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Application of Decision-Making Support Model in the Operations Planning Process at the Tactical Level

Aplikace modelu podpory rozhodování v procesu plánování operací na taktické úrovni

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Abstract: The paper is focused on research of military operations planning with the purpose of defining an efficient decision-making model at the tactical level for brigade-level offensive operation. Suggested model applies methods of multi-criteria decision-making – DIBR II (Defining Interrelationships Between Ranked Criteria II) and EDAS (Evaluation based on Distance from Average Solution) in order to decrease subjectivity while evaluating and ranking criteria, but also to select the most optimal course of action (COA). DIBR II method is used for the evaluation and determination of criteria coefficients, while the EDAS method enables choice between the most optimal COA. Application of simple and effective methods of multi - criteria decision - making accelerates the planning process and enables commanding officer to make optimal troop employment decision in a given operation.

Abstrakt: Článek je zaměřen na výzkum plánování vojenských operací za účelem definování efektivního modelu rozhodování na taktické úrovni pro útočnou operaci na úrovni brigády. Navrhovaný model využívá metody multikriteriálního rozhodování – DIBR II (Defining Interrelationships Between Ranked Criteria II) a EDAS (Evaluation based on Distance from Average Solution) s cílem snížit subjektivitu při hodnocení a klasifikaci kritérií, ale také vybrat optimální variantu činnosti. Pro hodnocení a stanovení koeficientů kritérií se používá metoda DIBR II, zatímco metoda EDAS umožňuje volbu optimální variantu činnosti. Aplikace jednoduchých a efektivních metod vícekriteriálního rozhodování urychluje proces plánování a umožňuje veliteli učinit nejoptimálnější rozhodnutí o použití jednotky v dané operaci.

Keywords: Course of Action; Decision-Making; DIBR II (Defining Interrelationships Between Ranked Criteria II); EDAS (Evaluation based on Distance from Average Solution); Operations Planning.

Klíčová slova: varianty činnosti; rozhodování; DIBR II; EDAS; plánování operací.

INTRODUCTION

Armed forces achieve their missions and tasks purposes by conducting operations. Commanding officers (CO) and commanders' intentions are used as initial operations planning process guidelines in order to reach the desired end state. Decision-making process is conducted through strict forms and procedures and does not allow improvisation.

Modern military operations are conducted in multidimensional and dynamic operational environment (OE). Operations planning process is influenced by a large number of factors that also condition modern military operations, with the task of maximizing the effects on the given objective. An operation as an organized activity that is conducted by certain parts of military units has the purpose of solving assigned task by using different means based on that task's characteristics. In that context, armed forces conduct different types of operations in OE that are characterized by uncertainty, complexity, and quick situation changes. According to Doctrinal documents, an operation is defined as a „set of combat and/or non-combat activities, movements and other actions, that are conducted by unique commander's intent in order to reach general purpose with diverse importance. It is conducted independently, in cooperation with other defence forces, partner or allied forces (Karović, 2012; The Doctrine of Operations of the Serbian Armed Forces, 2012)".

Decision-making, as a process function of command represents the right of the decision-maker (CO) to select the most favorable solution above all offered. Decision-making is CO's exclusive right to make decisions independently based on the staff-command proposal. Decisions are the means that allow COs to put their vision of the desired end state into action. Decision-making is not only knowledge but also a skill. Various aspects of military operations such as: maneuverability, weapon combat effectiveness, human and material resources of friendly and enemy forces, force protection level, etc. can be quantified and therefore represent a part of Military Sciences (Slavković et al., 2012).

Other aspects such as leadership influence, the complexity of operations, and uncertainty based on enemy intents are some of many art of war parts, or in other words – military skills. Both aspects of operational planning can be expressed through the matrix of decision-making in the operations planning process. This allows the ranking of various COAs and enables decision-makers to select the most optimal COA based on all relevant indicators.

Through the operations planning process staff-command suggests to CO multiple different COAs. The current Operational Planning and Command Activities Manual of the

Serbian Armed Forces utilizes numerical analysis in a decision-making matrix that has certain deficiencies and does not display reliable results to decision-makers when larger sets of criteria and alternatives are included.

The purpose of this research is to define an effective decision-making model that is resistant to subjective feelings while evaluating and ranking criteria, but also when selecting of final alternative – troop usage variant. Using these simple and effective methods of Multi-Criteria Decision Making (MCDM) will enhance the operations planning process and CO will be given a more stable solution – troop usage variant.

This paper displays the DIBR II – EDAS model. The defining Interrelationships Between Ranked Criteria II method is used to evaluate and determine criteria coefficients, while the EDAS method is used for the selection of the most optimal course of action.

1 TACTICAL LEVEL OPERATIONS PLANNING

Tactical level operations planning is a process that defines goals (purposes) and determines alternatives in order to reach them. It is conducted by staff-command in units up to the brigade or battalion level, but also task force units (operational, tactical, or battle groups), designed specifically for a given operation. The operations planning process includes logical analytics of all crucial data (Radovanović et al., 2023) through necessary procedures[1] in order to complete operational plans that lead to desired end state. This procedure enables COs to integrate efforts of available forces in the process of operations planning and to effectively make in complex OE. CO is responsible for decision making and in every situation, he is the one that defines which procedures are necessary to conduct, where it is important to emphasize battlefield visualization which directly impacts operations planning and decision-making process (Krstović, 2012).

In order to effectively make a decision, CO utilizes all available staff-command assets and resources. The decision-making process starts with the reception of the order (operational order – OPORD, warning order – WARNO) of higher command or it emerges from the previous operational flow. At the tactical level, this process is conducted through seven phases (Figure 1). Every phase is based on data and conclusions from the previous phase (Vidaković and Kovač, 2012). Assessments are made by CO and his staff-command which lead to conclusions that represent a base for decision-making.

MCDM methods are used in the operations planning process in order to select optimal deployment variants and it involves operations planning phases from the course of action (COA) development to the COA approval.

1 The procedure represents a technique for executing a process, specifically a chronological sequence of required actions for implementation rather than for deliberation. It specifies the manner in which the process of operational planning is conducted.

