

A NEW APPROACH TO THE HUMAN FACTOR'S ASSESSEMENT IN THE AUTOMATED CONTROL SYSTEM OF AVIATION SECURITY IN THE AIRPORT

¹Filippov V.L., ¹Elisov L.N., ²Ovchenkov N.I.,

¹State Research Institute of Civil Aviation, Moscow, Russian Federation

²P.G.Demidov Yaroslavl State University, Yaroslavl, Russian Federation

Abstract: *This report concludes a series of articles by the authors devoted to the human factor and published in scientific journals «Industry-4.0» in 2017, 2018. The problem of the human factor is shown from a new point of view in the article, namely: the human factor is not only the limited possibilities of professional activity, due to human physiology, it is, above all, the limited possibilities of technology that does not take into account the characteristics of a person in the human-machine system. There are considered various aspects of this problem.*

Keywords: Civil aviation, aviation security, human factor, integrated systems, harmonization of the human factor.

1. Introduction

The human factor (HF) in many industries refers to one of the most common concepts. This concept is especially widely used in civil aviation. It has become a regular occurrence to attribute the blame for most incidents to the human factor, while the understanding of what is related to this factor is often absolutely different. On the one hand, we can definitely consider that the human component is present almost everywhere. On the other hand, accusing the human factor of all the events essentially complicates the situation, since we cannot get a real accident picture, although this is not the purpose.

HF is a complex category with a fairly large number of components, not all investigated in case of an incident. HF is an inexhaustible field of research, even interdisciplinary. This is especially important in civil aviation, where, nevertheless, the main studies of the HF are concentrated in the field of flight safety, and even more often in the study of crew teams.

There has not been carried out any scientific research connected with the HF in the field of aviation security, although the importance of the HF is equally important. This work presents some approaches to the study of the HF in aviation security.

2. The human factor and the personnel threat

Aviation security as a scientific area deals with the issues of ensuring the protection of civil aviation from illegal interference in its activities. The objective functional of the system solving these problems is significantly different in its content from other systems as part of the aviation transport system. This fact determines the specifics of the means, methods and procedures used in aviation security. The human factor in the structure of the aviation security system occupies a particularly important place, since up to 80% of negative events are connected with it.

In modern safety systems, including flight safety systems, it is established that the causes of faulty actions of personnel are associated not only with the level of professionally important qualities of the individual, but also with the imperfection of the means of activity and its organization. I.e. the question of reducing the human factor's negative role is determined by the success in improving the parameters (characteristics) of a person and technology.

It is more complicated in aviation security systems because the procedures of personnel's professional activities are poorly formalized and algo-rhythmized, characterized by extreme manifestations, have a high degree of ambiguity, and the tasks are poorly structured and poorly formalized.

In terms of aviation security, it is proposed to consider the human (personal) factor as an inevitable evil, excluding a useful component, and all its negative manifestations are classified as security threats. In this case, the methodologies developed to protect the objects of the transport infrastructure can be used to study the human factor in order to reduce and/or eliminate its impact in aviation security, i.e. the well-known formula begins to work: detection-reflection-elimination.

The conceptual construct can be the basis for this approach. Indeed, the factor is the cause driving any process, determining

its nature or its individual features, where the cause is considered as the basis for any action. The threat involves the possible, the probable danger, the intention to cause harm. In this case, the concept of factor can be replaced by the concept of threat, and the actions of aircraft personnel in this part can be compared and equated to the actions of the offender, agreeing that these actions are not hostile, antagonistic, but are forced, random, often independent of the intentions of the personnel. In this way the concept of the personnel threat can be introduced.

The personnel threat (PT) in aviation security is a state of inadequate professional readiness of the operator and the situation's parameters in the safety system, determined by the limit level of the individual's psychophysiological parameters, allowing the appearance of a negative event. It should be noted that deliberate actions of personnel provoking negative events, even if it is an aviation security officer, automatically translate the situation into an act of unlawful interference (AUI).

3. Some approaches to the study of HF in aviation security

In modern aviation security systems, a person is considered as a source of threats, i.e. the security system should prevent and neutralize the anthropogenic impact. These can be terrorist threats, hooligan actions, negligence, theft, unauthorized photo and video shooting, violations of the regime and labor discipline, and much more. This is one category of threats. We consider personnel threats from the perspective of the man's imperfections and poor adaptation of the characteristics of the personnel to the protection parameters' technical means when working with personnel requirements can exceed the level of psychophysiological opportunity of the human-operator.

