за рахунок використання засобів автоматизованої обробки та когнітивного об'єднання великих масивів різнорідних даних на основі централізованих електронних систем збору, інформаційно-аналітичної обробки та збереження інформації про функціонування системи авіаційної діяльності. Виявлені позаштатні й небезпечні стани, інциденти та події, що відбулися. У статті запропоновано концепцію створення перспективної автоматизованої системи управління безпекою польотів державної авіації. Ця система дозволить реалізувати принцип завчасного виявлення та профілактики небезпечних факторів і ризиків для безпеки польотів з урахуванням людського та організаційного факторів за рахунок реалізації процесів централізованого збору, узагальнення й аналізу великих даних про стан авіаційної системи. Сформульовано актуальні наукові завдання щодо створення методичної бази для розробки спеціального програмного забезпечення такої автоматизованої системи.*
Ключові слова: *система управління, небезпечний фактор, ризик для безпеки польотів, фактор людини, управління ризиками, інформаційна технологія, ієрархічна система.*

Abstract. *At present, the problem of ensuring the necessary level of state aviation flights safety in terms of human and organizational factors is very urgent. Despite the ongoing measures aimed at expanding and strengthening control over the processes of aviation activity, flight incidents caused by insufficient reliability of personnel work and organizational errors continue to occupy leading positions. There is an insufficient efficiency of the flight safety management system to identify hazardous factors in their latent stage, which is necessary for the early prevention of accidents. The difficulty of timely identification of the aviation system dangerous states associated with these factors is due to the need to account, correlate and analyze data of a very large dimension and multifacetedness. According to the authors, a successful solution to this problem is possible through the use of automated processing and cognitive combination of large heterogeneous information arrays based on centralized electronic systems for collecting, information and analytical processing and storage of information about the functioning of the aviation system, identified abnormal and dangerous conditions, and incidents that have already occurred. The article presents the concept of creating a promising automated flight safety management system for state aviation. The proposed system will make it possible to implement the principle of proactive detection and prevention of hazardous factors and risks for flight safety, taking into account human and organizational factors, based on the implementation of processes for centralized collection, generalization and analysis of big data on*

the state of the aviation system. Topical scientific tasks for the creation of a methodological basis for the development of special software for such an automated system have been formulated.
Keywords: *control system, dangerous factor, risk for flight safety, human factor, risk management, information technology, hierarchical system.*

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1. Introduction

The organizational aspect of the problem of maintaining aviation safety, when analyzing the problems of the flight safety, has been highlighted since the 2000s. The main feature of this approach is that the failures in the operation of the protection system of the aviation system (AS) are considered as remote consequences of decisions issued by the aviation leadership. These consequences, being a hidden factor, do not appear in the system at all and work only in a worst-case scenario (human errors, technical failures, weather influences and other conditions) (Fig. 1).

