AEROSPACE SYSTEMS FOR MONITORING AND CONTROL

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FUZZY PROCEDURE FOR CALCULATING DAMAGE FROM RISKS ATTACHMENT AT AVIATION ACTIVITY BASED ON THE MODEL OF SELECTING OPTIMAL STRATEGIES

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Abstract

Safety management – is the main managerial function, which should be considered at a level that is at least adequate in importance to other functions of any airline, whose implementation should be based on a balanced allocation of resources to production tasks and means of protection, to contribute to the establishment of security space. When considering aspects of FS adopted the postulate that absolute, security does not exist. The essence of the postulate is that after the adoption of protective measures residual risk always remains, which is considered as a measure of probability, as well as the severity of harm to the safe functioning of the system and the environment. Damage – is defined as physical damage or harm associated with the deterioration of a person's health or vital functions, which reduces his or her ability to function normally in terms of physiology. Damage can be caused both directly, and indirectly and qualitatively classified by levels as catastrophic, critical, marginal, insignificant.

Keywords: flight safety; fuzzy networks; safety management system; risk analysis

1. Introduction

The safety management system is the main Safety management – is the main managerial function, which should be considered at a level that is at least adequate in importance to other functions of any airline, whose implementation should be based on a balanced allocation of resources to production tasks and means of protection, to contribute to the establishment of security space.. When considering aspects of FS adopted the postulate that absolute, security does not exist. The essence of the postulate is that after the adoption of protective measures residual risk always remains, which is considered as a measure of probability, as well as the severity of harm to the safe functioning of the system and the environment.

Damage – is defined as physical damage or harm associated with the deterioration of a person's health or vital functions, which reduces his or her ability to function normally in terms of physiology. Damage can be caused both directly, and indirectly and qualitatively classified by levels as catastrophic, critical, marginal, insignificant.

2. Analysis of the latest research and publications

Risk is defined as "an impact that can lead to any loss or damage" [3]. The international standard PMBOK defines a project risk as "a set of elements in a project management, including processes of identification, analysis and corresponding reactions to risks arising in a project". In [4] the risk is interpreted as "the level of losses, expressed in the possibility of not achieving the goal; b) in the uncertainty of the predicted result; c) in the subjectivity of the assessment of the predicted result". In [5], it is argued that risk management is a measure to prevent or reduce adverse effects on the results of long-term forecasting and strategic planning, the development of a sound concept, and development programs adapted to uncertainty. The risk management process is considered as one of the elements of the management system, representing the preparation and implementation of measures that reduce the consequences of making erroneous decisions and reduce the possible negative consequences of undesirable events that may arise during the implementation of accepted. In [8], risk management is defined as a process that maintains a balance between different perceptual resources to achieve its goals using technological, organizational and financial instruments. Some scientists define "risk management" as a set of management decisions aimed at reducing the likelihood of adverse outcomes in an enterprise's activities and reducing potential losses from their implementation [6, 7].

3 Theoretical part

Model of rational choice of strategies. Suppose there are *n* experts who seek to improve the performance criterion $\omega_i = (x_1 ... x_n)$, $i = 1,...,n$ by selecting a vector from the set X_i.

The coincidence of interests $\omega_i = \varphi_i(\omega)$, where $\varphi_i(t)$ the monotonically increase function, and $\omega = const$.

1. The opposite of interests, n=2, $\omega_i = \varphi_i(-\omega_1)$ where the monotonically $\varphi_i(t)$ increasing function.

2. The situation of the independent interests, $x_i \in X_i$, $\omega_i = \varphi_i(\omega)$

Activity setting performance criteria $\omega_i = F_i(x_1 ... x_n, \beta_i)$, $i = 1,...n$, $\beta_i = B_i$– uncertainty. Vector of controlled factors

$X = (x_1 ... x_n)$, the *i*-th expert imposes restrictions $x_i \in P_i$, for example $\varphi_i(t) \geq 0$ and referring on this to choose X_i.

