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AVIATION SAFETY ASSESSMENT AND FORECASTING: SCIENTIFIC AND PRACTICAL ASPECTS

The article is devoted to the problems and peculiarities of the airport safety provision process. A detailed informational research was conducted on the subject. The main concepts and principles of ensuring aviation safety in air transport have been analyzed, as well as the process of organizing aviation safety at the airport. The scientific and practical aspects of aviation safety assessment and forecasting are defined. The process of checking passengers and baggage for aviation safety was analyzed. It was founded that since the development of air transport the emergence of the possibility of air passenger, baggage and various cargoes transportation, there has been a need to develop an aviation safety system ensuring human safety in various aviation complexes and airport terminals. At the initial research stage aviation safety is perceived as a state of protecting aviation from any acts of unlawful interference in its activities. The aviation industry is one of the vivid examples of possible threats to human life.

Ensuring aviation safety requires new assessments, forecasts and response to terrorist acts and unlawful interference in the operation of air transport objects. This is facilitated by introducing into airlines practice new equipment for checking the documents authenticity, identification of passengers and detecting potentially dangerous substances. Therefore, the search and implementation of an effective method for assessing and forecasting the improvement of airport aviation safety is one of the scientific and practical problems requiring an urgent in-depth research.

The study has identified the most optimal methods and techniques for conducting research and relevant approaches, analyzed the main processes of passenger and baggage control for aviation safety with the aim of improving the safety technologies.

Key words: *aviation safety, model, air transportation, airport, means of ensuring aviation safety, flight safety, assessment and forecasting the aviation safety, acts of unlawful interference in aviation activity.*

Introduction. Aviation safety is a priority area of air transport activity and it is of crucial importance for the air transport system of the entire country.

Today, in the conditions of a high terrorist threat of using explosive devices towards civil aviation facilities and aircraft, the primary task is to increase the aviation safety level. One of the main measures of ensuring aviation safety as for related threats is screening passengers, their hand luggage and baggage.

In the aviation safety sector, the analysis has shown that the following negative trends prevail in this area: terrorist activity has increased significantly, becoming more sophisticated and brutal, terrorist organizations have an access to a wide range of financial opportunities and financial criminality is increasing.

All this forces people to put more serious attention to the problem of increasing the importance of ensuring civil aviation safety. Unauthorized interference in the activities of civil aviation, even partialy, can result in significant financial, material, moral and political damage. Possible public disclosure that may accompany all incidents regarding the safety of passenger and cargo transport should also be taken into account.

The requirements for the care of air passengers when entering the controlled airport area have been in place for a long time, as well as the requirements for the care of their luggage. However, until recently, implementation of these requirements usually remained in the background. This was partly because it was much cheaper to use through-arc metal detectors or magnetometers instead of more sophisticated

X-ray equipment for such inspections, or due to the fact that the industry was limited only to the production of means of detecting metal weapons and other prohibited objects that could be hidden under the passengers' clothes.

Formulation of the problem. Recently, a certain tendency has emerged to consider the issue of ensuring aviation safety from the point of view of management level optimization and consistently solving the tasks of identification, measurement, assessment and decision-making. The analysis of the results obtained in this direction shows that there is an urgent need to address the formalized problems of the subject area provided by mathematical models of the aviation safety management process optimization.

Considering aviation safety as a subject of scientific research, it should be noted that the focus at this stage is ensuring aviation safety, i.e. supporting facilities (technology, economy, regulations, resources, etc.). Modern airports operate in a competitive environment, so the quality of service becomes an important factor in attracting transit passengers and air carriers by airlines. Most world airports operate on a commercial basis, and attracting profitable users to them is an economic necessity. While ensuring aviation safety, it is also necessary to improve the culture of air passenger service in general [1].

For IATA member states the main task of protecting international civil aviation is to ensure the safety of crew, passengers, ground staff, aircraft as well as the airport facilities and services of civil aviation against acts of unlawful interference on the ground and in flight. This can usually be achieved through a combination of activities and the involvement of different human and material resources at the international and national levels, as well as at the airport itself [2].

To ensure aviation safety, new assessments, forecasts and responses to terrorist acts and acts of unlawful interference in the operation of air transport facilities are necessary. This is facilitated by the introduction into the airlines practice of new equipment for detecting the authenticity of documents, identification of passengers and detection of potentially dangerous substances.

Thus, the search and implementation of effective assessment and forecasting methods for the improvement of airports aviation safety level are one of the scientific and practical problems urgently needing an in-depth study [3].