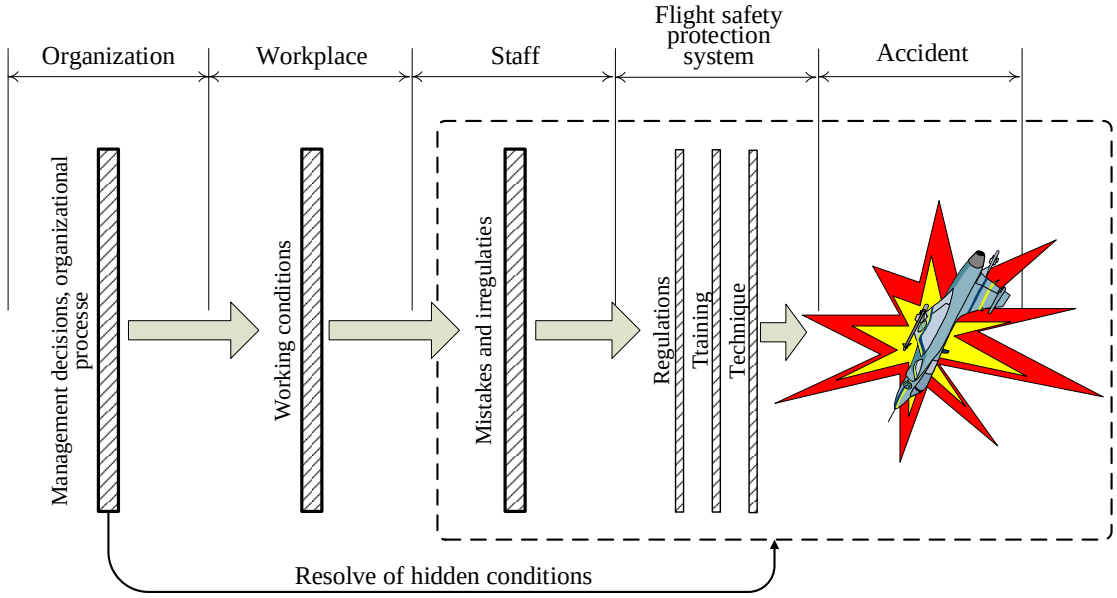

Figure 1 – The concept of causation of aviation accidents in the organizational aspect

Sometimes an adverse factor for the flight safety is the state of superposition and mutual reinforcement of the dangerous influence of several circumstances. For each separately taken control direction (pilot experience, the level of aircrew expertise, aircraft robustness, etc.), a satisfactory state of affairs could have occurred (in a normal range), but in a combination, for a specific flight mission, – the value of the risk can become critically large.

To prevent the detection of the listed above adverse factors, it is necessary to carry out constant monitoring of the planned flight work in all its aspects.

Such daily work on comparing and projecting all conditions for each flight mission and the circumstances of an aviation activity, the determining on this basis a forecasted level of risk and adjusting the previously adopted managerial decisions will take for officials a lot of time and energy. In addition, this type of activity (tracking the process, when the cases that require human reaction, are relatively rare) is difficult for a person. It is hard to keep attention on the requisite level all the time when nothing happens for a long time. The reduction of risk occurs relatively quickly, the exceptions from the defined sphere of responsibilities are allowed.

The holistic solution is the replacement of a person by the automation equipment which will collect, centrally process and correlate large amounts of data and, on this basis, generate warning signals for the senior management about the level of risk for the flight safety.

Such control will be especially efficient in relation to the human factor. As the analysis shows, the main reason of 80% of aviation accidents invariably has been the human factor. An aviation specialist (a person) is a central element in the «aircrew – aircraft – environment – flight mission» system who determines virtually all cause-and-effect relationships and the logic of events in the aviation system.

The main missions in the creation of a specialized centralized control system for the flight safety are the following:

– the creation of a centralized database on the state of aviation activities in the components of the national aviation system;

– mathematical methods, models and special software that allow processing, analysis, aggregation and ordering of different-type detailed information and, on this basis, the identification of dangerous factors and risks in their latent stage.

The combination of two factors: raising the completeness of information about the operated object, and developing a scientific and methodical apparatus for analytical processing of large amount of heterogeneous information – will improve the quality of control by the timely detection of manifestations of dangerous system (emergent) properties.

The article focuses on the issues of a conceptual design of the system for the flight safety control with consideration of the human factor.

2. Advanced automated flight safety control system based on modern information technologies

Many researchers, for example, S.D. Baynetov and S.S. Shamshin [1], have pointed out systematicity or synergistic properties of the manifestation of hazardous factors in the safety system of flights. This circumstance makes it necessary to resort to an increase in the dimensionality of the factor space of the data being processed, which is impossible without the use of some automation tools. The main elements characterizing the device of the methodical platform for such automated processing of big data on the state of the flight safety system were proposed in a number of works by A.A. Butov, M.A. Volkov, V.P. Makarov, V.D. Sharov [2–4].

