Assessment team decision-making: One way to assess the multi-criteria decision-making based on observation

Roberto Ferreira Júnior
Federal University of Rio de Janeiro
roberto.ferreira@ppgi.ufrj.br

Paulo Victor R. de Carvalho
Federal University of Rio de Janeiro
paulov@ien.gov.br

Salman Nazir
Buskerud and Vestfold University College
Salman.Nazir@hbv.no

José Orlando Gomes
Federal University of Rio de Janeiro
joseorlando@nce.ufrj.br

Gilbert Jacob Huber
Federal University of Rio de Janeiro
gilbert@archive.com.br

ABSTRACT

Decision-making has been a subject actively investigated in several areas of knowledge such as Philosophy, Economics, Psychology, Computer Science, among others. This paper explores the potential opportunities offered by two methodologies to assess the team decision-making at the end of a simulated exercise (training). We present a case study showing how to measure the team decision-making combining both methodologies to assess a team of three experienced Officers from the Military Fire Brigade of the State of Rio de Janeiro. The simulated exercise was carried out within the Integrated Center of Command and Control of Rio de Janeiro. We intend this study provide a pathway that can be helpful in reducing the subjectivity generated during the observation of the team decision-making in Emergency Management environments.

Keywords

Team decision-making, emergency management, assessment, observation.

INTRODUCTION

Emergency management is a set of actions taken to prepare and make societies less vulnerable and better able to respond to emergencies and is characterized by complexity, urgency and uncertainty (Danielsson and Ohlsson, 1999; Moynihan, 2008). Being one of the essential elements of emergency management, decision-making has been widely discussed (Cosgrave, 1996; Flin, 2001; Rosenthal and Kouzmin, 1997). Some approaches are directed to research aimed at behavioral principles of the individual (Bigley and Roberts, 2001), other approaches are conducted to team or group performance by observing behaviors and team trends (Driskell and Salas, 1991). Other researchers have focused their efforts on studying decision-making at the organizational level (Quarantelli, 1997; Rosenthal and Kouzmin, 1997), emphasizing how organizations make decision to respond to emergencies.

The methodologies found in the literature to facilitate decision-making for emergency response focus on training (Crichton, Flin and Rattray, 2000; Inzana, Driskell, Salas and Johnston, 1996; Lin and Su, 1998; Nazir, Sorensen, Øvergård and Manca, 2015), ergonomic work analysis (Jatobá, Bellas, Koster, Bonfatti, Vidal and Carvalho, 2014), disaster prevention systems (Dolif, Engelbrecht, Jatobá, Da Silva, Gomes, Borges, Nobre and De Carvalho, 2013), in decision support systems (Lindell, Prater and Peacock, 2005; Wallace and De Balogh, 1985) and simulation (Paton, 2003; Preston and Cottam, 1997) and are normally used to enhance decision-making capacity, individual or organizational in emergency response of any kind.

Tools and qualitative techniques are powerful means for representing and analysis phenomena in complex environments, however, the use of quantitative methods to generate indicators based on qualitative data, is still a challenge (Manca, Nazir, Colombo and Kluge, 2014). The generation of quantitative values for the generation of performance indicators from qualitative data is a challenge because, qualitative data are generated based on the observation of the activities of the operators, which can be influenced by the subjectivity of observation itself (Nazir, Manca and Colombo, 2012; Janssen and Vreugdenhil, 2015). To fill this gap, this study focused on the application of two methodologies to register and evaluate the team decision-making in emergency management simulation. The score is generated by observing the team decision-making and weighted to generate the final score. The framework was inspired by the methodology TARGETs (Fowlkes, Lane, Salas, Franz and Oser 1994) and by the methodology AHP (Saaty, 1977).

This paper is organized as follows: The next section describes the methodologies that inspired our study. In Section 3 we describe the case study that was carried out within a Command and Control Center. In Sections 4 and 5, we present the results and discussion. Finally, in Section 6 we present our conclusions and possible ways to undertake.

METHODOLOGY

The combined use of the two methods consists in (1) determine the weights of decision-making criteria through interviews with subject-matter expert (SME). For this, a form containing six sheets as shown in Table 3 was administered and the SME filled out the form correlating decision-making criteria. After filling the form, all weights for each decision were calculated using the AHP method and (2) during exercise the observer (through structured form) wrote down the decisions that the team has taken during the Simulated. Finally, (3) at the end of the exercise the researcher used the TARGETs points resulting from observation and made the weighting using the weights determined by interview with the SME.

