

MODEL OF SCENARIO DEVELOPMENT IN DEFENSE PLANNING – INTEGRATION OF SCENARIO AND DECISION – MAKING METHODS

Vlada M. Mitić*, Srđan H. Dimić** and Milan S. Kankaraš
Ministry of Defense of the Republic Serbia, Defence Policy Sector,
Strategic Planning Department

It is almost impossible to predict the future environment today, so instead of using prediction different methods of scenario development are used. Scenario as a hypothetical situation for future environment enables exploration of different possibilities of environment development in the future. Many methods based on a morphological analysis are used to develop scenarios. Numerous configurations of morphological fields prevent further use of scenarios and a practical description of the various scenarios. It is possible to reduce the number of configuration of morphological fields, classify configuration according to the different scenario classes and determine the representative configuration for the worst and best scenario case for each class of scenarios by integrating the method for scenario development with the decision-making methods. In this way further processing and description of scenarios is enabled, thus fulfilling a practical role of scenarios in the planning process.

Key Words: scenario development methods, morphological analysis, decision-making, classification, clustering, K-means, decision tree

Introduction

One of the preconditions for successful planning is to assess the environment, which ensures understanding of the environment in the future and the possibility of rapprochement of the organization with future environment requirements. When it comes to the defense system, the environment assessment is even more important since the main mission of the defense system is the protection of national interests from the challenges, risks and threats that jeopardize them. The complexity of the environment is characterized by mutual influence of many different factors, which the environment is composed of. Rapid technological advances and changes in the economic, social, political and other spheres of life cause the environment to constantly change.

* vlada.mitic@mod.gov.rs

** srdjan.dimic@mod.gov.rs

Due to the complexity of environment context it is impossible to predict future, so more frequently the term environment assessment is used. In contrast to the predictions, the basis of environment assessment is the development of different variants of the environment in the future. In order to describe the different variants of the environment in the future different methods of scenario development are used, so that each variant is represented with a single scenario. The most frequently used methods of scenario development are morphological analysis and methods based on morphological analysis such as Battelle and FAR analysis (Zwicky 1948, Kosow / Gaßner 2008, Nguyen / Dunn 2009, Kovač / Stojković 2009). The result of applying morphological analysis is represented by a large number of configurations. In real situations, when it comes to a large number of factors, where many of them may have numerous values, the number of consistent or compatible configuration can be several million. Too many configurations, which are the result of morphological analysis, do not allow efficient data processing, as well as identifying a limited number of configurations that will be used to describe the scenario.

The basic question to be answered is: *How to reduce the number of configuration of morphological fields?* In the literature, in the field of management and decision – making theory, different ways of reducing the number of configurations can be found. Some of the possible ways is the application of classification and clustering to reduce the number of configurations and identify scenarios (Kosow / Gaßner 2008, Nguyen / Dunn 2009, Fotr, et al. 2015, Calvo-Zaragoza, J.Valero-Mas/R.Rico-Juan 2015). Despite great literature dealing with the problems of reducing the number of configurations, there is no unique and systematic approach that integrates the methods of decision – making theory with the methods of scenario development.

This paper suggests a model that integrates the scenario development methods with the decision – making methods, principally classification and clustering supported by the methods of group decision-making and multi-criteria decision – making.

Model of scenario development

Scenario has double meaning (Kosow and Gaßner 2008): firstly, scenario is a description of a possible future situation; secondly, scenario includes a path of development that leads to some future situation. The term scenario planning prevails in the literature. This term is used to indicate the process of scenario development. The outcomes of scenario planning are: changed organization thinking, informative narrative or stories about possible or plausible future, improved decision - making about the future and enhanced human and organization learning and imagination (Chermack 2011). The scenario development identifies the set of possible situations in the future, where each can happen, but none is completely certain. The range of possible developments of values of environmental factors or positive and negative deviation from the value which is obtained on the basis of the trend function at a certain moment can be higher or lower.¹ If the time distance of estimation is closer to the present time, the range of deviation is smaller and as assessment goes to the longer term, the range is larger (Kosow / Gaßner 2008). This effect is usually called funnel model in literature (Figure 1).

¹ See more about environmental factors, values of the environmental factors and trend analysis in Mitić, Kovač / Kankaraš 2017.

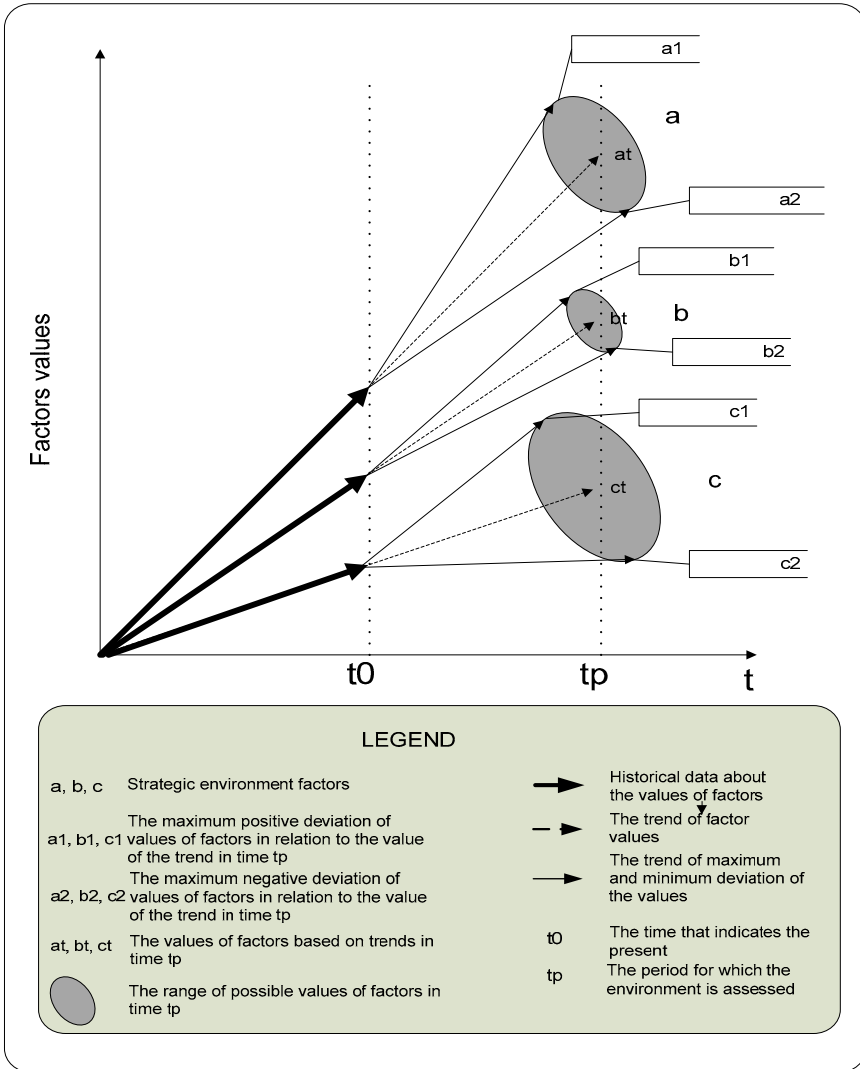


Figure1 – Funnel model of values of environmental factors (Mitić, Kovač/Kankaraš 2017)

