AEROSPACE SYSTEMS FOR MONITORING AND CONTROL

UDC 629.73:681.51(045)
DOI: 10.18372/2306-1472.82.14606

Volodymyr Kharchenko[1]
Dmytro Babeichuk[2]
Ruslan Pechevysty[3]
Oleh Alexeiev[4]

FORMATION OF INDICATORS AND CRITERIA FOR ASSESSING THE IMPACT OF RISKS ON AVIATION ACTIVITY

National Aviation University, 1, Lubomyr Husar ave., Kyiv, 03058, Ukraine
E-mails: [1]kharch@nau.edu.ua, [2]babeichuk@gmail.com, [3]rick999@ukr.net, [4]oalexeiev@yahoo.com

Abstract

A feature of modern aviation risk management is the lack of a unified approach to flight safety risk assessment, which is manifested by the fact that different risk measures are used in practice. An effective approach to provide a comprehensive assessment of aviation risks has not yet been proposed. Aviation activities are subject to specific risks, due to their sectoral identity and flight safety features. The article deals with the implementation of a combined approach to preventive management of aviation risks, which requires identification and monitoring of risks under uncertainty.

Keywords: external pilot; remotely piloted aircraft; workload; fatigue; risk; theoretical basis

1. Introduction

Given the potential for a positive impact of risks on aviation activities, understanding of the risk identification process should also be complemented by the identification and analysis of factors that can have not only a negative but also a positive impact on the enterprise.

From the algorithm of the combined approach developed in this paper, it follows that risk identification should be carried out at the stages of identification and analysis of potential risks and risk monitoring. Identification at the stage of identification and analysis of potential risks is necessary for the formation of their system and the choice of methods and tools for their management, at the monitoring stage identification is necessary for the identification of the main factors that caused the implementation of risks, assessment and indication of the effectiveness of the risk management measures and, if necessary, adjustment these measures. At the same time, the information obtained during the risk monitoring process should be used to accumulate the database needed to correct the system of potential risks and to select methods and tools for managing them. Thus, the process of risk identification at the stages of identification and analysis of potential risks and risk monitoring is iterative, since the system of potential risks is adjusted according to the results of monitoring [1].

The lack of complete and reliable a priori information about the nature of changes in the conditions of the external and internal environment of the enterprise in the future, and the complex unformalized nature of the influence of management decisions in different areas of activity of industrial enterprises on other areas of their activity, necessitates the construction of a system of interrelated indicators that provide identification and risk monitoring.

2. Problem statement

First of all, to solve this problem it is necessary to analyze similar methods to determine the level of workload. This will allow forming the basic concept, requirements and building the basis for new theoretical bases. In the next stage it is necessary to analyze the constituent elements, their characteristics and features, which will indicate exactly what to pay attention to when determining the constituent elements for the new theoretical basis [2].

The next step will be to identify the constituent elements that can affect the level of the external pilot workload. It is necessary to determine how and what they depend on, study their interaction and peculiarities; find the necessary distinguishing features, etc. Having received all the necessary data, it is possible to move on to deriving the theoretical bases – the creation of formulas, the order of calculation and description.

Such a system imbalances the indicator system with the strategic and operational management tool, the main elements are the map, the map of the balance indicator and the control panel. It is based on the concept of Norton and Kaplan, as well as key indicators of efficiency. In principle, there is a balanced system of indicators and a complete set of indicators in that all key indicators must be included in order to ensure that there is no reason to be unavailable [3].

3. Review of existing solutions

Ukrainian aviation is in the process of continuous development, adapting to changes in the socio-economic environment and the political situation in the country and in the world as a whole.

Ongoing changes need to be refined for methods of analyzing flight safety management, for developing procedures based on this analysis of flight safety management decisions and for maintaining them at an acceptable level [2].

The implementation of this requirement implies the need to process large amounts of information, the effective use of which is possible as a result of the introduction of modern structural methods and algorithms to support the decision making of both strategic and tactical decisions.

Unfortunately, as the analysis of flight safety shows, the analytical work is focused on gathering statistics on events and using a retroactive method of flight safety management.

Therefore, there is an urgent scientific and practical problem, which consists in the development, application and improvement of mathematical models, methods, oriented as a prospective planning in the field of information and analytical provision of procedures for preventive flight safety management [3].

