MONITORING AND MANAGEMENT AEROSPACE SYSTEMS

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[1]**Volodymyr P. Kharchenko,** D. E., Prof.
[2]**Oleh M. Alexeiev,** Candidate of Engineering
[3]**Dmytro G. Babeichuk,** Researcher

METHOD ANALYSIS OF MANAGEMENT DECISION MAKING WHILE AIR NAVIGATION FUNCTIONING IN EMERGENCY SITUATIONS

[1,2] National Aviation University
[1]E-mail: kharch@nau.edu.ua
[2]E-mail: oalexeiev@yahoo.com
[3] State Aviation Administration
E-mail: babeichuk@avia.gov.ua

To improve efficiency of the air navigation system in a variety of emergency situations one should identify criteria for proper decision making to put them into the methodology aimed at appropriate decision making on condition of lack of data, lack of factual information and no opportunity to make any changes.

Розглянуто критерії прийняття рішення, на основі яких необхідно визначити методологію, яка дозволить приймати обґрунтовані рішення у разі невизначеності ситуацій, недоліку фактичної інформації, для підвищення ефективності функціонування аеронавігаційної системи в умовах виникнення ризику.

Рассмотрены критерии принятия решения, на основе которых необходимо определить методологию, позволяющую принимать обоснованные решения при неопределенности ситуаций, недостатке фактической информации, для повышения эффективности функционирования аэронавигационной системы в условиях возникновения риска.

Statement of purpose

It is a well known fact that the work of air traffic is closely tied with risks and, therefore, it requires proper Decision Making to minimize the risks. To reach the goal it is important to improve all systems which provide quality functioning of air traffic.

Improvement of the air traffic systems lies in the area of the flight information technology development which normally involves various stakeholders.

Specificity of air traffic is represented by the requirement of flight scheduling in the area of responsibility of both Civil and Military Aviation Authorities. Specific key features are presented by:

– a three dimensional trajectory of aircraft movement and absence of firm contact with an environment (atmosphere) of aircraft movement;

– no possibility to break or to stop air traffic;

– high speed of air traffic resulting in quick flow of any processes occur during the air traffic work;

– significant dependence of air traffic quality on conditions and quality of air environment.

All the listed key features make it necessary to enhance the appropriateness of air traffic organization, assessment and management in emergency situations followed by DM with a purpose to minimize the risks [1].

Review of research results

Results of the researches carried out by Volodymyr P. Kharchenko, Olexiy M. Reva, Oleh M. Alexeiev demonstrated possible local actions to be undertaken for a proper outcome in jeopardizing circumstances. On the other hand, these results do not show any complex actions which are usually required to provide some flexibility for differential decisions.

Purpose of work

Researches provided in a system of decision making in aviation field showed that efficiency of recommendations in emergency non standard situations may decrease due to following:

– sudden increase of information flow directed to an operator within the time limits and intensive psychophysiologic stress.

– psychological discomfort of an operator often leads to ignoring useful recommendations because of mistrust and nonconfidence.

Taken into account the above mentioned factors it becomes evident that:

1. The mechanism of DM under threatening circumstances should be based on the principle of optimal laconism: focusing on minimal required information and visualizing the most significant details while ignoring important but not required at the moment data[2; 3].

2. An operator should be provided with psychologically comfortable and operationally convenient system of DM. In this way the operator's trust and confidence will be created and necessary actions will be undertaken quickly.

With this purpose the system is to provide three different regimes of work regarding the state of jeopardizing factors, namely time limits for DM and type of emergency situation and condition of the aircraft. The regimes are as follows:

– passive regime: the system delivers normative reference and operative information (technical specifications of the aircraft, details about aerodromes and locality, meteorological information); this regime is recommended in case of possibility for emergency landing on the nearest suitable aerodrome, e.g., in case of extinguished fire on board.

– half-passive regime: the system suggests a few alternatives to land the aircraft indicating potential losses as well as the main data and factors influencing the situation assessment; under this regime an operator makes a final decision, e.g., planning actions in case of engines failure.

– active regime: the system delivers the only possible and strongly recommended alternative to land the aircraft safely with minimal losses, e.g., in case of failure to extinguish fire on board.

The change of information supply format is available on an operator's request.

3. Possibility to process data through logic analysis of non formal information presented by and accumulated in experience of an expert.

The functions of each subsystem are identified by the tasks of assessment.

Criterion F defines the efficiency of decision option and presents the quantitative idea. All the factors that define the option efficiency are divided into groups.

$$F = F(X_1, X_2, ..., X_l, A_1, A_2, \dots$$
$$\dots, A_p, Y_1, Y_2, \dots, Y_q, Z_1, Z_2, \dots, Z_r, t),$$

where X are factors under control, the choice of which is determined by the experts in charge;

A are determined uncontrollable factors – fixed values with the definite values;

Y are incidental values and processes with the definite principles of estimation;

Z are undefined, their values are unknown at the moment of DM.

The situation with uncontrollable factors results in the decision option that can not be influenced by the experts. The part of uncontrollable factors is timet. The values of uncontrollable factors are limited by the outer causes, for instance by the resources limitationg.

The limits are mathematically fixed like this:

$$g_i = g_i(X_1, X_2, ..., X_l, A_1, A_2, ..., A_{p_i}, Y_1, Y_2, ..., Y_{q_i}, Z_1, Z_2, ...$$
$$...Z_{r_i}, t) \{\leq, =, \geq\} b_i,\ i = \overline{1, m}. \quad (1)$$

The conditions (1) define the areas Ω_{X_1}, Ω_{X_2}, …, Ω_{X_l} ,…, space, which contain the possible (acceptable) factors values X_1, X_2, …, X_l. The areas of possible uncontrollable factors values can be limited on the analogy.

