Application of the AHP and VIKOR methods of individual decision making and the Borda method of group decision making when choosing the most efficient way of performing preparatory shooting at serial number one from a 12.7 mm long range rifle M-93

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Abstract:

Introduction/purpose: The paper presents the method of applying multi-criteria decision-making methods in order to improve shooting and select the most favorable conditions for shooting. Alternatives were ranked by individual multi-criteria decision-making methods AHP and VIKOR by experts, and then the most favorable alternative was selected using the Borda method of group decision making. The aim of the work is to select *the most efficient way of shooting with minimal human fatigue, consumption of movable things and in the shortest possible time through a combination of multi-criteria decision-making methods, which will ensure the accuracy and precision of the rifle for subsequent shooting and other operations.*

Methods: The paper presents one of the ways of using multidisciplinary methods of multi-criteria decision making for a specific problem in the field of tactics with weapon systems. Experts from the field of armaments, using the AHP and VIKOR methods of individual multi-criteria decision making, selected the most favorable alternative in accordance with four given criteria. Then, by applying the Borda method of group decision making, the the most favorable alternative was selected - the most favorable conditions for the execution of preparatory shooting at serial number one with a 12.7 mm long range rifle. The alternatives are four shootings, namely, two ways of performing preparatory shooting with a 12.7 mm long range rifle at serial number one, one from the current Instructions and Program of Shooting with Infantry Weapons and the other newly proposed method, as well as two ways of realizing shooting for testing the accuracy and precision of a long range rifle.

Results: The selection of the most effective conditions for the execution of the first initial preparatory shooting at serial number one with a long range rifle, which will ensure maximum accuracy of the weapon and the minimum consumption of resources - time, ammunition, targets, and personnel fatigue.

Conclusion: The solution takes into account the simultaneous optimization of several criteria in order to select the most efficient way of performing preparatory shooting at serial number one in order to ensure rested and trained personnel as well as accurate and precise long range rifles for subsequent shootings, which leads to the maximum saving of resources, the satisfaction of personnel, and precise weapons.

Key words: long range rifle, rectification, shooting, AHP, VIKOR, Borda method.

Introduction

The application of individual and group methods of multi-criteria decision making is an unavoidable segment in the decision-making process in complex organizational systems such as the Serbian Armed Forces. The work represents one of the models for choosing the most economical conditions for the execution of preparatory shooting at serial number one with a 12.7 mm long range rifle M-93 with the application of the individual AHP and VIKOR methods and the Borda method of group multi-criteria decision making (Suknović et al, 2021).

The symbiosis of multi-criteria decision-making methods in solving problems in the field of tactics and weapons is already known, as well as in other fields. Jokic et al. (2024) write about the best caliber for rifles, while Petrović et al. (2018) used the DEMATEL-AHP method to select the best jet for the protection of Serbia's airspace. The same authors apply the Fuzzy - AHP approach in evaluating the criteria for choosing a missile system for anti-aircraft operations (Petrović et al, 2018). Radovanović & Stevanović (2020) apply the fuzzy AHP-VIKOR method to select the best method for testing the accuracy and precision of sniper rifles. Akmaludin et al. (2023) use the AHP-VIKOR methods for smartphone selection. Demir et al. (2023) use the AHP-VIKOR method extended by the Pythagorean set of fuzzy numbers to evaluate the railway transport system in Turkey. Akmaludin et al. (2021) use a combination of the AHP-VIKOR methods for the selection of the best swimming athletes. Radovanović et al. (2021) analyze the accuracy and precision of shooting with automatic rifles using the AHP method. Oufella (2024) uses a hybrid model of the Borda number and the PROMETHEE method to select a maintenance strategy. Sonatha et al. (2021) use the AHP, Topsis and Borda methods to support a group decision-making system.

The 12.7 mm long range rifle M-93 (named BLACK ARROW) is a tool of high accuracy and precision, which achieves its firepower by shooting immediate targets at distances of up to 1800 m (Zastava Arms, 2024) or 2000 m, depending on the optical sight it has. The stated conditions for the execution of the first shooting with a long range rifle in the Serbian Army do not give satisfactory results and require a lot of time. The subject of the research is the arrival of more efficient conditions for the execution of initial shooting with a long range rifle.

The paper proposes the conditions for the execution of preparatory shooting at serial number one, which at the same time represent a test of the accuracy and precision of a long range rifle and a check of a sniper in uniform aiming and firing. The described rectification procedure with the help of binoculars is unique and requires the introduction of binoculars into the tool kit. The aim of the work is to choose the most efficient and effective shooting procedure in relation to the presented alternatives by applying multi-criteria decision-making methods whose contribution will be a reduction in shooting time and a smaller amount of ammunition as well as, at the same time, an improvement in accuracy and weaponry for all subsequent shooting and combat tasks.

