AEROSPACE SYSTEMS FOR MONITORING AND CONTROL

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MODERN OPPORTUNITIES FOR AIR SAFETY MANAGEMENT

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Abstract

The article deals with the management of the basic elements of safety management system (SMS), due to a radical change in industrial relations and the creation of "non-punitive" production environment, and determination of the attitude to the experts in the course of their erroneous actions, as well as the introduction of a system of voluntary notification of personnel about dangerous factors (risk factors), mistakes and incidents. The basis for the creation of reliable functioning of SMS is the formation of modern professional and corporate culture in the airline, enterprise, aviation administration and more. An important part of it is a positive safety culture, which in the aggregate should allow us to reach an acceptable level of safrty flight.

Keywords: risks; decision making; risk factors; causation; decision support system

1. Introduction

Considering the statistic for the last decade on aviation events and incidents, issues of ensuring a guaranteed level of safety flight are the most relevant, since the problematic issues in the functioning of aviation activity are explained by the lack of general theoretical framework and generally accepted science-based approaches to flight safety management, the development of which should be based on the ICAO requirement, which specifies that no region should have an incident frequency greater than twice that is universal. These are the main directions:

- mandatory procedures to ensure the development and implementation of a flight safety management system;
- mandatory procedures to ensure the direct management of the safety flight within the accepted or established level (continuous monitoring and regular assessment of flight safety, corrective actions necessary to maintain and monitor agreed risk performance, analysis of flight information, incident risk management, etc.).

2. Analysis of recent research and publications

Various aspects of risk management in socio-economic systems are considered in [1-3], in these works the nature of the occurrence of risks is studied, their classification and various methods of qualitative and quantitative assessment are presented, recommendations for organization of risk management and decision-making in the conditions are offered of uncertainty. In [4, 6], approaches to the use of economic and mathematical methods at different stages of risk management have been proposed.

The analysis of modern scientific work has shown that nowadays statistical methods are often used for risk assessment, which include Bayesian networks - an effective tool for graphical representation of cause and effect relationships between many variables. At the same time, the practical methods and tools of risk management do not fully allow to keep a record of various types of factors of uncertainty of information and to analyze the quantitative and qualitative characteristics of risks, and, consequently, to carry out risk assessment and management in the light of -the condition and features of the internal and external environment of the enterprise.

Purpose of the article – in view of the above, there is no need to develop a methodology for providing and maintaining a guaranteed safety flight in aviation activity (hereinafter methodology) is to integrate into a single complex tasks of evaluation, verification and security of aviation actovity, as a complex hierarchical structure with independent critical elements, as well as hardware, software, network and ergonomic components, which are also a safety tool.

3. Theoretical basis for calcuating the external pilot workload

Aviation security is considered to be a state of the art of non-aviation, in which the risk of causing damage to people or property is reduced to an acceptable level as a result of a continuous process of determining and managing the level of danger in the following areas [3]:

- flight safety – a condition in which the risk of injury or injury to persons / property is limited to an acceptable level;
- aviation security – the state of protection of civil aviation against acts of unlawful interference with its activities;
- environmental safety – the state of environmental protection from the negative consequences of aviation activity;
- economic security – the state of the most efficient use of resources to prevent threats and ensure the stable functioning of aviation;
- information security – state of aviation security from internal and external information threats.

State regulation of civil aviation activities is performed by the State Aviation Service of Ukraine. One of the areas of implementation of comprehensive measures for ensuring flight safety, aviation, environmental, economic and information security is the certification of aviation entities [3]. In the conditions of technology development and improvement there is a problem of “human factor”. In managing complex processes, which is more acute for aviation than for most life-threatening industries. This is primarily due to the stringent requirements imposed on the human operator due to the high speed of processes occurring in the aviation ergatic system and their potential danger to human life and health.

The prevention of adverse aviation events in civil aviation has so far relied mainly on the concept of flight safety, the main principle of which is a retroactive approach, the essence of which is that an aviation accident prevention system and an incident - aimed at strict adherence to regulatory requirements and implementation of preventive recommendations developed on the basis of the investigation of the incident [3]. This approach does not imply continuous pre-emptive work aimed at preventing negative events before they occur. Therefore, it does not meet the current requirements for flight safety.

At this point, there is a new proactive approach to over-running incident, the so-called proactive approach. The new ideology of preventing incident and incidents involves the creation of a flight safety management system at the airline, which:

- detects actual and potential security threats;
- guarantees the adoption of corrective measures necessary to reduce risk/hazard factors;
- provides continuous monitoring and regular assessment of the achieved level of flight safety.