Analyzing the work of scientists in the field of aviation activity, it is determined:

- in [4] – analytics of transition from system efficiency of information-control systems to process is carried out. Ways of switching from system to process efficiency to ensure the reliability, security and efficiency of the processes of functioning of information management systems;
- in [5] – a systematic approach to safety management system for the investigation of safety failures of the system "aircraft - crew - environment" is outlined;
- in [6] – a number of aspects of the solution of problems, based on the analysis of airworthiness of aircraft are considered. The description of modern airborne systems of operational control, which have been widely used in the civil aviation of the Russian Federation, both to solve the problems of maintaining the airworthiness of the aircraft, and to ensure the basic functional orientation of the registrars, as information support in the investigation of accident and incidents;
- in [7] – the possibility of application of interval analysis in risk management is considered, namely, in solving the problems of quantitative estimation of risk of accident under conditions of uncertainty and ambiguity, under conditions of communication of risk of accident caused by changes in external conditions;
- in [8], we proposed to modernize the rare-case simulation method by determining the volume of the auxiliary sample, which allows us to more accurately estimate the likelihood of the aircraft approaching by one coordinate.

It should be noted that considerable attention of these scientific works is focused on local actions on forecasting, identification and management of risk factors, also the main methodological questions on creation and application of mathematical models, methodological approaches to the implementation of initial stages of modeling: conceptual design, formalization and algorithmization. However, there are virtually no materials containing a comprehensive integrated solution to the problem of flight safety management.

4. Theoretical basis for calculating the external pilot workload

Measuring the effectiveness of risk management includes an assessment of how well it is being done. Although, as a rule, the intersection of two circles is incomplete and non-zero and presents many situations in which hazards and threats are covered by rules, usually technology, training, or procedure oriented. They are the dangers of "ordinary causes" discussed above. Note that this is a subset of compliance, and if all the rules properly take into account the recognized levels of danger, then it will represent the extent of compliance.

The Safety Management System (SMS) request fits into this area of overlap between circles. This is based on the fact that the need for SMS is common to all service providers. It also recognizes that effective compliance entails the use of the Safety Risk Management (SRM) processes of the operator in order to adapt the method to suit his situation.

The etiology of special situations in flight stipulates that the methodology for estimating recommended indicators in the ICAO documents is not specified, but the specified level of flight safety is indicated, and the introduction of an acceptable level of aircraft operators is punished at the state level of monitoring the indicators of the aircraft, and incident predictors are not taken into account, which are not subject to classification under the definition of "incidents".

Given the ordinariness and incompatibility of the listed accidents in one flight, given that each event on the hierarchy below the event "K" has a certain probability of development in "K", the probability of the event "K" in flight in the general form is represented as the sum of the probabilities "K" for each of the identified of accidents:

$$P(K) = \sum_{i=1}^{m(j)} \sum_{j=1}^{n} P_{ij},$$

where $P(K)$ – the probability of the event "K" at the i-th event of the j-th type, i – the number of accidents j-th type, $i = 1,2, ...,n$; j – event type number, $j = 1,2, ...,$ n – considered number of accident of j-th type; n is the number of types of events selected for evaluation when estimating the probability of a K event.

The estimation of probability conditions when an aviation event is small can be determined by the statistically established ratio of the number of accident of each type in the totality of these events, that is, the "Pyramid of risk", which explains the rule "1: 600", the ratio "1 -10-30-600 "refers to accidents and incidents and indicates that only a methodological error of estimation due to such discretization of the ratio can reach 10%.

The decision of the main task of providing safety – prevention of accident caused the need to investigate the reasons of these events by the state. As far as incidents are the harbinger of accident, the practice of state investigation into the causes and these events has long been established in the world [3,4].

However, in practice, there is a large underlying layer of events that can be seen as predictors (prerequisites) of aviation incidents. These are events related to deviations in the actions of aviation personnel and the operation of aviation equipment, which according to the accepted classification by their consequences do not belong to accident and incidents.

The recurrence of these events is far higher than any other, which makes information about them very attractive for use in the proactive management of safety, and the significant expansion of information flows in SMS through the collection of data for continuous monitoring of normal flights that do not contain events that require organ state investigation.