In accordance with the description of the funnel model shown in the Mitić, Kovač / Kankaraš 2017 the combination of certain values of environmental factors results in different scenarios of environment. Generated number of scenarios depends on a number of factors in each scenario, as well as the possibility of combining specific values of environmental factors, so that the number of scenarios can be very large. It can be concluded that the generated scenarios also have their own funnel model, which will be determined by the different values of environmental factors that can be combined with each other.

A precondition for the application of the scenario development model are predetermined environmental factors, examined mutual influence of environmental factors and estimated or calculated trends of the value of environmental factors in the time the estimation is performed.² According to many authors, the best results in the development of scenarios are provided by integration of several methods which can reduce the disadvantages of certain methods and get better results. A possible model of scenario development is shown in Figure 2.

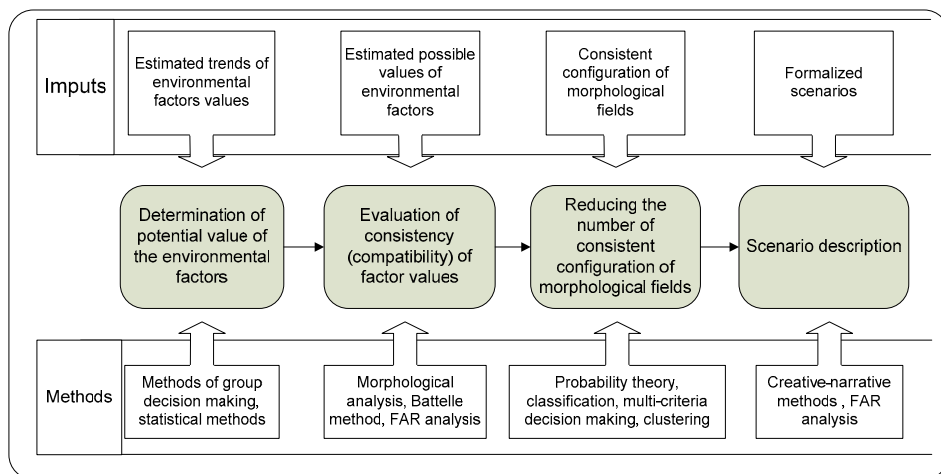


Figure 2 – Scenario development process

Scenario Development, as the phase of the Environment Assessment process, consists of the following steps: determination of a potential value of the factors, evaluation of consistency (compatibility) of factor values, reduction in the number of consistent configuration of morphological fields and description of the scenario.

Determination of a potential value of the environmental factors

The determination of a potential value of the environmental factors is the first step in the process of scenario development in which the funnel of possible values of environmental factors is expanded (Figure 1). The determination of potential values of the environmental factors begins by identifying a set of possible values that is limited by the maximum and minimum deviation of factor values in relation to the estimated or calculated trends. Potential values of the environmental factors are estimated or calculated on the basis of the method that is used for trend assessment. If the trends are calculated using statistical methods,³ the minimum and maximum deviation from the trend values is

² See more about processes of determination of environmental factors, collection of data on values of the factors and calculation and assessment of trends of the values of environmental factors in Mitić, Kovač / Kankaraš 2017.

³ If historical data on the values of environmental factors are available, if there is a connection between the data and if the data is numeric (quantitative), or if qualitative data can be transformed into quantitative by using fuzzy logic.

calculated using the standard deviation. If the trends are estimated using the method of group decision – making (e.g. Brainstorming and DELPHI),⁴ then methods of group decision – making (Čupić / Suknović 2008) will also be applied for the assessment of the maximum and minimum deviation from the estimated trend in the future.

After identifying a set of possible values of environmental factors, the overall field of possible values is divided into three to five subsets. On this basis a matrix of morphological fields or morphological boxes is formed (Zwicky 1948, Zwicky / Wilson 1967), which is shown in Table1.

Table 1 – Example of morphological field

Environmental factors	F1	F2	F3	F4	F5	F6
Values of environmental factors	f11	f21	f31	f41	f51	f61
	f12	f22	f32	f42	f52	f62
	f13	f23	f33	f43	f53	f63
		f24		f44		
				f45		

Only factors that have the greatest mutual influence will be in a single morphological field whereas factors that have no or small mutual influence are discarded or grouped into different morphological fields. DEMATEL method can be used to test the mutual influence of environmental factors (Bagheri Morghaddam, et al. 2010).

Evaluation of consistency (compatibility) of factor values

Evaluation of consistency (compatibility) of factor values is based on the application of Morphological analysis, Field Anomaly Relaxation analysis - FAR or Battelle methods. Morphological analysis is a method of structuring and researching a complex and multi-dimensional problem based on the expert assessment of the mutual consistency of individual parameter values (Zwicky 1948, Zwicky / Wilson 1967, Ritchey 2006, Kosow / Gaßner 2008, Nguyen / Dunn 2009, Fotr, et al. 2015). Each parameter of morphological analysis is a certain factor from the environment whereas parameter values are subsets of the possible values of environmental factors. The total number of combinations of morphological box (configuration) is equal to the product of the total number of possible values of all factors. Using an example in Figure 3 the total number of configuration is: $3 \times 4 \times 3 \times 5 \times 3 \times 3 = 1620$. The number of configurations can significantly increase to several million by increasing the number of factors, and also the value of factors. The next step is estimation of factor values consistency. Consistency is estimated by the association of the value of the factors with the values of all other factors. The experts as-

⁴ If historical data on the values of environmental factors are not available, if there is no correlation between the data and if nominal scale is applied to express the value of environmental factors, or factor values are qualitative.

sess whether it is possible that two factor values exist simultaneously in a future scenario, or if they can coexist together (Figure 4).

	f11	f12	f13	f21	f22	f23	f24	f31	f32	f33	f41	f42	f43	f44	f45	f51	f52	f53	f61	f62	f63	
f11																						
f12																						
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Figure 3 – Example of the consistency (compatibility) matrix

In Figure 3, marks + and - indicate assessment of the consistency of the values of the environmental factors whereas the red numbers in brackets represent the example of the compatibility assessment. Compatibility is most often expressed in scale from one to five, where 1 is inconsistent, 2 is weak inconsistency, 3 is neutral or no mutual influence, 4 means poor compatibility and 5 is strong compatibility (Kosow / Gaßner 2008).