The obtained theoretical results are reflected in a number of ICAO regulatory documents which set out the basic organizational principles, goals and stages of the formation of national flight safety management systems that use the risk management paradigm [7, 8]. In [5] the importance of the creation of a centralized database within a distributed automated flight safety management system is emphasized. The [6] points out the difficulty of collecting data that describes the circumstances of accidents and incidents. Without obtaining a sufficiently complete picture of the state of affairs in the aviation system, it is impossible to apply technologies of proactive detection of dangerous factors.

Taking into account ICAO regulations, as well as theoretical results presented by other researchers, the authors proposed the concept of creating a national automated aviation safety management system.

The proposed advanced military automated flight safety control system is intended to improve flight safety due to the timely identification of adverse factors caused by the lack of readiness of the aircraft staff (flight crews, people from the flight control team) to carry out the planned flight and other aviation activities under the stipulated conditions.

The level of risk in the relation to the assignment option of the aircraft staff for the planned aviation activity tasks is determined:

– by the degree of compliance with the content and the established conditions for the flight mission:

1) a current license of the flight crew for the pertinent types of flights in the appropriate conditions;

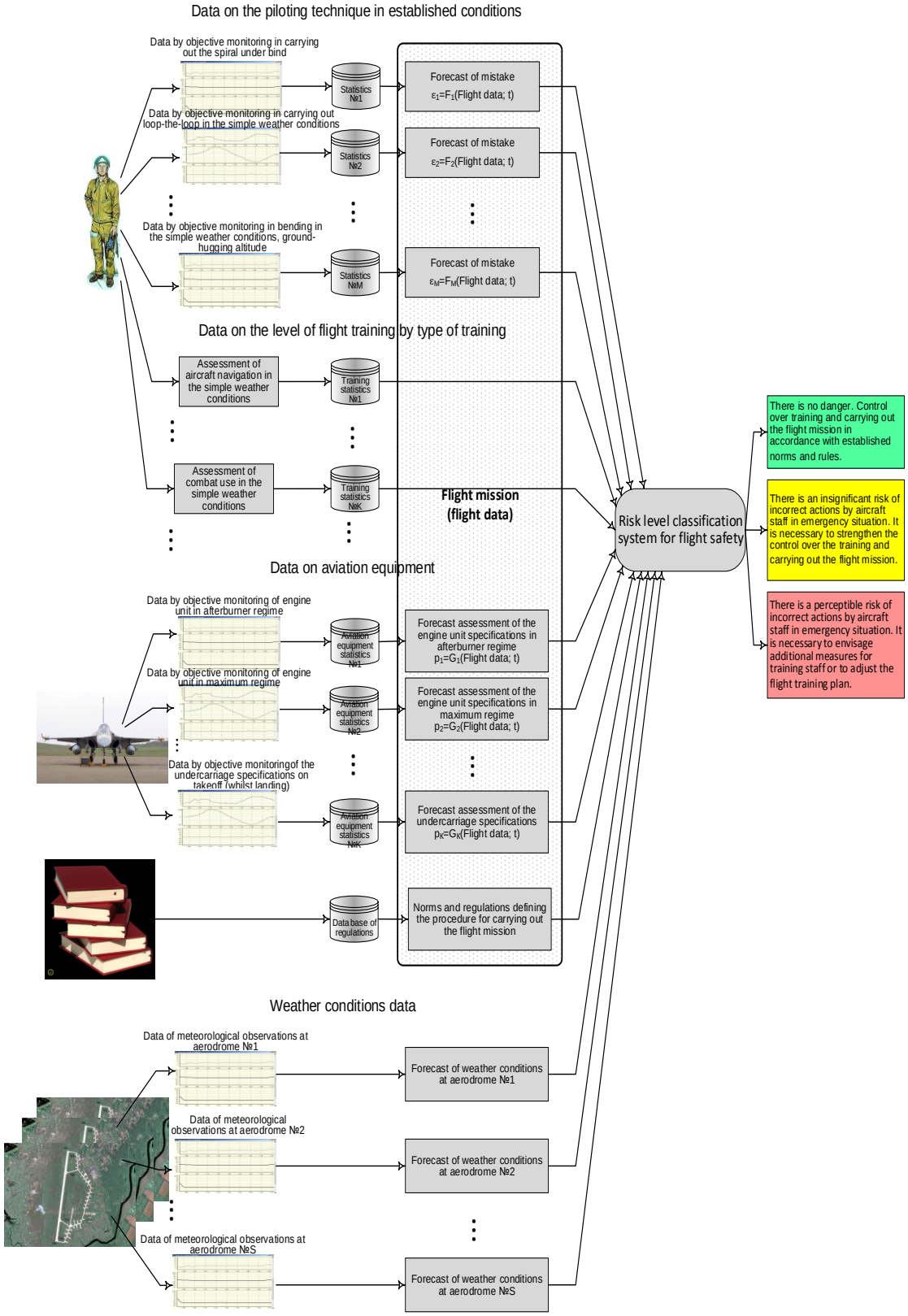

Figure 2 – The concept of the creation of an advanced automated control system of the flight safety

2) the actual level of the aircrew's pilotage technique for carrying out the planned flight elements in the established regimes under established meteorological conditions;

3) the achieved by the aircrew level of experience in flight navigation and combat use;

4) the characteristic of the organization of the aircrew flight work (crew proficiency, accumulated fatigue):

– by the degree of compliance with the content and conditions of the implementation of the planned missions, air traffic control, the reached level of training and pauses in the air traffic control activity of the ATC team.

In Fig. 2 there is presented a diagram that explains the concept of the creation of an advanced automated flight safety control system.

Among the conditions that characterize the process of carrying out the planned flight missions the following ones are considered:

– the adopted system of norms and regulations for the organization and conducting the aviation activity;

– meteorological conditions (visibility, precipitations, weather phenomena, wind);

