UDC 004.89

V. O. Temnikov, A. V. Temnikov
(National Aviation University, Ukraine)

Models and method of expert assessment of aviation security level of airports

A model and method for conducting expert assessments of the quality of aviation security of airports are presented. The use of fuzzy sets theory and perceptual calculations in the construction of the method makes it possible to overcome the uncertainties in the description of the subject domain and provide an expert format suitable for experts to conduct the assessment.

At present, the problem of analyzing the impact of various external and internal factors on aviation security (AS) of airports under the conditions of the uncertainty of the influence of these factors on the safety and lack of information in persons taking managerial decisions in the field of providing AS has acquired particular relevance.

The article presents the model and the method developed on its basis for the expert evaluation of AS airports in general and its individual components using fuzzy sets and perceptual calculations [1,2]. Application of these theories allows to overcome the uncertainties in the description of the subject area related to the subjective nature of human thinking, provide an expert format suitable for experts, and the possibility of a deeper analysis of the influence of various factors on AS airports.

Model of the process of expert assessment of the quality of aviation security airports.

The basis of the method developed by the authors for evaluating the quality of airport AS is a graph hierarchical distributed model, in which the quality of AS is calculated as a result of multilevel aggregation of assessments of the quality of individual input factors and the degree of influence of elements of input and intermediate levels of the model on each other, independently made by expert experts in various areas of safety and AS.

A generalized version of the model for conducting expert assessment of the quality of AS airports is shown in Fig. 1.

The basis for the choice of the input factors of the model lies in the postulate stated in the ICAO normative documents [3,4] on the need for a systematic approach to flight safety and AS – the integrated adoption of organizational and technical measures, as well as measures aimed at reducing the impact on the safety of the human factor. Therefore, the input nodes (vertices) of the model constitute indicators that characterize the quality of work:

– employees of the AS service and protection (the quality of the organization of the services, the functional condition of employees, etc.);

– technical means used by AS employees in carrying out various operational procedures (OP), including the inspection of passengers, hand luggage, baggage, cargo, aircraft, passport and ticket control, etc.;

– security systems (security alarm systems, video surveillance and access control systems) used to protect the controlled zones of airports from the intrusion of unauthorized persons, to ensure the access mode of airport employees.

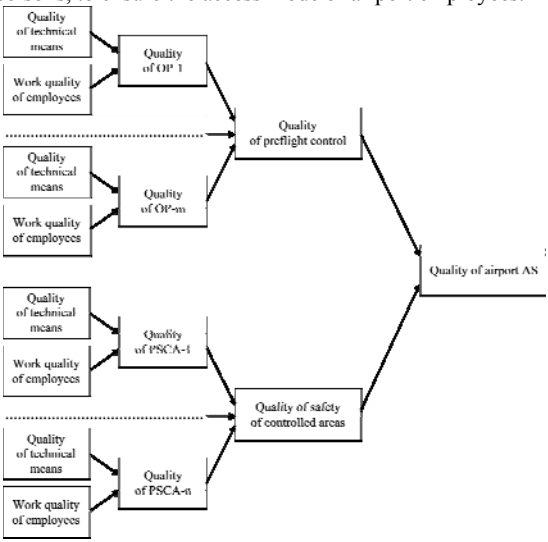

Fig. 1. Graph hierarchical distributed model for determining the quality of AS

Elements of intermediate levels of the model are factors related to two groups:

– the quality of conducting various OPs that determine the quality of preflight control of passengers, hand luggage, baggage, aircraft, etc.;

– the quality of the airport protected systems of controlled areas (PSCA), which determine the security quality of the monitored airport zones.

These groups of factors correspond to the main and, to a large extent, independent, AS airport areas.

The nodes (vertices) of the model are connected with each other by directed loaded arcs, which characterize the effect of the elements of one level of the model on others.

The application of theories of fuzzy sets and perceptual calculations for expert evaluation.

The task of experts assessing the quality of operation of technical facilities and airport services employees providing their AS in carrying out various OPs and providing effective protection of controlled areas against the illegal penetration of intruders into them is a complex subjective task and therefore requires the application of methods that can reduce the level of subjectivity.

The peculiarities of the method developed by the authors for assessing the level of AS airports is the application of the theory of fuzzy sets, as well as the linguistic nature of the assessment of the quality of technical facilities intended for conducting OP and protection of controlled areas, and the work of AS and security personnel, which make use of perceptual calculations [2] data. As fuzzy sets, the

authors propose to use fuzzy sets of type 2 (FS2) [1], since they give an advantage when using linguistic variables.

In the process of applying the developed method of conducting the assessment, several experts (specialists in different areas of the subject area) are interviewed and a set of intervals is determined which, in their opinion, best correspond to each word. Then each set of intervals corresponding to the given word is converted into interval FS2 [5]. The degree of influence of bonds (weight of connecting arcs) is also measured by interval values.