Targeted Acceptable Responses to Generated Events or Tasks (TARGETs)

The TARGETs (Fowlkes et al., 1994) is a structured method of teamwork observation in order to make event-based assessment. Since the events are set for the team, from a connection between the events and the goal of training, performance measures can be established and developed through pre-established scores for answers before the teams perform the task. An event takes place within the simulated exercise in the form of sentences (messages) written. These sentences relate to activities that the operator must perform and they will be assessed in the light of the method. The proposal of the sentences in the simulated exercise is that they are interpreted by operators and should serve as "triggers" to carry out the activities that will be punctuated by observers. As the exercise happens and critical events are triggered, each of the checklist items can be marked as correct (value 2), incorrect (value 0) or partially correct (value 1) (Dwyer, Oser, Salas and Fowlkes, 1999).

Analytic Hierarchy Process (AHP)

Quantitative assessment methods for multi-criteria decision-making can be applied in various domains (Ginevicius, 2008; Zavadskas and Vilutiene, 2006; Turskis, Zavadskas and Peldschus, 2009). The most common approach to determine the weights of the criteria is the comparative mirroring between them. This involves the comparison of pairs of all the criteria of evaluation by SME. For this, a sophisticated scale, mathematically well established and widely used was developed by Thomas Lorie Saaty in 1977, as shown in Table 1.

The AHP (Saaty, 1977) determines the criteria weights structured hierarchically in relation to those who belong to a higher level. It is based on a pair-wise comparison matrix, which SME compare all assessment criteria. The criteria comparison is made qualitatively and indicates whether a criterion is more meaningful than the other and in which level its priority belongs. This approach allows qualitative assessments provided by SME can be converted into quantitative data through the use of an inverse symmetric matrix (reciprocal matrix).

The filling of the array is simple because the SME indicates the importance of a particular criterion relative to each other. Saaty (1977) suggested a fundamental scale with five classifications set to values of 1 to 9 (1, 3, 5, 7, and 9) to be used during the evaluation, as shown in Table 1.

Value	Definition	Explanation
1	Equally importance	Identical contribution
3	Weak importance	Slightly superior judgment
5	Strong importance	Strongly judgment in favor
7	Very strong importance	Recognized dominance
9	Absolute importance	Confirmed dominance
2,4,6,8	***Intermediate values***	***When compromise is needed***

Table 1. Fundamental scale (Saaty, 1977)

THE CASE STUDY

The purpose of the Simulated was to assess how three experienced officers from the Military Fire Brigade of the State of Rio de Janeiro (CBMERJ, Portuguese acronym for Corpo de Bombeiros Militar do Estado do Rio de Janeiro), listed in Table 2, react to a chemical spill emergency in urban road. To this end, the three officials should manage the emergency and control teams being within the Integrated Center of Command and Control of Rio de Janeiro (CICC-RJ, Portuguese acronym for Centro Integrado de Comando e Controle do Rio de Janeiro). Team decisions (for this exercise) have been set according to the Standard Operating Procedure (SOP), referring to the increasing complexity of emergency which is divided into four levels: I, II, III and IV. Each emergency level set a specific complexity and requires the teams to be distributed in the field in a different way. The mission of the three officers was to use SOP to specialize Job Functions in emergency was classified as Level II. To achieve the objective, the three officials had to decide what would be the best way to distribute the agents in the operation because the number of agents it was not enough to complete all functions. Figure 1 show how the organizational structure should be constituted according to the SOP.

