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Research paper

Personnel selection for the aviation security service based on the threshold aggregation method

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Abstract

Aviation emergencies cause great property damage and claim many lives. The task of the aviation security service is strictly to follow the instructions for ensuring safety and prevent abnormal and emergency situations. The article is devoted to the problem of selecting the applicable personnel for the aviation security service. Analyzed the influence of the human factor on aviation safety. Discussed the existing methods of personnel selection in the aviation security service. Developed a method of selecting personnel for the aviation security service based on the threshold aggregation method.

Keywords: *Aviation Security Service; HR; Personnel Selection; Threshold Aggregation Method.*

1. Introduction

Ensuring the safety of transport infrastructure facilities is the most important strategic task for the government and aviation operating organizations. Emergencies in air transport occur with a certain regularity. The specificity of aviation leaves a special imprint on such situations - even minor violations of norms and rules usually lead to tragic consequences - an aircraft crash, a terrorist attack and other accidents (Hachikyan P., 2022). Such emergencies cause a significant number of victims and impressive material damage. State law enforcement officers and aviation security services, as well as private security companies, are involved in ensuring transport security. Security ensured with the help of special technical devices (X-ray passenger screening equipment, devices for spectral analysis of substances, metal detectors, etc.), which operate airport aviation security inspectors and other authorized personnel. All these functions form a complex ergatic system in which a person assumes the leading role. The person who operates, controls, and in some cases double-checks the correct operation of technical devices. The role of a person in this process imposes on him a special, personal responsibility for carrying out these activities. The cost of a mistake can be the lives of hundreds, and sometimes thousands of people, who can become victims of a plane crash in the sky and its devastating consequences on earth.
The summary statistics of airline fatal accidents in the world from 1950 to July 2019 shows (fig. 1) (Database of aviation accidents, 2023):

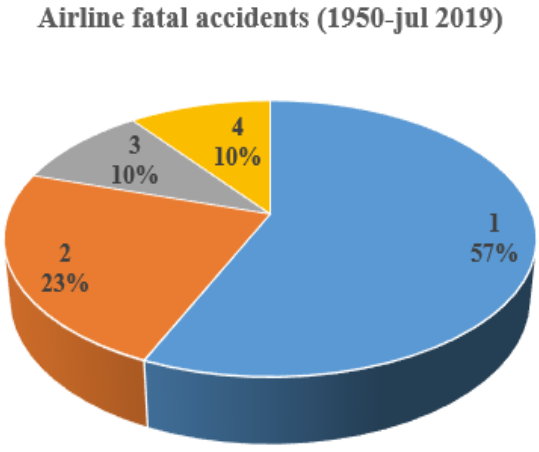

Fig. 1: The Summary Statistics of Airline Fatal Accidents in the World from 1950 to July 2019.

- 57% (614 cases) through the fault of aircraft piloting (which should also be attributed to the human factor, but not only in the field of aviation security) and actions of intruders (including the actions of terrorists who were able to realize their plans and other);
- 23% (253 cases) air crashes due to the fault of mechanical and technical devices and equipment faults;

- 10% (107 cases) due to weather conditions;
- 10% (111 cases) for other reasons (errors of ground services, bird strike, overload and etc.).

Terrorist attacks in aviation often occur due to the poor quality of screening and verification activities by the security services and insufficient attention to security vulnerabilities. The tragic events of September 11, 2001, with the hijacking and crashes of aircraft in the United States and other acts of aviation terrorism in the world, also show such problems.

All this data allows us to conclude that the problem of selecting personnel for the aviation security services is topical. It is necessary to develop and introduce new models and methods of personnel selection in airlines. Solving the problem and selecting the optimal candidates for the positions of aviation security officers will reduce the risk of emergencies in aviation, save human lives and prevent significant material damage in future.

Considering the personnel selection procedure, it should be noted that there is a problem of choosing the most suitable candidate who will suit the requirements of the vacancy in full. There are many ways to select personnel using psychological and psychophysiological tests, interviews, etc., meanwhile, there is a problem of selection for a HR specialist, when a candidate may have high indicators on a number of values of his personality and qualifications, while other indicators will be quite low level. In most cases, personnel selection specialists use only one or several personnel selection methods (tests), which also cannot provide a comprehensive assessment of the candidate. The use of two or more evaluation methods or criteria puts the HR specialist in a difficult position, since problems arise in comparing evaluation results from different scoring systems and comparing them. In the case of classical personnel selection systems, where various candidate criteria are added up to a total score by summation, there is a problem when some low indicators are compensated by other high ones, which overall gives this candidate a high score. However, such an assessment is unlikely to be an objective characteristic of the candidate. In this case, it is advisable to use other selection methods that will allow you to identify the candidate who is most balanced in terms of his qualities, and if there are several candidates, it will allow you to compare them with each other in a convenient form, taking into account the direct balance of their criteria.

2. Overview

International and local regulations of countries established criteria that aviation security service employees must be satisfied (Aviation Security Guide ICAO, Federal Laws, Federal Systems e.t.c, 2014-2023).

A number of scientific works are also devoted to the issues personnel selection in aviation and the human factor in aviation [Hoermann H., Stadler L., Wjum J., 2022; Vorobyov V., 2018; Rybalkina A., 2018, Martinussen, M. Hunter, R.D., 2010; Lounsbury, L.W. Gibson, F.L. Hamrick, 2004).