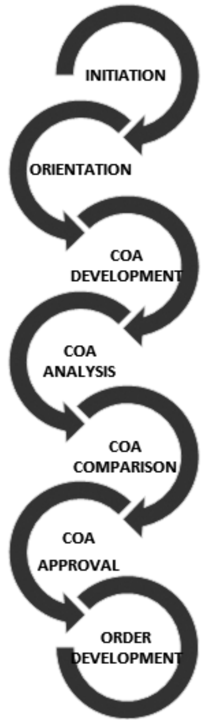

Figure 1: Operations planning phases at the tactical level

2 ANALYSIS OF PRESCRIBED MODEL DECISION-MAKING MATRIX AT THE TACTICAL LEVEL

Through the fifth phase of the operations planning process after the completion of war games, decision-making matrix is defined, followed by the comparison of suggested COA using defined instructions. This part of the research includes an analysis of decision-making matrix model which is included in the Operations Planning and Command Activities Manual (Instructions for Operational Planning and Operation of Commands in the Serbian Armed Forces – temporary, 2017). This model is also included in documents that define operations planning at the tactical level in large numbers of armed forces, especially armed forces of NATO countries. US Army Field Manual 5-0: Planning and Orders Production (2022) includes the same method, with slight differences that are related to the form of decision-making matrix (table design differences that include a textual explanation of every COA advantage and disadvantage for each COA). COA comparison starts with an analysis through which staff-command officers assess the advantages and disadvantages of defined COAs. Based on CO instructions, COA comparison criteria are being defined and their advantages and disadvantages are being identified.

Command-staff compares COAs by presenting their advantages and disadvantages in order to find the COA with the highest success possibility compared to the most likely and the most dangerous enemy COA.

It is necessary that selected COA: /1/ has minimal risk for human and material resources and mission accomplishment, /2/ provides the best deployment of forces for future operations, /3/ secures flexibility which reduces risks of surprise while conducting operation and /4/ enables maximum initiative of subordinate leaders.

COA comparison is crucial for decision-making. Command-staff utilizes every helpful technique to reach the best solution, but at the same time allows CO to make optimal decisions. The general technique is a decision-making matrix (table 1) which uses evaluation criteria and coefficients to assess COA effectiveness. Number tag from number 1 – for the most optimal COA, to number that is the same as the total number of COA which are compared – for the weakest COA (Field Manual 5-0: Planning and Orders Production, 2022). Criteria are being defined by CO through the planning instructions. The coefficient (column 2, Table 1) represents relative advantages and disadvantages for each criterion for defined COA. The initial value of each column is multiplied by the coefficient, and the result is noted down in brackets. A lower value represents a better option.

Numbers in brackets give a subjective evaluation of the best COA, without cross-criteria comparison. When results are being summed, the most optimal COA is the one with the lowest numerical value. The lowest value indicates the most optimal solution, but the problem with the application of this method is that it does not reduce subjectivity while making decisions. It is necessary to test the decision-making matrix in terms of sensitivity because the best COA that is selected by this method (in example 1 which is given in Table 1 the best is COA 2) does not have to be the most optimal one (in given example COA 2 is not optimal in terms of air defense). CO is the one that makes a decision on whether to request additional forces from higher command (in this case air defense assets) or to change COA.

Table 1: Decision-Making Matrix in the Operations Planning Process

CRITERIA	**COEFFICIENT**	**COA 1**		**COA 2**		**COA 3**	
		Rank	Points (2x3)	Rank	Points (2x3)	Rank	Points (2x3)
1	2	3	4	5	6	7	8
Maneuver	3	2	6	3	9	1	3
Simplicity	3	3	9	1	3	2	6
Fires	4	2	8	1	4	3	12
Intelligence	1	3	3	2	2	1	1
Air defense assets (ADA)	1	1	1	3	3	2	2
Mobility	1	3	3	2	2	1	1
Sustainment	1	2	2	1	1	3	3
Command and control - C2	1	1	1	2	2	3	3
Remaining risks	2	1	2	2	4	3	6
Anti-C2 actions	1	2	2	1	1	3	3
TOTAL		**2**	**37**	**1**	**31**	**3**	**40**

Significant disadvantage of this model is decision-maker subjectivity while ranking alternatives according to criteria. Because of that, it is necessary to establish a simpler model that will reduce decision-maker subjectivity to a minimum, but on the other hand, will give the most optimal results and stability needed for selected COA.

The analyzed documents (Planning and Orders Production Field Manual 5-0, 2022, Operational Planning and Command Activities Manual in Serbian Armed Forces, 2017) allow the usage of various methods and evaluation criteria in order to compare and select the most effective COA and therefore it is necessary to find the most optimal model.

3 DECISION-MAKING SUPPORT MODEL AT THE TACTICAL LEVEL BASED ON DIBR II – EDAS MULTICRITERIA DECISION-MAKING MODEL

Selection of the most optimal COA could be made by application of MCDM methods. There is a large number of various MCDM methods, but because of topic characteristics hybrid model is defined from DIBR II and EDAS methods. The model design is presented in Figure 2.

