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MULTIPLE CRITERIA ASSESSMENT OF ELITE SECURITY PERSONAL ON THE BASIS OF ARAS AND EXPERT METHODS

Abstract. *The philosophy of decision-making in personnel selection is to assess and select the most preferable solution, implement it and gain the maximum profit. Understanding of the multiple criteria method and knowledge of calculation algorithm of the method allow the decision maker to trust the solutions offered by solution support systems to a greater extent. It is the crucial task which directs the company's present and future. This paper presents a model for personnel assessment and ranking, which is based on expert evaluation method to determine criteria weights and on additive ratio assessment (ARAS) method to aggregate criteria values. The set of criteria is determined by leading security managers. They are as follows: theoretical and practical training – length of service in defence structure (years); professional activity – professional knowledge (number of mistakes made in professional questioning test) (units); mental qualities – aggressiveness–fighting capacity (units); physical development – circumference of chest; motor skills – measurement of speed, measurement of cardio respiratory condition, measurement of strength, the physical development rates are summarized; and fighting skills – the Sumo wrestling is the efficiency ratio. This methodology can help personnel managers to determine and localize problems of personnel, to enhance motivation and versatility of decisions. The criteria values of persons were determined based on Dadelo's methodology. ARAS method was applied to aggregate criteria values, to rank and assess personnel. The problem* *solution results were visualized as diagrams showing most problematic areas and performance level of each person.*

Keywords: *personnel selection, multiple criteria, criteria weights, competences, psycho-motoric, ARAS method, expert judgement method, Dadelo's methodology*

JEL Classification: A12, I00, I3, J01, M50.

1. INTRODUCTION

Peculiarities of professional training are crucially important to the adaptive processes of an organism. They develop specific abilities in different directions (Deneulin, Shahani 2009). For the purpose of defining specific professional requirements the concept of competences is used. Competences are the dimensions of behaviour related to superior job performance. They are the ways of behaving that some people carry out better than others (Bach, Sisson, 2000). Competence is often described as the broad range of knowledge, skills, attitudes, and observable behaviour that together account for the ability to deliver a specified professional service. Haag *et al.* (2000) extended the concept of competence to include the concept of psychomotor competences of human, thus, it represents a set of specific physical and mental abilities, qualities or skills accounting for smooth human effectiveness in carrying out definite professional or situational tasks. Specific characteristics of physical condition represent a vital prerequisite for the effective execution of different professional activities. For the evaluation of professional performance of a security worker the main competences relating to physical abilities, psychomotor and mental functions as well as character traits are brought into focus (Enerlich *et al.* 2003). Professional competences of security personnel have been hardly studied. Dadelo (2005) established that the selection of security personnel should rely, firstly, on the psychomotor functions and combat abilities of candidates; secondly, on the morphological and mental characteristics; and, lastly, on the theoretical and practical preparedness. It was found that physically distinguished individuals were able to accomplish the most complex tasks involving the necessity to fight in a direct clash. Elite security workers should possess the above characteristics. Members of the elite security personnel are assigned to do the tasks involving huge responsibility and risk. According to Ryan *at al.* (2003), only 10 - 12% of feasible candidates manage to carry out the elimination competition tasks for Special Forces. Sakalas and Šilingiene (2000) indicated that 5% of competitors may be given the highest scores in the appraisal of enterprise personnel under normal distribution. Dessler (1999) argued that only 15% of competitors may be graded "very good" in the obligatory distribution of enterprise personnel by categories. Results of the evaluation of the private security enterprise workers and of the personnel selection bring to light the lack of experience and information in this area. Private security enterprises engaged in the provision of security services to clients face the necessity of personnel selection and training. Otherwise, they may encounter increasing risks connected with multiple (material and human) resources (Судоплатов, Лекарев 2001). So, elite security personnel must be available when carrying out especially important security tasks (relating to increased levels of risk) or achieving the maximum effectiveness of security. In order to secure the maximum effectiveness of security personnel selection it is vital to employ modern repeated evaluation methods. Van Iddekinge *et al.* (2011) reconsidered some widely held beliefs concerning the (low) validity of interests for predicting criteria important to personnel selection, and reviewed theory and empirical evidence that challenge such beliefs. Then they described the development and validation of an interest-based selection measure. The evaluation of professional competences possessed by security personnel, the selection and rating of security workers is an important problem encountered by the representatives of many fields of science.

2. MULTIPLE CRITERIA ANALYSIS, DECISION-MAKING AND CRITERIA WEIGHTING

Traditional decision support techniques lack the ability to simultaneously take into account different criteria and conditions. The opinions are uncertain and preferences appear for possible consequences or outcomes. Utility theory has been developed by Von Neumann and Morgenstern (1947), it gives us the elements that we need, for to make a quantification of preferences in the process of making decision under uncertainty.

Many multiple criteria decision analysis methods have been proposed to model the decision-making phase. Computations of different examples reveal the fact that evaluation outcome depends on both, choice of utility function and its parameters (Zavadskas and Turskis (2008); Podvezko and Podviezko 2010). Kelemenis *et al.* (2011) presented an overview of recent studies on the personnel selection problem (from 1992 till 2009). They pointed out that different techniques and conceptual models are used. The most recent applications of different multiple criteria decision-making (MCDM) methods to assess, rank and select the best alternatives are listed below: Kelemenis and Askounis (2010) applied TOPSIS; Han and Liu (2011) modified fuzzy TOPSIS; Dursun and Korsak (2010) – fuzzy TOPSIS method with 2-tuple linguistic representation of criteria values; Zavadskas and Turskis (2010), Bakshi and Sarkar (2011), Baležentis and Baležentis (2011) – Additive Ratio Assessment method (ARAS); Turskis and Zavadskas (2010a) – ARAS-F; Turskis and Zavadskas (2010b) – ARAS-G; Turskis (2008) – ordering of feasible alternatives of solutions in terms of preference technique; Keršuliene *et al.* (2010) – Step-wise weight assessment ratio analysis (SWARA); Sivilevičius and Maskeliūnaitė (2010), Bojovic *et al.* (2010); Yan *et al.* (2011) – AHP; Chen *et al.* (2010) – AHP with fuzzy weighting and linguistic measurement; Shahhosseini and Sebt (2011) - fuzzy AHP method. Steuten *et al*. (2010) applied AHP weights to fill missing gaps in Markov decision models; Hadi-Vencheh and Niazi-Motlagh (2011) – an improved voting AHP-data envelopment analysis methodology; Lin (2010) – a decision support tool using an integrated analytic network process (ANP) and fuzzy data envelopment analysis (DEA) approach; Bindu Madhuri *et al*. (2010) – COPRAS; Bojković *et al.* (2010) – ELECTRE. Tomić-Plazibat *et al*. (2010) – PROMETHEE. Over the last decade scientists and researchers have developed a set of new MCDM methods (Kapliński and Tupenaite 2011; Zavadskas and Turskis 2011): Brauers and Zavadskas (2010) – MULTIMOORA; Brauers *et al.* (2011) –MULTIMOORA with fuzzy number theory. Greco *et al.* (2011) – introduced the concept of a representative value function in robust ordinal regression applied to multiple criteria sorting problems. The proposed approach can be seen as an extension of $UTADIS^{GMS}$, a new multiple criteria sorting method that aims at assigning actions to *p* pre-defined and ordered classes. Zavadskas *et al* (2009) – COPRAS-G. Some of the newly presented MCDM methods are integration of different MCDM methods to the one decision-making model: Chatterjee *et al*. (2011) – COPRAS and EVAMIX methods; Kaya and Kahraman (2011) AHP and ELECTRE; Keršuliene and Turskis (2011) – SWARA and ARAS-F methods; Ginevičius *et al*. (2010) – SAW, VIKOR and TOPSIS methods. Azadeh *et al*. (2011) applied an integrated Data Envelopment Analysis–Artificial Neural Network–Rough Set Algorithm for assessment of personnel efficiency. Zhang and Liu (2011) - proposed an intuitionistic fuzzy multi-criteria group decision-making method with grey relational analysis. Intuitionistic fuzzy entropy is used to obtain the entropy weights of the criteria.