Analysis of recent research and publications. Issues related to aviation safety were directly or indirectly investigated by: M.M. Avakov, V.D. Bordunov, M.M. Volkov, R.O. Gerasimov, A.H. Lyakhov, Yu.M. Maleev, A.Yu. Pizhakov, V.I. Ryzhiy, G.R. Khilimov, R.I. Abeyratne, A. Abramovsky, S.K. Agrawala, Y. Alexander, I. Awford, R.P. Boyle, J. Busuttil, C.F. Butler, K Chamberlain, J.T. Choi, D.Y. Chung, J.H. Daniel, P.S. Dempsey, C. Emanuelli, A.E. Evans, M.J. Fenello, M.E. Fingerman, D. Fiorita, G.F. Fitzgerald, D. Gero, L.C. Green, B. Hoffman, B. Jenkins, N.D. Joyner, O.J. Lissitzyn, R.H. Mankiewicz, R.J. McGrane, E. McWhinney, A.I. Mendelsohn, A. Merari, M. Milde, J.F. Murphy and other scientists.

Task statement. The study of scientific and practical provisions of increasing the aviation safety level at the airport.

Outline of the main material of the study. Lately, there has been a clear trend to consider the protection of aviation safety in terms of aviation safety levels optimal management with coherent solutions of identification, measurement, assessment and decision-making tasks.

The heterogeneity of the environment is determined by the point character of the shield. It depends on the principles of physical implementation of protection means. Instability is determined by the dynamics of the protected object parameters.

The concept of vulnerability, which is the degree of a transport infrastructure object protection level assessed by the characteristics of protection and established requirements, quantitatively reflects the status of a protected object from the point of view of aviation safety. The concept of quality is also well known, and it is considered as the degree of compliance with the inherent characteristics of a requirement. In this context, it can be said that the quality of object protection, within certain limits, can be defined as the opposite of vulnerability.

An important conclusion can be drawn from this: the quality of transport infrastructure means of protection is an environmental parameter ensuring the protection of objects. In other words, there are imaginary zones of civil aviation objects protection that provide countermeasures against a complex of current or foreseeable threats, the controlled parameter of which is the quality of protection means.

The proposed model belongs to the class of boundary value problems described by partial differential equations. It should be noted that the proposed presentation of the mission language, especially the structural-logical model of vulnerability, is very imperfect and does not reflect some nuances of physical processes that actually exist in aviation safety. At the same time, this statement of the task is acceptable in the absence of any model at all, provided that the

model is refined after the completion of the formalization stage [4].

Based on the above, the purpose at this stage is to analyze the mathematical apparatus of boundary tasks theory to assess the possibility of its application for the formalization of parameters in the field of transport infrastructure objects protection against acts of unlawful interference.

Perfection of aviation safety provision (ASP) systems of civil aviation objects is defined by their quality, determined by the relevant indicators in accordance with the criteria for choosing the best combination. The quality indicator of the ASP system can be understood as the signs that allow us to evaluate the characteristics of the system and its functioning. These indicators are well established in terms of reliability, stability, ergonomics, cost, etc. The ASP system of a civil aviation facility is a complex territorially distributed system consisting of subsystems based on different physical principles, different engineering methods and service personnel [4].

Such subsystems include, for example, means of monitoring the state of civil aviation facilities, information support for the functioning of the air traffic control system, communication, computer equipment, information security, etc. A distinctive feature of the air traffic control system is the direct participation of aviation personnel – experts who control the process of implementing acts of unlawful interference at the civil aviation facility.

The main characteristics of ASP:

1) stability – the ability of systems to perform and timely restore their functions in the conditions of all possible types of dangerous influences (including the influence of performers) and obstacles;

2) responsiveness – the ability to respond to acts of unlawful interference in a timely manner;

3) continuity – the ability to function stably at any time;

4) secrecy – the ability to keep from the guilty the secret as to means of detecting and preventing the acts of unlawful interference against accidental and intentional destructive effects of a natural or artificial nature.

In this regard, it is necessary to formulate a concept of the ASP system effectiveness and build a criterion for evaluating the best option for its formation using values $X = \{xn\}$, $n = 1, 2, ..., N$, indicating the realized of the ASP system characteristics (topology, engineering and technical means, algorithms of the ASP system, the number and qualifications of personnel, etc.). The W^{ASP} efficiency indicator of the ASP system, in addition to other quality indicators, depends on the specific task of detecting and interrupting the act of unlawful interference [5]:

$$W^{ASP} \in \Pi \quad (1)$$

where Π – value dependent on an infinite number of the ASP system performance indicators.