Some scientific works also include issues of constructing mathematical models and solving the problem of multicriteria assessment, which is presented in the studies (Aarushi S.K.M., 2016; Aliyev, R.R., 2021; Hakan Oktal & Atilla Onrat. 2020; Langer, M., König, C.J. & Busch, V., 2021)

As a rule, within the framework of testing, a candidate is considered as a conditional object that has certain criteria (parameters, characteristics). In fact, each candidate has many criteria (qualities, properties, characteristics), while objectively, none of the candidates can be ideal according to all criteria, but can succeed in many of them. Another candidate may perform perfectly on some criteria, but extremely poorly on others.

Research of candidates for suitability for the position held is usually carried out in two directions: a) psychodiagnostics and/or psychophysiological diagnostics; b) qualification assessment.

Research is carried out both by filling out test surveys and by conducting interviews with relevant specialists, analyzing «cases», and various practical tasks. The main basic indicators of candidates (psychological and psychophysiological) are assessed using classical testing methods. Considering such well-known methods of psychological diagnostics of a person as the Minnesota Multidimensional Personality Inventory (MMPI), the Bass -Perry Aggression Questionnaire (BPAQ), and the Eysenck Personality Questionnaire (EPQ), we can conclude that the results are calculated by the sum of scores (Artamonov B., Nikoforova L., 2003; Butcher J., 2010; Buss A., Perry M., 1992; Webster G., 2015; Zimonyi S., 2021; Maslow A., 1954; Eysenck H., 1999; Luscher M., 1972).

Most methods of psychological tests are based on a quantitative comparison of the responses of representatives of the normative group with the typical responses of patients in whom one or another psychopathological syndrome clearly predominated in the picture of clinical disorders: hypochondria, depression, hysteria, psychopathy, psychasthenia, paranoia, schizophrenia, hypomania. The MMPI test (or its variations, for example, the SMIL, widespread in the CIS countries) consists of more than 500 statements forming 10 main diagnostic scales, and may contain additional scales (Berezin F., Miroshnikov M., Rozhanets R., 1976). For each of the statements, the candidate must answer «true», «false» or «can't say». An answer that matches the key is scored as one. Based on the obtained estimates, the so-called construction is carried out. «personality profile», as a result of which the scores are converted into standard scores for the test with an average value of 50 and a standard deviation of 10, where going beyond the deviation will be considered as a particular pathology or personality trait, depending on the strength of the deviation (Sobchik L., 2007) . An example of calculating scores and assessing a candidate for such a test will look like this, where readings from 30 to 70 can be considered as variants of the norm or minor features, then going beyond 70 and 30, respectively, as more serious changes (Fig. 2):

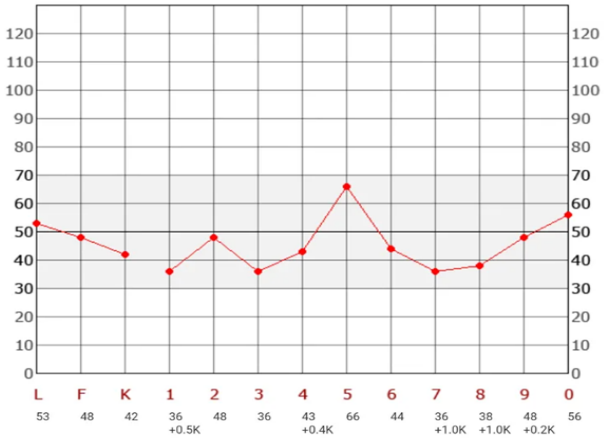

Fig. 2: Personality Assessment Values According to the SMIL Test.

Based on the results of such tests, candidates with the most balanced and moderate character and personality traits will be most preferred. A certain danger for a future employer, especially in responsible positions related to countering violators, can be caused by candidates with pronounced character traits and extreme personality traits, which is confirmed by the theory of accentuation set forth in the works (Leonhard L., 1992).

There are many other candidate criteria that are not considered in psychological testing. As such criteria in the framework of the study, the author set the following: experience, physical qualities (strength, endurance, etc.), stress resistance, corruption resistance, education level, special qualities (special awards, courage and etc.), mobility and adaptability (the ability to adaptation to new conditions, relocation, etc.). These are some criteria's, that can be documented without direct interaction with the candidate (level of education - according to educational documents, special qualities according to the presence of state and/or departmental awards, commendations, work experience - according to information about the length of service from the candidate's personal file). The criteria can be assessed both through appropriate testing and on the basis of expert assessments based on the results of interviews conducted with the candidate, completion of tasks or based on the provided documents. The procedure for expert evaluation of criteria itself is not the topic of this study.

As a result of testing the candidate and identifying psychophysiological and qualification indicators, the HR specialist receives data in the form of a set of final assessments based on criteria that should allow the selection of the most suitable candidate. A suitable is that candidate whose testing results have high scores for all criteria if this is a comparative test and no less than the established ones if a certain minimum level for them is specified. However, the task arises of evaluating one candidate according to several criteria at once, which may not have a common scale and may vary significantly. In this case, required a solution to the subtask of processing and aggregating results.

Currently, standard methods for aggregating candidate's indicators are common (also used to calculate grades in the education system, rating players in sports, etc.), which are based on the following principles for calculating the final results (scores):

1) The sum of scores method and its variations. The scores for all criteria are summed or the arithmetic average is calculated for all criteria of the candidate.
2) Method of sum of evaluation scores with criterion weight. Calculation of the arithmetic average of all candidate criteria, where each criterion has a predetermined by HR weight.
3) Other methods of aggregation and evaluation of criteria, information on the use of which in personnel selection is not available (weighted sum of criteria method (Podinovsky V., Potapov M., 2013), ELECTRE method (Figueira J., Salvatore G., Matthias E., 2005), Borda rules (Tannenbaum P., Arnold R., 1992).