There are only few applications of ARAS method (Tupenaite *et al.* 2010; Zavadskas *et al.* 2010b; Bakshi and Sarkar 2011).

ARAS method allows determining alternative's performance level and shows ratio of each alternative to the ideal alternative. It is necessary in such cases when it is seeking to select elite personnel and determining ways for personnel training.

A major criticism of MCDM is that different techniques may yield different results when applied to the same problem. Dissimilarities in weights produced by these methods become stronger in problems with few alternatives. However, the corresponding final rankings of the alternatives vary across methods more in problems with many alternatives.

The different characteristics of the persons are counted and the level of matching to the ideal personnel model is calculated by ARAS method.

The performance of a personnel area can be described on the basis of a criteria system including many criteria with different meanings and dimensions. Multiple criteria decision-making is widely used in selecting the best alternative from a finite set of decision alternatives with respect to multiple, usually conflicting criteria. Many methods in multiple criteria decision-making require information about the relative importance of each criterion (Hwang and Yoon, 1981). A special feature of the model is the determination of criteria weights. Multiple criteria decision-making methods that generate a cardinal preference of the alternatives require the decision maker to provide information in specific ways on:

- Relative importance (weights) of the criteria with respect to the objectives of the decision problem;

- Performance ratings of the alternatives in relation to each criterion (Keeney and Raiffa, 1976).

In order to find the best and worst persons, the decision-making matrix is calculated to perform comparative multiple criteria analysis of the alternatives. Comparing criteria values and weights leads to making a selection. One of the major problems is to determine the weights of the criteria. A number of methods for determining criteria weights in multiple criteria decision-making have been developed. It is usually given by a set of weights which is normalized to sum to 1. Eckelrode (Eckenrode, 1965) suggests six techniques for collection of the judgements of decision makers concerning the relative value of criteria. Hwang and Yoon (1981) four techniques developed: eigenvector method, weighted least square method, entropy method and LINMAP. In eigenvector method the Saaty (1977) scale ratio gives an intensity of importance. A weighted least square method is proposed by Chu *et al.* (1979) to obtain the weight. When the data of the decision matrix are known, instead of the Saaty's pairwise comparison matrix, the entropy method and the LINMAP (Linear programming techniques for Multidimensional Analysis of Preference) (Srinivasan and Shocker, 1973) method can be used for evaluating weights. Buckley (1985) and Juang and Lee (1991) further extend this approach to accommodate the subjectivity and imprecision inherent in the pairwise comparison process using fuzzy set theory (Zadeh, 1965, 1973, 1975a, 1975b, 1979). Von Winterfeldt and Edwards (1986) and Tabucanon (1988) propose a direct ranking and rating approach. The decision maker is required first to rank all criteria according to their importance, and then give each criterion an estimated numerical value to indicate its relative degree of importance.

Figueira and Roy (2002) explain a very simple procedure proposed by Simos (1990), using a set of cards, allowing to determine indirectly numerical values for weights.

A comparison of some weight assessment techniques is given by Hobbs (1980) and Zavadskas (1987). Approaches to criterion weighting are well discussed by Voogd (1983).

To determine the significances of the criteria, the expert judgement method proposed by Kendall (1970) was used. Zavadskas (1987), Turskis *et al.* (2006) and Zavadskas *et al.* (2010a) discussed the application of this method.

3. PROBLEM SOLUTION

Different elements can be extracted that are supporting one decision rather than another. The criteria can be modified after the relative evaluation of each of them has been estimated. Security company „G4S Lietuva“ selected 11 elite workers from 118 security workers based on Dadelo‘s (2005) methodology for multiple atribute assessment and ranking them having taken the main criteria into account, which have influence on professional competences of security workers. Set of the most significant criteria were selected to describe workers under consideration for solving problem. They are as follows: Theoretical and practical training (x_1) –

length of service in defence structure (years); Professional activity (x_2) – professional knowledge (number of mistakes made in professional questioning test) (units); Mental qualities (w_3) – aggressiveness–fighting capacity (units); Physical developments (x_4) – circumference of chest (cm); Motor skills (x_5) – measurement of speed (psychomotor reaction time, mls), measurement of cardio respiratory condition (run of 3000 m, s.), measurement of strength (30 s. sit–up test, units), the physical developments rates are summarized; Fighting skills (w_6) – the Sumo wrestling is the efficiency ratio (%). The values of qualitative criteria must be put into a numerical and comparable form. They must be comparable because a "medium" value for one qualitative criterion must receive approximately the same numerical values as "medium" values of other qualitative criteria.

22 leader managers (experts) of „G4S Lietuva" Company with not less than 10 years of service at private security structures involving the execution and organization of security have rated the competences chosen by us:

1) Theoretical and practical training (x_1): knowledge, skills, abilities, practical experience – acquired throughout the life;
2) Professional activity (x_2): carrying out the tasks necessary in professional activities;
3) Mental qualities (x_3): individual–psychological personal peculiarities vital for the performance of professional activities;
4) Physical development (x_4): morphological indications of the body;
5) Motor skills (x_5): personal physical conditions allowing to carry out physical tasks at work, home, leisure, and reflecting the level of physical qualities;
6) Fighting skills (x_6): a set of physical and mental qualities influencing the ability to carry out effectively the actions in the fight against an adversary in direct contact.

The object of the research is valuation of the elite security personnel competences of UAB „G4S Lietuva" in the hierarchy chain. Success of the representatives of this profession is determined mostly by psycho-physical (psycho-motor) abilities – competences grounded on genetics and training.

First of all, Dadelo's methodology was applied to determine criteria values for each person under consideration. Criteria values are described in Figs. 1–

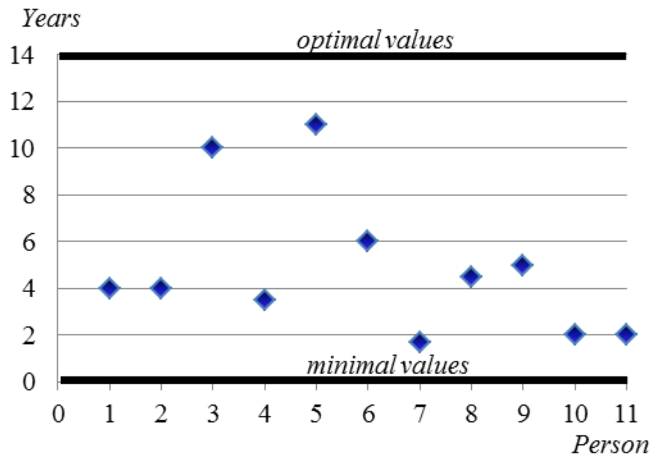

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Figure 1. Theoretical and practical training (x_1) – length of service in defence structure (years)

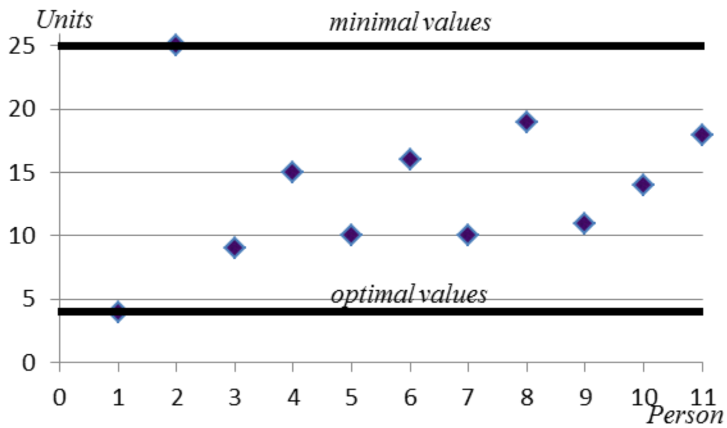

Figure 2. Professional activity (x_2) – professional knowledge (number of mistakes made in professional questioning test) (units)