According to safety management system, the upper limits are set for acceptable levels of probability of occurrence of special situations in flight:

- for catastrophic situation – $Q_{KS} < 10^{-7}$;
- for difficult situation – $Q_{DS} < 10^{-4}$;
- for complication of flight conditions – $Q_{CFS} < 10^{-3}$.

If you take the unit of risk of catastrophe (as a permissible probability of occurrence of this event per 100 hours of flight), then indicators of other types of events can be determined by the formula

$$r_i = Q_1 \quad Q_i \;, i = 2,3,...,5 .$$

The ratios of normalized recurrences for classes of negative events and the degree of their danger are graphically represented in the form of a pyramid known as the Heinrich pyramid in the upper case [5,6].

A set of systematic methods for assessing the impact of the risk system on aviation performance. Thus, it is determined that the dynamics of PR consists in the gradual receipt and use of information on the components of a vector, which characterizes the freedom of choice of the operator and is indicated by $x=(x_1, x_2,\ldots,x_n)$ and $y=(y_1, y_2,\ldots,y_n)$the factors that are selected respectively by the first and second experts, who have the criteria of efficiency. $w_i=f_i(x,y)$, $i=1,2$ the lower bounds of the function are reached if f_i *is at* $X_i^0 \times \ldots \times X_n^0 \times Y_1^0 \times \ldots \times Y_n^0$ finite sets. X_i^0 *and* Y_i^0 , $x=(x_1,\ldots,x_i)$, $y=(y_1,\ldots,y_i)$, $ij=1,\ldots,n$ – truncated x and y vectors. So the strategies of the first operator will be any function of the form $x_i = (x_{i-1},\ldots y_{i-1}), i = 1\ldots n, y_{i-1}, i \le l = const$. The greatest guaranteed result and the optimal strategies of experts are determined by entering the following values:

$$L_n(x, y) = f_2(x, y),$$

$$L_j(\bar{x}_j, \bar{y}_j) = \max_{v_{j+1} \in Y_{j+1}^0} \min_{x_{j+1} \in X_{j+1}^0} L_{j+1}(\bar{x}_{j+1}, \bar{y}_{j+1}),$$

$$0 \le j \le n-1,$$

$$x_j^H(\overline{x}_{j-1}, \overline{y}_j) = \{x_j^* \mid \min_{x_{j+1} \in X_{j+1}^0} L_{j+1}(\overline{x}_j, \overline{y}) = L_j(\overline{x}_{j+1}, \overline{y_j}, x_j^*)\}$$

$$1 \le j \le n,$$

$$E_j(\overline{x}_{j-1}, \overline{y}_{j-1}) = \{\tilde{y}_j \mid L_j(\overline{x}_{j+1}, \overline{y}_{j+1}, x_j^*, \tilde{y}_j) = L_{j-1}(\overline{x}_{j-1}, \overline{y}_{j-1})\}$$

$$1 \le j \le n$$

$$M_n(x, y) = f_1(x, y),$$

$$M_j(\overline{x}_j, \overline{y}) = \inf_{v_{j+1} \in E_{j+1}(\overline{x}_j, \overline{y})} \sup_{x_{j+1} \in X_{j+1}^0} M_{j+1}(\overline{x}_{j+1}, \overline{y}_{j+1})$$

$$0 \le j \le n-1.$$

Strategy $x_j^a(\overline{x}_{j-1}, \overline{y_j})$ implements,

$$\max_{x_j \in X_j^0} M_j(\overline{x}_j, \overline{y}_j) = M_j(\overline{x}_{j-1}, \overline{y}_j, x_j^a),$$

$$1 \le j \le n$$

$$D_j = \left\{ (\overline{x}_j, \overline{y}_j) \left| \begin{array}{l} L_j(\overline{x}_j, \overline{y}_j) > L_0 \\ L_j(\overline{x}_j, \overline{y}_j) > L_1(\overline{x}_j, \overline{y}_j) \\ \dots\dots\dots\dots \\ L_j(\overline{x}_j, \overline{y}_j) > L_{j-1}(\overline{x}_{j-1}, \overline{y}_{j-1}) \end{array} \right. \right\},$$