– robustness of the aircraft during the flight;

– the planned regimes and types of flight in the missions.

The robustness of the aircraft is expected to be predicted according to the following set of data:

– failure statistics by the types of aviation equipment and Airborne systems;

– statistics on the change in the parameters of the technical state of systems and aggregates of each specific sample of the aviation equipment (kilometer and fuel flow rate, oil, other liquids and gases, temperature behind the turbine, amplitude of vibration, etc.);

– the operating time and the balance of the total and overhaul life of the aviation equipment;

– a real state of radio technical support means of flights;

– an actual state of runways at the aerodrome network.

It is supposed that the use of the automation equipment based on latest information technologies, the combination of the complex of the data set on the state of aircraft staff, the actual conditions of the aviation system operation, and the flight plans in the near future will automatically classify future actions of the aviation activity according to the risk level and, at the same time, diagnose the causes of its occurrence.

Due to the centralization of the processing of the mentioned above data, a significant increase in the flight safety level for the human factor is expected.

The flight safety control process could be as follows. On the screen of the automated workplace of the official, responsible for the outcome of the planned flight missions, an information model, that contains the following element, is displayed (Fig. 3):

– the information about the current time period (at the top part of the model) (1);

– three time scales: the scale of the days of the current and next week (2); the scale of the days of the month (3) and the scale of hours of the current day (4);

– a state map with the scheme of the national aerodrome network (5), piloting zones (6) and flight routes (7) for the planned flight missions of military aviation;

– the indicators that show how the flights near the aerodromes (8), where they are planned, are carried out.

The flight data form is shown at the top of the indicator of the flight history sheet (9) which contains the name of the aerodrome, the date of the flight and the nature of the planned flight missions (a variant of meteorological conditions, the period of the day). The lower part of the indicator contains a strip scheduled flight plan (10). The points of time of the commencement and completion of flights are displayed at the left and right of the scheduled plan. The middle part of the indicator shows a period of time for a meal and the transfer of aircraft activities from day to night flights.