Aviation management security system is a process of rational behaviour of the system based on the measurement, assessment and analysis of the situation (contingency management) [10]. Contingency management is the process of measuring the parameters of the system, transferring it from one state to another in the interests of the target function, it is contemplated that there is no stage-by-stage approach in the solution of control problems, i.e. there may not be a solution algorithm. In this case, the heuristic approach becomes relevant.

Heuristics can be understood as methods of solving problems in conditions of uncertainty, which are opposed to formal methods of solution. Heuristic methods should be considered as having no prescriptive value, as in the case of using algorithmic methods. A heuristic algorithm is an algorithm for solving a problem, the correctness of which is not proved for all possible cases, but it is known that it gives a fairly good solution in most cases, i.e. it is not completely mathematically justified, but at the same time it is a practically useful algorithm.

Heuristic algorithms and procedures give the greatest effect in combination with the theory of decision-making [11, 12].

The decision-making procedure can be single-criteria and multi-criteria, depending on the complexity of the problem.

If the control efficiency is characterized by some optimal test F:

$$F = F(X_1, X_2, \dots, X_p, A_1, A_2, \dots, A_p, Y_1, Y_2, \dots, Y_q, Z_1, Z_2, \dots, Z_r; t), \quad (1)$$

where X is the control, A, Y, Z - the factors influencing the decision, mathematically, the control objective is expressed in the desire for the maximum possible increase (or decrease) in the value of the criterion F : $F \rightarrow \max$ (or \min).

The person responsible for decision-making has a task: with the given values and characteristics of the selected factors $A_1, \dots, A_p, Y_1, \dots, Y_q, Z_1, \dots, Z_r$ find the optimal values of X_1, \dots, X_l , controls X_1, X_2, \dots, X_l of the set of their admissible values that would convert to the maximum (minimum) of the optimality criterion F .

For a multicriteria problem, the strategy of the operating side X can be a scalar, a vector, a matrix, or an even more complex formation, for example, n -dimensional vector, i.e. $X = (x_1, x_2, \dots) = (x_j), j \in \overline{1, n}$.

The means of achieving the management goal is the appropriate choice of strategy X from the area of its permissible values, i.e. it is necessary to find the optimal strategy X , determined by two conditions: strategy X must be admissible and must be the best in the sense of the principle of the adopted compromise in the task.

There are popular studies [6, 14, 15, 16], which present the results of modeling separate processes of aviation security, which investigated different types of models: linguistic, mathematical, qualimetric, structural and logical, predictive, and some others.

The study [17] shows the principal possibility of mathematical modeling of the tasks in the field of aviation security, related to the human factor, in the format of mathematical physics' boundary value problems.

The boundary value problem for partial differential equations is the problem of obtaining the solution of a partial differential equation in a given domain under given additional limitations on the solution at boundary points, edge or boundary conditions. Partial differential equations are classified either depending on their mathematical nature or depending on the physical meaning of the problems they solve: second-order equations, equations with two variables, linear equations, for example, second-order equations with two independent variables

$$A \frac{\partial^2 u}{\partial x^2} + B \frac{\partial^2 u}{\partial x \partial y} + C \frac{\partial^2 u}{\partial y^2} + D \frac{\partial u}{\partial x} + E \frac{\partial u}{\partial y} + Fu = G \quad (3)$$

where A, B, C, D, E, F and G - constants or prescribed functions of independent variables x and y , nonlinear, describing a nonstationary process in three-dimensional space

$$\frac{\partial}{\partial x} \left[\sigma_1(x, y, z, t, u) \frac{\partial u}{\partial x} \right] + \frac{\partial}{\partial y} \left[\sigma_2(x, y, z, t, u) \frac{\partial u}{\partial y} \right] + \frac{\partial}{\partial z} \left[\sigma_3(x, y, z, t, u) \frac{\partial u}{\partial z} \right] = \quad (4)$$

$$= a(x, y, z, t, u) \frac{\partial^2 u}{\partial t^2} + b(x, y, z, t, u) \frac{\partial u}{\partial t} + c(x, y, z, t, u)u + d$$

The values of the function u are searched inside a certain area S , and boundary conditions are set on the boundary:

$$\left(\alpha u + \beta \frac{\partial u}{\partial n} \right) \Big|_{\Gamma} = f, \quad (5)$$

where α and β - prescribed functions of the boundary Γ , f - known function, possibly solution-dependent u , $\frac{\partial u}{\partial n}$ - the derivative of the sought function by the normal to the boundary Γ .