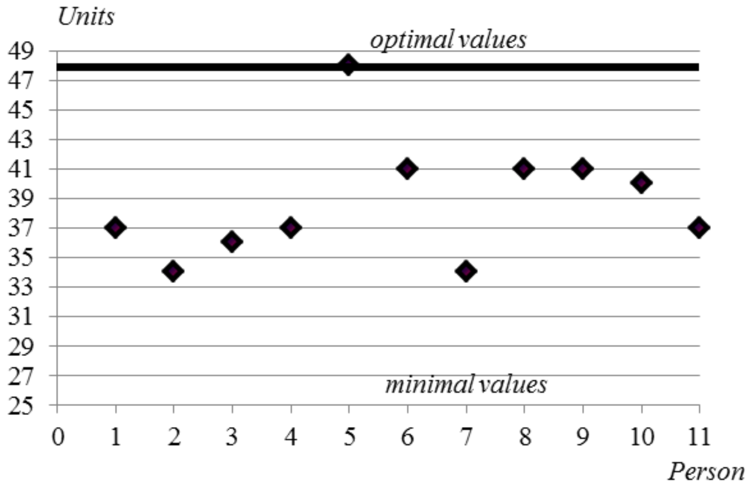

Figure 3. Mental qualities (x_3) – aggressiveness–fighting capacity (units)

At the second step expert judgement method was applied to determine criteria weights. This expert judgement method was implemented at the following stages (Turskis *et al.* 2006):

- Calculation of values t_{jk};
- Calculation of weights q_j;
- Calculation of values S;

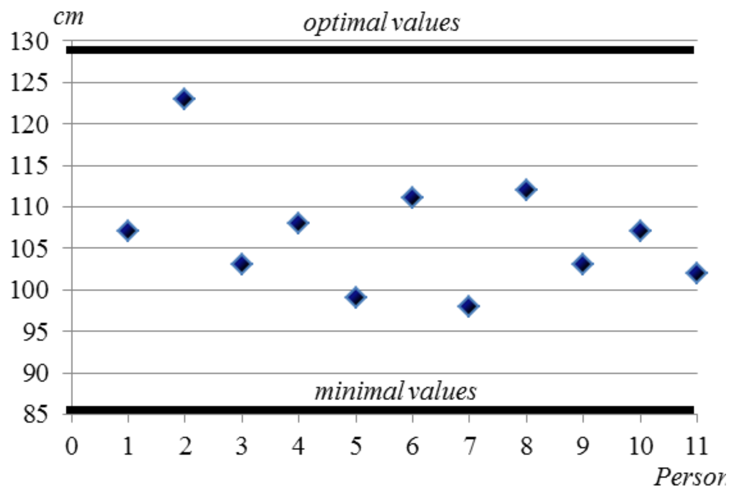

Figure 4. Physical development (x_4) – circumference of chest (cm)

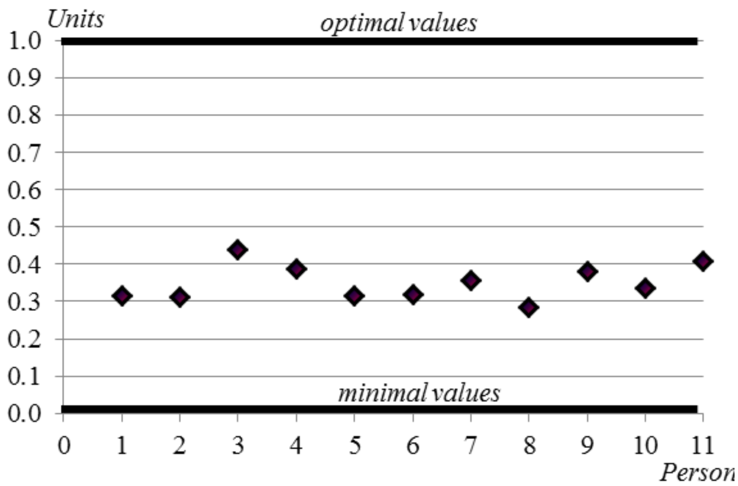

Figure 5. Motor skills (x_5) – measurement of speed (psychomotor reaction time, mls), measurement of cardio respiratory condition (run of 3000 m, s), measurement of strength (30 s. sit–up test, units), the physical developments rates are summarized

- Calculation of values T_k;
- Calculation of values W;
- Calculation of values $\chi^2_{\alpha,v}$;
- Testing the statement $\chi^2_{\alpha,v} > \chi^2_{tbl}$.

The values t_{jk} for statistical processing were obtained by interviewing 22 leader managers of „G4S Lietuva“ Company (Table 1). At the second step expert judgment method was applied to determine criteria weights. This expert judgment method was implemented at the following stages (Turskis *et al.* 2006):

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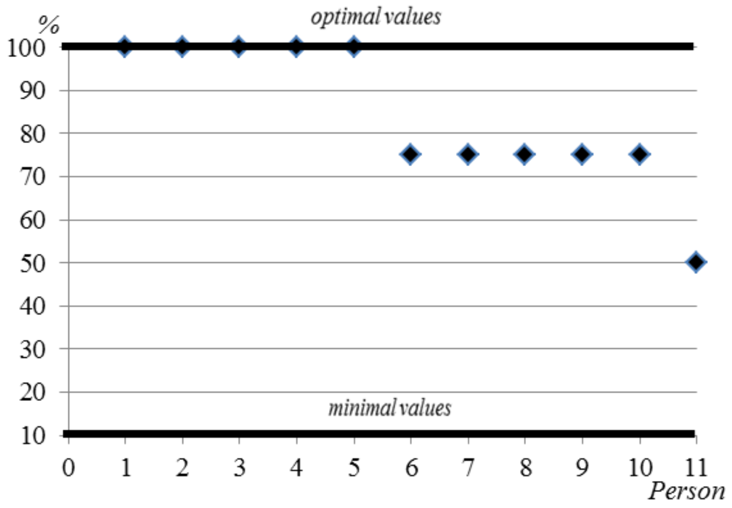

Figure 6. Fighting skills (x_6) – the Sumo wrestling is the efficiency ratio (%)

The algorithm of criteria weight establishment and process of calculation (Turskis *et al.* 2006) is presented in Table 2. After performed calculations we established criteria weights.

Kendall (1970) has shown that, when $n > 7$, the value $\chi^2 = Wr(n-1)$ has a distribution with degrees of freedom $v = n-1$, where n is the number of criteria considered and r the number of experts.