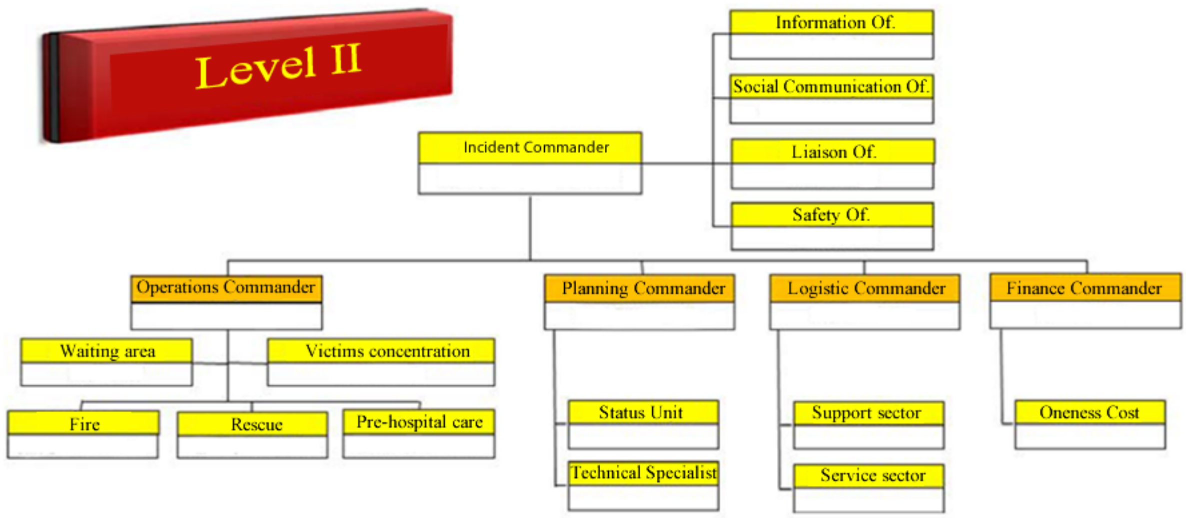

Figure 1. Level II Organization Chart of Firefighters

The scenario of the simulated exercise was made available on a web page (in text format) that the three officers were able to access through computers. It had all the elements to which participants were able to gather information about the emergency situation. Also, text fragments were purposely made available so that they could read and make the association with which job function should be specialized to solve certain task. For example, the fragment *"[...] provide information to the media and guide agents [...]"*, to the job function of Officer of Social Communication or the fragment *"[...] supervise the correct use of protective equipment [...]"*, to the job function of Safety officer. Beyond these, sixteen other job functions (see Figure 1 and Table 4) would be required to respond to emergency classified as Level II.

Post	Age	Time experience (years)
Lieutenant Colonel	43	25
Lieutenant Colonel	36	18
Major	37	14

Table 2. Team assessed in the simulation exercise

Decision-making criteria were inserted into the exercise scenario, through propositions, to be extracted by the three officials during exercise and serve to support decision-making. Five decision-making criteria were defined, with the following: Urban mobility (UM); The presence of media at the site (PM); Family members of victims at the site (FV); Presence of other agencies at the place (OA); and Victims presence at the site (VS). The words "site" or "place" used on some criteria refer to the perimeter or the surroundings of the emergency. Beyond the matrix shown in Table 3, five other matrices were filled during the interview with the SME. For each criterion, one associated proposition was available within the text that formed the scenario. For example, for the criterion *"The presence of media at the place"* has been placed within the text, the proposition *"the media is on place, requesting information"*.

	VS	UM	PM	FV	OA
Victims presence at the site	**1**	3	7	5	9
Urban mobility	1/3	**1**	5	3	7
The presence of media at the place	1/7	1/5	**1**	5	3
Family members of victims at the place	1/5	1/3	1/5	**1**	3
Presence of other agencies at the place	1/9	1/7	1/3	1/3	**1**

Table 3. Matrix of global criteria

During the simulated exercise were used: one Video wall, three computers, one Google Sites page and one Google Docs form. Figure 2 shows the layout of exercise. In computers, the participants had access to the internet page containing all the details of the scenario and the decisions to be executed. The video wall was used to show the location of the accident, using Google Maps. Thus, it was possible to see the details of the site where raced the chemical spill disaster.