It is necessary to find analytical dependencies of the efficiency indicator W^{ASP} of ASP system on the set Π values of all other indicators of its quality, as well as the set of β types of acts of unlawful interference in the activity of a specific civil aviation object and conditions ϕ for their implementation in the form of descriptions of civil aviation objects and acts of unlawful interference [5]:

$$W^{ASP} = W^{ASP}(\Pi, \beta, \phi) \quad (2)$$

At the same time, it is necessary to take into account the vulnerability of the civil aviation object and the damage to it caused by the act of unlawful interference. For this purpose, the concept of probability of losses occurrence is introduced U_{ijl} l-th type i-th civil aviation object, given its vulnerability $W_i(B_j)$ to j-th act of unlawful interference with the probability of receiving the specified damage under the condition of this act of unlawful interference implementation an indicator is offered [5]:

$$W_{ijl}^{ASP} = 1 - W_{(Uijl),}^{i}\ j = 1,2\ldots,J, l = 1,2\ldots,L \quad (3)$$

where $W_{(Uijl),}^{i} = W_{(Bj)}^{i} W_{(Uijl)} / B_j$ is formulated as the risk of the *i-th* civil aviation object receiving damage $U_{ijl} \in K_{vijl}$. Thus, risk here is a probability, $W_{(Bj)}^{i}$ – vulnerability of the *i-th* civil aviation object to the implementation of the *j-th'* act of unlawful interference in the object's activity.

$W_{(Uijl)} / B_j$ – conditional probability of receiving damage by the *i-th* civil aviation object $U_{ijl} \in K_{vijl}$ provided that the *j-th* act of unlawful interference occured; K_{vijl} – set of damage values of the *l-th* type of the *i-th* civil aviation object determining it v ($v = 1, 2, ..., v$) category of importance.

Next, an average value (for each attempt to carry out the *j-th* type of unlawful interference act) of the *l-th* type of damage is considered:

$$k_{ijl} = W_i(k_{ijl})\, U_{ijl} \quad (4)$$

From this it turns out:

$$W_{ijl}^{ASP} = 1 - k_{ijl} / U_{ijl} \quad (5)$$

where the ratio k_{ijl} / U_{ijl} characterizes the share of the loss that falles on each attempt to commit an act of unlawful interference, up to the amount of the loss upon successful implementation of this unlawful interference act. Here it can be noted that the idea of damage is constructive, but finding the average value

with an unknown probability that cannot be calculated, is impossible.

Quantitative evaluation of the performance indicator of the aviation safety provision system can be carried out on the basis of the analysis and processing of statistical data on act of unlawful interference during civil aviation facilities operation and their consequences (damages) for these facilities. At present, expert methods and methods of statistical processing of information on the quality indicators value are used to research and evaluate the quality indicators (including efficiency) of complex systems including the system of the civil aviation object – the system of its aviation safety provision, physical modeling, mathematical modeling. Expert survey by *Delphi* method is based on answers in the quantitative form.

The *Delphi method,* as some researchers state [5], can provide an assessment of the performance indicator of the aviation safety provision system, and in some cases is the only possible scientific tool for obtaining the necessary information, for example, the justification of the types of civil aviation objects categories. We can agree with the authors of the research that sometimes under certain conditions it is fair, but in general it is necessary to switch to Fuzzy Sets. The fact is that Delphi has an indicator $W^{i}_{(Uijl),}$ the frequency of implementation of the *j-th* act of unlawful interference, which led to the loss of the *l-th* type to the *i-th* object of civil aviation, makes sense, and the value of W^{ASP}_{ijl} is determined in the form:

$$W^{ASP}_{ijl} = 1 - m_{ijl} \,/\, M_{ijl} \qquad (6)$$

where m_{ijl} – number of successful implementations of the act of unlawful interference, M_{ijl} – total number of execution attempts of the act of unlawful interference.

At the same time, the lack of complete statistics, which is necessary, does not allow to forecast reliably the value of the efficiency indicator in a certain range of warnings. It is necessary to use proactive management methods according to the ICAO methodology, because there are no algorithms and methods for simple statistical forecasting with small volumes of sample results.

Physical modeling of the process of countering the violator with the aviation safety provision system is implemented during training the aviation safety provision system personnel. This is the only correct approach thgough it's non-stochastic.

Models of average dynamics, probabilistic models in a continuous system (model) of mass service, stochastic duels, discrete (Markov) chains of various forms, models of statistical tests (Monte Carlo method) are proposed in [6].

All this should be recognized as non-constructive, since there is no mass experiment. The nature of uncertainties in the actions of violators is practically not described here, with a large number of factors of various physical content contributing to act of unlawful interference implementation in the activity of civil aviation objects, which is an insurmountable obstacle for the analytical description of the risk factors affecting this process.

The concept of flight safety is based on the definition of the meaning of safety as a state of systems with an acceptable level of risk of consequences or damage in the conditions of exposure to the considered systems of dangerous factors generated by the external environment and the system itself [7].

Issues of hazard model development, risk assessment and determination of safety levels are discussed, taking into account product reliability characteristics and airworthiness indicators.