There are also elliptic equations, Laplace equation, Poisson equation, parabolic and hyperbolic equations, biharmonic equation and others. The analytical solution of such equations is almost impossible due to the insurmountable complexity of the computational process, that is why numerical methods are used. Brain-computer models are of particular interest, they reduce the degree of uncertainty in the formation of the model due to the procedure of training neurocomputer network [18,19].

The simulation prediction is a certain distribution of the intensity of personnel threats on the topology of the transport infrastructure object, which allows identifying extreme points of impact of threats and including them in the list of priority when monitoring the situation in the TF (transport facility).

The situation in the TF related to the security is assessed through the dynamics of incidents, which represent threat manifestation. It is through the incident that the negative impact of personnel is manifested to the maximum extent, so the task is to make a decision on the management of these personnel, i.e. to exclude this negative impact. The control system should provide the possibility of automated adjustment of the work's algorithm with the inclusion of tools for reconstruction of the structure of the aviation security management system.

4. Conclusion

The problems in the field of aviation security related to the human factor are multifaceted and quite complex. Classical approaches to solving these problems have almost reached their limits. There are needed new approaches, one of which you can find in this report.

The idea of the new approach is a fundamental revision of the human factor's physical meaning, realizing that the HF in rigorous definition is not a factor, but a much more complex and multifaceted category relating to complex systems and having an objective functional that is not amenable to the strict mathematical investigation.

The authors introduce a new concept: the personnel threat, by which we understand the state of inadequacy of the operator's professional readiness and the parameters of the situation in the security system, determined by the limit level of the individual's psychophysiological parameters, allowing a negative event appearance. Monitoring of this threat and its study involves the use of known methods, mathematical or heuristic, with their specific adaptation and limitations, subsequent measurement and analysis in a quantitative format, which simplifies the procedure for making decisions on personnel management.

The suggested approach increases the level of aviation security of the transport infrastructure's object by reducing the level of negative impact from the aviation personnel.

5. REFERENCES

1. Elisov L.N. Metodologiya I sredstva kvalimetrii inzhenerno-tehnicheskogo sostava grazhdanskoj aviatsii. Aftoref.diss.dokt.tekhn.nauk [Methodology and means of qualimetry of civil aviation engineering and technical staff. Dr. techn. Sci. abstract of the thesis]. Moscow, 1995. (In Russian).
2. Elisov L.N., Ovchenkov N.I., Fadeev R.S. Introduction to the theory of aviation security, Yaroslavl, Filigran` Publ., 2016, 320 p. (In Russian).
3. Elisov L.N. To the question of the accuracy of heuristic algorithms for solving optimization problems in operation. Nauchnyj Vestnik MGTUGA=Scientific Bulletin of MSTU CA, 2012, no. 179, pp. 123-126. (In Russian).
4. Filippov V. L., Ovchenkov N. Some problems of automation of aviation security management procedures at the airport // Scientific Bulletin of the State Research Institute of Civil Aviation. 2019. No. 24. P. 66-74.
5. Elisov L.N., Ovchenkov N.I. Aviation security as an object of mathematical modeling. Nauchnyj Vestnik MGTUGA=Scientific Bulletin of MSTU CA, 2017, vol.20, no. 3, pp. 13-20. (In Russian).
6. Elisov, L. N., Ovchenkov N. Some of the questions of the grid and neural network modeling task control of aviation security of the airport. Scientific Bulletin of the Moscow State Technical University of Civil Aviation, volume 20. Moscow, 2017. No. 3. P. 21-29.
7. Elisov L. N., Gorbachenko V. I., Zhukov M. V. Learning Radial Basis Function Networks with the Trust Region Method for Boundary Problems // Automation and Remote Control. - 2018, Vol. 79. - No. 9. - P. 1621-1629.