The operator of the automated workplace has the ability to set a time period concerning which the flight safety state is analyzed. To determine the time period, the mobile indicators that

specify the day of the week and the hour of the day, which pertinent to the time of the end of the analyzed period of time, are used. The elements of the scale of days and the scale of the hours, placed between the left and right pointers, are painted with a darker color and thus indicate the period of time set by the operator to perform the analysis.

The database contains information on the state of preparedness of aviation specialists, on the nature of the planned flight missions, on the actual and forecasted meteorological conditions, on the state of aviation equipment and the aerodrome network, the norms and regulations establishing the procedure for carrying out the considered flight missions. The system automatically assigns each of the above-mentioned flight missions, which fall within the controlled period of time, to the listed factors and determines the risk level. Three levels of risk for the flight safety are considered: high, moderate and nonexistent.

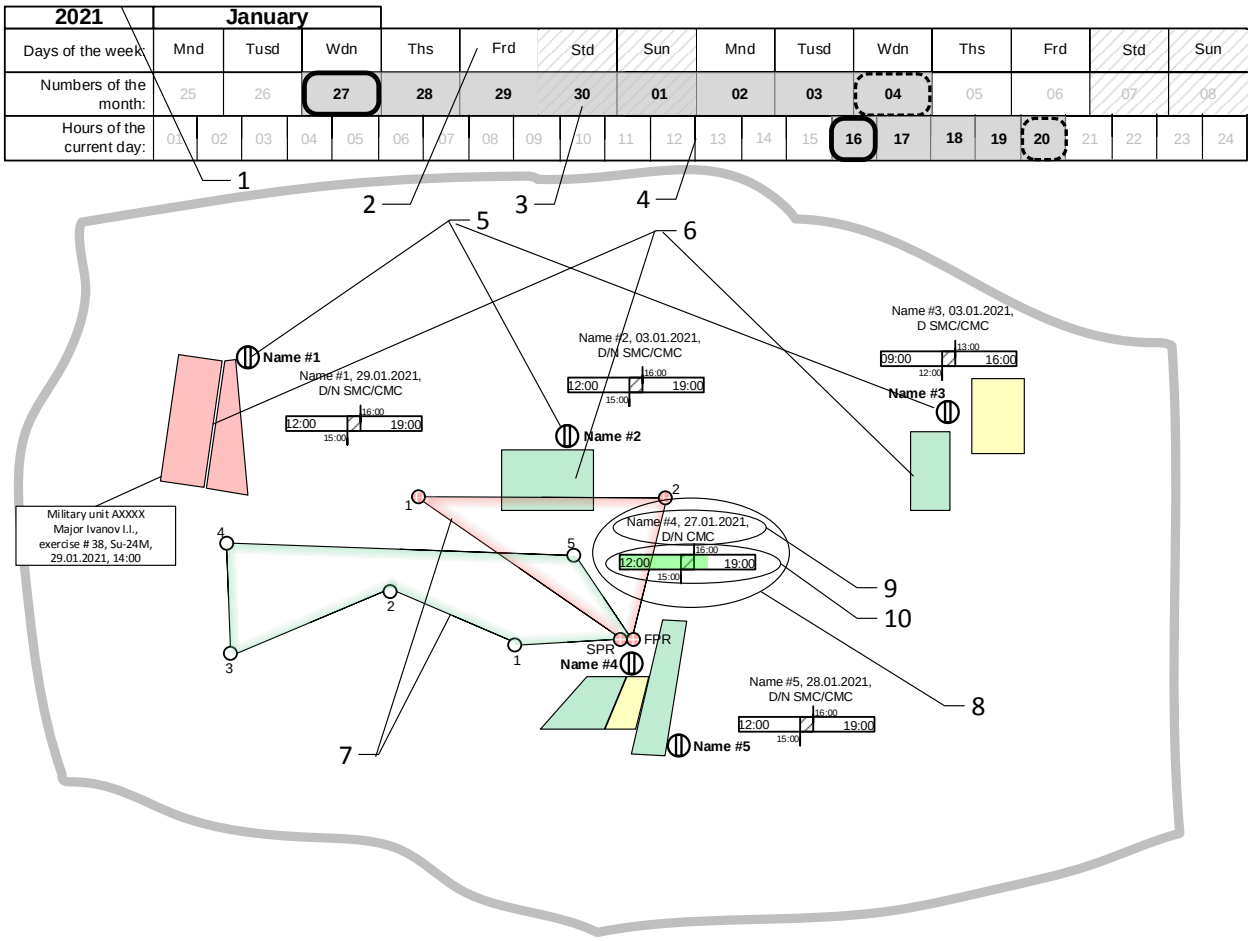

Figure 3 – The information model of the flight safety control

Depending on the established values of the risk level of the planned flight missions, the pilot zones and flight routes, which are suitable to these missions, are painted with red, yellow or green. Red is used if the risk level is high. It is necessary to provide some additional measures for staff training or adjusting a training flight plan. Yellow is used if there is a low risk of incorrect actions taken by the aircrew in an emergency situation. It is necessary to strengthen the control over the training process and carrying out the flight mission. The green color shows that the risk level is normal, it corresponds to the background of the hazard, depending on the specificity of the activity. The control over the training and performance of the flight mission is carried out in accordance with the established norms and rules.

The reasons that led to the flight safety level decrease are diagnosed at the same time with the classification of the planned flight missions by the risk level. As the information about

the increased risk reasons, the display shows: the last name of a licensed crew member, who has not been well prepared, the type of sortie and the flight element, etc. The diagnosed cause is displayed on the screen in the form of an information sheet on the analyzed flight mission.

To get some help with the identified risk factors for the planned flight safety, the operator of the automated workplace combines the cursor of the manipulator with the area of the information model where the corresponding flight zone or the corresponding flight route is displayed, and presses the right key of the manipulator. The information sheet appears over the information model. The type of information sheet for the flight zone of Name # 1 aerodrome is shown in Fig. 3.