The use of standard methods with the main goal of identifying the best candidate shows different results in practice, which may not always present an objective and realistic picture of the candidate. At the beginning of this study, a conditional situation was simulated with the selection of a candidate for a position using various standard methods. For this purpose, the presence of 4 candidates was assumed (Table 1):

Table 1: Candidates for Position (1-4)

No.	Candidate
1.	Candidate №1
2.	Candidate №2
3.	Candidate №3
4.	Candidate №4

The following evaluation criteria have been introduced and described (Table 2):

Table 2: Criteria for Evaluating Candidates for the Position

No.	Abbr. name of criterion	Candidate Criteria	Description of candidate criteria
1.	EX	Experience	Work experience in a similar position
2.	PH	Physical qualities	Physical qualities of the candidate (health group, physical form)
3.	PY	Psychological qualities	Moral stability, fortitude, strong-willed character traits and etc.
4.	SR	Stress resistance	Ability to perform job duties without fail in stressful situations
5.	CR	Corruption resistance	Ability to resist corruption temptations
6.	EL	Education level	Level of education and knowledge
7.	SQ	Special qualities	The level of special skills and qualities necessary for the performance of job duties (special awards, courage and etc.)
8.	MA	Mobility and adaptability	Readiness to relocation, adaptability to irregular working hours and etc.

When selecting the most suitable candidate, the HR specialist evaluates candidates on a commission based on various qualities - criteria (in the assessment, both classical methods of psychological and personnel testing and selection can be used, as well as mathematical and

psychological approaches, including those based on classic Lefebvre models (Lefebvre V., 1968, 1991) and other combined models and methods.
A candidate rating scale with the following scores was proposed for use (Table 3):

Table 3: Candidates Rating Scale (Gradation)

Grade	Score	Grade description
Excellent	5	Result that exceeds expectations
Very good	4	High score
Good	3	Good score, better than average
Satisfactory	2	Satisfactory score
Fail	1	The score doesn't satisfy the minimum requirements

Suppose that the commission assigned the following expert scores to candidates criteria's (Table 4):

Table 4: Expert Evaluation Results

No.	Candidate	Evaluation criteria, grade scores							
		EX	PH	PY	SR	CR	EL	SQ	MA
1	Candidate №1	4	5	5	1	1	1	1	2
2	Candidate №2	1	5	5	1	1	5	4	1
3	Candidate №3	3	4	3	2	2	2	4	3
4	Candidate №4	5	1	1	5	1	1	5	5

As the first example of calculation, the method of calculating the sum of scores and determining the arithmetic average value of the final score for each candidate was used (Table 5):

Table 5: Method For Calculating the Sum of Scores and Determining the Arithmetic Average Value of the Candidate's Final Score

No.	Candidate	Evaluation criteria, grade scores								Sum. sc.	Aver. arithm . sc.
		EX	PH	PY	SR	CR	EL	SQ	MA		
1	Candidate №1	4	5	5	1	1	1	1	2	20	2.5
2	Candidate №2	1	5	5	1	1	5	4	1	23	2.9
3	Candidate №3	3	4	3	2	2	2	4	3	23	2.9
4	Candidate №4	5	1	1	5	1	1	5	5	24	3

As a second example of calculation, we used the method of calculating the sum of scores and determining the arithmetic average score with a predetermined weight for each criterion (we also conditionally set weights for the criteria for kind of example) (Table 6):

Table 6: Method For Calculating the Sum of Scores and Determining the Arithmetic Average Value of the Candidate's Final Score, Taking into Account the Established Weight of Each Criterion

No.	Candidate	Evaluation criteria, grade scores								Sum. sc.	Aver. arithm . sc.
		EX (0.5)	PH (0.6)	PY (0.7)	SR (0.8)	CR (1)	EL (0.4)	SQ (0.5)	MA (0.3)		
1	Candidate №1	2	2	3	0.8	1	0.4	0.5	0.6	10.3	1.29
2	Candidate №2	0.5	2	3	0.8	1	2	2	0.3	11.6	1.45
3	Candidate №3	1.5	1.6	1.8	1.6	2	0.8	2	0.9	12.2	1.53
4	Candidate №4	2.5	0.4	0.6	4	1	0.4	2.5	1.5	12.9	1.61

The analysis of the initial data on the candidates, as well as the theoretical results in both cases, showed the following: in fact, as we can see in Table 4, the only candidate balanced in terms of its criteria (characteristics) is Candidate No. 3. His grades were distributed fairly balanced across all criteria and are at a level no lower than satisfactory. Candidates No. 1, 2, 4 are examples of candidates unbalanced in terms of criteria (characteristics), who have both extremely low scores on a number of criteria and extremely high scores on others.

- According to Table 5, candidates in order of priority are located in the following order: No. 4, 2 and 3 (same score value), 1.
- According to Table 6, candidates are located in the following order of priority: No. 4, 3, 2, 1.