In practice, usually more than 90% of the configuration is not consistent (Ritchey 2006), thereby significantly reducing the total number of consistent combinations that are the subject of further analysis. Despite the significant reduction in the number of possible consistent combinations when it comes to large morphological box with ten or more factors, there is still the problem of a large number of consistent configurations that are difficult to be further processed. Application of Field Anomaly Relaxation analysis and Battelle methods allows further reduction in the total number of configurations. Battelle method is basically the same as the morphological analysis, and the difference is reflected in the assessment of consistency or compatibility (Nguyen / Dunn 2009). Morphological analysis is the basis of FAR analysis, as well as the application of Battelle method. However, in addition to consistency of value pairs, consistency of overall configurations is also estimated (Nguyen / Dunn 2009).

Reduction in the number of consistent configuration of morphological fields

Reduction in the number of consistent configuration of morphological fields is the third step in the process of scenario development that creates the optimum number of scenarios. Reduction in the number of configurations can be achieved in one of following ways:

- 1) Criteria of compatibility (Nguyen / Dunn 2009, Kosow / Gaßner 2008);
- 2) Criteria of probability (Kosow / Gaßner 2008, Nguyen / Dunn 2009, Fotr, et al. 2015, Turoff, et al. 2016, Medina, de Arce and Mahía 2016);
- 3) Classification (Calvo-Zaragoza, J.Valero-Mas and R.Rico-Juan 2015, Kwakkel / Jaxa-Rozen 2016, Damodaran 2008);
- 4) Clustering (Nguyen / Dunn 2009, Fotr, et al. 2015, Changyong, Juram and Sungjoo 2016).

The methods of classification and clustering are applied in this paper to reduce the number of configuration, which is shown in Figure 4.

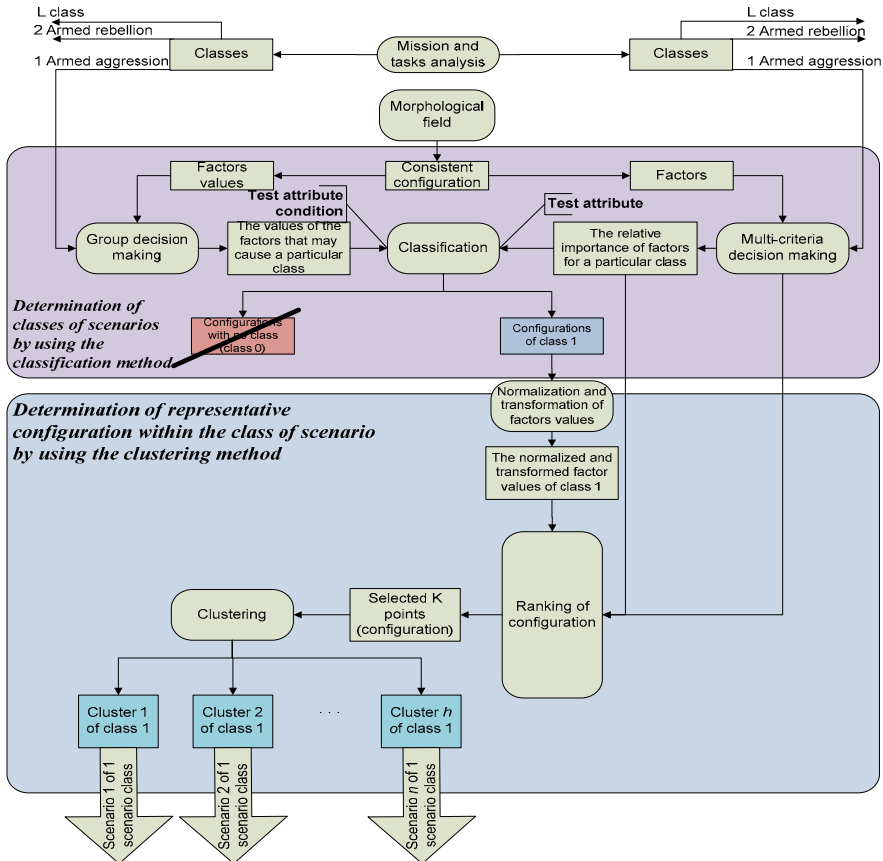


Figure 4 – Model of reduction in the number of configuration of morphological fields by using the classification and clustering method

Determination of scenario classes by using the classification method

Classification is the process of assigning objects to one or more specific categories, which are previously determined (Tan, Steinbach / Kumar 2006). Categories for the classification result from the analysis of the mission and tasks of the defense system and point to security challenges, risks and threats that the defense system has to confront in the future in order to protect national and defense interests. Modern military forces usually carry out three basic missions: defense of the country from armed threats, participation in the international peacebuilding and support to civil authorities in countering non-military forms of security threats (Kovač / Stojković 2009). In the context of protection of national interests, the most important mission of the defense system of the Republic of Serbia is to defend the state from armed threats, especially military ones. In this context, the primarily military threats are armed aggression and armed rebellion (Zakon o odbrani 2015).

In order to reduce the number of configuration using the classification method it is necessary to allocate the most important configurations that are included in tasks and missions of the defense system. In this regard, the classes for grouping configurations are armed aggression and armed rebellion. The basic concept of the classification method predicts the existence of training sets – data on the values of the environmental factors (Tan, Steinbach / Kumar 2006) and a specific test set – a sample of the historical data. The training set is a basis for the formation of the classification algorithm, which can be made by using decision tree techniques (Damodaran 2008). Unlike the basic concept for the classification method, to classify configuration in the class of armed aggression and armed rebellion, it is necessary to have the following facts in mind:

- armed aggression and armed rebellion in most cases are described by different factors from the environment;
- constant changes in the physiognomy of the armed conflict cause the appearance of armed aggression or armed rebellion to be influenced by various environmental factors depending on the historical period, international relations, state power, technological progress and other;
- different values of the environmental factors depending on the historical period, international relations, the role of force and power of the state and other conditions, affect differently the occurrence of armed aggression or armed rebellion.