Table 1. Criteria weights determined by the experts

Expert $k = 1,...,22$	Efficiency criteria ranks values, t_{jk}; $j = 1,...,n$; $n = 6$					
	x_1	x_2	x_3	x_4	x_5	x_6
1	6	1	5	3	2	4
2	5	2	3	1	6	4
3	5	1	3	2	6	4
4	6	1	5	3	4	2
5	6	1	5	2	3	4
6	5	1	4	2	6	3
7	4	2	3	1	6	5
8	6	2	5	3	4	1
9	5	4	6	3	2	1
10	5	4	6	1	2	3
11	4	1	3	2	6	5
12	6	2	4	1	5	3
13	6	4	5	1	3	2
14	6	3	5	1	4	2
15	4	1	3	2	6	5
16	4	1	3	2	6	5

17	6	1	4	2	3	5
18	6	3	4	1	5	2
19	4	1	5	2	6	3
20	6	2	4	1	5	3
21	5	2	6	3	4	1
22	4	1	6	3	2	5

It has been proved that if the calculated value χ^2 is larger than the critical tabular value χ^2_{tbl} for the pre-selected level of significance is $\alpha = 0.01$, therefore the above mentioned conditions should be satisfied. If the $\chi^2_{\alpha,v} > \chi^2_{tbl}$ is obtained, the respondents' opinions are not in agreement, which implies that they differ substantially and the hypothesis on the rank's correlation cannot be accepted. The concordance coefficient based on the criteria weights is $W = 0.66$. In this case the tabular value was taken from Fisher and Yates (1963) statistical tables. When the degrees of freedom is $v = n - 1 = 6 - 1 = 5$ and pre-selected level of significance is $\alpha = 0.01$ (or error probability $P = 1\%$), in that case we have the value $\chi^2_{tbl} = 15.09$. Since $\chi^2_{\alpha,v} > \chi^2_{tbl}$, then, the assumption is made that the coefficient of concordance is significant and expert rankings are in concordance with 99% probability.

It is obvious that 3 criteria are very important, 2 criteria are of medium importance and one criterion is important.

Having a set of different criteria and determined the criteria weights it is important to integrate the criteria, which describe alternatives and values to one optimal value. Integrating different criteria values to one optimality criterion is performed by applying ARAS method.

Table 2. Algorithm of criteria weights establishment (Zavadskas, 1987)

Process of calculation	Efficiency criteria x_j; $j = 1,\dots,n$; $n = 6$.					
	x_1	x_2	x_3	x_4	x_5	x_6
Sum of ranks $\bar{t}_j = \sum_{k=1}^{r=22} t_{jk}$	114	41	97	42	96	72
The average criterion's rank value $\bar{t}_j = \frac{\sum_{k=1}^{r=22} t_{jk}}{r}$	5.111	2.000	4.500	1.833	4.333	3.222
Criterion's rank	1	5	2	6	3	4
Criterion's weight $q_j = \frac{\bar{t}_j}{\sum_{j=1}^{n=6} t_j}$	0.247	0.089	0.210	0.091	0.208	0.156

$\sum_{k=1}^{r=22}(t_{jk}-\bar{t}_j)^2$	15.38	25.00	25.50	13.94	51.11	42.42
Dispersion of experts ranking values $\sigma^2=\frac{1}{r-1}\sum_{k=1}^{r=22}(t_{jk}-\bar{t}_j)^2$	0.73	1.19	1.21	0.66	2.43	2.02
Variation $\beta_j=\frac{\sigma}{\bar{t}_j}$	0.167	0.546	0.245	0.444	0.360	0.441
Ranking sum average	$V=\frac{1}{r}\sum_{j=1}^{n=6}\sum_{k=1}^{r=22}t_{jk}=114+41+97+42+96+72=77$					
The total square ranking deviation	$S=\sum_{j=1}^{n=6}\left(\sum_{k=1}^{r=22}t_{jk}-V\right)^2=(114-77)^2+(41-77)^2+(97-77)^2+(42-77)^2+(96-77)^2+(72-77)^2$					
The coefficient of concordance	$W=\frac{12S}{r^2(n^3-n)}=\frac{12\cdot 4676}{22^2(6^3-6)}=0.552$					
The significance of the concordance coefficient (no related ranks) $\chi^2_{\alpha,v}$	$\chi^2_{\alpha,v}=\frac{12S}{rn(n+1)-\frac{1}{n-1}\sum_{k=1}^{r}T_k}=\frac{12\cdot 4676}{22\cdot 6(6+1)}=60.73$, where $\frac{1}{n-1}\sum_{k=1}^{r}T_k=0$					
Rank of table concordance χ^2_{tbl} when the importance equal to 1 %.	The freedom degrees value of a solved problem $v=n-1=6-1=5$; $\chi^2_{tbl}=15.09$					
Compatibility of expert judgment (Kendall, 1970).	$\chi^2_{\alpha,v}=60.73\succ\chi^2_{tbl}=15.09$ - The hypothesis about the consent of experts in rankings is accepted					

Figure 7 represents criteria weights according to the experts' opinion.

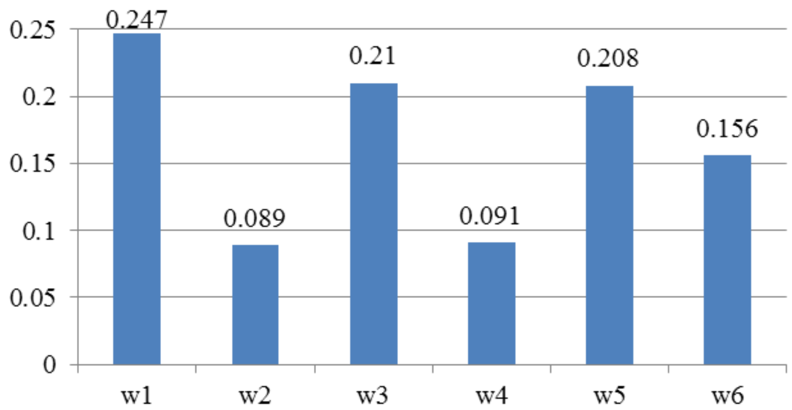

Fig. 7. Criteria weights of elite security workers (w_1 – theoretical and practical training; w_2 – professional activity; w_3 – mental qualities; w_4 – physical developments; w_5 – motor skills; w_6 – fighting skills)

Decision maker having the system of criteria, weights of criteria, criteria values formed initial decision-making matrix (Table 3) and, in order to rank alternatives and select the best alternative, applied ARAS method (Zavadskas, Turskis 2010).

The typical MCDM problem is concerned with the task of ranking a finite number of decision alternatives, each of which is explicitly described in terms of different decision criteria which have to be taken into account simultaneously. According to the ARAS method, a utility function value determining the complex relative efficiency of a feasible alternative is directly proportional to the relative effect of values and weights of the main criteria considered in a project.

The first stage is decision-making matrix (DMM) forming. In the MCDM of the discrete optimization problem any problem to be solved is represented by the following DMM of preferences for *m* feasible alternatives (rows) rated on *n* signful criteria (columns):

$$X = \begin{bmatrix} x_{01} & \cdots & x_{0j} & \cdots & x_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix}; \qquad i = \overline{0, m}; \; j = \overline{1, n}, \tag{1}$$

where m – number of alternatives, n – number of criteria describing each alternative, x_{ij} – value representing the performance value of the i alternative in terms of the j criterion, x_{0j} – optimal value of j criterion.

If optimal value of j criterion is unknown, then

$$\begin{aligned} x_{0j} &= \max_i x_{ij}, && \textit{if } \max_i x_{ij} \textit{ is preferable, and} \\ x_{0j} &= \min_i x_{ij}^{*}, && \textit{if } \min_i x_{ij}^{*} \textit{ is preferable}. \end{aligned} \tag{2}$$

Usually, the performance values x_{ij} and the criteria weights w_j are viewed as the entries of a DMM. The system of criteria as well as the values and initial weights of criteria are determined by experts. The information can be corrected by the interested parties by taking into account their goals and opportunities.

Then the determination of the alternative priorities is carried out in several stages.

Usually, the criteria have different dimensions. The purpose of the next stage is to receive dimensionless weighted values from the comparative criteria. In order to avoid the difficulties caused by different dimensions of the criteria, the ratio to the optimal value is used. There are various theories describing the ratio to the optimal value. However, the values are mapped either on the interval [0; 1] or the interval $[0; \infty]$ by applying the normalization of a DMM.