Based on the displayed information, there such prepared offers for the official officer: about the adjustment of the flight exercise timeline of aviation units for the current and following weeks; about the staff changes in the structure of the air traffic control team, in the maintenance and repair plan for the aircraft, and the aerodrome network.

3. Mathematical models and methods needed to solve problems of the automated risk management for the flight safety in aviation

Mathematical models and methods, which necessary for the creation of a special software for such automated control system of the flight safety, should implement the following functions (Fig. 4):

– the assessment of the level of aircrew's flight training according to their types (aircraft navigation, combat use, tactical training);

– the assessment of the level of the aircrew pilotage technique according to objective monitoring (flight data records);

– the assessment of the training level of the air traffic control team;

– the formalization of existing norms and rules for the implementation of the aviation activity in relation to the assessment of the flight safety level;

– the assessment of the aircraft condition on the basis of objective monitoring of data;

– the classification of the planned flight missions according to the risk level, based on the actual level of readiness of aircrews, ATC (flight control team), the aircraft condition, meteorological conditions and established norms and rules for the organization of the aviation activity.

In this regard, the following scientific tasks are advanced for finding a successful solution to the problem of automated risk management for the flight safety in the aircraft (Fig. 5):

– forecasting (based on the known mathematical models of engineering psychology) the level of preparedness of a particular pilot for piloting in specific conditions of carrying out and for the specific content of the established flight mission on the basis of accumulated statistics on the quality of his pilotage or pilot rating;

– automatic data processing for objective monitoring (flight data record) over the carrying out of flight elements: data filtering (based on the Kalman estimator or alpha-beta filters), the recognition of flight elements and determination of characteristic points of the trajectory (based on the methods of classifying objects with many explicit signs), the assessment of pilot's flight errors at certain characteristic points;

– the assessment of the actual state, trends in the reliability level of the aviation equipment samples on the basis of the statistics on the operation of their aggregates and systems (based on the theory of reliability and the processing of statistical data);

– the assessment of the risk level for the flight safety, taking into account the preparedness of the pilot and air traffic control team to carry out the specified flight mission in specified conditions and with the established norms and rules of aircraft activity, the state of aviation equipment and terrestrial infrastructure for flight support (based on statistical recognition methods of multiparametric objects and the «Internet of things» technology, methods of extracting expert knowledge in the construction of knowledge bases.