On the basis of the abovementioned facts the following starting points in the application of the classification method can be derived:

1) the same decision trees cannot be used for the classification of the configuration into the class of armed rebellion and armed aggression. A separate decision tree must be formed for each class of classification, wherein the type of the attribute is binary conditional testing (e.g. either is or is not armed aggression);

2) for the determination of the test attributes from a set of the environmental factors it is not applicable to form a training set from the historical data as the historical factors variously affect the emergence of armed aggression or armed rebellion;

3) to determine values of the environmental factors as the condition test attributes, a training set from the historical data cannot also be used because the different values of the environmental factors have different historical contribution to the emergence of armed aggression or armed rebellion.

Taking into account the abovementioned limitations of the application of the classification method in reducing the number of configuration, it is suggested that a multi-criteria decision - making methods are used to determine test attributes (Fotr, et al. 2015). On the other hand, the methods of group decision - making may be used for determining the values of the environmental factors, which can be used for attribute test conditions (e.g. Brainstorming and DELPHI).

The first step in the application of multi-criteria decision method is to determine the weight of criteria, in this case the determination of the weight or importance of the environmental factors for armed aggression or armed rebellion. Weighting of factors can be performed through use of Saaty model. In accordance to Saaty model, the first thing is to form a matrix $n \times n$, where the header of a row and column of the matrix contains all the environmental factors. Then, the weight is estimated in pairs ($t_{n\#}$, where n is the ordinal number of the factors in rows and $\#$ is the ordinal number of the factors in columns), or the importance of each factor with respect to all the other factors separately in a scale of one to nine, in the context of a particular class, or challenges, risks and threats (for example, armed aggression). The weight in the pairs n and $\#$ is determined in such manner that the pairs are examined by how much the factor n (from row) is more important for certain scenario class than the factor $\#$ (from column). If the importance of the factor n (e.g. for armed aggression) is higher than the importance of the factor $\#$ then the weight per pairs is $t_{n\#}$, otherwise, if the importance of the factor n is less than $\#$ then the weight is $1/t_{n\#}$. During the next step the sum of each column of the matrix is calculated, and then each weight in pairs shall be divided by the resulting sum in the columns. Finally, the pre-corrected values are summed by rows and for each row arithmetic average is determined (Čupić / Suknović 2008). In this way, the total importance or weight of the environmental factor T_n is calculated for a particular class (in this case for armed aggression) and can be represented by equation 1.

$$T_n = \frac{\sum_{\#=1}^i \left(\frac{t_{n\#}}{\sum_{n=1}^i t_{n\#}} \right)}{n} \quad (1)$$

In the presented equation the following insignia are used:

T_n – Weight of the environmental factors (for a particular class of scenarios),

$T_{n\#}$ – Estimated weight in pairs of the matrix,

n – Ordinal number of factors in the rows of the matrix,

i – The maximum number of the environmental factors,

$\#$ – Ordinal number of factors in the column of the matrix.

A useful tool for estimating the weight of the environmental factors can be software Expert Choice. Figure 5 shows an example of determining the importance of certain environmental factors for armed aggression, which is set as an objective.

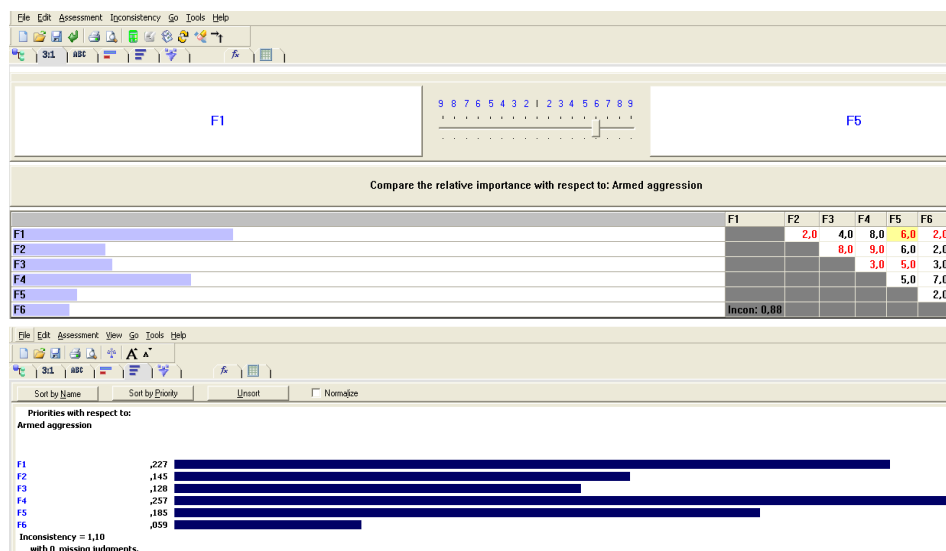


Figure 5– An example of using the software Expert Choice in determining the importance of the environmental factors on armed aggression

The estimated importance of the environmental factors for armed aggression will determine the order of test attributes in the construction of a decision tree. For example, looking at Table 2, the order of factors for classification of configurations per class of armed aggression would be: F4, F1, F5, F2, F3, F6. After determination of importance of the environmental factors, by using the method of group decision it is necessary to determine the value of the environmental factors (G_n), as well as condition (\leq or $\geq G_n$) for testing per each attribute that can lead to armed aggression. Value G_n is determined from the set of the value F_{nm} , where n is the ordinal number of factors and ranges from 1 to i , where i is the maximum number of the environmental factors, and m is the number of the factor values and ranges from 1 to j , where j is the maximum number of factor value of i -th factor and it is recommended that it ranges from three to five (Table 2).

Table 2– An example of the determination of the attribute test conditions for classification in the morphological field

F4	F1	F5	F2	F3	F6
f41	f11	G5	f21	G3	f61
f42	G1	f52	f22	f32	G6
f43	f13	f53	f23	f33	f63
G4			G2		
f45					

On the basis of the abovementioned assessment, using multi-criteria and group decision-making methods, classification decision trees can be constructed for the class of military aggression, as well as armed rebellion (Figure 6).