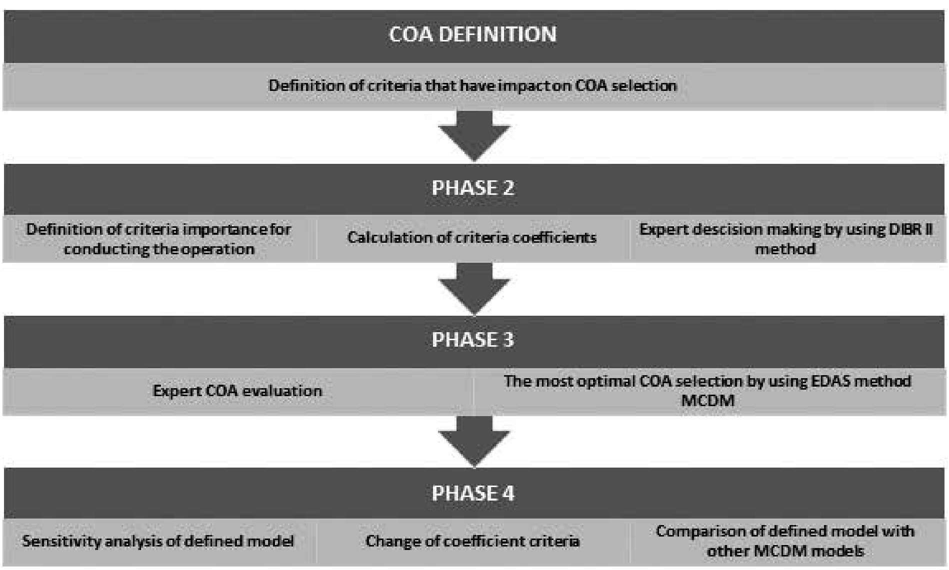

Figure 2: MCDM model for selection of the most optimal COA

The first phase of this model defines unit's COA, followed by identification and definition of criteria that impact selection of the most optimal COA by staff officers. The second phase defines the importance of criteria for conducting the operation, but also ranks criteria from the most important to the least important, followed by application of the DIBR II method of MCDM and expert evaluation by calculating criteria coefficients. The third phase expertly evaluates COAs by staff officers and by using the EDAS method, selection of the most optimal COA has been conducted. Sensitivity analysis of the defined DIBR II – EDAS model has performed through the fourth phase by using the criteria coefficients model, followed by the comparison of the defined model with other MCDM models.

Multi-criteria optimization selects the most optimal COA of units in the operation. The first phase of the model represents a definition of criteria that impact the COA selection. Criteria define quality and represent comparison reference through the COA selection process. The criteria are expressed by the multi-criteria function. The definition of criteria and their coefficients represents a significant phase in the application of this decision-making model. While defining criteria for the most optimal COA it is necessary to encompass all relevant characteristics which can impact operational flow and are related to some of COAs.

Criteria are defined by topic experts and their selection is based on literature analysis and experience of senior officers who performed Chief of Staff (COS) and Executive Officer (XO) duties.

3.1 Description of the DIBR II method MCDM

The DIBR II method for determining weight coefficients of criteria, introduced in 2023, is elucidated in the papers (Božanić and Pamučar, 2023; Tešić et al., 2023a), evolving from the earlier DIBR method (Tešić et al., 2022a; Radovanović et al., 2023; Tešić et al., 2023b; Pamučar et al., 2021; Tešić et al., 2022b). This method was conceived to address limitations observed in prior methodologies for calculating criteria weight coefficients. To date, its application has been limited. The subsequent sections of the paper outline the steps of the DIBR II method (Tešić et al., 2023c). The steps of the DIBR II method are presented below.

Step 1. Defining criteria that are significant for the selection of the most optimal COA $C = \{C_1, C_2, ... C_n\}$

Step 2. Evaluating and ranking criteria by significance $C_1 > C_2 >_{...} > C_n$

Step 3. Model of defining relations with close criteria

$$\frac{w_1}{w_2} = \frac{d_{1,2}}{1} \rightarrow \frac{w_1}{w_2} = d_{1,2} \tag{1}$$

$$\frac{w_2}{w_3} = \frac{d_{2,3}}{1} \rightarrow \frac{w_2}{w_3} = d_{2,3} \tag{2}$$

$$\frac{w_{n-1}}{w_n} = \frac{d_{n-1,n}}{1} \rightarrow \frac{w_{n-1}}{w_n} = d_{n-1,n} \tag{3}$$

The discernment between the foremost ranked criterion and the least ranked one entails a simultaneous evaluation aimed at contrasting their individual attributes, relevance, and significance within the context of the decision-making process. This meticulous analysis enables the identification of nuanced differences in performance, impact, and alignment with predefined objectives, thereby facilitating a refined understanding of their respective contributions and limitations.

$$\frac{w_1}{w_n} = \frac{d_{1,n}}{1} \rightarrow \frac{w_1}{w_n} = d_{1,n} \quad (4)$$

Step 4. Establishing the relationship dynamics between the primary criterion and others

$$w_2 = \frac{w_1}{d_{1,2}} \quad (5)$$

$$w_3 = \frac{w_2}{d_{2,3}} = \frac{w_1}{d_{1,2} \times d_{2,3}} \quad (6)$$

$$\cdots$$

$$w_n = \frac{w_1}{d_{1,2} \times d_{2,3} \times \ldots \times d_{n-1,n}} \quad (7)$$

Step 5. Assigning Weight Coefficients to the Primary Criterion

$$w_1 = \frac{1}{1 + \frac{1}{d_{1,2}} + \frac{1}{d_{1,2} \times d_{2,3}} + \ldots + \frac{1}{d_{1,2} \times d_{2,3} \times \ldots \times d_{n-1,n}}} \quad (8)$$

Step 6. Establishment of weight coefficients for residual criteria: a predefined methodology using Eqs. (5) to (7).

Step 7. Conducting a meticulous scrutiny of the interrelations among criteria involves a nuanced examination. Specifically, the focus is on establishing a correlation between deviation values (as defined in Equation 9) and the corresponding control values (outlined in Equation 10). This analysis anticipates an approximate equivalence, allowing for a permissible variation of up to 10%. However, this expectation is contingent upon the fulfillment of the condition $0 \leq R \leq 0.1$, ensuring the integrity of the comparison and validation process within the defined parameters.

$$R_n = \left|1 - \frac{w_n}{w_n^c}\right| \quad (9)$$

$$w_n^c = \frac{w_1}{d_{1,n}} \quad (10)$$

3.2 Description of the EDAS method

EDAS (Evaluation based on Distance from Average Solution) was developed by Mehdi Keshavarz-Ghorabaee (2015), in order to analyze the MCDM problem by using the calculation of negative ideal distances and positive ideal distances from average value to get the final result of ranking. They represent the difference between each (alternative) solution and the average solution. Assessment of alternative desirability is conducted according to higher values positive distance from average (PDA) and lower values negative distance from average NDA, higher or lower value indicate that the alternative is better than the average solution.