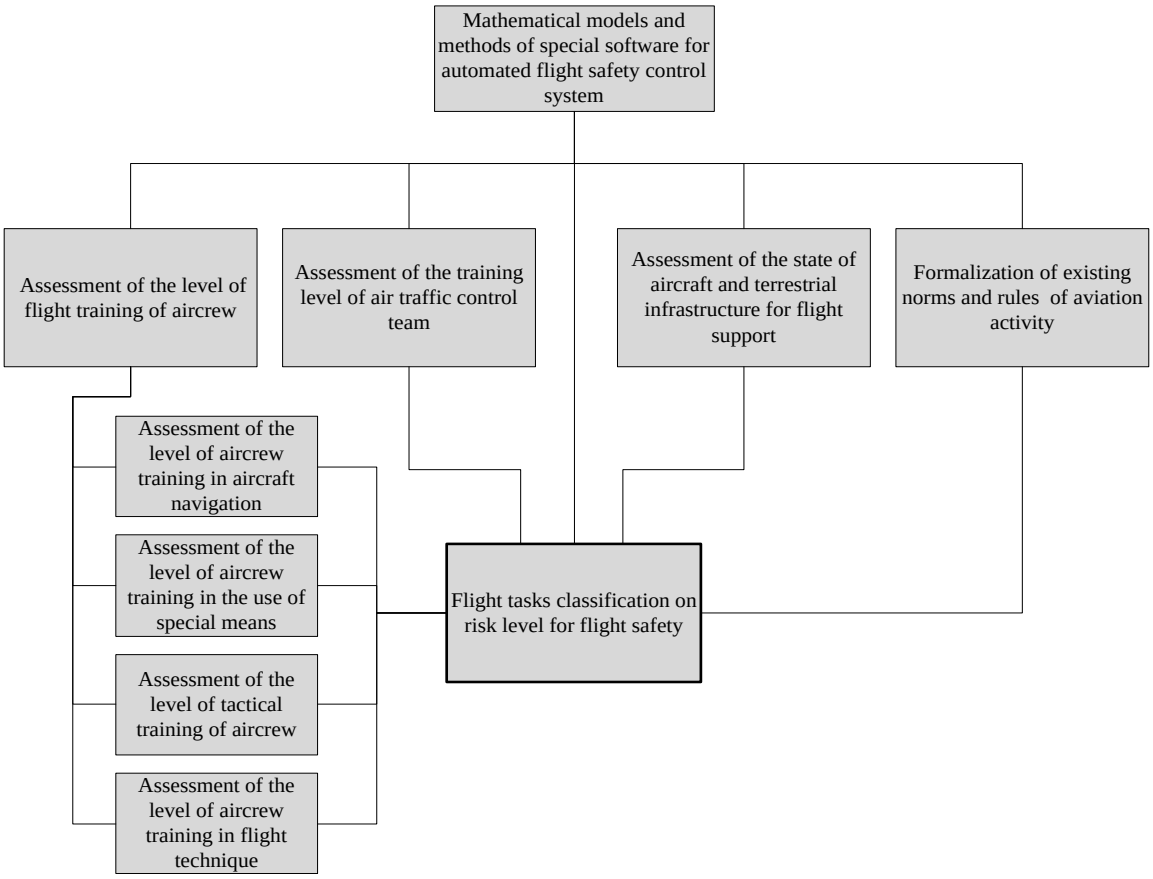

Figure 4 – Mathematical models and methods needed to create a special software for the automated control system of the flight safety