$$1 \le j \le n.$$

There is a point in the specified area

$(x_{1j}^0, y_{1j}^0, x_{2j}^0, y_{2j}^0, \dots, x_{jj}^0, y_{jj}^0)$ that

$$K_j = \begin{cases} \sup_{(\overline{x}_j, \overline{v}_j) \in D_j} M_j(\overline{x}_j, \overline{y}_j) = M_j(x_{1j}^0, y_{1j}^0, x_{2j}^0, y_{2j}^0, \dots, x_{jj}^0, y_{jj}^0) \\ -\infty \end{cases}$$

$$D_j \ne \phi \quad D_j = \phi \quad 1 \le j \le n.$$

The desire of each of the experts to increase the guaranteed result is realized in the following way: when given by the first expert of the strategy, the expert chooses any strategy, from which it follows that the expert's participation in the interaction procedure is reduced to solving the optimization problem. The first expert, when choosing, strives for the realization of its greatest guaranteed result [7,8].

5. Conclusions

Evaluation of the effectiveness of the developed recommendations was carried out according to the following criteria: 1) effectiveness: the number of documents processed, the number of documents delayed, the number of errors in the documents; 2) resource intensity: the amount of expenditures on stockpiling, technology, training; 3) efficiency: time of processing of documents.

Consistent increase in the power of the main input stream reveals the structural elements of the computer network, which are vulnerable and weak elements of the studied organizational system in terms of information security. The method of estimation of safety based on the construction of a system of models of information confrontation is proposed. After determining the typical structures of such models, a process simulation is performed in which the interaction of the most significant factors is evaluated in a given range of change in the original data [3].

Thus, the achievement of this goal is ensured by the consistent implementation of the following actions:

- selection of existing techniques to evaluate the performance of the critical system against the target;
- identification of information parameters in the developed methods, as well as the range of their changes in destructive actions;
- development of a calculation algorithm when changing the output data in the specified range of information impact.

Developing on the basis of existing methods in which variables are indicators of safety flight by the target indicator, conducting these studies in order to obtain baseline data for models of complex estimation of aviation activity in real time.

Assessment methodology can be used both at the corporate and industry (state) levels to solve the following problems of BP management:

- guaranteeing an acceptable level of safety in terms of the number of accident with human casualties;
- control of the achieved (current) level of safety for compliance with the acceptable level (including at the initial stage of operation of the aircraft operator;
- forecasting the level of flight safety in airlines (aviation units) - both statistical and expert;
- flight safety level management within the corporate flight safety management system (accident probability management in flights, including preventive), a priori and a posteriori evaluation of airline flight safety level management effectiveness.

References

[1] Alexeiev O.M. (2017). Municipal aviation functioning as one of future types of the aviation activities /V. Kharchenko, O.Alexeiev, R. Yurchik, I.Ali. // Proceeding of the National Aviation University, №2(71), – pp.24-30.

[2] Alexeiev O.M. General principles of decision– making support in provision of guaranteed level of safety / *V. Kharchenko O. Alexeiev //*

Proceeding The seventh world congress “Aviation in the XXI-st century” Safety in aviation and Spase Technologies/September 19-21, 2016, Kyiv.

[3] Alekseev O.N. (2018). Systema upravlinnya ryzykamy aviatsiynoyi diyal′nosti. [The system of managing the risks of the aviation industry]. Kharchenko V.P., Alekseev OM., K.: NAU, 241 p. (in Ukrainian)

[4] Al-Ammory Ali. (2007). Analysis of the transition from system to process efficiency of promising information management systems for new-generation aircraft vessels / Al-Ammory Ali. Flight Safety Issues. M .: VINITI, – 51 p.

[5] Zhuravleva L.A. (1997). The concept of a system safety-free base as the basis for the pre-paid security of the "ship-ship-crew-middle" system / L.A. Zhuravleva // Problems of aeronautics (thematic zbirnik of science prats). Vip. III part II. - Kirovograd, pp. 91-100.

[6] Zubkov B.V. (2007). Bezopasnost' poletov. [Flight safety. Part II. Provision and maintenance of aircraft airworthiness]. B.V. Zubkov, R.V. Sakach, V.A. Kostikov. Textbook, M.: MSTU GA, 76 p. (in Russian)

[7] Berger J. O. (1993). Statistical Decision Theory and Bayesian Analysis / J. O. Berger. – New York : Springer, – 569 p.