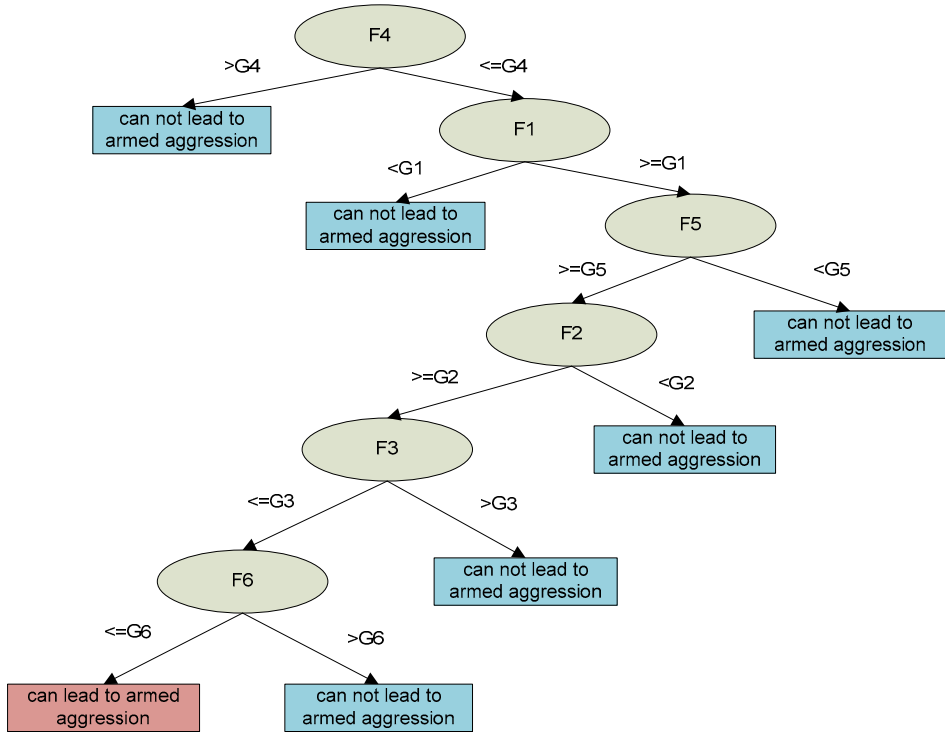


Figure 6 – Decision trees for classification of morphological configuration fields in the class of armed aggression

The application of the classification method, as well as multi-criteria and group decision-making methods to create a decision tree, enable configurations that can cause armed aggression or armed rebellion to be distinguished from the whole morphological field. In further analysis of scenarios only the configurations that can lead to armed aggression and armed rebellion are considered whereas other configurations are discarded. Taking into consideration the class of armed aggression and using the above-described example the total number of configurations is reduced from 1620 to $4 \times 2 \times 3 \times 1 \times 1 \times 2 = 48$.

However, despite a significant reduction in the number of configurations, depending on the number of factors to be analysed, there is a large number of configurations for each class. Such a large number of configurations disables further use of scenarios in the planning process.

Determination of representative configuration within the class of scenario by using the clustering method

To reduce the number of configurations for each class, using the principle of similarities configuration (Nguyen / Dunn 2009), grouping is carried out and determination of the reference configuration as a representative of the group (Fotr, et al. 2015). Clustering methods or cluster analysis is used for the purpose of grouping configuration. Clusters are potential classes, and cluster analysis techniques are based on learning with the aim of finding an automated class, as well as the most representative prototype of a class (Tan, Steinbach, / Kumar 2006). In the context of scenario development, prototypes represent configuration from morphological fields whereas clustering is applied for the purpose of compression of a large number of configurations. Cluster analysis is exclusively based on the information in the database, which describes objects and their relationships. Since the configurations obtained by morphological analysis are structured as database, clustering can be successfully used for data processing.

When it comes to types of clustering, taking into account the characteristics of the configuration of morphological field, as well as the objective that should be achieved by clustering, it is best to apply partitional clustering. Moreover, any configuration from a set of available configurations should be assigned to a single cluster. When it comes to types of clusters, taking into account that the configurations are structured by a large number of factors (attributes), and there is often the small and undefined difference between configurations, the most suitable cluster to apply is the one based on the prototype. Accordingly, for clustering configuration of morphological field *K-means* technique can be efficiently used.

K-means clustering is based on the presentation of the cluster through prototype (Tan, Steinbach / Kumar 2006). As a prototype configuration in the application of *K-means* method the most appropriate one to use is medoid, where the representative or prototype of the cluster is one of the existing configurations. The first step in the application of *K-means* clustering technique is the selection of a certain number of *K* points, which simultaneously determines the total number of clusters. *K* points represent the configurations of morphological fields, which are the basis for the calculation of the final medoids by repeating the operations of assigning a configuration to the *K*-point, calculation and determination of new *K* points until the calculated and the new set of *K* points do not differ from the previous one. In case of any change of *K* point, the clusters which are assigned to the configurations are also changed, so the condition for termination of clustering can be interpreted as the absence of changes in the allocation of configurations among clusters. In practice, the final condition for clustering is difficult to achieve, so the condition for the completion of clustering is such that less than 1% of the configurations change clusters that are assigned.

The characteristics of configuration obtained by morphological analysis are such that it is difficult to spot potential *K* points, mostly due to a lot of attributes used for their description. In order to determine the optimum *K* points, the configuration has to be processed and ranked. Multi-criteria decision-making methods can be successfully applied for the ranking of the configuration.

Prior to the application of the multi-criteria decision-making methods it is necessary to transform quantitative and qualitative values of the environmental factors into the quantitative values in the range from zero to ten, as well as normalize the values of the environmental factors.

The normalized values of the environmental factors (N_{np}) are calculated according to the equation 2 (Čupić / Suknović 2008):

$$N_{np} = \frac{F_{np}}{\left(\sum_{p=1}^s F_{np}^2\right)^{\frac{1}{2}}} \tag{2}$$

In the presented equation the following insignia are used:

N_{np} – the normalized values of factors values F_{nm} , which fulfill a condition of classification (\leq or $\geq G_n$),

p – the ordinal number of values of the environmental factors, which fulfills a condition of classification (\leq or $\geq G_n$) and ranges from one to s ,

s – the maximum number of values of n -th factors, which fulfills a condition of classification (\leq or $\geq G_n$) and $s \leq j$.

An example of the normalized values of the environmental factors is shown in Table 3.

Table 3 – An example of the normalized values of the environmental factors

F4	normalized values (N_{4p})	F1	normalized values (N_{1p})	F5	normalized values (N_{5p})	F2	normalized values (N_{2p})	F3	normalized values (N_{3p})	F6	normalized values (N_{6p})
f41	1	f11		G5	0	f21		G3	0	f61	1
f42	0,66	G1	0	f52	0,5	f22		f32		G6	0
f43	0,33	f13	1	f53	1	f23		f33		f63	
G4	0					G2	0				
f45											

Using the previously calculated weight or the importance of the environmental factors for a particular class of scenario, as well as the normalized values of the environmental factors, the relative importance of each of the configuration can be determined by using equation 3.

$$R_q = \sum_{n=1}^i T_n \times N_{np} \tag{3}$$

In the presented equation the following insignia are used:

R_q – the relative importance of q -th configuration,

q – the ordinal number of configurations or index of configuration, and it ranges from one to w , and w is the maximum number of configuration of morphological fields of a certain scenario class,

T_n – the importance of n -th environmental factor, where n is the ordinal number of factors and ranges from one to i , where i is the maximum number of the environmental factors.