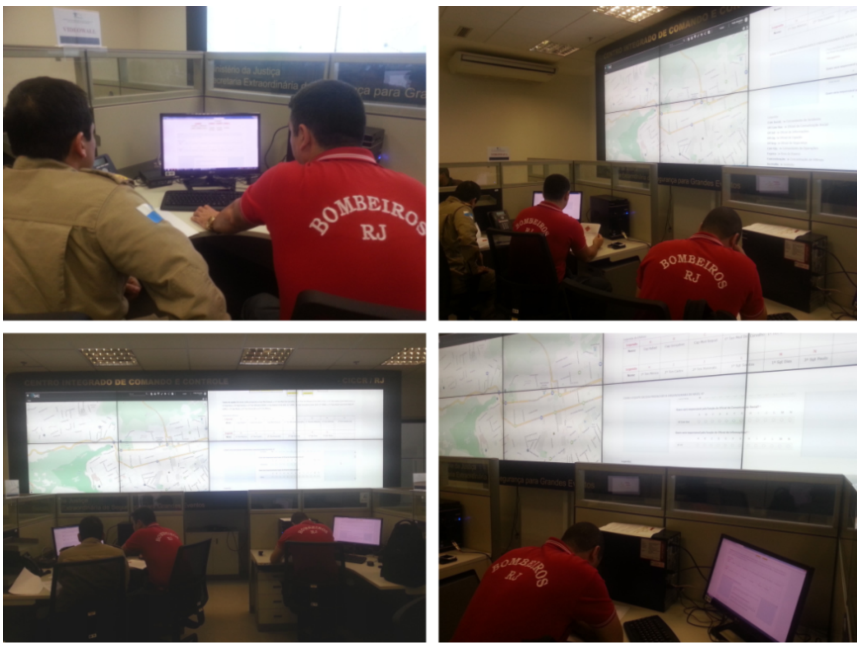

Figure 2. Decision makers team during the simulated

RESULTS

The results of observation are shown in Table 4 and are separated by columns O (Observed), D (Desirable) e S (Score). In addition, the table describes the decisions grouped by "macro decision" (Staff, Operations, Planning, Logistics e Finances). The column O contains the decisions that were taken by the team during exercise, in column D are the decisions defined by SME as desirable during the decision-making process, being the primary marked in bold and secondary marked in italics (only one choice is possible), and finally the column S represents the score according to the method TARGETs (Fowlkes et al., 1994), generated by the team's decisions grouped by macro decisions in the column M.

M	Decisions	O	D	S
Staff	Information Officer	J	**I**	1
	Social Communication Officer	J	**H**, *J*	
	Liaison Officer	J	**H**, *J*	
	Safety officer	N	**I**, *H, J*	
Operations	Operations commander	E	**B**	1
	Waiting area	M	**M**, *L*	
	Victims concentration	C	**C**	
	Fire	G	**N**, *L, M*	
	Rescue	G	**G**, *I*	
	Pre-hospital care	D	**D**	
Planning	Planning commander	H	**A**	1
	Status Unit	H	**L**, *M, N*	
	Technical Specialist	F	**F**	
Logistics	Logistic Commander	B	**E**, *I*	0
	Support sector	B	**M**, *L*	
	Service sector	B	**M**, *L*	
Finances	Finance Commander	L	**J**, *H*	0
	Oneness Cost	L	**J**, *H*	

Table 4. Results of observation of the simulated

The data shown in Table 4 are the result of decision-making based on qualitative results from the observation of teamwork. These data were weighted according to the weights (decision vectors) shown in the column AHP of Table 5. Thus, added to the matrix, two columns representing the score generated by the observation (TARGETs column) and the score generated by applying the decision vector (AHP column) using the weighted average.

SCORING MATRIX								
Decision matrix							Assessment matrix	
Decision	Global Criteria (%)					AHP	TARGETs	Score
	VS	UM	PM	FV	OA			
Operations	51.07	52.28	30.77	42.26	28.64	47.71%	1	0.477
Staff	26.42	13.49	42.45	27.50	52.56	25.78%	1	0.258
Planning	11.71	24.37	16.74	19.03	11.10	16.13%	1	0.161
Logistics	7.82	7.34	7.31	8.58	4.68	7.57%	0	0.000
Finances	2.98	2.53	2.74	2.63	3.02	2.81%	0	0.000
					TOTAL	1	3	**0.896**

Table 5. Final Score Matrix

Thus, the team achieved a score TARGETs equal to 3 and final score equal to 0.896.

DISCUSSION

The data that appears in the scoring matrix (Table 5) show that the team managed to score in one part of the decisions, but in others, it did not score. The final team score was quite different compared to the desirable score, based on interviews with SME. The difference can be seen in Figure 3, which shows the area affected by the team in the graph in red color, called Performed. We can also see that the team has achieved partially the desired results in relation to decision-making for Operations, Staff, and Planning. However, with relation to Finance and Logistics, the team has not achieved the minimum score, obtaining overall score less than fifty percent of the desirable result (blue) set by SME through interviews. The desired result can be achieved when all data in the column named targets (Table 5) assume the value equal two, in other words, the maximum value generated by the observation using the method TARGETs (Fowlkes et al., 1994).