[8] Kharchenko V.P., Kukush A.G., Znakovskaya E.A. (2003). Modeling of aircrafts collision using importance sampling technique // Proceeding of the National Aviation University – №2, pp. 27–30.

В.П. Харченко[1], Д.Г. Бабейчук[2], Р.П. Печевистий[3], О.М. Алєксєєв[4]

Формування показників і критеріїв оцінки впливу ризиків на авіаційну діяльність

Національний авіаційний університет, просп. Любомира Гузара, 1, Київ, Україна, 03058
E-mails: [1]kharch@nau.edu.ua, [2]babeichuk@gmail.com, [3]rick999@ukr.net, [4]oalexeiev@yahoo.com

Особливістю сучасного управління авіаційними ризиками є відсутність єдиного підходу до оцінки ризику безпеки польотів, що проявляється тим, що на практиці застосовуються різні заходи ризику. Ефективний підхід до надання всебічної оцінки авіаційних ризиків ще не запропонований. Авіаційна діяльність піддається певним ризикам через їх галузеву ідентичність та особливості безпеки польотів. У статті розглядається реалізація комбінованого підходу до превентивного управління авіаційними ризиками, що вимагає ідентифікації та моніторингу ризиків у невизначеності.

Ключові слова: зовнішній пілот, віддалене пілотування літального апарату, навантаження, втома, ризик, теоретична база

В.П.Харченко[1], Д.Г. Бабейчук[2], Р.П. Печевистый[3], О.Н. Алексеев[4]

Формирование показателей и критериев для оценки влияния рисков на авиационную деятельность

Национальный авиационный университет, просп. Любомира Гузара, 1, Киев, Украина, 03058
E-mails: [1]kharch@nau.edu.ua, [2]babeichuk@gmail.com, [3]rick999@ukr.net, [4]oalexeiev@yahoo.com

Особенностью современного управления авиационными рисками является отсутствие единого подхода к оценке рисков безопасности полетов, что проявляется в том, что на практике используются различные меры риска. Эффективный подход к комплексной оценке авиационных рисков пока не предложен. Авиационная деятельность подвержена конкретным рискам, обусловленным их отраслевой идентичностью и особенностями безопасности полетов. В статье рассматривается реализация комбинированного подхода к превентивному управлению авиационными рисками, который требует выявления и мониторинга рисков в условиях неопределенности.

Ключевые слова: внешний пилот, дистанционно пилотируемый летательный аппарат, нагрузка, усталость, риск, теоретические основы

Volodymyr Kharchenko. Doctor of Engineering. Professor.
Vice-Rector on Scientific Work of the National Aviation University, Kyiv, Ukraine.
Editor-in-Chief of the scientific journal Proceedings of the National Aviation University.

Winner of the State Prize of Ukraine in Science and Technology, Honored Worker of Science and Technology of Ukraine.
Education: Kyiv Institute of Civil Aviation Engineers, Kyiv, Ukraine.
Research area: management of complex socio-technical systems, air navigation systems and automatic decision-making systems aimed at avoidance conflict situations, space information technology design, air navigation services in Ukraine provided by CNS/ATM systems, unmanned aerial systems.
Publications: 579.
E-mail: knarch@nau.edu.ua

Dmytro Babeichuk.
Senior teacher. Department of aeronavigation systems, National Aviation University
Education: Kirovohrad flight academy of Ukraine, 1985
Research area: safety management system, risk management, flight safety.
Publications: 8.
E-mail: babeichuk@gmail.com

Ruslan Pechevysty.
Ait traffic control operator of UkSATSE in Boryspil Flight information region.
Education: Kyiv International University of Civil Aviation, Ukraine (1999).
Research area: safety management system, risk management, flight safety.
Publications: 4.
E-mail: rick99@ukr.net

Oleh Alexeiev. Candidate of Engineering
Assosiate Professor. Department of aeronavigation systems, National Aviation University
Education: Kirovohrad flight academy of Ukraine, 2000
Research area: safety management system, risk management, flight safety.
Publications: 60.
E-mail: oalexeiev@yahoo.com