On the basis of the relative importance, the configurations can be ranked from the best - optimistic through basic to the most dangerous – pessimistic (Changyong, Juram and Sungjoo 2016). In this way, the relative importance of configurations represents danger or the estimated consequences that may arise if such a scenario occurs. A calculation example of the relative importance of configuration in a scenario class of armed aggression is shown in Table 4.

Table 4 – A calculation example of the relative importance of configuration in a scenario class of armed aggression

Index	Configuration						N _{4m}	T ₄	N _{1m}	T ₁	N _{5m}	T ₅	N _{2m}	T ₂	N _{3m}	T ₃	N _{6m}	T ₆	R _s	Rank
11	f41	f13	f53	f24	f31	f61	1	0.254	1	0.241	1	0.195	0	0.126	0	0.119	1	0.063	0.753	1
12	f41	f13	f53	f24	f31	f62	1	0.254	1	0.241	1	0.195	0	0.126	0	0.119	0	0.063	0.690	2
23	f42	f13	f53	f24	f31	f61	0.66	0.254	1	0.241	1	0.195	0	0.126	0	0.119	1	0.063	0.667	3
9	f41	f13	f52	f24	f31	f61	1	0.254	1	0.241	0.5	0.195	0	0.126	0	0.119	1	0.063	0.656	4
24	f42	f13	f53	f24	f31	f62	0.66	0.254	1	0.241	1	0.195	0	0.126	0	0.119	0	0.063	0.604	5
10	f41	f13	f52	f24	f31	f62	1	0.254	1	0.241	0.5	0.195	0	0.126	0	0.119	0	0.063	0.593	6
35	f43	f13	f53	f24	f31	f61	0.33	0.254	1	0.241	1	0.195	0	0.126	0	0.119	1	0.063	0.583	7
21	f42	f13	f52	f24	f31	f61	0.66	0.254	1	0.241	0.5	0.195	0	0.126	0	0.119	1	0.063	0.569	8
7	f41	f13	f51	f24	f31	f61	1	0.254	1	0.241	0	0.195	0	0.126	0	0.119	1	0.063	0.558	9
36	f43	f13	f53	f24	f31	f62	0.33	0.254	1	0.241	1	0.195	0	0.126	0	0.119	0	0.063	0.520	10
5	f41	f12	f53	f24	f31	f61	1	0.254	0	0.241	1	0.195	0	0.126	0	0.119	1	0.063	0.512	11
22	f42	f13	f52	f24	f31	f62	0.66	0.254	1	0.241	0.5	0.195	0	0.126	0	0.119	0	0.063	0.506	12
47	f44	f13	f53	f24	f31	f61	0	0.254	1	0.241	1	0.195	0	0.126	0	0.119	1	0.063	0.499	13
8	f41	f13	f51	f24	f31	f62	1	0.254	1	0.241	0	0.195	0	0.126	0	0.119	0	0.063	0.495	14
33	f43	f13	f52	f24	f31	f61	0.33	0.254	1	0.241	0.5	0.195	0	0.126	0	0.119	1	0.063	0.485	15
19	f42	f13	f51	f24	f31	f61	0.66	0.254	1	0.241	0	0.195	0	0.126	0	0.119	1	0.063	0.472	16
6	f41	f12	f53	f24	f31	f62	1	0.254	0	0.241	1	0.195	0	0.126	0	0.119	0	0.063	0.449	17
48	f44	f13	f53	f24	f31	f62	0	0.254	1	0.241	1	0.195	0	0.126	0	0.119	0	0.063	0.436	18
17	f42	f12	f53	f24	f31	f61	0.66	0.254	0	0.241	1	0.195	0	0.126	0	0.119	1	0.063	0.426	19
34	f43	f13	f52	f24	f31	f62	0.33	0.254	1	0.241	0.5	0.195	0	0.126	0	0.119	0	0.063	0.422	20
3	f41	f12	f52	f24	f31	f61	1	0.254	0	0.241	0.5	0.195	0	0.126	0	0.119	1	0.063	0.415	21
20	f42	f13	f51	f24	f31	f62	0.66	0.254	1	0.241	0	0.195	0	0.126	0	0.119	0	0.063	0.409	22
45	f44	f13	f52	f24	f31	f61	0	0.254	1	0.241	0.5	0.195	0	0.126	0	0.119	1	0.063	0.402	23
31	f43	f13	f51	f24	f31	f61	0.33	0.254	1	0.241	0	0.195	0	0.126	0	0.119	1	0.063	0.388	24
18	f42	f12	f53	f24	f31	f62	0.66	0.254	0	0.241	1	0.195	0	0.126	0	0.119	0	0.063	0.363	25
4	f41	f12	f52	f24	f31	f62	1	0.254	0	0.241	0.5	0.195	0	0.126	0	0.119	0	0.063	0.352	26
29	f43	f12	f53	f24	f31	f61	0.33	0.254	0	0.241	1	0.195	0	0.126	0	0.119	1	0.063	0.342	27
46	f44	f13	f52	f24	f31	f62	0	0.254	1	0.241	0.5	0.195	0	0.126	0	0.119	0	0.063	0.339	28
15	f42	f12	f52	f24	f31	f61	0.66	0.254	0	0.241	0.5	0.195	0	0.126	0	0.119	1	0.063	0.328	29
32	f43	f13	f51	f24	f31	f62	0.33	0.254	1	0.241	0	0.195	0	0.126	0	0.119	0	0.063	0.325	30
1	f41	f12	f51	f24	f31	f61	1	0.254	0	0.241	0	0.195	0	0.126	0	0.119	1	0.063	0.317	31
43	f44	f13	f51	f24	f31	f61	0	0.254	1	0.241	0	0.195	0	0.126	0	0.119	1	0.063	0.304	32
30	f43	f12	f53	f24	f31	f62	0.33	0.254	0	0.241	1	0.195	0	0.126	0	0.119	0	0.063	0.279	33
16	f42	f12	f52	f24	f31	f62	0.66	0.254	0	0.241	0.5	0.195	0	0.126	0	0.119	0	0.063	0.265	34
41	f44	f12	f53	f24	f31	f61	0	0.254	0	0.241	1	0.195	0	0.126	0	0.119	1	0.063	0.258	35
2	f41	f12	f51	f24	f31	f62	1	0.254	0	0.241	0	0.195	0	0.126	0	0.119	0	0.063	0.254	36
27	f43	f12	f52	f24	f31	f61	0.33	0.254	0	0.241	0.5	0.195	0	0.126	0	0.119	1	0.063	0.244	37
44	f44	f13	f51	f24	f31	f62	0	0.254	1	0.241	0	0.195	0	0.126	0	0.119	0	0.063	0.241	38
13	f42	f12	f51	f24	f31	f61	0.66	0.254	0	0.241	0	0.195	0	0.126	0	0.119	1	0.063	0.231	39
42	f44	f12	f53	f24	f31	f62	0	0.254	0	0.241	1	0.195	0	0.126	0	0.119	0	0.063	0.195	40
28	f43	f12	f52	f24	f31	f62	0.33	0.254	0	0.241	0.5	0.195	0	0.126	0	0.119	0	0.063	0.181	41
14	f42	f12	f51	f24	f31	f62	0.66	0.254	0	0.241	0	0.195	0	0.126	0	0.119	0	0.063	0.168	42
39	f44	f12	f52	f24	f31	f61	0	0.254	0	0.241	0.5	0.195	0	0.126	0	0.119	1	0.063	0.161	43
25	f43	f12	f51	f24	f31	f61	0.33	0.254	0	0.241	0	0.195	0	0.126	0	0.119	1	0.063	0.147	44
40	f44	f12	f52	f24	f31	f62	0	0.254	0	0.241	0.5	0.195	0	0.126	0	0.119	0	0.063	0.098	45
26	f43	f12	f51	f24	f31	f62	0.33	0.254	0	0.241	0	0.195	0	0.126	0	0.119	0	0.063	0.084	46
37	f44	f12	f51	f24	f31	f61	0	0.254	0	0.241	0	0.195	0	0.126	0	0.119	1	0.063	0.063	47
38	f44	f12	f51	f24	f31	f62	0	0.254	0	0.241	0	0.195	0	0.126	0	0.119	0	0.063	0.000	48