In the second stage the initial values of all the criteria are normalized – defining values $\bar{x}_{ij}$ of normalised decision-making matrix $\bar{X}$:

$$\bar{X} = \begin{bmatrix} \bar{x}_{01} & \cdots & \bar{x}_{0j} & \cdots & \bar{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \bar{x}_{i1} & \cdots & \bar{x}_{ij} & \cdots & \bar{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \bar{x}_{m1} & \cdots & \bar{x}_{mj} & \cdots & \bar{x}_{mn} \end{bmatrix}; \qquad i = \overline{0, m}; \; j = \overline{1, n}. \tag{3}$$

The criteria, whose preferable values are maxima, are normalized as follows:

$$\bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}}. \tag{4}$$

The criteria, whose preferable values are minima, are normalized by applying two-stage procedure:

$$x_{ij} = \frac{1}{x_{ij}^{*}}; \; \bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}}. \tag{5}$$

When the dimensionless values of the criteria are known, all the criteria, originally having different dimensions, can be compared.

The third stage is defining normalized-weighted matrix - $\hat{X}$. It is possible to evaluate the criteria with weights $0 < w_j < 1$. Only well-founded weights should be used because weights are always subjective and influence the solution. The values of weight w_j are usually determined by the expert evaluation method. The sum of weights w_j would be limited as follows:

$$\sum_{j=1}^{n} w_j = 1 . \tag{6}$$

$$\hat{X} = \begin{bmatrix} \hat{x}_{01} & \cdots & \hat{x}_{0j} & \cdots & \hat{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \hat{x}_{i1} & \cdots & \hat{x}_{ij} & \cdots & \hat{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \hat{x}_{m1} & \cdots & \hat{x}_{mj} & \cdots & \hat{x}_{mn} \end{bmatrix}; \qquad i = \overline{0, m}; \; j = \overline{1, n} . \tag{7}$$

Normalized-weighted values of all the criteria are calculated as follows:

$$\hat{x}_{ij} = \bar{x}_{ij} w_j ; \qquad i = \overline{0, m} , \tag{8}$$

where w_j is the weight (importance) of the j criterion and $\bar{x}_{ij}$ is the normalized rating of the j criterion.

The following task is determining values of optimality function:

$$S_i = \sum_{j=1}^{n} \hat{x}_{ij} ; \qquad i = \overline{0, m} , \tag{9}$$

where S_i is the value of optimality function of *i* alternative.

The biggest value is the best, and the smallest one is the worst. Taking into account the calculation process, the optimality function S_i has a direct and proportional relationship with the values x_{ij} and weights w_j of the investigated criteria and their relative influence on the final result. Therefore, the greater the value of the optimality function S_i, the more effective the alternative. The priorities of alternatives can be determined according to the value S_i. Consequently, it is convenient to evaluate and rank decision alternatives when this method is used.

The degree of the alternative utility is determined by a comparison of the variant, which is analysed, with the ideally best one S_0. The equation used for the calculation of the utility degree K_i of an alternative a_i is given below:

$$K_i = \frac{S_i}{S_0}; \qquad i = \overline{0, m}, \tag{10}$$

where S_i and S_0 are the optimality criterion values, obtained from Eq. (9).

The algorithm of problem solution is described by formulae 1-10. Problem solution process is described in Table 3-6.

The solution results show that rationality of the alternatives is not even and K_i varies from 0.38 to 0.66 (Fig. 8). According to the graphic view of the Fig. 9 it is obvious that no one of persons reaches optimality level of 67 percent from optimal level. So, each of the considered persons has big opportunities to develop some of the different competences and skills.

Table 3. Determined initial data for multiple criteria analysis of elite personnel (initial decision-making matrix)

Elite security persons	Criteria					
	Theoretical and practical training	Professional activity	Mental qualities	Physical developments	Motor skills	Fighting skills
	x_1	x_2^*	x_3	x_4	x_5	x_6
Optimum direction	*max*	*min*	*max*	*max*	*max*	*max*
Criteria weights	0.247	0.089	0.210	0.091	0.208	0.156
a_0 (optimal values)	14	4	48	129	1	100
a_1	4	4	37	107	0.316	100
a_2	4	25	34	123	0.311	100
a_3	10	9	36	103	0.438	100
a_4	3.5	15	37	108	0.389	100
a_5	11	10	48	99	0.316	100
a_6	6	16	41	111	0.318	75
a_7	1.7	10	34	98	0.358	75
a_8	4.5	19	41	112	0.285	75
a_9	5	11	41	103	0.380	75
a_{10}	2	14	40	107	0.335	75
a_{11}	2	18	37	102	0.407	50

Table 4. Changed initial data for multiple-criteria analysis of elite personnel (initial decision-making matrix)

Elite security persons	Criteria					
	Theoretical and practical training	Professional activity	Mental qualities	Physical developments	Motor skills	Fighting skills
	x_1	x_2	x_3	x_4	x_5	x_6
Criteria weights	0.247	0.089	0.21	0.091	0.208	0.156
a_0 (optimal values)	14	0.250	48	129	1	100
a_1	4	0.250	37	107	0.316	100
a_2	4	0.040	34	123	0.311	100
a_3	10	0.111	36	103	0.438	100
a_4	3.5	0.067	37	108	0.389	100
a_5	11	0.100	48	99	0.316	100
a_6	6	0.063	41	111	0.318	75
a_7	1.7	0.100	34	98	0.358	75
a_8	4.5	0.053	41	112	0.285	75
a_9	5	0.091	41	103	0.38	75
a_{10}	2	0.071	40	107	0.335	75
a_{11}	2	0.056	37	102	0.407	50
$\sum$	67.7	1.251	474	1302	4.853	1025

Table 5. Normalised decision-making matrix

Elite Security Persons	Criteria					
	Theoretical and practical training	Professional activity	Mental qualities	Physical developments	Motor skills	Fighting skills
	$\bar{x}_1$	$\bar{x}_2$	$\bar{x}_3$	$\bar{x}_4$	$\bar{x}_5$	$\bar{x}_6$
Optimum direction	*max*	*min*	*max*	*max*	*max*	*max*
Criteria weights	0.247	0.089	0.21	0.091	0.208	0.156
a_0 (optimal values)	0.2068	0.1999	0.1013	0.0991	0.2061	0.0976
a_1	0.0591	0.1999	0.0781	0.0822	0.0651	0.0976
a_2	0.0591	0.0320	0.0717	0.0945	0.0641	0.0976
a_3	0.1477	0.0888	0.0759	0.0791	0.0903	0.0976
a_4	0.0517	0.0533	0.0781	0.0829	0.0802	0.0976
a_5	0.1625	0.0799	0.1013	0.0760	0.0651	0.0976
a_6	0.0886	0.0500	0.0865	0.0853	0.0655	0.0732
a_7	0.0251	0.0799	0.0717	0.0753	0.0738	0.0732
a_8	0.0665	0.0421	0.0865	0.0860	0.0587	0.0732
a_9	0.0739	0.0727	0.0865	0.0791	0.0783	0.0732
a_{10}	0.0295	0.0571	0.0844	0.0822	0.0690	0.0732
a_{11}	0.0295	0.0444	0.0781	0.0783	0.0839	0.0488