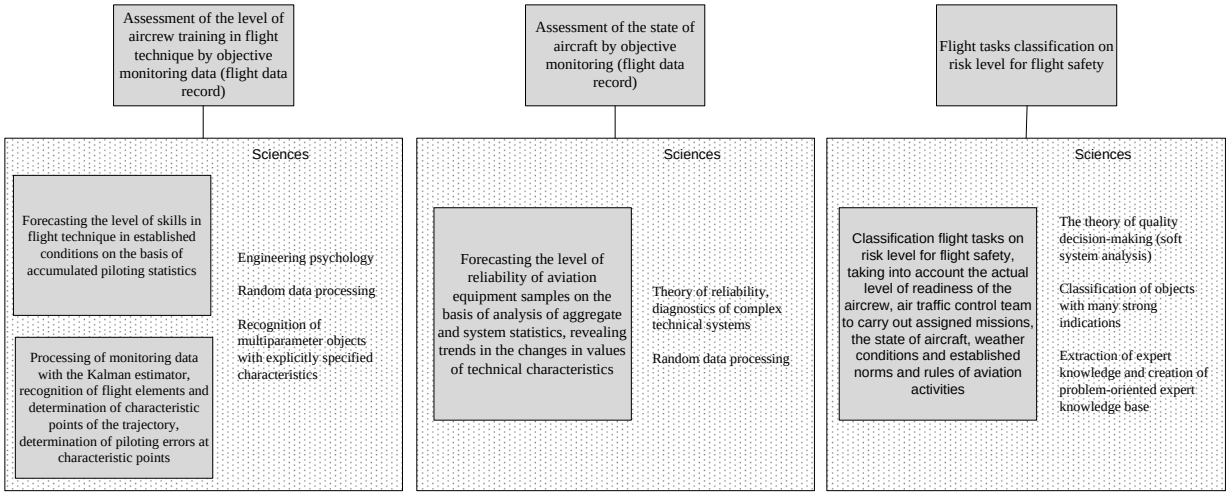

Figure 5 – Relevant scientific problems for solving the problem of the automated risk management for the flight safety of military aviation, taking into account the human factor

4. Conclusion

1. Nowadays in the flight safety area, the organizational aspect is becoming more and more relevant, when failures in the operation of the automated system protection system are considered as remote consequences of the organizational decisions taken earlier. These consequences, being a hidden factor, are manifested. They lead to aviation accidents that happen as a result of human errors, equipment failures, unexpected weather changes and other conditions.

2. When creating the advanced control systems of the flight safety, the main criterion for their successful implementation should be considered – the achievement of reliable detection of dangerous factors in their hidden stage. Especially it concerns the control of the human factor, as the main cause of adverse factors.
3. Enhancing the effectiveness of revealing hidden hazards and risks is possible due to the increase in the completeness of the analyzed information which will take into account information on aviation specialists, equipment, weather, content and complexity of the planned flight missions.
4. The information considered in the analysis of the flight safety is possible only on the basis of the introduction of some automation tools that allow the centralized collection, processing and comparison of large volumes of data using special mathematical models and methods.
5. The proposed concept for the creation of the advanced automated control system of the flight safety in aviation contains risk management for the flight safety associated with the designation of an insufficiently trained aviation staff (aircrews, air traffic control team) to carry out planned flight and other aviation activity missions in specified conditions.
6. The scientific problem in the creation of a special software for the advanced flight safety control system consists in the development of mathematical methods and models for assessing the current state of the aviation system and identifying dangerous factors and risks for the flight safety in their hidden stage.
7. When solving the problem of creating special software of the automated flight safety control system, the following scientific tasks are considered relevant to the creating of methods:

– the assessment of the aircrew pilotage technique according to the objective control data;

– the assessment of the aviation equipment state based on objective control data;

– the classification of the planned flight missions according to the risk level, based on the actual state of affairs in the aviation system.

8. The authors consider that in the case of successful implementation of such automated flight safety control system, which, if possible, would cover all subjects of the aviation activity in the national aviation system, and thus a significant increase in the level of the flight safety will be obtained. The possibility of occurrence of accidents and serious incidents both through human fault and due to the influence of other factors will be substantially reduced.

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