Ranking of configuration provides better orientation in a large number of configurations and helps determine the K points. After determining the initial K points, the clustering algorithm determines the clusters and allocates certain configurations to clusters. The overall number of scenarios or cluster of one class is k and ranges from 1 to h (where h is the total number of the initial K points and it usually ranges from 3 to 5. At the end, medoid is determined in each cluster or the configuration, which represents a prototype of the cluster. The prototype of the cluster is the basis for further development of scenarios or description of scenarios.

Scenario description

Scenario description is the last step in the process of scenario development, which aims to compile a textual description of scenario or Storytelling by converting scenarios that are presented into text using different configurations. The basis of scenario description is Roadmap or scenario tree which is obtained by FAR analysis (Nguyen / Dunn 2009, Changyong, Juram and Sungjoo 2016). Within each class the specific Roadmap is made for each cluster. The starting point for the Roadmap construction is the mutual influence between the values of the environmental factors in a single cluster. To assess the mutual influence between the values of the environmental factors DEMATEL method can be used (Bagheri Morghaddam, et al. 2010).

The results of the evaluation of the mutual influence between the values of the environmental factors within a cluster (scenario) are processed by calculating the total active and passive impact and the obtained values are normalized (Table 5).

Table 5 – An example of evaluation of the mutual influence between the values of the environmental factors within a cluster

Configuration No.5	f41	f12	f53	f24	f31	f61	Active influence	Normalized value
f41	0	3	1	5	6	5	20	0,31
f12	3	0	6	1	3	3	16	0,00
f53	2	5	0	1	7	6	21	0,38
f24	1	2	4	0	5	9	21	0,38
f31	4	7	1	3	0	8	23	0,54
f61	3	6	9	6	5	0	29	1,00
Passive influence	13	23	21	16	26	31		
Normalized value	0,00	0,74	0,68	0,52	0,84	1,00		

On the basis of the results of DEMATEL method the values of the factors that have the most passive⁵ and active⁶ mutual influence, the value of factors that have a small influence, as well as the value of factors with a large both active and passive influence are determined (Figure 7).

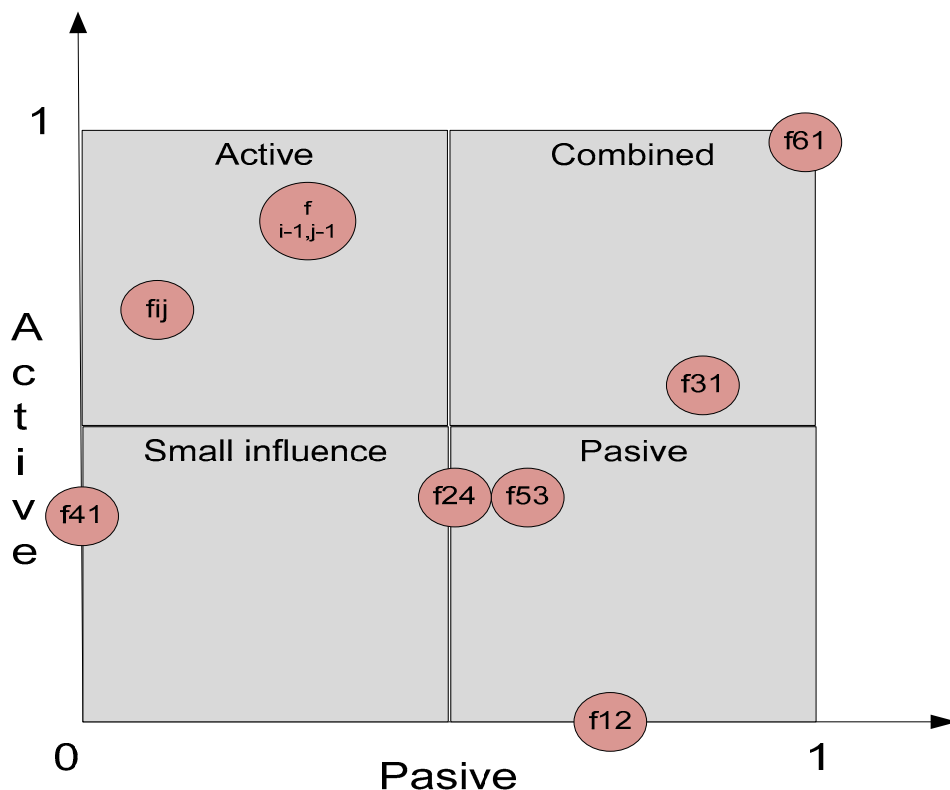


Figure 7 – An example of impact assessment matrix of the values of the environmental factors

Taking into consideration the result of DEMATEL analysis, it is possible to draw the Roadmap by application of FAR analysis (Nguyen / Dunn 2009). Only values of the factors with active, passive and combined influence are used to create the Roadmap whereas the values of the factors with low influence are not entered into the map. However, they are used in the description of a scenario (Figure 8).