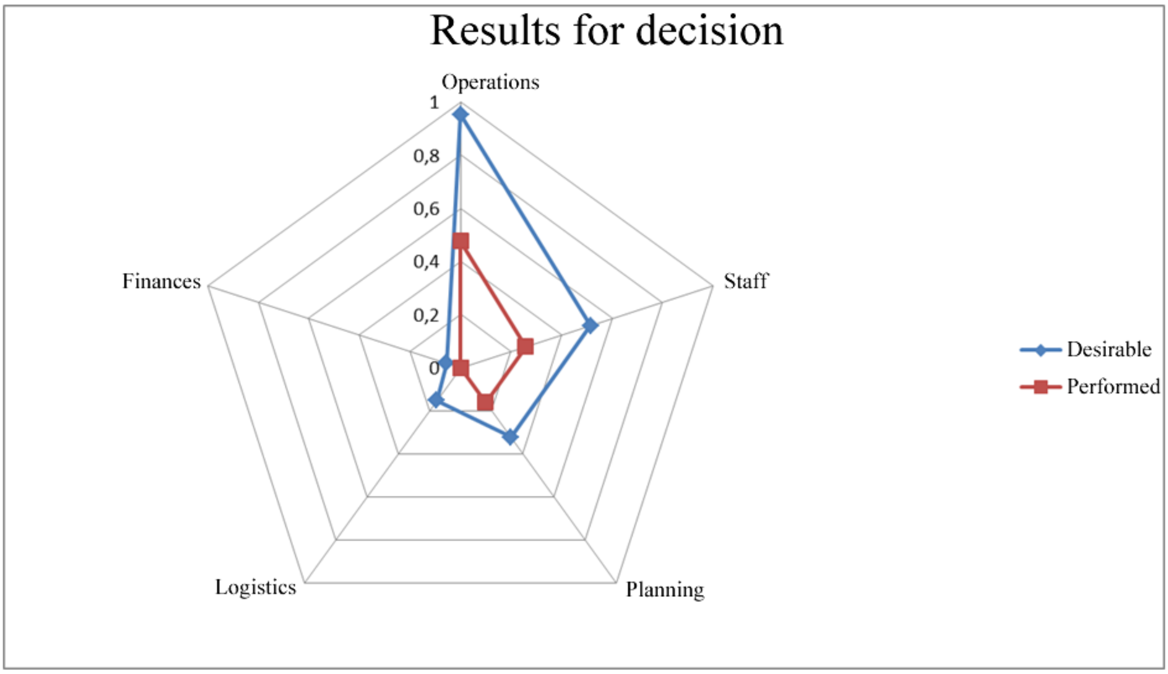

Figure 3. Comparison Chart of the final outcome and the desired outcome

An important factor to clarify is that the score calculated using the methodology was based on interviews with SME, representing his perspective about the desirable results. On the other hand, the team fails to score on two criteria, representing 10.38% of the total weight, thus if during the evaluation of SME, part of that percentage to be distributed among the other three criteria, the team score could reach a better index.

CONCLUSION

This paper presented a study for the evaluation of team decision-making in a simulated exercise emergency response within a Command and Control Center in the Rio de Janeiro State. The study was inspired by the difficulty of making quantitative assessments based on qualitative data from the observation of human activity. Despite the effectiveness in the application of methodologies to evaluate the decision-making, we do not know to what extent the mental workload can interfere in the setting of the weights of decision-making criteria during the interview with the SME and evaluation of the three Officers during the simulated exercise. We know that decision-making processes in organizations dealing with emergency response include many factors such as organizational leadership, interdisciplinarity, organizational structure, communication and human cognition. These factors were not considered in the scope of the search for the reason we want to just test the combination of methodologies (TARGETs and AHP) to evaluate the team decision-making. The combination of methodologies (in the future) may be used in software or Application Programming Interface (API) for games or simulators for the purpose of assess the participants in the simulation. These aspects are opportunities for future research in decision-making for emergency response domain. Thus, we understand that there is a long way and many answers to be found in the Domains: Decision-making, complex systems management, and information systems.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of Conselho Nacional de Pesquisas (CNPq) and Fundação de Amparo à Pesquisa do Rio de Janeiro (FAPERJ).