It is possible to apply the EDAS method in its original form in the way presented in papers (Behzad et al., 2020; Darwis et. al., 2023; Trung et al. 2024), or in the improved form that is shown in research (Ghorabaee et al., 2016; Radovanović et al., 2024a; Xu et al., 2020; Radovanović et al., 2024b). The following part of this paper displays the steps of the original EDAS form.

Step 1. Forming of the initial decision-making matrix

$$\text{Y}= \left[y_{ij}\right]_{m\times n} = \begin{bmatrix} [\underline{y}_{11}] & [\underline{y}_{12}] & \cdots & [\underline{y}_{1n}] \\ [\underline{y}_{21}] & [\underline{y}_{22}] & \cdots & [\underline{y}_{2n}] \\ \vdots & \vdots & \ddots & \vdots \\ [\underline{y}_{m1}] & [\underline{y}_{m2}] & \cdots & [\underline{y}_{mn}] \end{bmatrix}_{m\times n} \quad (11)$$

where: represents the value of performance, i-alternative around, j- criterion.

Step 2. Calculation of the average value by all criteria (equation 12).

$$D_j = \frac{\sum_{i=1}^{n} Y_{ij}}{n} \quad (12)$$

Step 3. Calculation of positive distance () and negative distance () from the mean Equations 13 and 14 are used for benefit type criteria.

$$d_{ij}^{+} = \frac{\max[0,(y_{ij}-D_j)]}{D_j} \quad (13)$$

$$d_{ij}^{-} = \frac{\max[0,(D_j-y_{ij})]}{D_j} \quad (14)$$

Equations 15 and 16 are used for cost type criteria.

$$d_{ij}^{+} = \frac{\max[0,(D_j-y_{ij})]}{D_j} \quad (15)$$

$$d_{ij}^{-} = \frac{\max[0,(y_{ij}-D_j)]}{D_j} \quad (16)$$

Step 4. Calculation of total positive distance (S) and total negative distance (S) based on equations 17 and 18.

$$Sd_i^{+} = \sum_{j=1}^{m} w_j \times d_{ij}^{+} \quad (17)$$

$$Sd_i^{-} = \sum_{j=1}^{m} w_j \times d_{ij}^{-*} \quad (18)$$

Step 5. Normalization of positive and negative distance is calculated through equations 19 and 20.

$$®Sd_i^+ = \frac{d_i^+}{max_i(d_i^+)} \quad (19)$$

$$®Sd_i^- = \frac{d_i^-}{max_i(d_i^-)} \quad (20)$$

Step 6. Calculation of average final values (equation 21).

$$AS_i = \frac{1}{2}(®Sd_i^+ + ®Sd_i^-) \quad (21)$$

Where: $0 < AS_i < 1$

Step 7. Ranking alternatives according to decreasing average value (*AS*). The alternative with the highest *AS* value is the best.

4 APPLICATIONS OF THE DIBR II - EDAS MODEL IN SUPPORT OF THE PROCESS OF OPERATIONS PLANNING AT THE TACTICAL LEVEL

Based on COs instructions COA evaluation criteria are being defined in relation to the enemies most likely and the most dangerous COA. Criteria are defined through the mission analysis step and case of need are corrected (upgraded or improved) through the COA development process. It is important to mention that there is no unique list of criteria, but the command-staff is given the responsibility and freedom to create them in relation to the assigned mission characteristics and type of operation. Usually, the following elements are used as criteria: war fighting functions (C2, maneuver, fires, intelligence, force protection and sustainment), principles of a certain type of operations related to the doctrine of specified armed forces (surprise, assault tempo, cooperation, etc), effects and counter-effects, but also other significant elements that have a large impact of mission accomplishment. The defined MCDM model will be applied in offensive operations conducted by brigade-level units. The definition of criteria that impact the selection of the most optimal COA is conducted through the first phase of this model. The complexity and specificity of the research problem requires hiring of experts (staff officers from different branches and services with experience in brigade-level operations planning) for the purposes of defining the criteria for choosing the most optimal COA in the operations planning process.

For the selection of the most optimal COA, 10 criteria are defined and presented in Table 2.