Analysing the data, we can notice that the final scores are not able to meaningfully evaluate and identify the most balanced candidate. This example is given for a small number of people (only 4 candidates), as well as a 5-score rating scale and 8 evaluation criteria (characteristics). Accordingly, with an increase in the number of candidates, an increase in criteria and a 10-score scale, the task of choosing the most balanced and suitable candidate will become even more complicated.
The imbalance in the indicators of the criteria of these candidates can be seen quite clearly in the fig., where Candidate No. 3 noticeably stands out from the others due to its balance (Fig. 3):

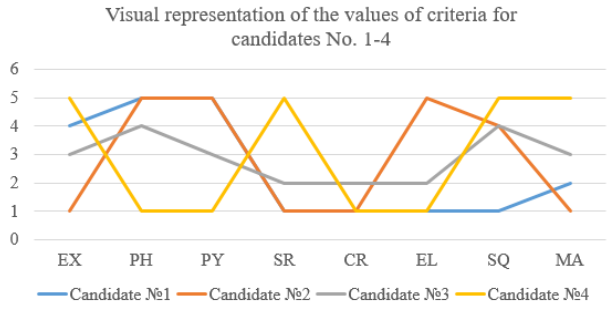

Fig. 3: Values of Criteria for Candidates.

The above theoretical analysis allows us to conclude that when identifying the weaknesses and strengths of a candidate, a situation arises in which the candidate's overall (final) score assessment may be at an acceptable level, whereas in fact it will be formed on the basis of several extremely low indicators and one or two too high. Thus, summing the scores of a candidate's indicators or assigning weights to the criteria will not be the optimal solution to such a problem. The disproportionality of the candidate's characteristics in this case may not be obvious, and comparing several candidates with different characteristics at once without the use of appropriate models will turn out to be a task that cannot be solved in a standard daily job format by HR specialist who do not have the appropriate experience in calculations and math. The above predetermines the need to use methods that allow for a multi-criteria assessment of candidates and presenting data in a form convenient for a HR specialist.
In order to test the presented theoretical experiments and assumptions, a recruitment was carried out for the aviation security service of the airline. In the process of selecting candidates, a comparison was made of the standard method of assessing candidates by summing up points with the method of threshold aggregation proposed by the author. As a result, an analysis of the effectiveness indicators of the proposed method in practice was carried out, which is described in detail further in the text of the article.

3. Methods

The personnel selection for the aviation security service requires the identification of the most appropriate personnel in terms of their personal and qualification qualities. To solve this problem, it is required to evaluate these indicators - criteria for candidates. Usually, such a choice is not made in a completely correct way. The specificity of such a choice has the character of multi-criteria and involves evaluative (subjective) grading of candidates. As usual, only one expert acts as a decisive opinion in the selection. Polygraph tests of candidates have recently become widespread. It is worth noting that the decision based on the results of the check may be the subjective opinion of a polygraph examiner and is not really based on objective data results. In some cases, the results of data using a polygraph are questionable. There is also a selection of personnel due to the corruption component. In this case, the choice of an employee occurs due to the patronage of decision-makers.
The most objective is the adoption of commission decisions. In order to make commission decisions, the airline's HR service must conduct an expert assessment and set evaluation scores for candidates on a conditional scale. During the evaluating, the commission must objectively and impartially evaluate candidates according to their criteria. As a result, rank the considered candidates in the order of their correspondence. In fact, in such cases, the problem of multi-criteria evaluation and choice must be solved. At the same time, each candidate has both certain advantages and disadvantages. It leads to the classic compensatory problem, where the candidate gets a high enough final total score formed with one (or more) criteria too high, while several of the candidate's most important criteria may be too low. Understanding this, we can formulate the task in the following form: «How to choose the most applicable candidates for the aviation security service according to their most important qualities for the functioning of the aviation security system, taking into account the importance of all the criteria for their selection?».
In 2022, in order to eliminate personnel shortages in the aviation security services of airlines, the LLC «STATE DEFENSE ORDER» (Russia, Moscow) carried out a preliminary selection of candidates from among the recommended former employees of law enforcement agencies and paramilitary organizations (dismissed from their previous jobs not for negative reasons) to staff the aviation security services. To test the theoretical assumptions, the author used information about the candidates as the basis for the study, and proposed to distribute them into two groups of equal numbers to test the research and use various methods of their selection.
A total of 30 candidates were considered. It was decided to divide the candidates into two equal groups of 15 people (Group No. 1 and Group No. 2) and select the 7 most suitable candidates from each, in order to subsequently, after the end of the probationary work period (3 months), request reference data from the final employers (airline companies) about the results of the probationary work period.

3.1. Method of summing scores to evaluate candidates

Group No. 1 - 15 candidates received expert assessments of the criteria from specialized specialists (which is not the topic of this study), their results were processed using the standard method of summing up the scores and finding the arithmetic average score.
As a result of processing, the following values were obtained (Table 7):

Table 7: Group No. 1 - Selection of 15 Candidates Using the Method of Calculating the Sum of Scores and Determining the Arithmetic Mean Value of The Candidate's Final Score

No.	Candidate	Evaluation criteria, grade scores								Sum. sc.	Aver. arithm . sc.
		EX	PH	PY	SR	CR	EL	SQ	MA		
1	Candidate №1	2	3	1	2	5	5	1	4	23	2.88
2	Candidate №2	4	3	5	2	1	4	4	3	26	3.25
3	Candidate №3	1	2	4	3	1	1	2	2	16	2.00
4	Candidate №4	2	3	1	1	3	2	3	4	19	2.38
5	Candidate №5	1	1	5	3	2	2	3	4	21	2.63
6	Candidate №6	5	1	5	5	1	4	5	4	30	3.75
7	Candidate №7	4	1	3	4	2	1	4	5	24	3.00
8	Candidate №8	2	4	1	3	2	2	1	3	18	2.25
9	Candidate №9	4	4	2	3	1	1	5	3	23	2.88
10	Candidate №10	5	3	3	1	5	1	5	1	24	3.00
11	Candidate №11	3	2	5	2	3	4	3	2	24	3.00
12	Candidate №12	4	3	5	2	4	5	2	4	29	3.63
13	Candidate №13	3	5	2	3	3	1	3	4	24	3.00
14	Candidate №14	1	3	3	5	2	1	2	1	18	2.25
15	Candidate №15	4	3	3	2	2	4	3	3	24	3.00

From group No. 1, 7 most suitable candidates with the highest scores were selected; they were candidates with numbers: 6, 12, 2, 7, 10, 11, 13.
Candidate No. 15 was removed from consideration during the evaluation process by personal wishes due to family circumstances (moving to another city).
The listed candidates were accepted for the positions of aviation security inspectors with a probationary work period of 3 months.