Table 6. Normalised-weighted decision –making matrix and solution results

Elite Security Persons	Criteria						Results		
	Theoretical and practical training	Profes-sional activity	Mental qualities	Physical develop-ments	Motor skills	Figh-ting skills	S	K	Rank
	$\hat{x}_1$	$\hat{x}_2$	$\hat{x}_3$	$\hat{x}_4$	$\hat{x}_5$	$\hat{x}_6$			
a_0 (optimal values)	0.0511	0.0178	0.0213	0.0090	0.0429	0.0152	0.1572	1.0000	Optimal
a_1	0.0146	0.0178	0.0164	0.0075	0.0135	0.0152	0.0850	0.5407	3
a_2	0.0146	0.0028	0.0151	0.0086	0.0133	0.0152	0.0696	0.4430	8
a_3	0.0365	0.0079	0.0159	0.0072	0.0188	0.0152	0.1015	0.6458	2
a_4	0.0128	0.0047	0.0164	0.0075	0.0167	0.0152	0.0733	0.4665	6
a_5	0.0401	0.0071	0.0213	0.0069	0.0135	0.0152	0.1042	0.6627	1
a_6	0.0219	0.0044	0.0182	0.0078	0.0136	0.0114	0.0773	0.4917	5
a_7	0.0062	0.0071	0.0151	0.0068	0.0153	0.0114	0.0620	0.3943	10
a_8	0.0164	0.0037	0.0182	0.0078	0.0122	0.0114	0.0698	0.4438	7
a_9	0.0182	0.0065	0.0182	0.0072	0.0163	0.0114	0.0778	0.4947	4
a_{10}	0.0073	0.0051	0.0177	0.0075	0.0144	0.0114	0.0634	0.4029	9
a_{11}	0.0073	0.0040	0.0164	0.0071	0.0174	0.0076	0.0598	0.3805	11

According to the solution results person ranks as follows:
$a_5 \succ a_3 \succ a_1 \succ a_9 \succ a_6 \succ a_4 \succ a_8 \succ a_2 \succ a_{10} \succ a_7 \succ a_{11}$.
It means that the best alternative is the first person and the worst is the eleventh person.
The optimality level of each person is presented in Fig. 9.

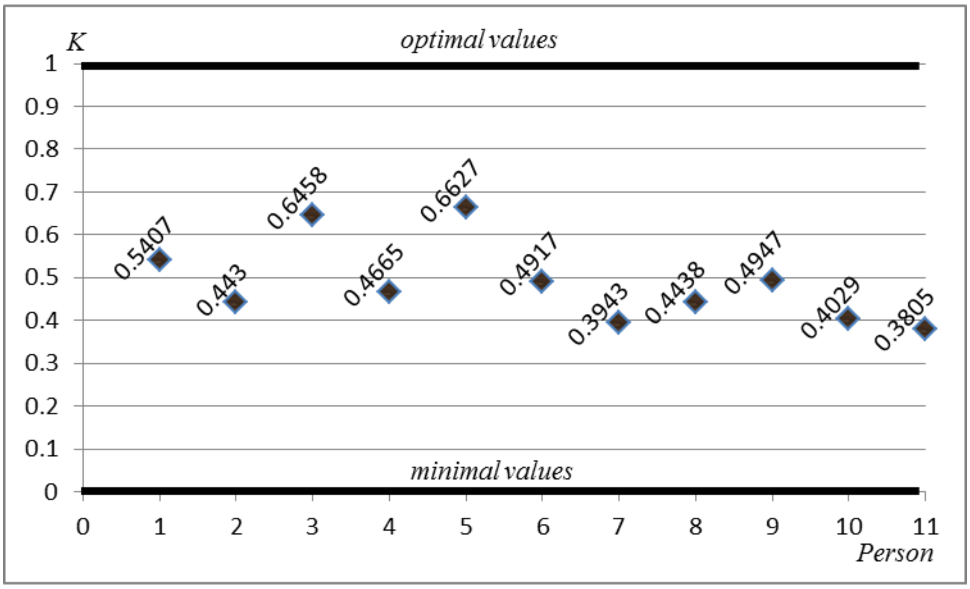

Figure 8. The final evaluation results of security workers

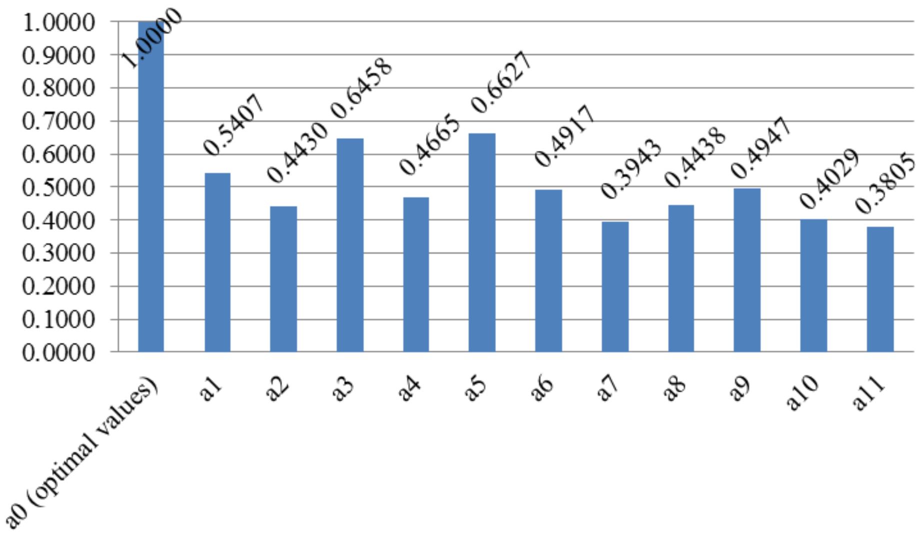

Fig 9. Integrated optimality level of persons

4. CONCLUSIONS

Estimating personnel performance is a complex problem. The method described in this article can be used as a basis for further development. A simple set of five criteria describing basic skills of elite security workers was used. Workers' performance must be described by many criteria. Criteria weights and sets can vary according to different situations and character of research. Additional criteria and different sets can be applied for this universal method.

When science is used for policy making, an appropriate management of decisions implies including the different stakeholders, participants, aims and perspectives. This also implies the impossibility of reducing all dimensions to a single unity of measure. Our concern is with the assumption that in any dialogue, all valuations or 'numeraires' should be reducible to a single one-dimension standard. Multiple criteria evaluation supplies a powerful framework for the implementation of the incommensurability principle.

In this work graphical charts of different criteria were made to indicate problematic areas. These charts can be used as well as by selectors as a motivation for decisions to deal with specific problem as well as by persons, who are looking into future and seeks for better results in career.

This work presents a universal methodology and simplified practical model for measuring of performance level of security personnel.

REFERENCES

[1] **Azadeh, A.; Saberi, M.; Moghaddam, R. T.; Javanmardi, L. (2011),** ***An Integrated Data Envelopment Analysis–Artificial Neural Network–Rough Set Algorithm for Assessment of Personnel Efficiency****; Expert Systems with Applications* 38(3): 1364-1373. doi:10.1016/j.eswa.2010.07.033;
[2] **Bach S.; Sisson, K. (2000),** ***Personnel Management – A Comprehensive Guide to Theory and Practice.*** Blackwell Publiscers Ltd. 403 p.;
[3] **Bakshi, T.; Sarkar, B. (2011),** ***MCA Based Performance Evaluation of Project Selection;*** *International Journal of Software Engineering & Applications (IJSEA)*, 2(2): 14–22. DOI: 10.5121/ijsea.2011.2202 14;
[4] **Baležentis, A.; Baležentis, T. (2011),** ***Integrated Assessment of Lithuanian Economic Sectors Based on Financial Ratios and Fuzzy MCDM Methods****; Technological and Economic Development of Economy* 17(3) (In press);
[5] **Bindu Madhuri, C.; Anand Chandulal, J.; Padmaja, M. (2010),** ***Selection of Best Web Site by Applying COPRAS-G Method***; *International Journal of Computer Science and Information Technologies* 1(2):138–146;
[6] **Bojković, N.; Anić, I.; Pejčić-Tarle, S. (2010),** ***One Solution for Cross-country Transport-sustainability Evaluation Using a Modified ELECTRE Method****; Ecological Economics* 69(5): 1176–1186. doi:10.1016/j. ecolecon.2010.01.006;
[7] **Bojovic, N.; Boskovic, B.; Milenkovic, M.; Sunjic, A. (2010),** ***A Two-level Approach to the Problem of Rail Freight Car Fleet Composition*** *; Transport* 25(2): 186–192. doi:10.3846/transport.2010.23;
[8] **Brauers, W. K. M.; Baležentis, A.; Baležentis, T. (2011) ,** ***MULTIMOORA for the EU Member States Updated with Fuzzy Number Theory*** ;*Technological and Economic Development of Economy* 17(2): 259–290. doi:10.3846/20294913.2011.580566;
[9] **Brauers, W. K. M.; Zavadskas, E. K. (2010),** ***Project Management by MULTIMOORA as an Instrument for Transition Economies***; *Technological and Economic Development of Economy* 16(1): 5–24. doi:10.3846/tede.2010.01;
[10] **Buckley, J. J. (1985),** ***Ranking Alternatives Using Fuzzy Numbers***. *Fuzzy Sets and Systems*, 15(1), p. 21–31;
[11] **Chatterjee, P.; Athawale, V. M.; Chakraborty, S. (2011),** ***Materials Selection Using Complex Proportional Assessment and Evaluation of Mixed Data Methods*** *.Materials & Design* 32(2): 851–860. doi:10.1016/j.matdes.2010.07.010;
[12] **Chen, S. H.; Wang, P. W.; Chen, C. M.; Lee, H. T. (2010),** ***An Analytic Hierarchy Process Approach with Linguistic Variables for Selection of an R&D Strategic Alliance Partner****; Computers & Industrial Engineering* 58: 278-287. doi: 10.1016/j.cie2009.10.006;
[13] **Chu, A. T. W., Kalaba, R. E.; Spingarn, K. (1979),** ***A Comparison of Two Methods for Determining the Weights of Belonging to Fuzzy Sets***. *Journal of Optimization Theory and Applications*, 27(4), p. 531–538;