Table 2: Criteria description

criterion	criteria description
C_1 - Maneuver	Maneuver presents synchronized movement and force action in order to bring own forces in a more optimal position than the enemy position at all command levels (Slavković et al., 2018; The Doctrine of Operations of the Serbian Armed Forces, 2012)
C_2 - Simplicity	COA simplicity is related to the reference of how easy and effective is to conduct an operation by using certain troops and tactics in relation to the enemy. It depends on a few key factors: /1/ Ability to understand and apply, /2/ Operation execution, /3/ Sustainment, /4/ Flexibility and adaptivity, /5/ Protection and security capabilities.
C_3 - Fires	Fire is a basic asset to display loss effects on the enemy and is constantly planned, organized, and realized. It is realized by displaying effects from different kinds of weapons, surprise, elasticity and supremacy (Military Lexicon, 1981). Successful usage of fires as determining factor of operation results is evaluated by material effects and crews training.
C_4 – Intelligence	Intelligence in operation is a base-stone element of all military operations that is related to data gathering, analysis, and distribution about the enemy, terrain, civil environment, and other relevant factors. This intelligence process type has the purpose of feeding decision-makers with necessary data and intelligence in order to make optimal decisions and reach desired end states (The Doctrine of Operations of the Serbian Armed Forces, 2012)
C_5 -ADA	Air defence assets (ADA) is the key factor in military operations that is related to the protection of friendly forces, territory and resources from adversaries that come from the air (airplanes, unmanned aerial vehicles or drones, rockets). This element has an important role in modern warfare due to the increased usage of air forces with reconnaissance, assault, transport, and other operational tasks. Key aspects of ADA as a factor in military operations are: /1/ Identification and threat tracking, /2/Decision and reaction, /3/ Vital resources protection, /4/ Coordination with other forces, /5/ Different situation adaptivity. ADA has a key role in the protection of military operations enabling friendly forces to sustain superiority, reduce losses and secure mission accomplishment. Effective ADA is necessary to comprehensive protection of military and civil targets in modern warfare.
C_6 – Mobility	Force mobility as an element for the selection of the most optimal COA is related to force ability for rapid and effective movement and deployment in various avenues in operation. This includes the ability of quickly transfer from one position to another, adapt to situational changes in the field, and keeping a high level of war fighting capabilities during that movement. In tactics, mobility is a key factor because it enables COs to quickly react to enemy actions, avoid assaults, or take assault opportunities. In the context of COA selection, mobility is used to define how and where forces will be deployed in order to reach operational goals. As an element for COA selection, mobility enables COs to develop and implement flexible and adaptable plans that can maximize the advantages of their forces and minimize risks.
C_7 – Logistical support	Logistical support to forces in an operation as a factor in selecting the course of action refers to all activities and resources necessary to maintain the operational capabilities of military forces. This support includes the procurement, storage, distribution, and maintenance of materials, equipment, food, fuel, ammunition, medical assistance, and other essential resources. Logistical support is a critical element in the planning and execution of military operations as it directly affects the ability of units to remain functional and effective in the field. Factors considered include: /1/ Resource availability, /2/ Terrain accessibility, /3/ Duration of the operation, /4/ Risk and protection, /5/ Flexibility and adaptability. Effective logistical support enables commanders to choose courses of action that maximize operational effects and minimize risks of resource shortages or logistical issues. This includes assessing the feasibility of offensive and defensive operations, the speed of unit advancement, and maintaining a high level of combat capability throughout the entire operation.
C_8 – Command and Control (C2)	Command and Control (C2) as a factor in selecting the course of action refers to the processes and systems that enable military commanders to effectively make decisions, plan, coordinate, and oversee the operations of their forces. C2 encompasses a wide range of activities essential for the successful execution of military operations, including decision-making, planning, coordination, supervision, and control. Key aspects of C2 include: hierarchical structure, communication systems, decision support systems (software and analytical tools), and intelligence support. In the context of choosing a course of action, C2 enables commanders to assess different scenarios and select the most effective method of employing forces. Effective C2 is crucial for the successful execution of military operations as it allows commanders to have a comprehensive understanding of the situation, make rapid decisions, and efficiently coordinate the activities of their forces. This capability allows for the selection of a course of action that maximizes operational effectiveness and minimizes risks during the operation.

criterion	criteria description
C_9 _ The element of residual risk	The element of residual risk as a factor influencing the selection of a course of action refers to the assessment and management of risks that remain after all possible measures have been taken to reduce or eliminate risks during a military operation. Residual risk is the level of risk that cannot be entirely eliminated and must be considered by commanders when making decisions about the employment of forces. Key aspects of residual risk include: /1/ Risk identification, /2/ Risk assessment, /3/ Risk mitigation, /4/ Remaining risk. In the context of choosing a course of action, residual risk influences decision-making through factors such as: risk acceptability, prioritization of objectives, flexibility and adaptability, and operational measures.
C_{10} – ACTIONS AGAINST ENEMY COMMAND AND CONTROL (C2)	Actions against enemy command and control (C2) elements in an operation involve all activities aimed at disrupting, degrading, or destroying the enemy's ability to effectively make decisions, plan, coordinate, and oversee their operations. These activities are crucial for gaining operational and tactical advantage on the battlefield. Key objectives of actions against enemy C2 include: /1/ disrupting communications, /2/ degrading intelligence capabilities, /3/ neutralizing command centers, /4/ electronic warfare, /5/ cyber-attacks. Essentially, actions against enemy C2 are a vital component of modern military operations, as they enable friendly forces to seize the initiative, confuse and demoralize the enemy, and secure an advantage on the battlefield.

The definition of criteria coefficients is performed by applying the DIBR II method. Criteria ranking by importance is conducted by decision maker – unit CO. Formulas from 1 to 10 are used for the definition of criteria coefficients. Results are displayed in Table 3. Criteria ranking is presented in equation 22.

$$C_3 > C_1 > C_2 > C_9 > C_7 > C_6 > C_5 > C_4 > C_8 > C_{10} \tag{22}$$

Table 3: Criteria coefficients (w) by DIBR II method

	C_3	C_1	C_2	C_9	C_7	C_6	C_5	C_4	C_8	C_{10}
w	0.2278	0.1752	0.1524	0.1051	0.0778	0.0741	0.0674	0.0630	0.0573	0.0498

Based on COA development and analysis five COA alternatives are defined in relation to the most dangerous and the most likely enemy COA. Characteristics of COA are shown in Table 4 in the initial decision making matrix (presented values are given by one officer). Having in mind the fact that all criteria are lingual, the translation scale is defined and shown in Table 4. Aggregated values are presented in Table 6 in a quantified decision-making matrix.

Table 4: Lingual assessment scale

Scale	Crisp value
Absolutely satisfies (AS)	9
Very good satisfies (VGS)	7
Satisfies (S)	5
Partially unsatisfactory (PU)	3
Not satisfy (NS)	1

Table 5: Initial decision-making matrix

	w	COA 1	COA 2	COA 3	COA 4	COA 5
C_1	0.1752	AS	VGS	S	NS	AS
C_2	0.1524	S	PU	AS	S	VGS
C_3	0.2278	VGS	AS	VGS	NS	PU
C_4	0.063	S	S	S	PU	PU
C_5	0.0674	NS	PU	VGS	AS	AS
C_6	0.0741	VGS	VGS	S	S	PU
C_7	0.0778	NS	PU	VGS	VGS	PU
C_8	0.0573	AS	VGS	VGS	AS	VGS
C_9	0.1051	PU	S	S	VGS	VGS
C_{10}	0.0498	PU	NS	NS	PU	S

Table 6: Quantified decision-making matrix

	w	COA 1	COA 2	COA 3	COA 4	COA 5
C_1	0.1752	9	7	5	1	9
C_2	0.1524	5	3	9	5	7
C_3	0.2278	7	9	7	1	3
C_4	0.063	5	5	5	3	3
C_5	0.0674	1	3	7	9	9
C_6	0.0741	7	7	5	5	3
C_7	0.0778	1	3	7	7	3
C_8	0.0573	9	7	7	9	7
C_9	0.1051	3	5	5	7	7
C_{10}	0.0498	3	1	1	3	5

Using the hybrid DIBR II – EDAS model final results and COA ranking are reached for brigade–level assault operation COA. Results are shown in Table 7.