3.2. Personnel selection using the threshold aggregation method and multi-criteria assessment with a non-compensatory character
Group No. 2 - 15 candidates received expert assessments of the criteria from specialized specialists (which is not the topic of this study). The results obtained became the initial data for their processing by the threshold aggregation method (Table 8).

Table 8: Group No. 2 - Results of Expert Assessment of 15 Candidates for the Position

No.	Candidate	Evaluation criteria, grade scores							
		EX	PH	PY	SR	CR	EL	SQ	MA
1	Candidate №1	1	2	4	2	5	2	2	2
2	Candidate №2	1	3	3	5	3	1	2	4
3	Candidate №3	5	5	1	3	4	2	1	1
4	Candidate №4	3	3	3	1	5	2	2	5
5	Candidate №5	5	1	2	2	5	4	2	3
6	Candidate №6	5	4	3	3	1	5	2	1
7	Candidate №7	2	5	1	3	1	3	5	5
8	Candidate №8	5	3	1	3	5	1	3	1
9	Candidate №9	4	5	4	2	4	1	3	4
10	Candidate №10	5	5	3	5	4	1	3	5
11	Candidate №11	5	3	1	2	4	3	1	3
12	Candidate №12	1	2	5	3	3	4	3	5
13	Candidate №13	5	4	5	4	1	3	3	3
14	Candidate №14	3	2	5	5	5	2	2	3
15	Candidate №15	1	2	4	4	2	2	5	3

As follows from Table 8, the evaluation results do not allow us to definitely select applicable candidate, we haven't got any information about final scores in the table. Some candidates may excel in some areas, while others may fail in them, but excel in others. We should have a preference index that specifically tells us that this candidate is the right one. As we said before, simply summing up the scores according to the criteria will not be enough. Such a simple calculation will not be able to show the most balanced candidate. This is the actual task. Next, we will solve this problem by the method of threshold aggregation and multi-criteria evaluation with a non-compensatory character (Aleskerov F., Kataeva E., Pislyakov V., Yakuba A., 2007, 2013; Aleskerov F., Chistyakov V., Kalyagin V., 2010; Aleskerov F., Khabina E., Shvartz D., 2010, 2012; Goncharov A., Chistyakov V., 2011, Razumnikov S., 2018, Prankevich D., 2020).
Let's take A as a finite set of alternatives that are evaluated according to n criteria. Each alternative x from A is assigned a vector $(x_1,\ldots,x_n)$, where x_i is the rank of the candidate according to the corresponding criterion i, that is, $x_i \in \{1,\ldots,5\}$, $i=1,\ldots,n$. It is necessary to rank the set A on the basis of the estimates $(x_1,\ldots,x_n)$ set by the personnel department for all alternatives x. Each candidate will receive his ordinal number in accordance with his compliance with the requirements. Since for any $x_j \in A$, we have $x=(x_1,\ldots,x_n)$, then the set A will consist of all possible n-dimensional vectors of the form $(x_1,\ldots,x_n)$. To solve this problem, it is necessary to apply the threshold rule and calculate the index using the threshold estimation method. The threshold aggregation rule can be explained as follows:

1) Compare the number of fail scores in the vectors x and y. If they are not equal, then the vector with the least number of fail scores has the greatest preference.
2) If in x and y the number of fail scores equally, then the number of ratings is compared satisfactorily. If they are not equal, then the vector with the fewest satisfactorily scores has the highest preference.
3) Similarly to pp. 1 and 2, we can calculate good, very good and excellent scores.

If all estimates are equal, then such vectors are considered equal and incomparable. In this case, if the fail scores are equally divided, the best will be the one that has less than the average.
How it applies to solving threshold aggregation problems:
m – number of gradations;
n – number of criteria;
$V_j(x)$ – the number of ranks j in the vector x, that is - $V_j(x)=\{1\le i\le n: x_i=j\}$,
Moreover, $0\le V_j(x)\le n$ for all $j \in \{1,\ldots 5\}$ and $x \in A$, as well as $V_1(x)+\ldots+V_4(x)=n$ for all $x \in A$.
Let's represent it in the following form, where the index of alternatives will be equal to the sum of the number of combinations from a to b:

$$F(x) = \sum_{j=1}^{m} C_{a(j)}^{b(j)}, \quad (1)$$

The number of combinations extended in the following form:
$C_{-1}^{0} = 1$ and $C_n^{n+1} = 0$, a and b depend on j and are defined as follows:

$$a(j) = n - V_j(x) + m - j - 1; \quad (2)$$

$$b(j) = m - j, \quad (3)$$

$V_j(x)$ is defined as the sum: $V_j(x) = \sum_{q=1}^{j} \eta(q)$ and $\sum_{j=1}^{m} V_j(x) = n$, and $\eta(q)$ is defined as the number of criteria for which a given alternative has a value of q (q: gradation from 1 to m). After finding the number of combinations a by b we find C using the combinatorial formula:

$$C_a^b = \frac{a!}{b!(a-b)!}. \quad (4)$$

We use the preference function F known from works (Aleskerov F., Chistyakov V., Kalyagin V., 2010). Substituting formulas 2 and 3 into 1, we obtain the following combinatorial formula:

$$F(x) = \sum_{j=1}^{m} C_{n-V_j(x)+m-j-1}^{m-j} = \sum_{j=1}^{m} C_{n-(\eta(1)+\eta(2)+\cdots+\eta(j))+m-j-1}^{m-j} \quad (5)$$