The fact that when performing perceptual calculations the input of the computing system is given by the words of the natural language, it allows a person to interact with the computer system using a dictionary – a set of words modeled as FS2 [2].

When using perceptual calculations, words are processed using the following three components [2]:

1. An encoder that converts words to their representation of FS2 using a codebook.

2. Fuzzy set converter, which processes FS2 from the encoder output and forms one or more other FS2 output.

The authors construct converters of fuzzy sets on the basis of linguistically weighed mean values [2], which in the most general case are determined by the formula

$$Y_{LWA} = \frac{\sum_{i=1}^{n} X_i W_i}{\sum_{i=1}^{n} W_i}, \qquad (1)$$

where each of the weighing criteria X_i and each of the weights of the connecting arcs W_i are FS2.

In the case of the representation of the target value of the overall quality AS, as well as the quality levels of each factor and the weights of the connecting arcs in the form of the intervals $[a_i, b_i]$ and $[c_i, d_i]$ ($i = 1, ..., n$), respectively (this representation makes it possible to simplify considerably the interval weighted average can be written as $Y_{IWA} = [y_l, y_r]$, where:

$$y_l = \frac{\sum_{i=1}^{L} a_i d_i + \sum_{i=L+1}^{n} a_i c_i}{\sum_{i=1}^{L} d_i + \sum_{i=L+1}^{n} c_i}, \qquad y_r = \frac{\sum_{i=1}^{R} b_i c_i + \sum_{i=R+1}^{n} b_i d_i}{\sum_{i=1}^{R} c_i + \sum_{i=R+1}^{n} d_i}, \qquad (2)$$

$L \in [1, n\text{-}1]$ and $R \in [1, n\text{-}1]$ – switching points that can be found, for example, using the improved Carnik-Mendel algorithms described in [6].

3. A decoder that converts the output of the fuzzy set converter into one of the following options [2]: a word from the codebook most similar to the output of the fuzzy set converter, a number of competing alternatives or a class.

The model of expert estimation of AS airport level with the use of fuzzy sets theories and perceptual calculations developed by the authors is presented in Fig.2. The model allows to obtain an aggregated verbal assessment of the AS airport's quality, based on verbal expert evaluation of the quality of operation of technical facilities and AS employees and security in the conduct of OP and protection of the monitored airport zones from unauthorized access by intruders.

Conclusions.

The technology for assessing the quality of AS is proposed, which allows to take into account the opinion of a large number of experts who are experts in various areas of airport security, on the impact on AS of various factors (including the quality of work and technical equipment of various airport services) and the extent to which these factors impact final result.

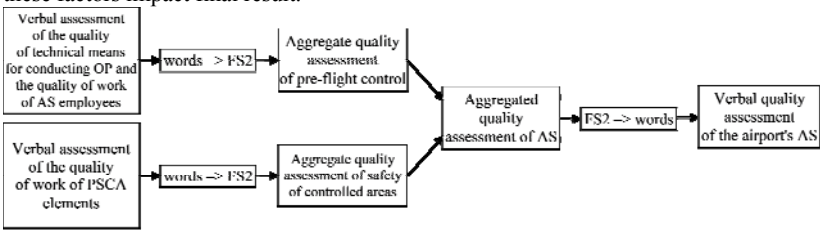

Fig. 2. Model of expert evaluation of the AS airport level using the theory of perceptual calculations

Application of the method and models of expert estimation of AS airports, constructed with the use of fuzzy sets theories and perceptual calculations developed by the authors, allows:

– to conduct quality assessment of AS airports in the context of uncertainty in the description of the subject area;

– to improve the quality of evaluation of AS in conditions of substantial subjectivity of assessments of factors and the degree of their impact on the final result;

– to facilitate the work of experts in assessing the quality of various operating procedures and ensuring the safety of controlled areas.

References

1. Zadeh L. A. Fuzzy logic = computing with words // IEEE Trans. on Fuzzy Systems, vol. 4, issue 2, May 1996, pp. 103–111.

2. Mendel J. M, Wu D. Perceptual computing. Aiding people in making subjective judg-ments. John Wiley & Sons, Inc., Hoboken, New Jersey, 2010, 339 p.

3. Doc 9859: Safety Management Manual, International Civil Aviation Organization, 3rd ed., 2013, 251 p.

4. Doc 8973: Aviation Security Manual, International Civil Aviation Organization, 9th ed., 2014, 818 p.

5. Liu F., Mendel J.M. Encoding words into interval type-2 fuzzy sets using an Interval Approach // IEEE Trans. on Fuzzy Systems, vol. 16, issue 6, December 2008, pp 1503–1521.

6. Wu D., Mendel J. M. Enhanced Karnik-Mendel algorithms // IEEE Trans. on Fuzzy Systems, vol. 17, issue 4, August 2009, pp. 923–934.