When maintaining restrictions and relevant discontinuous performance criteria (1) and (2) is replaced by activities without restrictions P_i any numbers less $\omega_i = f_i(x_i \beta_i) = -\infty$

$$R_i = \inf_{x \in p_i, \beta_i \in B_i} F_i(x_i, \beta_i)$$

The ability to expand strategies by converting (3) the information obtained from *ikj* via $Zij \omega_i f_i - \sum_{j=1}^{n} Z_{ij} + \sum_{j=1}^{n} \lambda_{ij} Z_{ij}$ efficiency ratio λ_{ij} determine the value for the *i*-th expert piece of information is transmitted by *j* operator, with $i \leq m$

$$Z_i = \sum_{j=1}^{m} \lambda_{ij} Z_{ij} - \sum_{j=1}^{n} Z_{ij} U_i = \sum_{j=m+1}^{n} \lambda_{ij} Z_{ij}$$

With $i < m$

$$t_i = \sum_{j=m+1}^{n} \lambda_{ij} Z_{ij} - \sum_{j=1}^{n} X_{ij}; \quad \gamma_i = \sum_{j=1}^{m} \lambda_{ij} Z_{ij}$$

Then,

$$\omega_i = f_i(x\beta) + Z_i + u_i; i = 1...m$$

$$\omega_i = f_i(x\beta) + t_i + \gamma_i; i = 1...m + 1...n$$

The assessment of the value of risk is determined on the basis of the calculation of two indicators: the possibility of a risk and the value of damage. When calculating the value of the damage, it is advisable to use a fuzzy-logical approach, which is also distinguished by taking into account the independent factors of damage. To assess the value of the damage caused by the occurrence of risks, a fuzzy production damage model has been developed that is filled with elements extracted from an available knowledge data base and it's based on expert opinion. To reduce redundancy, elements at each level should be grouped according to similar characteristics or ranked by degree of significance.

Direct methods for constructing membership functions suggest that the expert determines the rules for setting the values of the membership function $\mu_A(X)$, describing X element.

We choose these values on the set of elements X in accordance with the following rules.

1. For $\forall x_A, x_2 \in X$ the ratio of their membership functions is determined by the inequality $\mu_A(x_1) \langle \mu_A(x_2)$ when *x2* more preferably than *x1*, that is, more described by the property A.

2. For $\forall x_A, x_2 \in X$ the ratio of their membership functions is determined by the equation $\mu_A(x_1) = \mu_A(x_2)$ and *x2* identical with respect to property A.

Traditionally, direct methods for determining membership functions are used for quantitatively measurable variables or in cases where opposite values can be distinguished. A subclass of direct methods is direct group methods that assume that a particular object is presented to a certain expert group and each of the experts need to determine whether the given object belongs to a given set. In this case, the number of positive answers divided by the cumulative number of experts determines the value of the function of the object belonging to a given fuzzy set.

Direct methods also include setting the membership function graphically, as well as in the form of a table, a formula.

Analysis of the literature and the results of various studies [2, 3, 5, 7, 9], as well as practical tools for solving information processing problems showed that it is advisable to use direct methods if there are guarantees that experts rarely make random errors, and they can be queried about the values of the membership function directly. At the same time, distortions arise in any case, for example, a subjective desire to move the estimates of objects to the extreme points of the scale used. In this regard, direct methods should be applied only in cases where expert errors are unlikely.

Indirect methods for determining the object's membership function are applied in cases where there are no measurable properties that define fuzzy sets and are more difficult to implement in practice, but their advantage lies in their persistence with respect to distortions [4].

In indirect methods, the membership functions must comply with predetermined conditions that can determine the type of information received and the procedures for its conversion. Indirect methods include the statistical method, pairwise comparisons, expert assessments, and others [8].

The method of statistical data is based on the processing of statistics. The degree to which an object belongs to a fuzzy set is defined as the estimated value of the frequency of use of a linguistic term describing a fuzzy set to characterize this object. At the same time, the use of specialized hint matrices allows obtaining smooth membership functions.

Membership function $\mu_s(X)$ assigns to each element $x \in X$ a number from interval [0, 1], characterizing the degree of belonging of an element *X* to the set *A*. Perceiving information, the expert does not use specific numbers, but converts them into terminological concepts - the values of a specific linguistic variable, which is described by the membership function, individual for each expert.

Let analyzing the state of an object for a certain period of time, n times attention is focused on whether fact *A* occurred. An event consisting of *n* checks for the presence of fact *A* is an estimate. Suppose fact *A* occurred in the checks. The expert determines the frequency $p=k/n$ of fact *A* and describes it using the words “often”, “rarely” and others.