⁵ The value of the observed factor is greatly influenced by the values of other factors.

⁶ The value of the observed factor has a great influence on the values of other factors.

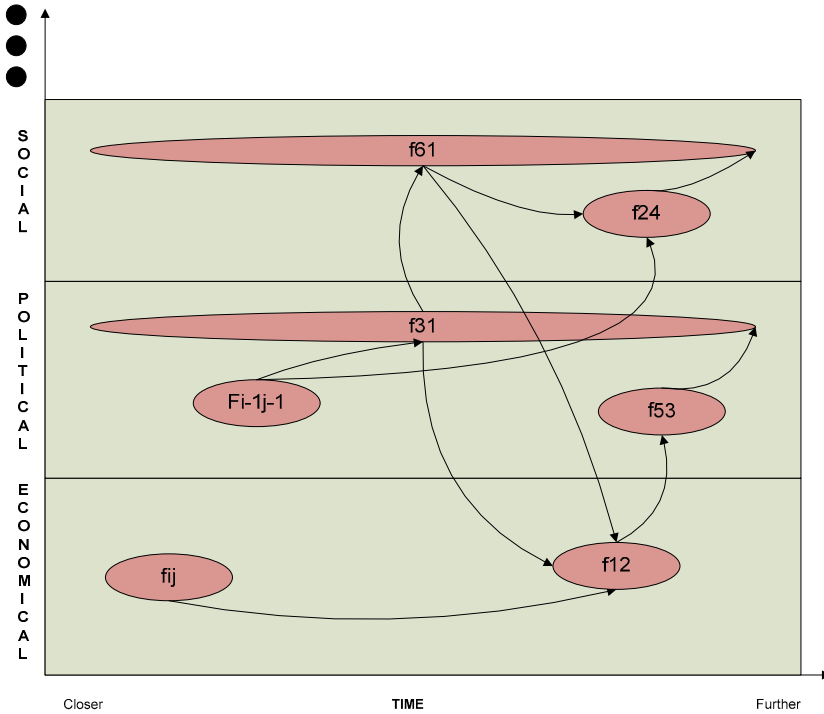


Figure 8 – An example of a roadmap

On the X-axis of the coordinate system of the Roadmap the entries are a timescale of assessments closer to the far future. The Y-axis entries are the environmental sectors (economic, political, military, social, technological, energy and others). The values of the environmental factors are entered in the coordinate system of the Roadmap according to the sector they belong to, as well as the result of DEMATEL analysis. Regarding the timescale, the values of factors with the active influence are entered on a closer future scale whereas the values of factors with passive influence are entered on the further future scale. In contrast to this, the values of factors with combined influence are presented in the entire timeline.

Roadmap is a basis for the application of creative-narrative methods (Kosow / Gaßner 2008) for the transformation of the configurations, which are expressed by the factors and the values of factors into the text scenario, which "tells the story". In accordance with the description of the scenario for a single cluster, by using the Roadmap and DEMATEL method, different scenarios may also be connected. In this case, the Y-axis of the Roadmap refers to the different classes of scenarios whereas different scenarios (clusters) for each class of a scenario are entered in the coordinate system. This approach allows the connection of different scenarios and the detection of parallel and independent scenarios, as well as the possibility of transition of one scenario to another.

Conclusion

The application of morphological analysis and the method of scenario development based on morphological analysis (Battelle and FAR analysis) enables the structuring of the problem of environment, as well as flexibility in the assessment of possible development of options of the environment phenomena in the future. This formalized approach to assessing the environment instead of a single variety, gives a number of possible answers to the question „How would the environment of the defense system look like in the future?”. The output of the morphological analysis is the configuration, whose total number is equal to the product of the values of the environmental factors that have been entered in the morphological field. Since each configuration is a potential scenario for the future environment, a large number of configurations is difficult for further analysis. Therefore, the selection of the representative configuration has been made.

By its structure, consistent or compatible configurations of morphological fields are database with specific attributes and attribute values. In terminology, the environmental factors are equal to the parameters of morphological fields, as well as the attributes in decision - making theory. In order to reduce the number of configuration of morphological fields and determine the representative configuration for a required number of scenarios, decision - making methods can be used. The basic decision - making methods which are used to reduce the number of configuration of morphological fields are classification and clustering (grouping), as well as the methods of group or multi-criteria decision-making to support the methods of classification and clustering.

The classification method, mostly using decision tree techniques, provides guidance to the environmental assessment of configurations that are the most important for the defense system. The most important configurations are those which are associated with the tasks and missions of the defense system, and they represent security challenges, risks and threats which the defense system should confront in order to protect the national interest. It can be concluded that the basis for the determination of a class of scenarios is security challenges, risks and threats that jeopardize the defense system. Taking into consideration the characteristics of challenges, risks and threats, as well as the continuous changes in the environment, it is not possible to apply the decision tree technique originally or to construct decision tree based on historical data. These limitations impose the need for application of the method of multiple-criteria decision – making for the determination of the importance of the environmental factors. Also, setting the value of the environmental factors that may lead to certain challenges, risks and threats, using the method of group decision – making can be the basis for the determination of attribute test conditions for each decision tree. In this way, the number of configuration of morphological fields can be reduced and configuration can be separated by the different classes.

Besides the significant reduction in the number of configurations, and their classification according to security challenges, risks and threats, there is still a large number of configurations which prevent the determination of the optimal representative scenarios. The use of the clustering method with the configurations previously ranked by danger in order to determine the initial configuration (K point), clustering algorithm enables the grouping of configurations of a particular scenario class to pre-determined number of clusters. Configurations that are representatives of clusters (medoids) are the basis for further description of the scenarios for each cluster, using the FAR analysis and creative-narrative methods.

The presented model enables more objective process of scenario development, as well as the rationalization of time and human resources necessary for the scenario development and

data processing. Furthermore, the application of the model requires IT support for the implementation of methods and techniques, as well as a high level of expertise in the assessment of the importance, influence and consistency (compatibility) of factors and values of the factors.

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