REFERENCES

1. Bigley, G. A. and Roberts, K. H. (2001) The incident command system: High reliability organizations for complex and volatile task environments. Academy of Management Journal, 44(6), 1281–1299.
2. Cosgrave, J. (1996) Decision making in emergencies. Disaster Prevention and Management, 5(4), 28–35.
3. Crichton, M. T., Flin, R. and Rattray, W. A. (2000) Training decision makers-tactical decision games. Journal of Contingencies & Crisis Management, 8(4), 208–219.
4. Danielsson, M. and Ohlsson, K. (1999) Decision making in emergency management: A survey study. International Journal of Cognitive Ergonomics, 3(2), 91–99.
5. Dolif, G., Engelbrecht, A., Jatobá, A., Da Silva, A.J.D., Gomes, J.O., Borges, M.R., Nobre, C.A. and De Carvalho, P.V.R. (2013) Resilience and brittleness in the ALERTA RIO system: a field study about the decision-making of forecasters Natural Hazards, 65 (3), pp. 1831–1847.
6. Driskell, J. E. and Salas, E. (1991) Group decision-making under stress. Journal of Applied Psychology, 76(3), 473–478.
7. Dwyer, D. J., Oser, R. L., Salas, E. and Fowlkes, J. E. (1999) Performance measurement in distributed environments: initial results and implications for training. Military Psychology, 11(2), 1189–1215.
8. Flin, R. (2001) Decision making in crises: The Piper Alpha disaster. In Rosenthal, U., Boin, A. R., & Comfort, L. (Eds.), Managing crises: Threats, dilemmas, opportunities (pp. 103–118). Springfield, IL: Charles C. Thomas.
9. Fowlkes, J. E., Lane, N. E., Salas , E., Franz , T. and Oser , R. (1994) Improving the measurement of team performance: The TARGETS methodology. Military Psychology, 6(1), 47-61.
10. Ginevicius, R. (2008) Normalization of quantities of various dimensions, Journal of Business Economics and Management 9(1): 79–86.
11. Inzana, C. M., Driskell, J. E., Salas, E. and Johnston, J. H. (1996) The effects of preparatory information on enhancing performance under stress. Journal of Applied Psychology, 429–435.
12. Janssen, A. and Vreugdenhil, H. (2015) Objective oriented exercise evaluation with TARCK-it. In: Proceedings of the 12th International ISCRAM Conference. Kristiansand.
13. Jatobá, A., Bellas, H. C., Koster, I., Bonfatti, R., Vidal, M., C., R. and Carvalho, P. V. R. (2014) Acolhimento com classificação de risco em saúde da família: uma abordagem para apoiar a tomada de decisão. Ação Ergonômica, v. 9, p. 34-46.
14. Lindell, M. K., Prater, C. S. and Peacock,W. G. (2005) Oganizational communication and decision making in hurricane emergencies. Pomona, CA: Hazard Reduction & Recovery Center.
15. Lin, D.-Y. M. and Su, Y.-L. (1998) The effect of time pressure on expert system based training for emergency management. Behaviour & Information Technology, 17(4), 195–202.
16. Manca, D., Nazir, S., Colombo, S. and Kluge, A. (2014) Procedure for automated assessment of industrial operators. Chemical Engineering Transactions, 36, 391-396.
17. Moynihan, D. P. (2008) Learning under uncertainty: Networks in crisis management. Public Administration Review, 68(2), 350–365.
18. Nazir, S., Manca, D. and Colombo S. (2012) Performance indicators for training assessment of control-room operators. Chemical Engineering Transactions, 26, 285-290.
19. Nazir, S., Sorensen, L. J., Øvergård, K. I. and Manca, D. (2015) Impact of training methods on Distributed Situation Awareness of industrial operators. Safety Science, 73, 136-145.

20. Paton, D. (2003) Stress in disaster response: A risk management approach. Disaster Prevention and Management, 12(3), 203–209.
21. Preston, T. and Cottam, M. (1997) Simulating US Foreign Policy Crises: Uses and Limits in Education and Training. Journal of Contingencies and Crisis Management, 224-230.
22. Quarantelli, E. L. (1997) Ten criteria for evaluating the management of community disasters. Disasters, 21(1), 39–56.
23. Rosenthal, U. and Kouzmin, A. (1997) Crises and crisis management: Toward comprehensive government decision making. Journal of Public Administration Research & Theory, 7(2), 277–305.
24. Saaty, T.L. (1977) Scaling method for priorities in hierarchical structures, Journal of Mathematical Psychology, 15/3, 234-281.
25. Turskis, Z., Zavadskas, E. K. and Peldschus, F. (2009) Multi-criteria optimization system for decision making in construction design and management, Inzinerine ekonomika – Engineering Economics 1(61): 7–17.
26. Wallace, W. A. and De Balogh, F. (1985) Decision support systems for disaster management. Public Administration Review, 45, 134–146.
27. Zavadskas, E. K. and Vilutiene, T. A. (2006) A multiple criteria evaluation of multi-family apartment block's maintenance contractors: I—Model for maintenance contractor evaluation and the determination of its selection criteria, Building and Environment 41: 621–632.