Estimating the frequency *p*, the expert takes into account his experience, which determines the frequency of occurrence of fact *A* in the events of the past that seem to him similar to the event in question. It also receives information based on third-party observations of the occurrence of fact A_t that is, information reflecting public knowledge. Depending on the level of trust in the source of information, it acquires various weight coefficients in order of importance.

The values of the linguistic variable are determined on the scale [0, 1]. Then the belonging of a specific value to a fuzzy set is calculated as the ratio of the number of experiments in which it occurred in a given interval of the scale to the maximum number of experiments for all considered intervals for the considered value. The statistical method is based on the condition that in each interval of the scale used is an equal number of experiments. This condition is not always respected. In practice, an empirical table is constructed, in which experiments can be unevenly distributed over intervals.

The considered method allows to obtain reliable and adequate estimates of the membership functions in the presence of complete statistical information.

The method of constructing the membership function is based on expert assessments. This method of determining membership functions is to use fuzzy numbers, approximately equal to a clear number, and approximate interval estimates, reflecting expert opinions on the analyzed issue. The task is to find the parameters of a certain exponential function, for the solution of which the results of an expert survey are applied.

When constructing the membership function using the parametric method, modified fuzzy terms are constructed based on the existing ones.

The described method of obtaining membership functions was created on the basis of the assumption that an expert, describing the linguistic value of any attribute, can determine three points of the universal scale with minimal cost. Such as: *A, B, C,* two of which - points *B* and *C* – also (or) do not belong to the linguistic meaning being described, *A* is a point definitely belonging to it.

The sequence of construction of membership functions:

1. On the line $\mu=1$, a point is marked opposite to the value of the carrier *x1*, which definitely belongs to this term (points *A* and *D*).
2. On the line $\mu=0$, points are marked opposite the nearest values to the left and right of $x1$ on the carrier (*X* axis), which definitely do not belong to this term (points *B, C,* and *E*).
3. The points marked on the straight lines $\mu=1$ and $\mu=0$ are connected by straight line segments.
4. The shading marks the part of the carrier related to the constructed description.

The method of constructing membership functions using interval estimates. This method is used for the formalized description of selection problems in which there is no distinction between the admissible and the unacceptable, as well as between the ideal and non-ideal states.

The choice of a specific method for constructing membership functions is determined by the class of the problem being solved, the difficulty of acquiring expert and statistical information, the reliability of the data obtained, and the complexity of the algorithms for analyzing and processing information when determining membership functions.

Formation of the production knowledge base describing the influence of the states of the ancestor nodes of the graph on the value of the descendant node specified as a set of production rules.

Obtaining the final damage value of each type of information risk based on the construction of hierarchical systems of fuzzy-logical inference with fuzzy specified input variables based on the fuzzy implication of Larsen and the composition max-prod.

Fuzzy inference is carried out using Larsen's fuzzy implication according to the formula [10]:

$$\mu_R(x,y) = \mu_A(x)\mu_B(y)$$

As a convolution operation, the multiplication operation is used. Thus, the basis of fuzzy inference is the use of *max-prod composition*

$$\mu_B(y) = \max_{x\in X}\{\mu_A(X)\mu_R(x,y)\}$$

The selection of this compositional rule is due to the ease of implementation and great sensitivity to changes in input variables in the premises of fuzzy production rules [1].

Reduction to clarity (defuzzification) is to convert the fuzzy values of the output variables found in clear. Moreover, all methods for obtaining a clear value of the output variable can be divided into two groups [7]:

– methods of defuzzification accumulated at the previous stage (from the activated conclusions of all the rules of the base) of the output variable;

– methods for defuzzifying the output variable without first accumulating the conclusions of the rules.

The first group includes the following defuzzification methods [9, 10]:

1. Center of gravity. This defuzzification method can be used only for models based on fuzzy linguistic production rules, in which the sequences are fuzzy statements. A clear value of ***y***' output variable is defined as the center of gravity of the obtained membership function and is calculated by the formula:

$$y' = \frac{\int_{y_{\min}}^{y_{\max}} y\mu_B(y)dy}{\int_{y_{\min}}^{y_{\max}} \mu_B(\mathrm{y})\mathrm{dy}}$$

where $Y_{\min}\,and Y_{\max}$ – the bounds of the carrier interval of a fuzzy set of the output variable ***y***.