Accordingly, for our model: n - the number of criteria for evaluation (in our case – 8, tab. 2), m=5 - the number of gradations (tab. 3). Then for the case 1, 2, 3, 4, 5 we have $V_j(x)$ – the number of ratings j for the candidate for position x. The function F(x) takes a natural value on any vector x equal to the ordinal number of this vector in the strict preference described above. The function has the optimal properties of Pareto dominance, symmetry, and others, which showed in works (Aleskerov F., Kataeva E., Pislyakov V., Yakuba A., 2007, 2013; Aleskerov F., Chistyakov V., Kalyagin V., 2010; Aleskerov F., Khabina E., Shvartz D., 2010, 2012; Goncharov A., Chistyakov V., 2011,).
The normalized preference index according to the threshold aggregation method will be equal to:

$$I_{Threshold} = \frac{F}{F_{max}}, \quad (6)$$

Where F_{max} – the maximum value of the preference index.
The normalized index varies from 0 to 1, respectively that is - the higher the index value is defined, then the higher the score will be. According to formula (5), calculate the preference index and the index of the best alternative F_{max} how it is typically done in the works (Aleskerov F., Kataeva E., Pislyakov V., Yakuba A., 2007, 2013; Aleskerov F., Chistyakov V., Kalyagin V., 2010; Aleskerov F., Khabina E., Shvartz D., 2010, 2012; Goncharov A., Chistyakov V., 2011, Razumnikov S., 2018, Prankevich D., 2020)
The index of the best alternative in our case will be $F_{max} = 495$.

Next, Calculate the Preference Indices for All Fifteen Candidates, and Also Calculate the Normalized Values Using Formula (6):

Alternative 1 - Candidate №1

ŋ(1) = 1; ŋ(2) = 5; ŋ(3) = 0; ŋ(4) = 1; ŋ(5) = 1;

V(1) = 1; V(2) = 6; V(3) = 6; V(4) = 7; V(5) = 8;

a(1) = 10; a(2) = 4; a(3) = 3; a(4) = 1; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_1 = 210 + 4 + 3 + 1 + 1 = 219$

$I_1 = 0{,}442$

Alternative 2 - Candidate №2

ŋ(1) = 2; ŋ(2) = 1; ŋ(3) = 3; ŋ(4) = 1; ŋ(5) = 1;

V(1) = 2; V(2) = 3; V(3) = 6; V(4) = 7; V(5) = 8;

a(1) = 9; a(2) = 7; a(3) = 3; a(4) = 1; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_2 = 126 + 35 + 3 + 1 + 1 = 166$

$I_2 = 0{,}335$

Alternative 3 - Candidate №3

ŋ(1) = 3; ŋ(2) = 1; ŋ(3) = 1; ŋ(4) = 1; ŋ(5) = 2;

V(1) = 3; V(2) = 4; V(3) = 5; V(4) = 6; V(5) = 8;

a(1) = 8; a(2) = 6; a(3) = 4; a(4) = 2; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_3 = 70 + 20 + 6 + 2 + 1 = 99$

$I_3 = 0{,}200$

Alternative 4 - Candidate №4

ŋ(1) = 1; ŋ(2) = 2; ŋ(3) = 3; ŋ(4) = 0; ŋ(5) = 2;

V(1) = 1; V(2) = 3; V(3) = 6; V(4) = 6; V(5) = 8;

a(1) = 10; a(2) = 7; a(3) = 3; a(4) = 2; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_4 = 210 + 35 + 3 + 2 + 1 = 251$

$I_4 = 0{,}507$

Alternative 5 - Candidate №5

ŋ(1) = 1; ŋ(2) = 3; ŋ(3) = 1; ŋ(4) = 1; ŋ(5) = 2;

V(1) = 1; V(2) = 4; V(3) = 5; V(4) = 6; V(5) = 8;

a(1) = 10; a(2) = 6; a(3) = 4; a(4) = 2; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_5 = 210 + 20 + 6 + 2 + 1 = 239$

$I_5 = 0{,}483$

Alternative 6 - Candidate №6

ŋ(1) = 2; ŋ(2) = 1; ŋ(3) = 2; ŋ(4) = 1; ŋ(5) = 2;

V(1) = 2; V(2) = 3; V(3) = 5; V(4) = 6; V(5) = 8;

a(1) = 9; a(2) = 7; a(3) = 4; a(4) = 2; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_6 = 126 + 35 + 6 + 2 + 1 = 170$

$I_6 = 0{,}343$

Alternative 7 - Candidate №7

ŋ(1) = 2; ŋ(2) = 1; ŋ(3) = 2; ŋ(4) = 0; ŋ(5) = 3;

V(1) = 2; V(2) = 3; V(3) = 5; V(4) = 5; V(5) = 8;

a(1) = 9; a(2) = 7; a(3) = 4; a(4) = 3; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_7 = 126 + 35 + 6 + 3 + 1 = 171$
$I_7 = 0{,}345$