This approach in the prevention of aviation actions was called "proactive" [1].

In addition, the basic elements of safety management system (SMS) are security policy, a radical change in industrial relations and the creation of a "non-punitive" production environment, determine the attitude to professionals in the performance of erroneous actions, as well as the implementation of a system of voluntary notification of staff about dangerous factors (risk factors) , soaps and incidents. The basis for the creation and reliable functioning of SMS is the formation of modern professional and corporate culture in the airline. A positive security culture becomes an important part of it. All this should allow to reach an acceptable level of aviation activity.

At the same time, when considering the management of aviation activity, it is necessary, first of all, to ensure that the aeronavigation system has an optimal (strictly balanced) structure, reliable functioning of each component and good protection against negative phenomena.

Thus, safety management is a fundamentally new highly effective way of preventing adverse aviation events, fundamentally changing the style of production activity and industrial relations. The transition to safety management is a radical one, in the process of which a number of problems should be solved. However, the implementation of SMS does not undermine the development of standards and their strict implementation. For a deeper understanding of the ideology of air traffic control, it is advisable to dwell separately on the content of a "proactive" approach in addressing aviation accident prophylaxis.

Performance-based approach - approach. In the case of ICAO, it constantly develops and refines more proactive, risk-based methods to further reduce the number of aviation events in the world, and calls on aviation communities to recognize the importance of adopting a unified global approach to improving and monitoring security [2].

The modern performance-based approach [5] is based on the following three principles:

- the main focus on the desired/necessary results;

- making informed decisions, focused on the desired / desired results;

- use of facts and data in making decisions.

The principle of "use of facts and data in decision making" suggests that the tasks must meet the SMART criterion [5], which is an abbreviation of five English words:

– specific (specific),
– measurable,
– achievable,
– relevant (comparative),
– timebound (timed).

Such a level of accuracy of task definitions can only be achieved by a consistent and structured description of the heterogeneous components of the aviation industry - aviation enterprises, aviation personnel, aviation infrastructure, technical equipment, procedures, rules and information aimed at creating conditions and the use of airspace by a person using aircraft [6, 7].

As part of improving the new concept of incident prevention, the ideology of flight safety management with quantitative assessment of risk in terms of risk and uncertainty is proposed.

Innovative processes in SMS are related to the use of management tools of all kinds.

The implementation of the SMS functions requires not only abstract ideas, goals and strategies to achieve them. Non-essential mathematical justification for each decision, supported by the analysis of statistical, financial and economic data on the state of the internal and external environment of SMS. In addition, the implementation of the management decision itself requires the use of a number of mathematical tools to calculate, control and predict the target values of strategic indicators of the implementation of a particular program or project. When performing different calculations, a large number of factors and indicators must be taken into account, as well as risk assessments. Various types of information systems are used to simplify these tasks.

Consider the basic mathematical methods used in innovation. We give a classification of methods depending on the type of solved problems.

The method of chain substitutions allows you to mathematically determine the dependence of the main characteristics of the organization's activities on the factors that affect it. In addition, such dependence will be numerically significant and can be analyzed in the implementation of different scenarios of the flight safety process. As a result, the organization will be able to develop preventative measures to respond to changing factors. In order to identify the impact of each factor on the considered indicators, use the method of elimination.

Factor analysis is a procedure for establishing the force of the influence of factors on a function or a result (a useful effect of the object, the elements of total costs, labor productivity, fund-giving, etc.) in order to rank factors for the development of a plan of organizational and technical measures to improve function.

All the above methods of analysis should be used when conducting system analysis.

System analysis – a comprehensive analysis of an object as a system from the standpoint of a systematic approach, including:

- analysis of the quality level of all components of all safety flight system sub-systems;

- analysis of the effects of external and internal factors;

- analysis of the scientific level of risk management.

With safety flight, the task of forecasting is one of the main tasks. Because all investment calculations allow the use of the forecast values of the main indicators of the organization.

The regulatory forecasting method can be used for various purposes. Normative forecast means target forecasting.

One of the most common methods of normative prediction can be identified: information-logical models, goal trees, flowcharts of successive tasks, morphological models. Goal trees can be used to analyze systems or processes for presenting them in the form of levels of complexity, levels of causal relationships, or ie-rarchical levels. In cases where the system or process can be decomposed into elements, morphological models can be used that can be transformed independently. In cases where the system, process can be represented in the form of one, as well as several chains of successive stages, you use the flowcharts of the sequence of tasks.