2. Center Square. The clear value of the output variable *y'* is determined by this method from the equation:

$$\underbrace{\int_{y_{\min}}^{y}\mu_B(y)dy}_{S_1} = \underbrace{\int_{y}^{y_{\max}}\mu_B(y)dy}_{S_2}$$

3. Maximum membership function. A clear value of the output variable is calculated by the formula:

$$y' = \arg_y \sup(\mu_B(y))$$

where $\mu_B(y)$ – unimodal function, the shape of which can be arbitrary.

4. The first maximum, also called the left maximum. A clear value of ***y'*** is defined as the smallest value at which the maximum of the total fuzzy set is reached:

$$y' = \min\{y_{\max} : \mu_B y_{\max}) = \max{}_y : \mu_B(y)\}$$

The rightmost maximum. The clear value of the variable ***y*** is found as the largest value at which the maximum of the total fuzzy set is reached:

$$y' = max\{y_{\max} : \mu_B y_{\max}) = \max{}_y : \mu_B(y)\}$$

4. Conclusions

The assessment of the probability of information risk is traditionally based on the use of a statistical approach, of which Bayesian networks are an effective tool. However, the probabilistic approach to accounting for uncertainty requires a large amount of statistical information presented in the form of tables of conditional probabilities, which cannot be constructed for the described factors. In this case, the use of qualitative characteristics or interval values and the approach based on fuzzy logic and the related theory of possibility is more reasonable.

The assessment of information risk is determined on the basis of the calculation of two indicators: the possibility of a risk and the amount of damage. When calculating the level of the damage, it is advisable to use a fuzzy-logical approach, which is also distinguished by taking into account the independent factors of damage.

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Нечітка процедура розрахунку збитків від настання ризиків при авіаційній діяльності на основі моделі вибору оптимальних стратегій

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Управління безпекою – це головна управлінська функція, яка повинна розглядатися на рівні, принаймні адекватному за важливістю до інших функцій будь-якої авіакомпанії, реалізація якої повинна базуватися на збалансованому розподілі ресурсів на виробничі завдання та засоби захисту, сприяти створенню охоронного простору. При розгляді аспектів ПС прийнятий постулат, що абсолютний, безпеки не існує. Суть постулату полягає в тому, що після прийняття захисних заходів залишковий ризик завжди залишається, що розглядається як міра ймовірності, а також тяжкість шкоди для безпечного функціонування системи та навколишнього середовища. Пошкодження – це фізичне пошкодження або шкоду, пов'язане з погіршенням здоров'я людини або життєво важливих функцій, що зменшує його здатність нормально функціонувати з точки зору фізіології. Збиток може бути викликаний як безпосередньо, так і опосередковано і якісно класифікованим за рівнями як катастрофічний, критичний, маргінальний, незначний.

Ключові слова: аналіз ризиків; безпека польотів; нечіткі множини; система управління безпекою

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Нечеткая процедура расчета ущерба от наступления рисков при авиационной деятельности на основе модели выбора оптимальных стратегий

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Управление безопасностью полетов – это основная управленческая функция, которую следует рассматривать на уровне, который по меньшей мере адекватен по важности другим функциям любой авиакомпании, реализация которых должна основываться на сбалансированном распределении ресурсов для производственных задач и средств защиты, для способствовать созданию пространства безопасности. При рассмотрении аспектов ФС принят постулат о том, что абсолютной безопасности не существует. Суть постулата заключается в том, что после принятия защитных мер всегда остается остаточный риск, который рассматривается как мера вероятности, а также серьезность ущерба для безопасного функционирования системы и окружающей среды. Ущерб – определяется как физический ущерб или вред, связанные с ухудшением здоровья или жизненных функций человека, что снижает его или ее способность нормально функционировать с точки зрения физиологии. Ущерб может быть нанесен как прямо, так и косвенно и качественно классифицирован по уровням как катастрофический, критический, незначительный, незначительный.

Ключевые слова: анализ рисков; безопасность полетов; гарантированный нечеткие множества; система управления безопасностью

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