Alternative 8 - Candidate №8

ŋ(1) = 3; ŋ(2) = 0; ŋ(3) = 3; ŋ(4) = 0; ŋ(5) = 2;

V(1) = 3; V(2) = 3; V(3) = 6; V(4) = 6; V(5) = 8;

a(1) = 8; a(2) = 7; a(3) = 3; a(4) = 2; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_8 = 70 + 35 + 3 + 2 + 1 = 111$

$I_8 = 0{,}224$

Alternative 9 - Candidate №9

ŋ(1) = 1; ŋ(2) = 1; ŋ(3) = 1; ŋ(4) = 4; ŋ(5) = 1;

V(1) = 1; V(2) = 2; V(3) = 3; V(4) = 7; V(5) = 8;

a(1) = 10; a(2) = 8; a(3) = 6; a(4) = 1; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_9 = 210 + 56 + 15 + 1 + 1 = 283$

Alternative 10 - Candidate №10

ŋ(1) = 1; ŋ(2) = 0; ŋ(3) = 2; ŋ(4) = 1; ŋ(5) = 4;

V(1) = 1; V(2) = 1; V(3) = 3; V(4) = 4; V(5) = 8;

a(1) = 10; a(2) = 9; a(3) = 6; a(4) = 4; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_{10} = 210 + 84 + 15 + 4 + 1 = 314$

$I_9 = 0,572$

$I_{10} = 0,634$

Alternative 11 - Candidate №11

ŋ(1) = 2; ŋ(2) = 1; ŋ(3) = 3; ŋ(4) = 1; ŋ(5) = 1;

V(1) = 2; V(2) = 3; V(3) = 6; V(4) = 7; V(5) = 8;

a(1) = 9; a(2) = 7; a(3) = 3; a(4) = 1; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_{11} = 126 + 35 + 3 + 1 + 1 = 166$

$I_{11} = 0,335$

Alternative 12 - Candidate №12

ŋ(1) = 1; ŋ(2) = 1; ŋ(3) = 3; ŋ(4) = 1; ŋ(5) = 2;

V(1) = 1; V(2) = 2; V(3) = 5; V(4) = 6; V(5) = 8;

a(1) = 10; a(2) = 8; a(3) = 4; a(4) = 2; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_{12} = 210 + 56 + 6 + 2 + 1 = 275$

$I_{12} = 0,556$

Alternative 13 - Candidate №13

ŋ(1) = 1; ŋ(2) = 0; ŋ(3) = 3; ŋ(4) = 2; ŋ(5) = 2;

V(1) = 1; V(2) = 1; V(3) = 4; V(4) = 6; V(5) = 8;

a(1) = 10; a(2) = 9; a(3) = 5; a(4) = 2; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_{13} = 210 + 84 + 10 + 2 + 1 = 307$

$I_{13} = 0,620$

Alternative 14 - Candidate №14

ŋ(1) = 0; ŋ(2) = 3; ŋ(3) = 2; ŋ(4) = 0; ŋ(5) = 3;

V(1) = 0; V(2) = 3; V(3) = 5; V(4) = 5; V(5) = 8;

a(1) = 11; a(2) = 7; a(3) = 4; a(4) = 3; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_{14} = 330 + 35 + 6 + 3 + 1 = 375$

$I_{14} = 0,758$

Alternative 15 - Candidate №15

ŋ(1) = 1; ŋ(2) = 3; ŋ(3) = 1; ŋ(4) = 2; ŋ(5) = 1;

V(1) = 1; V(2) = 4; V(3) = 5; V(4) = 7; V(5) = 8;

a(1) = 10; a(2) = 6; a(3) = 4; a(4) = 1; a(5) = -1;

b(1) = 4; b(2) = 3; b(3) = 2; b(4) = 1; b(5) = 0;

$F_{15} = 210 + 20 + 6 + 1 + 1 = 238$

$I_{15} = 0,481$

The calculated results presented in tabular form as a ranked rating of candidates with the values of preference functions (table 9):

Table 9: Rating of Candidates with Preference Function Values

No.	Candidate	The value of the function F(x) (preference index)	The normalized value of the preference index
1	Candidate №14	375	0.758
2	Candidate №10	314	0.634
3	Candidate №13	307	0.620
4	Candidate №9	283	0.572
5	Candidate №12	275	0.556
6	Candidate №4	251	0.507
7	Candidate №5	239	0.483
8	Candidate №15	238	0.481
9	Candidate №1	219	0.442
10	Candidate №7	171	0.345
11	Candidate №6	170	0.343
12	Candidate №2	166	0.335
13	Candidate №11	166	0.335
14	Candidate №8	111	0.224
15	Candidate №3	99	0.200

For easy comparison, we plot the value of the function F(x) (preference index) and indicate the relevant data about the candidates (Fig. 4):

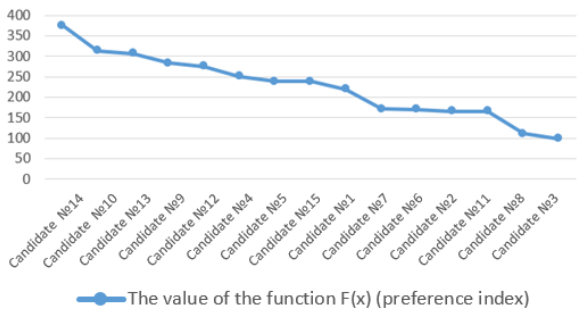

Fig. 4: The Value of the Function F(X) (Preference Index).