Extrapolation is a method of scientific research, which is based on the dissemination of past and present tendencies, patterns, relationships to the future development of the object of forecasting. The purpose of extrapolation methods is to show what state an object may come to in the future if its current is developed at the same speed or acceleration as in the past. The use of extrapolation methods implies two assumptions: a) basic factors, trends of the past will retain their manifestation in the future; b) the phenomenon under study develops on a smooth trajectory that can be expressed, described mathematically.

Parametric forecasting methods are divided into two types: specific indicators and regression equations.

To establish regression equations, it is necessary that the number of statistics be at least three times the number of factors. For facilities that do not meet these requirements, the benefit or cost is recommended to be determined by specific indicators.

Statistical forecasting methods incorporate a large number of modern methods of analysis and forecasting based on statistical information. The scientific base of statistical forecasting methods is applied statistics and decision theory. Methods and tools of applied statistics are applied in many fields of activity of organizations. They are used not only for forecasting. Economics trick is responsible for solving economic problems within the framework of applied statistics.

The methods that can be used in forecasting include: regression analysis, time series analysis, panel analysis.

Decision-making theory is based on the use of concepts and methods of mathematics, economics, statistics, management and psychology in order to study the patterns of choice of alternatives. The core of the theory is the method of choice under uncertainty. Prediction is a task in which the researcher is forced to face a great degree of uncertainty about the realization of certain events in the future. In such a situation, predictions are made of a possible event implementation. The choice is then made using one of the tools of decision theory, for example by fuzzy logic.

Artificial neural networks provide great opportunities to make predictions of a new level of accuracy. Unlike the standard forecasting methods described above, they involve the construction and calculation of nonlinear mathematical models. This greatly increases the accuracy of the forecasting and provides additional accounting for more factors that affect the forecast parameter. The ability of a neural network to predict is directly mediated by its ability to generalize and highlight hidden relationships between inputs and outputs. After training, the network is able to predict the future value of a sequence based on several previous values and (or) any current factors. It should be noted that forecasting is only possible when previous changes really do determine the future.

Another task that needs to be solved within the safety flight is optimization. The solution to this problem is due to the use of linear and nonlinear programming methods, as well as special methods of operations research. Linear programming - linear transformation of changes in systems of linear equations. These include the simplex method, the distribution method, the static matrix method for solving material balances, game theory, the transport problem, and so on.

The index method finds its application at almost all stages of innovative design. It allows you to compare the current performance of a project organization with past values. It allows to compare the characteristics of products and in the implementation of the project can serve as a tool for assessing the degree of implementation of the plan.

More over, the index method can also be used to solve some prediction problems. For example, the index method is used to predict the useful effect, the power of each type of equipment. Types of increased costs of resources as a whole at the enterprise. The forecast period is up to 5 years.

Similarly, a comparative method, a balance method, a method of chain substitutions, a method of elimination, a graphical method can be used to solve a number of narrow problems at different stages of development of an innovative project. All of these methods can act as elements of a systematic analysis of an organization conducted in the framework of evaluating the possibility of implementing an innovative project.

More profound methods of analysis, such as factor analysis, must be used to make management decisions on project implementation.

Artificial neural networks – mathematical models, as well as their software or hardware implementations, built on the principle of the organization and functioning of biological neural networks - between the nerve cells of a living organism. The advantages of neural networks over basic methods in pro-gnosis lie in their ability to isolate and generalize latent relationships between input and output. If there is any connection between the input and output data, even if it cannot be detected by traditional correlation methods, then the neural network can automatically tune into it with a given degree of precision. In addition, modern neural networks have additional capabilities: they allow you to evaluate the relative importance of different types of input information, reduce its volume without losing significant data, recognize the symptoms of approaching critical situations, etc.

Consider the main tasks that neural networks can solve in the framework of innovative design:

- cash flow forecasting;
- sales forecasting;
- forecasting demand for new products;
- forecasting changes in the price level of materials and components of the product;
- forecasting the cost of an innovative product.

The disadvantage of neural networks is that they are not child-friendly.

We have the fact that after training there is a "black box" that somehow works, but the logic of decision making by the neural network is completely hidden from the expert. In principle, there are algorithms of "extracting knowledge from the neural network" that formalize the trained neural network to the list of logical rules, thereby creating a network-based expert system. Unfortunately, these algorithms are not built into neural network packages, and the rule sets generated by such algorithms are quite voluminous.