[14] **Dadelo, S. (2005),** ***Factors Determining Competency of Security Workers in Lithuania.*** *(Czynniki determinujace kompetencje pracowników ochrony na Litwie: monografia).* (In Polish). Warszawa–Vilnius: Wydawnicstwo AWF. 117 p.;
[15] **Deneulin, S.; Shahani, L. (eds) (2009),** ***An Introduction to the Human Development and Capability Approach****: Freedom and Agency*. London: Earthscan.
[16] Dessler, G. (1999) *Essentials of Human Resource Management*, Upper Saddle River, NJ: Prentice Hall. 298 p.;
[17] **Dursun, M.; Karsak, E. E. (2010),** ***A Fuzzy MCDM Approach for Personnel Selection.*** **Expert** *Systems with Applications* 37(6): 4324-4330. doi:10.1016/j.eswa.2009.11.067;
[18] **Eckenrode, R. T. (1965),** ***Weighting Multiple Criteria***. *Management science*, 12(3): 180–192;
[19] **Enerlich, M.; Wojtal, J.; Milewicz, M. (2003),** ***Protection of Persons and Property.*** *(Ochrona osób i mienia).* (In Polish). Torun: Dom Organizatora. 878 p.;
[20] **Figueira, J.; Roy, B. (2002),** ***Determining the Weights of Criteria in the ELECTRE Type Methods with a Revised Simos' Procedure.*** *European Journal of Operational Research*, 139, p. 317–326;
[21] **Fisher, R.A.; Yates, F. (1963),** ***Statistical Tables for Biological, Agricultural and Medical Research***. 6th ed. London: Oliver and Boyd;
[22] **Ginevičius, R.; Krivka, A.; Šimkūnaitė, J. (2010),** ***The Model of Forming Competitive Strategy of an Enterprise under the Conditions of Oligopolic Market****; Journal of Business Economics and Management* 11(3): 367–395. doi:10.3846/jbem.2010.18;
[23] **Greco, S.; Kadziński, M.; Słowiński, R. (2011),** ***Selection of a Representative Value Function in Robust Multiple Criteria Sorting***; *Computers & Operations Research* 38(11):1620-1637. doi:10.1016/j.cor.2011.02.003;
[24] **Haag, H.; Haag, G.; Kaulitz, B. (2000),** ***From Physical Fitness to Motor Competence. Aims-Content-Methods-Evaluation***. *Sports Sciences International*, Vol. 3. Frankfurt: Lang;
[25] **Hadi-Vencheh, A.; Niazi-Motlagh, M. (2011),** ***An Improved Voting Analytic Hierarchy Process-data Envelopment Analysis Methodology for Suppliers Selection****; International Journal of Computer Integrated Manufacturing* 24(3): 189–197. doi:10.1080/0951192X.2011.552528;
[26] **Han, Z.; Liu, P. (2011),** ***A Fuzzy Multi-attribute Decision-making Method under Risk with Unknown Attribute Weights***; *Technological and Economic Development of Economy* 17(2): 246–258;
[27] **Hobbs, B. F. (1980),** ***A Comparison of Weighting Methods in Power Plant Citing***. *Decision Sciences*, 11, p. 725–737;
[28] **Hwang, C. L.; Yoon, K. (1981),** ***Multiple Attribute Decision Making - Methods and Applications***. *A State-of-the-Art Survey*. Springer, New York;
[29] **Juang, C. H.; Lee, D. H. (1991),** ***A Fuzzy Scale for Measuring Weights of Criteria in Hierarchical Structures***. IFES, pp. 415 – 421;

[30] **Kaplinski, O.; Tupenaitė, L. (2011),** ***Review of the Multiple Criteria Decision Making Methods, Intelligent and Biometric Systems Applied in Modern Construction Economics***. *Transformations in Business & Economics* 10(1): 166–181;
[31] **Kaya, T.; Kahraman, C. (2011),** ***A Fuzzy Approach to e-Banking Website Quality Assessment Based on an Integrated AHP-ELECTRE Method***; *Technological and Economic Development of Economy* 17(2): 313–334;
[32] **Keeney, R. L.; Raiffa, H. (1976),** ***Decisions with Multiple Objectives****: Preferences and Value Tradeoffs*, *John Wiley & Sons*, New York;
[33] **Kelemenis, A.; Askounis, D. (2010),** ***A New TOPSIS-based Multi-criteria Approach to Personnel Selection****; Expert Systems with Applications* 37(7): 4999-5008. doi:10.1016/j.eswa.2009.12.013;
[34] **Kelemenis, A.; Ergazakis, K.; Askounis, D. (2011),** ***Support Managers' Selection Using an Extension of Fuzzy TOPSIS****; Expert Systems with Applications* 38(3): 2774-2782. doi:10.1016/j.eswa.2010.08.068;
[35] **Kendall, M.G. (1970) ,** ***Rank Correlation Methods***; 4th ed. *Griffin*, London;
[36] **Keršulienė, V.; Turskis, Z. (2011),** ***Integrated Fuzzy Multiple Criteria Decision Making Model for Architect Selection***; *Technological and Economic Development of Economy* 17(4): 645–666. doi: 10.3846/20294913.2011.635718;
[37] **Keršulienė, V.; Zavadskas, E. K.; Turskis, Z. (2010),** ***Selection of Rational Dispute Resolution Method by Applying New Step-wise Weight Assessment Ratio Analysis (SWARA)*** , *Journal of Business Economics and Management* 11(2): 243–258. doi:10.3846/jbem.2010.12;
[38] **Lin, H.-T. (2010),** ***Personnel Selection Using Analytic Network Process and Fuzzy Data Envelopment Analysis Approaches***; *Computers & Industrial Engineering* 59(4): 937-944. doi:10.1016/j.cie.2010.09.004;
[39] **Podvezko, V.; Podviezko, A. (2010),** ***Dependence of Multi-criteria Evaluation Result on Choice of Preference Functions and their Parameters****; Technological and Economic Development of Economy* 16(1): 143–158. doi:10.3846/tede.2010.09;
[40] **Ryan, M., Mann, C., Stilwell, A. (2003),** ***The Encyclopedia of the World's Special Forces: Tactics, history, strategy, weapons***. Amber Books Ltd., London. 256 p.;
[41] **Saaty, T. L. (1977) ,** ***A Scaling Method for Priorities in Hierarchical Structures***. *Journal of Mathematical Psychology*, 15(3): 234–281;
[42] **Sakalas, V., Šilingiene, V. (2000),** ***Human Resource Management*** *(Personalo valdymas).* (In Lithuanian).Technologija. Kaunas. 205 p.;
[43] **Shahhosseini, V.; Sebt, M. H. (2011),** ***Competency-based Selection and Assignment of Human Resources to Construction Projects***. *Scientia Iranica, Transactions A: Civil Engineering* 18(2): 163-180. doi: 10.10.1016/j.scient.2011.03.026;
[44] **Simos, J. (1990),** ***Evaluer l'impact sur l'environnement: Une approche originale par l'analyse multicritère et la négociation***. Presses Polytechniques et Universitaires Romandes, Lausanne ;