Table 7: Final alternative ranking

	ASi	Rank
COA1	0.687	4
COA2	0.725	3
COA3	0.889	1
COA4	0.298	5
COA5	0.751	2

5 SENSITIVITY ANALYSIS

Sensitivity analysis is conducted by using the applied mathematical model DIBR II – EDAS, in order to enable CO to receive rationality and quality confirmation of the obtained solution, in other words, to determine how criteria weight changes impact on alternative rankings (Božanić et al., 2022) . Sensitivity checking of the used MCDM model represents an indispensable step in the production of the decision-making support model (Radovanović et al., 2021) .

Table 8: Weight changes scenarios

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
$_{S}1$	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
S_2	0.2	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089
S_3	0.089	0.2	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089
S_4	0.089	0.089	0.2	0.089	0.089	0.089	0.089	0.089	0.089	0.089
S_5	0.089	0.089	0.089	0.2	0.089	0.089	0.089	0.089	0.089	0.089
S_6	0.089	0.089	0.089	0.089	0.2	0.089	0.089	0.089	0.089	0.089
S_7	0.089	0.089	0.089	0.089	0.089	0.2	0.089	0.089	0.089	0.089
S_8	0.089	0.089	0.089	0.089	0.089	0.089	0.2	0.089	0.089	0.089
S_9	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.2	0.089	0.089
S_{10}	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.2	0.089
S_{11}	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.2

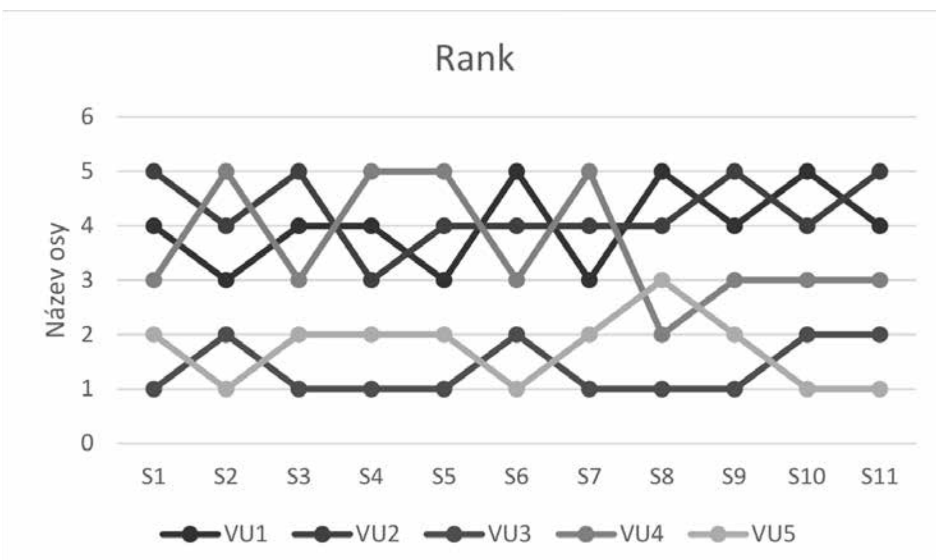

Figure 3: COA Rankings Given By Different Scenarios

Results in Figure 3 show that in most of the scenarios, COA 3 took the first rank. Results also display that COA 5 was ranked first in a few cases, depending on criteria coefficients changes.

Spearman's coefficient is used in order to determine a correlation between ranks given by different types of scenarios:

$$Sp = 1 - \frac{6\sum_{i=1}^{n} D_i^2}{n(n^2-1)} \quad (23)$$

where D_i represents a difference in ranking by a given scenario and ranking in the corresponding scenario, and n represents the number of ranked elements. Spearman coefficient belongs to segment [-1,1]. Values of the Spearman's coefficient for the selection of COA are displayed in the figure below.

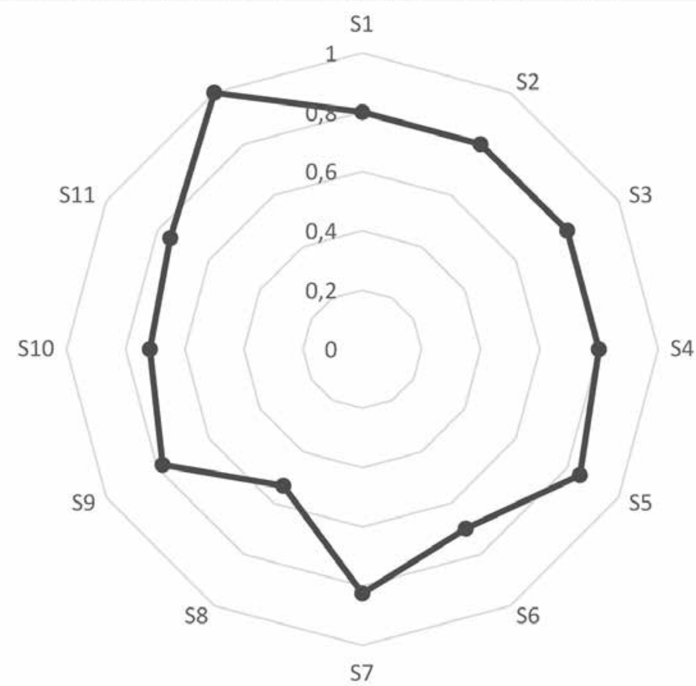

Figure 4: Spearman's coefficient values for ranking changes correlation between criteria coefficients

Figure 4 displays Spearman's coefficient ranking correlation for changes of weight criteria coefficients in relation to initial ones. Figure concludes that in all scenarios, results are trended towards positive correlation tightly aligned with the ideal.