Consider some of the most common neural networks:

1. Perceptrons – systems consisting of a single layer of artificial neurons, connected by auxiliary weighting factors with multiple outputs. The essence of the operation of perceptrons, from the point of view of solving specific problems, is to classify (generalize) the input signals. Therefore, within the design of an innovative project, perceptrons can only be used to solve classification problems.

2. Counter-propagation neural networks – the union of different neural structures in a single architecture or, in other words, a network consisting of the input layer of neurons and the so-called layers of Kohonen and Grossberg neurons. A distinctive feature of this network is its good ability to generalize, which allows you to more effectively solve the problem of pattern recognition and clustering, compared to the networks of one hidden layer of neurons, even with incomplete or noisy input vector. Due to its simplicity and ability to learn quickly, the network is an effective forecasting tool that enables you to build dependencies and functions.

3. Hopfield neural networks – a network consisting of a single layer of neurons, the number of which is simultaneously the number of inputs and outputs of the network. Each neuron is connected by synapses to all other neurons, and also has one input synapse through which the signal is input. This network is most applicable in solving the problem of image restoration. Within the framework of innovative design, this network is not applicable.

4. Radical organic matter network – this network is a two-layer network with no feedback, which is capable of breaking a layer of radially symmetric neurons (template layer). Networks solve similar neural network tasks described above in innovative design, but have several advantages over direct-to-network networks. First, as already stated, they simulate a arbitrary nonlinear function with just one intermediate layer, thereby eliminating the need to solve the number of sha-dit. Secondly, the parameters of the linear combination in the output layer can be fully optimized with the help of well-known linear simulation methods, which work quickly and do not have difficulty with local minima, so interfere with learning using the error back propagation algorithm. Therefore, the JAVR network learns very quickly (an order of magnitude faster than using the error reverse propagation algorithm).

5. The probabilistic neural network is estimated by nuclear approximation.

6. Generalized regression neural network – arranged similarly to a probabilistic neural network (Rome), but it is intended to solve regression problems, not classification. The network replicates all the training observations inside and uses them to evaluate the response at any point. The final baseline network estimate is obtained as the weighted average of the outputs across all training observations, where weights reflect the distance from those observations to the point at which the assessment is made (and thus closer points contribute more to the assessment).

4. Conclusions

Unlike the flight safety system, the SMS is not focused on anticipating a negative event, but on detecting unsafe facts in the aviation system that have not yet emerged but can cause accidents, crashes and aviation growth. Thus, security is a dynamic characteristic of the aviation industry through which risk factors for flight safety must be steadily reduced. It is important to note that the adoption of performance indicators for flight safety is often influenced by national and international standards as well as cultural characteristics [4]. As long as the risk factors for flight safety and operational errors are reasonably controlled, such an open and dynamic system as civil aviation can be managed, providing the necessary balance between the operation of modern aircraft and the requirement to protect passengers and property[3].

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Сучасні можливості для управління безпеки польотів

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У статті йдеться про управління основними елементами системи управління безпекою, що зумовлено докорінною зміною виробничих відносин та створенням "не карального" виробничого середовища, а також визначення ставлення до експертів у процесі їх помилкових дій, а також запровадження системи добровільного сповіщення персоналу про небезпечні фактори (фактори ризику), помилки та інциденти. Основою для створення надійного функціонування системи управління безпекою є формування сучасної професійної та корпоративної культури в авіакомпанії, на підприємстві, в авіаційній адміністрації тощо. Важливою його частиною є позитивна культура безпеки, яка в сукупності повинна дозволяти нам досягти прийнятного рівня польоту в безпеці.

Ключові слова: ризики, прийняття рішень, фактори ризику, причинна ситуація, система підтримки прийняття рішень.

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Современные возможности управления безопасностью полетов

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В статье рассматриваются вопросы управления основными элементами системы управления безопасностью обусловленные радикальным изменением производственных отношений и созданием «некарательной» производственной среды, а также определением отношения к специалистам в ходе их ошибочных действий. , а также внедрение системы добровольного оповещения персонала об опасных факторах (факторах риска), ошибках и инцидентах. Основой для создания надежного функционирования системы управления безопасностью является формирование современной профессиональной и корпоративной культуры в авиакомпании, на предприятии, в авиационной администрации и многое другое. Важной частью этого является позитивная культура безопасности, которая в совокупности должна позволить нам достичь приемлемого уровня безопасности полетов.

Ключевые слова: риски, принятие решений, факторы риска, причинно-следственная связь, система поддержки принятия решений.

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