[45] **Sivilevičius, H.; Maskeliūnaitė, L. (2010),** ***The Criteria for Identifying the Quality of Passengers' Transportation by Railway and their Ranking using AHP Method***; *Transport* 25(4): 368–381. doi:10.3846/transport.2010.46;
[46] **Srinivasan, V.; Shocker, D. A. (1973),** ***Linear Programming Techniques for Multidimensional Analysis of Preference***. *Psychometrica*, 38(3), p. 337–369;
[47] **Steuten, L. M. G.; Hummel, M. J. M.; Izerman, M. J. (2010),** ***Using AHP Weights to Fill Missing Gaps in Markov Decision Models*. In: *Value in health* 13, 241**. Prague.- UT-I-IGS-GoI, UT-I-IGS-MoI.;
[48] **Tabucanon, M. T. (1988),** ***Multiple Criteria Decision Making in Industry***. Elsevier, New York;
[49] **Tomić-Plazibat, N.; Aljinović, Z.; Pivac, S. (2010),** ***Risk Assessment of Transitional Economies by Multivariate and Multicriteria Approaches***. *PANOECONOMICUS* 57(3): 283–302. doi:10.2298/PAN1003283T;
[50] **Tupenaite, L.; Zavadskas, E. K.; Kaklauskas, A.; Turskis, Z.; Seniut, M. (2010),** ***Multiple Criteria Assessment of Alternatives for Built and Human Environment Renovation***; *Journal of Civil Engineering and Management* 16(2): 257–266;
[51] **Turskis, Z. (2008),** ***Multi-attribute Contractors Ranking Method by Applying Ordering of Feasible Alternatives of Solutions in Terms of Preference Technique***; *Technological and Economic Development of Economy* 14(2): 224–239. doi:10.3846/1392-8619.2008.14.224-239;
[52] **Turskis, Z.; Zavadskas E. K. (2010a),** ***A New Fuzzy Additive Ratio Assessment Method (ARAS-F). Case study: The analysis of fuzzy multiple criteria in order to select the logistic centers location***; *Transport* 25(4): 423–432. doi:10.3846/transport.2010.52;
[53] **Turskis, Z.; Zavadskas E. K. (2010b),** ***A Novel Method for Multiple Criteria Analysis: Grey Additive Ratio Assessment (ARAS-G) Method***; *Informatica* 21(4): 597–610.
[54] **Turskis, Z.; Zavadskas, E. K.; Zagorskas, J. (2006),** ***Sustainable City Compactness Evaluation on the Basis of GIS and Bayes Rule***; *International Journal of Strategic Property Management* 10(3): 185-207;
[55] **Van Iddekinge, C. H.; Putka, D. J.; Campbell, J. P. (2011),** ***Reconsidering Vocational Interests for Personnel Selection: The Validity of an Interest-Based Selection Test in Relation to Job Knowledge, Job Performance, and Continuance Intentions***; *Journal of Applied Psychology* 96(1): 13-33. doi:10.1037/a0021193;
[56] V**on Neumann, J.; Morgenstern O. (1947),** ***Theory of Games and Economics Behavior***; Princenton Univ. Press, Princenton, N.;
[57] **Von Winterfeldt, D.; Edwards, W. (1986),** ***Decision Analysis and Behavioural Research***. Cambridge University Press, London;
[58] **Voogd, H. (1983),** ***Multicriteria Evaluation for Urban and Regional Planning***. Pion, London;
[59] **Yan, M. R.; Pong, C. S.; Lo, W. (2011),** ***Utility-based Multicriteria Model for Evaluating BOT Projects***; *Technological and Economic Development of Economy* 17(2): 207–218;

[60] **Zadeh, L. A. (1965),** ***Fuzzy Sets*****.** *Information and Control*, 8, p. 338–353;
[61] **Zadeh, L. A. (1973),** ***Outline of a New Approach to the Analysis of Complex System and Decision Process*****.** *IEEE Transactions on Systems, Man, and Cybernetics SMC-2*, p. 28–44;
[62] **Zadeh, L. A. (1975a),** ***The Concept of a Linguistic Variable and its Application to Approximate Reasoning–I***. *Information Sciences*, 8(3), p. 199–249;
[63] **Zadeh, L. A. (1975b),** ***The Concept of a Linguistic Variable and its Application to Approximate Reasoning–II.*** *Information Sciences, 8(4), p. 301–357;*
[64] **Zadeh, L. A. (1979),** ***A Theory of Approximate Reasoning***. In: Hayes, J.E., Michie, D., Kulich, L.I. (Eds.), *Machine Intelligence*, 9, p. 149–194;
[65] **Zavadskas, E. K.; Kaklauskas, A.; Turskis, Z.; Tamošaitienė, J. (2009);** ***Multi-Attribute Decision-Making Model by Applying Grey Numbers***; *Informatica* 20(2): 305–320;
[66] **Zavadskas, E. K.; Turskis, Z. (2008),** ***A new logarithmic normalization method in games theory*** ; *Informatica* 19(2): 303–314;
[67] **Zavadskas, E. K.; Turskis, Z. (2010) ,** ***A new additive ratio assessment (ARAS) method in multicriteria decision-making***; *Technological and Economic Development of Economy* 16(2): 159–172. doi:10.3846/tede.2010.10;
[68] **Zavadskas, E. K.; Turskis, Z. (2011),** ***Multiple criteria decision making (MCDM) methods in economics: an overview***; *Technological and Economic Development of Economy* 17(2): 397-427, doi: 10.3846/20294913.2011.593291
[69] **Zavadskas, E. K.; Turskis, Z.; Ustinovichius, L.; Shevchenko, G. (2010a),** ***Attributes weights determining peculiarities in multiple attribute decision making methods***. *Inzinerine Ekonomika-Engineering Economics* (1): 32–43;
[70] **Zavadskas, E. K.; Turskis, Z.; Vilutiene, T. (2010b),** ***Multiple criteria analysis of foundation instalment alternatives by applying Additive Ratio Assessment (ARAS) method***; *Archives of Civil and Mechanical Engineering* 10(3): 123–141;
[71] **Zavadskas, E. K. (1987),** ***Complex Evaluation and Solution of Resourse-Saving Decisions in Civil Engineering***. Vilnius: Mokslas (In Russian);
[72] **Zhang, S.-F.; Liu, S.-Y. (2011),** ***A GRA-based Intuitionistic Fuzzy Multi-criteria Group Decision Making Method for Personnel Selection***; *Expert Systems with Applications* 38(9):11401-11405.doi:10.1016/j.eswa.2011.03.012 ;
[73] **Судоплатов, А.; Лекарев, С. (2001). Security of business** *(Безопасность предпринимательской деятельности)*. (In Russian). ОЛМА-ПРЕСС. Москва. 382 p.