The use of threshold aggregation made it possible to reveal that the best candidates available (with conditional expert assessments, the assessment of which was not the subject of this study) are candidates for the position of airport security inspector with numbers in descending order: 14, 10, 13, 9, 12, 4, 5.
Also, for the objectivity of this study, a comparison was made of the results obtained as a result of applying the threshold aggregation method with the data of a typical summation of scores and an arithmetic mean estimate (Table 10):

Table 10: Group No. 2 – An Example of Calculating the Sum of Scores and Determining the Arithmetic Mean of the Candidate's Final Score to Compare the Results of Methods 1 and 2.

No.	Candidate	Evaluation criteria, grade scores EX	PH	PY	SR	CR	EL	SQ	MA	Sum. sc.	Aver. arithm . sc.
1	Candidate №1	1	2	4	2	5	2	2	2	20	2.50
2	Candidate №2	1	3	3	5	3	1	2	4	22	2.75
3	Candidate №3	5	5	1	3	4	2	1	1	22	2.75
4	Candidate №4	3	3	3	1	5	2	2	5	24	3.00
5	Candidate №5	5	1	2	2	5	4	2	3	24	3.00
6	Candidate №6	5	4	3	3	1	5	2	1	24	3.00
7	Candidate №7	2	5	1	3	1	3	5	5	25	3.13
8	Candidate №8	5	3	1	3	5	1	3	1	22	2.75
9	Candidate №9	4	5	4	2	4	1	3	4	27	3.38
10	Candidate №10	5	5	3	5	4	1	3	5	31	3.88
11	Candidate №11	5	3	1	2	4	3	1	3	22	2.75
12	Candidate №12	1	2	5	3	3	4	3	5	26	3.25
13	Candidate №13	5	4	5	4	1	3	3	3	28	3.50
14	Candidate №14	3	2	5	5	5	2	2	3	27	3.38
15	Candidate №15	1	2	4	4	2	2	5	3	23	2.88

As a result of the calculations by scores, the following seven candidates with numbers can be identified in descending order: 10, 13, 14, 9, 12, 7, 6 and so on.
As we can see, the data on the order of candidate matching using the two methods differs. However, the most important thing is to check the following hypothesis - even if unsuitable candidates are hired, they can work for some time without problems, but - in the near future, for example, within the probationary period of work - they will definitely show their shortcomings and will not pass the probationary work period successfully.
According to the design of the study and its practical implementation, the final identification of candidates in group No. 2 was carried out using the threshold aggregation method, the final results of which are given below.

4. Results and discussion

As a result of the selection process, the following candidates were selected in two different ways:
1) Group No. 1 - 6, 12, 2, 7, 10, 11, 13 (Table 7, method of sum of scores)
2) Group No. 2 - 14, 10, 13, 9, 12, 4, 5 (Table 9, threshold aggregation method)
These candidates were hired as aviation security inspectors in 2 unrelated airlines. In order to maintain the purity of the experiment, neither candidates nor HR-specialist knew about the existence of another group and the use of various methods for selection.
This study was conducted from July 2022 and was fully completed with the end of the probationary period of the last hired employee only in February 2023.
In the process of collecting data on the results of passing the probationary period by candidates from airline HR-services, the following data was obtained:

1) Group No. 1 – of 7 employees:
a) dismissed at the initiative of the employer, did not successfully complete the probationary work period - 4 employees;
b) voluntarily dismissed – 1 employee.

Conclusion: 2 out of 7 employees continued working after completing the probationary period.

2) Group No. 2 – of 7 employees:
a) dismissed at the initiative of the employer, did not successfully complete the probationary work period - 1 employee;
b) voluntarily dismissed – 1 employee.

Conclusion: 5 out of 7 employees continued working after completing the probationary period.
The presented results allow us to conclude that even on a small group scale, the study showed the greater effectiveness of the method of selecting personnel using the threshold aggregation method in comparison with the standard method of summing up scores.
Based on the results of the personnel selection, the proposed method was approved by the management of the airline and was successfully implemented into the work of the HR service, taking into account the positive experience gained Group No. 2.
Unlike the standard method of summing up evaluation scores, the implemented method allows you to highlight the preference index F(x) and more accurately assess the balance of candidates' criteria, in contrast to the standard score system, where the total score of candidates may be the same or differ by insignificant values. It is permissible to conclude that without the use of this methodology, we would not be able to make such a balanced assessment of candidates and compile a rating, since in the case of simply adding up a candidate's scores, the result does not turn out to be balanced and objective, which was proven by an actual study using two groups of candidates.
Automation of the calculations given in the article can be implemented using software tools for working with tables and formulas based on paid and freely distributed software, which will ensure ease of data entry and processing, and the delivery of ready-made results for the personnel department of the airline.

5. Conclusion

Emergencies in aviation occur with sufficient frequency and cause great resonance in the world community. It is not always possible to avoid such disasters. The main role to save us from such situations plays aviation security personnel of the airport. The safety of passengers

and airport visitors depends on the quality of the personnel of the aviation security service. The selection of personnel for the aviation security service is the task of the airline HR-service.
There is a problem of evaluating candidates, the inability to determine the best candidate. It is not always possible to evaluate candidates qualitatively and quantitatively according to the relevant selection criteria. Solving the problem personnel for the aviation security service using the non-compensatory threshold aggregation rule and multi-criteria assessment will allow the HR-services of the airline to select the best staff.
The presence of qualified aviation security personnel will reduce the risk of emergencies and contingencies in air transport, help to save human lives and prevent significant material damage.

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