Problem description

During the realization of the preparatory shooting at number one in accordance with the regulations, certain problems appear. The existing way of performing preparatory shooting at serial number one with a long range rifle is realized at a distance of 400 m, and before that it is necessary to test the accuracy and precision of the rifle at a distance of 100 m or 400 m, depending on the optical sight it has. The optical sight M-93 has an aiming distance on the distance mechanism of 0, and it is possible to carry out a test at both 100 and 400 m, while the optical sight M-94 has an aiming distance of 4, and no rule or instruction describes the use of the existing targets for testing accuracy and precision. This work is the first place where a unique procedure for the rectification of both optical sights and the procedure for testing the accuracy and precision of the sights at the same target for testing accuracy and precision at a distance of 100 m is described, which can also represent preparatory shooting at serial number one. The rectification procedure is necessarily performed after every removal and re-installation of the optical sight on the rifle.

The optical sight rectification procedure is carried out in such a way that the test target is placed at a distance of 100 m and with the help of a universal stand and binoculars for the rectification of a long range rifle, the barrel is aimed at the control point 400, and that the optical sight, on which the distance mechanism is set to 4 and the direction mechanism to 0, brings it to the aiming point which is at the bottom of the target, i.e., 30 cm vertically below the control point 400. Then, with 4 bullets, the accuracy and precision of the rifle is tested on the same target with sight 4, aiming at the aiming point at the bottom of the target. Hits should be grouped around control point 400 in a 12 cm diameter circle described around the control point. The procedure for testing accuracy and precision can also be a preparatory shooting at serial number one, which, compared to the existing conditions, saves 3 test bullets and shortens the distance from 400 m to 100 m.

The procedure can also be implemented at control point 800, which is 72 cm above the aiming point, sight 8; then, at the same distance of 100 m, the hits will be grouped around control point 800 in a circle with a diameter of 12 cm. This method of rectification and testing of accuracy and precision combines shooting for testing accuracy and precision with preparatory shooting at serial number one and ensures the accuracy of the rifle at all aiming distances depending on the model of the optical sight.

Description of the methods used

The work will use the AHP and VIKOR individual multi-criteria decision-making methods (Hanif et al, 2022; Göbeloğlu & Ungan, 2023; Abdillah et al, 2023; Komazec & Petrović, 2019); and the Borda group multi-criteria decision-making method.

Description of the AHP method

The Analytical Hierarchy Process method was developed by Thomas Satti (1988). The method has undergone a large number of modifications (Petrović et al, 2018; Božanić et al, 2016; Ayvaz et al, 2024), but in some cases it is still used in its original form (Radovanović & Stevanović, 2020) both in individual and group decision making (Tešić et al, 2024), and is used in a large number of different decision-making cases.

For pairwise comparisons, which are the basis of this method, the Saati scale is used, Table 1. The pairwise comparison leads to the initial decision matrix. Satie's scale is used to determine the value of criteria and can also be used to rank alternatives.

Table 1 – Saati's scale of comparison

Standard values	Dominance of strength	Derived/invasive values
1	same meaning	1
3	weak dominance	1/3
5	strong dominance	1/5
7	very strong dominance	1/7
9	absolute dominance	1/9
2, 4, 6, 8	limit	1/2, 1/4, 1/6, 1/8

The first step of using the method is to compare the alternatives in accordance with the criteria. In individual as well as in group decision making and the application of the AHP method, it is first necessary to perform a comparison of alternatives in pairs in accordance with each criterion separately, respecting the following: on the diagonals of the matrix, the value is

$$aij= 1/aji \; . \qquad (1)$$

Then a new matrix is formed for the same criteria and all alternatives, and it is filled based on the previous one in such a way that the sum total value of the column is divided by the value from the cell of that column of the previous matrix and the value is entered in the same cell of the new matrix. The next step is to determine the mean value of each type of the second matrix. In this way, a certain value of the criterion column is obtained for all alternatives in accordance with the given criterion in the decision matrix. The sum of the resulting column is 1 and represents the degree of confidence in the alternatives for the given criterion.

The next step is the comparison of n pairs of criteria, i.e., determining the eigenvector W for the criteria - determining the degree of confidence in the criteria or the weight of the criteria or weights. A matrix of criteria by type and column is formed and filled in as described above. Then the types are summed up and a new matrix is formed as mentioned above. The mean value of the species of the second tick is represented by the vector W and the sum of that column is 1.