The analysis of single criterion decision making task. The DM efficiency depends on the decision option (control strategy) and some other fixed incidental factors that are absolutely known to the person responsible for the decision [4].

Control strategies can be represented in values of n – measured vector X = $x_1, x_2, \dots, x_n$. Vector components are limited and determined by the line of outer causes:

$$g_i = g_i(A_i, X)\{\le, =, \ge\}b_i; \quad i = \overline{1,m}; \quad m\{<,=,>\}n, \tag{2}$$

where A_i are fixed determined parameters vector-line, which characterize the properties of the objects that are involved in the control and the conditions of its operation.

The conditions (2) define the area Ω_X strategies X permissible values.

Undetermined – the values are not estimated at the moment of decision – making $Z_1, Z_2, \dots, Z_r$.

The efficiency of DM making is defined by a definite numeric optimal criteria F:

F = F(X, C),

where C is a group of fixed parameters, that characterize objects properties, involved in control and the operational conditions.

The person who is in charge of the decision has to choose the value

$$\overline{X} = \overline{x_1}, \overline{x_2}, \dots, \overline{x_n}$$

in the area Ω_X of its maximum acceptable value $\overline{F}$:

$$\overline{F} = F(\overline{X}, C) = \max_{X \in \Omega_X} F(X, C).$$

The area Ω_X is represented by the condition Symbols $\overline{F}$ and $\overline{X}$ denote the maximum acceptable optimal criteria value F in the conditions (2) and control vector value X:

$$\overline{F} = \overline{F}(\overline{X}) = \operatorname*{opt}_{X \in \Omega_X}[F(X), \Lambda]. \tag{3}$$

Multi criteria MDM

We select one of the multiple X decisions in the area Ω_X of their permissible values. But despite the mentioned above, each selected decision is estimated by the criteria combination $f_1, \dots, f_2, \dots, f_k$ that can differ in the coefficients of their relevant importance $\lambda_1, \lambda_2, \dots, \lambda_k$. Criteria f_q, $q = \overline{1,k}$, are called partial or local criteria; they form the integral or vector criterion of optimality F = $\{f_q\}$.The coefficients λ_q, $q = \overline{1,k}$, form the vector of importance $\Lambda = \{\lambda_q\}$.

Each local criterium charecterizes the definite local objective of the decision that is made the optimal decision must refer to the correlation (3).

The area of the permissible decisions Ω_X can be divided into two parts:

Ω_X^c is the area of agreement, where the quality of the decision can be enhanced simultaneously for all the local criteria or without criteria level decrease;

Ω_X^κ is the area of compromise, where the increase of the quality of one decision criteria leads to the decrease of the other criteria quality.

The optimal decision may refer to the area of compromise only, while at the area of agreement the decision must be enhanced in accordance with definite criteria [5].

The focus on the area of compromise makes the area of possible decisions narrower, but in order to choose the single decision option it's necessary to find the optimization operator objective (3), in other words – to choose the model of compromise by means of the choice of the aggregation function of efficiency indices.

During decision making under the undefined conditions, when the probability of possible situation outcomes is not clear, there can be applied a series of criteria. The option of any criteria together with the task aims and limits, depends on the human factor.

The classical criteria under the undefined conditions are the following.

Gurvits criteria (perssimism-optimism) can be used when we must focus our analysis between the course of actions with the worst predictions and the course with the best ones:

$$G_i = \left\{ k \min a_{ij} + (1-k) \max a_{ij} \right\},$$

where k is a coefficient, that is referred to as the optimism indicator $(0 \le k \le 1)$;

a_{ij} is the optimal choice, referring to the i – decision at j – version of the situation.

When k = 0 is the line of the course of actions with the best predictions, k = 1 is the line with the worst predictions.

Gurvits criterion with k = 1 equals to the Wald criterion, thus demonstrating the tendency to cautious actions. k = 0 is the tendency to marginal risk, as far as the best decision is associated with the big risk.

The values between 0 – 1 are intermediary between risk and cautiousness and are chosen individually, dependant on human factor [6].

We have reviewed classical methods, that give us possibility to take grounded decisions in undefined situations, with the lack of factual information and the vague prospective changes. It is important to add here, that the devised ways of task- solving under the risky conditions are not limited by the reviewed methods. During the analysis process there can be used some other methods regarding risk minimization. There is an effective decision matrix dependant on the possible conditions of their realization. It is necessary to choose the best version according to the criteria.

Minimax Servidge criterion is used when it is necessary to eliminate the risky hazard. Consequently, the decision with the minimal loss of all the maximal losses will be preferable. We estimate possible losses on the basis of the difference between the expected result on condition that there are precise data and the potential results.

Generalized Gurvits maximism criterion is usedwhen it is necessary to focus our attention between the line of a coarse of actions with the worst predictions and the line with the best ones.

Conclusion

We have reviewed and analysed the classical methods of DM, that allow to take grounded decisions under the undefined conditions and the lack of factual information. It is important to add here, that the devised ways of task- solving under the risky conditions are not limited by the reviewed methods. During the analysis process ther can be used some other methods regarding risk minimization. There is an effective decision matrix dependand on the possible conditions of their realization.

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