Based on the results displayed in Figures 3 and 4, the conclusion can be made – ranking results are stable and the selection of the COA 3 represents a very stable solution to this problem.

CONCLUSION

The conclusion of this research encompasses a few key aspects in terms of the improvement operations planning process in the Serbian Armed Forces, with a special review on the MCDM methods. Through analysis of current practice and suggested methods, significant insights that can improve decision-making in military operations planning are made.

Modern military operations are characterized by a high level of complexity and uncertainty, which require precise and well-structured planning. In complex battle conditions, each element of operation has to be carefully analyzed, and planned in order to reach optimal results. Traditional planning methods usually do not manage to make adequate responses to all challenges of modern warfare, which emphasizes the need to introduce new methods and techniques.

NATO forces, but also other armed forces that took over this decision-making model made by the US military including the Serbian Armed Forces in practice usually rely on numerical analysis methods. Although this method has its advantages, it displays significant disadvantages when it's introduced with larger criteria and alternative numbers. Subjectivity and inconsistency in criteria evaluation can lead to making non-optimal decisions which can affect the result of military operations.

The suggested model, which involves DIBR II and EDAS methods, represents a significant step towards improving the decision-making process. DIBR II method enables objective evaluation and selection of criteria coefficients, decreasing subjectivity that is present in traditional methods. On the other hand, the method EDAS enables the selection of the most optimal COA, additionally increasing the effectiveness and reliability of made decisions.

Application of this method in brigade-level offensive operation has demonstrated how key criteria could be defined for evaluating COA. Criteria are clearly defined and evaluated using the DIBR II method. EDAS method enabled ranking different COAs, identifying the one that responds the best to given criteria.

The suggested model displays a few key advantages:

- **Objectivity**: Decreases subjectivity in criteria evaluation, enabling consistent and precise decision-making.
- **Flexibility**: Ability to adapt to different OEs and different command levels, from brigade to larger units.
- **Effectiveness**: Accelerates planning process enabling COs to quickly make effective decisions in dynamic fighting conditions.
- **Reliability**: Results given by this model are stable, reliable and reduce planning mistakes and other risks.

Based on the given results, further research and improvement of this model is recommended. Future research may include:

- Integration with other decision-making methods: Research possibilities for integration of the suggested model with other MCDM methods in order to additionally increase its effectiveness and precision.

- Application within diverse operational scenarios: Testing model in different military operations, including defense operations, peace-keeping operations and crisis.
- Software development: Production of software solutions that could automatize evaluation and decision-making processes in order to increase the speed and simplicity of the planning process.

Developing operational planning of the Serbian Armed Forces by applying MCDM methods represents a significant step towards the modernization and effectiveness of military operations. Through objective evaluation of criteria and selection of the most optimal unit COA, COs can bring informed and reliable decisions that directly display effects on operational success. The suggested model, based on DIBR II and EDAS methods displayed its own potential and effectiveness and can be treated as a valuable asset for further development.

Finally, this paper represents the base for further research and development of decision-making methods in military planning, providing specific instructions and tools that can improve the operational capabilities of armed forces. With further development and adaption of this model, it is possible to reach better results in more complex and dynamic conditions of modern warfare.

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REFERENCES

Behzad, Masoud, Sarfaraz Hashemkhani Zolfani, Dragan Pamučar, and Moein Behzad. "A Comparative Assessment of Solid Waste Management Performance in the Nordic Countries eBased on BWM-EDAS." *Journal of Cleaner Production* 266 (September 2020): 122008. https://doi.org/10.1016/j.jclepro.2020.122008

Božanić, Darko, and Dragan Pamučar. "Overview of the Method Defining Interrelationships between Ranked Criteria II and Its Application in Multi-Criteria Decision-Making." *Lecture Notes in Electrical Engineering*, 2023, 863–73. https://doi.org/10.1007/978-981-19-8493-8_64

Božanić, Darko, Dragan Pamučar, Aleksandar Milić, Dragan Marinković, and Nenad Komazec. "Modification of the Logarithm Methodology of Additive Weights (LMAW) by a Triangular Fuzzy Number and Its Application in Multi-Criteria Decision Making." *Axioms* 11, no. 3 (February 23, 2022): 89. https://doi.org/10.3390/axioms11030089

Darwis, Dedi, Heni Sulistiani, Dyah Ayu Megawaty, Setiawansyah Setiawansyah, and Intan Agustina. "Implementation of EDAS Method in the Selection of the Best Students with ROC Weighting." *Komputasi: Jurnal Ilmiah Ilmu Komputer dan Matematika* 20, no. 2 (July 23, 2023): 112–25. https://doi.org/10.33751/komputasi.v20i2.7904

General Staff of the Serbian Armed Forces. *„Instructions for operational planning and operation of commands in the Serbian Armed Forces – temporary. (Only in Serbian: Uputstvo za operativno planiranje i rad komandi u Vojsci Srbije – privremeno).“* 2017, Belgrade, Serbia.

Ghorabaee, Mehdi Keshavarz, Edmundas Kazimieras Zavadskas, Laya Olfat, and Zenonas Turskis. "Multi-Criteria Inventory Classification Using a New Method of Evaluation Based on Distance from Average Solution (EDAS)." *Informatica* 26, no. 3 (January 1, 2015): 435–51. https://doi.org/10.15388/informatica.2015.57

Ghorabaee, Mehdi Keshavarz, Edmundas Kazimieras Zavadskas, Maghsoud Amiri, and Zenonas Turskis. "Extended EDAS Method for Fuzzy Multi-Criteria Decision-Making: An Application to Supplier Selection." *International Journal of Computers Communications & Control* 11, no. 3 (March 24, 2016): 358. https://doi.org/10.15837/ijccc.2016.3.2557.

Karović, Samed, Mile Jelić, and Miloš Gajić. "Documentary Records in Operations." *Vojno delo* 64, no. 4 (2012): 150–59. https://scindeks.ceon.rs/article.aspx?artid=0042-84261204150K.

Krstović, Vojislav, Rade Slavković, and Vladimir Kevac. "Organization of Work in the Command Post and Military Decision Making Process during the Operations." *Vojno delo* 64, no. 4 (2012): 84–90.