The definition and classification of risks are based on indications of risk events with the nature of events, such as randomness and consequential losses.

At the same time, the physical meaning of risk as a mathematical category and the corresponding risk value or measure of risk (a measure that can be measured or managed according to the principles of classical management theory) is useful and necessary based on the application of the concept of risk defined by the phenomena. A widely used risk assessment formula is defined as a vague set: "high risk", "low risk".

The presented risk as a characteristic of the class is reasonably considered to be a mathematical value that determines the predicted amount of danger in a dangerous state of the system when a dangerous or risky event *R* is possible (here – a discrete event that may or may not occur).

Therefore, the state of the system can be understood to a first approximation in terms of the definition of reliability theory as one of the combinations of reliability elements in such physical states as failure, fail-safe. The measure of the possibility of any noticeable states of the considered type appearance when analyzing groups of events at the stage of analyzing the structure of the result space (in the complete group of events) is irrelevant and the distribution function of events or other indicators, the method of linking event properties with type arguments, is not taken into account for probability parameter in the form of a random moment during element failure. This approach makes it possible to develop models of system hazards, as required by ICAO, Boeing, IATA, and the Federal Aviation Administration for flight safety management in civil aviation. Such an approach is proposed here for aviation safety provision.

Conclusions. Aviation safety is a set of measures, as well as human and material resources, aimed at protecting civil aviation against acts of unlawfull interference in its activities. Aviation safety is a priority area of air transport activity and is of key importance for the transport system of the entire country.

The research has found that in order to constantly improve the effectiveness of aviation safety, the state must create appropriate organizational conditions that will ensure the sustainable functioning of special institutional mechanisms – organizations (scientific and educational centres, institutes, associations) at the international, regional, national or branch level. Their activities should be aimed at: practical implementation of the strategy and tactics of development and improvement of the aviation safety system; solving the key problems of increasing the efficiency of aviation area.

It should be noted that increasing the productivity of civil aviation facilities raises the need to introduce and implement precautionary measures to ensure their safety. So, the introduction of modern technologies ensuring a high level of aviation safety in an aviation enterprise is an urgent issue for the development of airlines.

The research has analysed the state of the global air transport market and an assessed the conditions of aviation safety at the global level, based on which it was established that the issue of ensuring flight safety and improving the aviation safety level is higly significant and requires constant monitoring, as well as the improvement and use of modern methods and technologies for their solution.

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Акмалдінова В.Є., Волковська Г.Г. ОЦІНКА ТА ПРОГНОЗУВАННЯ АВІАЦІЙНОЇ БЕЗПЕКИ: НАУКОВО-ПРАКТИЧНІ АСПЕКТИ

Статтю присвячено проблемам та особливостям процесу забезпечення безпеки аеропорту. З цього питання було проведено детальне інформаційне дослідження. Проаналізовано основні поняття та принципи забезпечення авіаційної безпеки на повітряному транспорті, а також процес організації авіаційної безпеки в аеропорту. Визначено наукові та практичні аспекти оцінки та прогнозування авіаційної безпеки. Проаналізовано процес перевірки пасажирів і багажу на авіаційну безпеку. Встановлено, що з моменту розвитку авіаційного транспорту і появи можливості повітряних перевезень пасажирів, багажу та різноманітних вантажів виникла необхідність у розробці системи авіаційної безпеки, що забезпечує безпеку людей у різноманітних авіаційних комплексах та терміналах аеропорту. На початковому етапі дослідження авіаційна безпека сприймається як стан захищеності авіації від будь-яких актів незаконного втручання в її діяльність. Авіаційна промисловість є одним із яскравих прикладів можливих загроз життю людей.

Забезпечення авіаційної безпеки вимагає нових оцінок, прогнозів і реагування на терористичні акти та акти незаконного втручання в роботу об'єктів повітряного транспорту. Цьому сприяє впровадження в практику авіакомпаній нового обладнання для перевірки достовірності документів, ідентифікації пасажирів та виявлення потенційно небезпечних речовин. Тому пошук і впровадження ефективного методу оцінки та прогнозування підвищення рівня авіаційної безпеки аеропортів є однією з науково-практичних проблем, що потребують невідкладного поглибленого дослідження.

У результаті дослідження визначено найбільш оптимальні методи, методики та актуальні підходи до проведення досліджень, проаналізовано основні процеси контролю пасажирів і багажу на авіаційну безпеку з метою вдосконалення технологій авіаційної безпеки.

Ключові слова: *авіаційна безпека, модель, повітряні перевезення, аеропорт, засоби забезпечення авіаційної безпеки, безпека польотів, оцінка та прогнозування авіаційної безпеки, акти незаконного втручання в авіаційну діяльність.*