Military Lexicon (Only in Serbian: Vojni Leksikon). Belgrade, Serbia: Military Publishing House, 1981.

Pamučar, Dragan, Muhammet Deveci, Ilgin Gokasar, Mehtap Işık, and Mališa Zizovic. "Circular Economy Concepts in Urban Mobility Alternatives Using Integrated DIBR Method and Fuzzy Dombi Cocoso Model." *Journal of Cleaner Production* 323 (November 2021): 129096. https://doi.org/10.1016/j.jclepro.2021.129096.

Planning and Orders Production (Field Manual 5-0). 2022. Department of the Army, Washington, chapter 5, page 54.

Radovanović, Marko, Aleksandar Petrovski, and Vinko Žnidaršič. "The C5ISR System Integrated with Unmanned Aircraft in the Large-Scale Combat Operations." *Vojenské rozhledy* 32, no. 2 (June 8, 2023a): 98–118. https://doi.org/10.3849/2336-2995.32.2023.02.098-118.

Radovanović, Marko, Aleksandar Petrovski, Elif Cirkin, Aner Behlić, Željko Jokić, Denis Chemezov, Elshan Giyas Hashimov, Mouhamed Bayane Bouraima, and Chiranjibe Jana. "Application of the New Hybrid Model LMAW-G-EDAS Multi-Criteria Decision-Making When Choosing an Assault Rifle for the Needs of the Army." *Journal of Decision Analytics and Intelligent Computing* 4, no. 1 (January 21, 2024a): 16–31. https://doi.org/10.31181/jdaic10021012024r.

Radovanović, Marko, Aleksandar Petrovski, Vinko Žindrašič, and Aca Ranđelović. "Application of the Fuzzy AHP -Vikor Hybrid Model in the Selection of an Unmanned Aircraft for the Needs of Tactical Units of the Armed Forces." *Scientific Technical Review* 71, no. 2 (2021): 26–35. https://doi.org/10.5937/str2102026r.

Radovanović, Marko, Darko Božanić, Aleksandar Petrovski, and Aleksandar Milić. "Use of the DIBR-Grey EDAS Model of MCDM to the Selection of a Combat Unmanned Ground

Platform .” *Operations Research and Engineering Letters* 3, no. 1 (January 27, 2024b): 8–18.

Radovanović, Marko, Darko Božanić, Duško Tešić, Adis Puška, Ibrahim M. Hezam, and Chiranjibe Jana. “Application of Hybrid DIBR-FUCOM-LMAW-Bonferroni-Grey-EDAS Model in Multicriteria Decision-Making.” *Facta Universitatis, Series: Mechanical Engineering* 21, no. 3 (October 31, 2023b): 387. https://doi.org/10.22190/fume230824036r.

Serbian Armed Forces General Staff. *“The doctrine of operations of the Serbian Armed Forces. (Only in Serbian: Doktrina operacija Vojske Srbije).“* 2012, Medija centar Odbrana, Belgrade.

Slavković, Rade, Branko Šipka, and Jadranko Jukić. “Maneuver in the offensive operation of the land forces. (Only in Serbian: Manevar U Napadnoj Operaciji Snaga Kopnene Vojske).” *Vojno delo* 70, no. 4 (2018): 277–97. https://doi.org/10.5937/vojdelo1802277s.

Slavkovic, Rade, Miroslav Talijan, and Mile Jelić. “Projection of Military Operations.” *Vojno delo* 64, no. 4 (2012): 129–39.

Tešić, Duško, Darko Božanić, and Aleksandar Milić. “A Multi-Criteria Decision-Making Model for Pontoon Bridge Selection: An Application of the DIBR II-NWBM-FF MAIRCA Approach.” *Journal of Engineering Management and Systems Engineering* 2, no. 4 (October 20, 2023a): 212–23. https://doi.org/10.56578/jemse020403.

Tešić, Duško, Darko Božanić, Dejan Stojković, Adis Puška, and Ilija Stojanović. “DIBR–Dombi–Fuzzy Mairca Model for Strategy Selection in the System of Defense.” *Discrete Dynamics in Nature and Society* 2023 (June 3, 2023b): 1–14. https://doi.org/10.1155/2023/4961972.

Tešić, Duško, Darko Božanić, Dragan Pamučar, and Jamalud Din. “DIBR - Fuzzy Marcos Model for Selecting a Location for a Heavy Mechanized Bridge.” *Vojnotehnicki glasnik* 70, no. 2 (2022a): 314–39. https://doi.org/10.5937/vojtehg70-35944.

Tešić, Duško, Darko Božanić, Marko Radovanović, and Aleksandar Petrovski. “Optimising Assault Boat Selection for Military Operations: An Application of the DIBR II-BM-Cocoso MCDM Model.” *Journal of Intelligent Management Decision* 2, no. 4 (October 13, 2023c): 160–71. https://doi.org/10.56578/jimd020401.

Tešić, Duško, Marko Radovanović, Darko Božanić, Dragan Pamucar, Aleksandar Milić, and Adis Puška. “Modification of the DIBR and MABAC Methods by Applying Rough Numbers and Its Application in Making Decisions.” *Information* 13, no. 8 (July 25, 2022b): 353. https://doi.org/10.3390/info13080353.

Trung, Do Duc, Nguyen Xuan Truong, Hoang Tien Dung, and Aleksandar Ašonja. “Combining Doe and EDAS Methods for Multi-Criteria Decision Making.” *Lecture Notes in Networks and Systems*, 2024, 210–27. https://doi.org/10.1007/978-3-031-51494-4_19.

Vidaković, Milorad, and Mitar Kovač. “Designing of military operations.” *Vojno delo* 64, no. 4 (2012): 102-14.

Xu, Dongsheng, Xiangxiang Cui, and Huaxiang Xian. “An Extended EDAS Method with a Single-Valued Complex Neutrosophic Set and Its Application in Green Supplier Selection.” *Mathematics* 8, no. 2 (February 19, 2020): 282. https://doi.org/10.3390/math8020282.