The next step is to calculate the consistency ratio of the CR matrix, which must be less than 0.1.

$$CR=CI/RI \quad (2)$$

where

- CI is the consistency index

$$CI = (\lambda max-n) / (n-1) \quad (3)$$

- RI is a random index according to Sati and depends on the number of criteria and is taken from the table (in this case it is 4 criteria, i.e., 0.9)
- λmax is its own value which is calculated in accordance with the formula for each criterion

$$\lambda max = (Aw*w)/w*w \quad (4)$$

A - is the criteria comparison matrix.

Table 2 – Random index by Saati

n	3	4	5	6	7	8	9	10
RI	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The matrix is multiplied by the vector by multiplying W by each row-row cell and summing the products. If the consistency ratio (CR) is greater than 0.1, the criteria matrix is inconsistent and it is necessary to check the comparisons or change the method. The closer CR is to 0, the more consistent the matrix is, and one goes to the initial - main matrix.

Then the weighted sum is calculated for all alternatives, by multiplying the matrix by W. This is done by writing W below the alternatives and adding the product of the cells of the matrix and the vector W. In this way, the cells of the alternatives are joined. Again, the number of columns is 1. By comparing the numbers, the most favorable alternative is reached. The higher the value, the more acceptable the alternative.

Description of the VIKOR method

Multi-criteria Compromise Ranking is a method proposed by the Serbian scientist Serafim Opricović in 1998 (Opricović, 1998). The VIKOR method was applied in a large number of works in its original form (Nisel, 2014; Opricović & Tzeng, 2004; Delibašić et al, 2023; Yue & Lv, 2024; Khan et al, 2024; Sennaroglu & Celebi, 2018) as well as in vague envinronment (Chatterjeea & Chakrabortib, 2016). It is favorable in cases where decision makers do not have equality in decision making, when individuals have the right of veto, when they are committed to certain criteria, and when the criteria are easily measurable. It represents a compromise when choosing alternatives, observing the minimum or the maximum in the desired criteria.

First, the initial matrix is filled based on the qualitative properties of the criteria for each alternative, where the criteria are in the first row, and the alternatives are in the first column of the matrix. Then, another type is formed above the criteria, where it is defined whether it is necessary for the criterion to be minimal if it is a negative property, for example, costs, or the maximum if good performance is in question.

It is necessary to define the weighting coefficients of the criteria obtained on the basis of some other method, in this case on the basis of the AHP method. A weight-normalized matrix is formed by multiplying each cell of the previous matrix by the weight coefficient of the criterion.

Then, at the end of each column, two more types of the minimum and the maximum are formed. The minimum and the maximum for each criterion are extracted from each column.

Then, the strategy S is calculated as the sum value of each type, that is, the sum of all criteria for a given alternative, as well as the strategy R which is obtained as the minimum of each type, that is, criteria for each alternative. If more than one strategy R is minimal, i.e., 0, it is necessary to determine the corrected value of the strategy R* by subtracting Rmin from S.

The matrix is formed based on the formulas:

$$\text{for MAX: } t=X - X(min) / X(max) - X(min) \quad (5)$$

$$\text{for MIN: } t=X(max) - X / X(max) - X(min) \quad (6)$$

The next step is to determine the normalized strategy Sn, in accordance with the formula:

$$Sn = (S – Smin) / (Smax – Smin) \quad (7)$$

Next, it is necessary to determine the normalized strategy Rn, which is obtained by the formula:

$$Rn = (R^* - R^*min) / (R^*max - R^*min) \quad (8)$$

Finally, a compromise strategy Q is obtained for the value of the parameter v=0.5. The highest value of Q represents the most favorable alternative, but if the conditions are met:

that it is sufficiently better than the second-ranked alternative

$$DQ(a") - DQ(a"") \geq DQ \quad (9)$$

$$DQ = \min (0{,}25,\ 1 / 1 - J) \quad (10)$$

where J-number is an alternative.

That is, J = 4 in this case. So, DQ is 0.25 because it is less than 0.333; and

that it has a strong enough position, that one of the three conditions is met: (it maintains the first position for v=0.25 and for v=0.75; or it maintains the first position for v=1 or it maintains the first position for v =0).

Description of the Borda method of group reading

The Borda method is one of the oldest methods of group decision making, developed by the Frenchman Borda in 1781. It was widely used in the process of voting for the election of deputies in many countries of the world (Barberà et al, 2023; Sonatha et al, 2021; Saari, 2023; Suknović et al, 2021). It can be used in its original form (Murti et al, 2021; Everaere et al, 2023; Ilmiyah et al, 2023), and there are a number of modifications (Costa, 2017; Lin & Lin, 2023; Jones & Wilson, 2024). The basis of the method is to choose the alternative that in most cases was the first or tended to be the first one.

First, a matrix is formed in accordance with the rank of all decision makers, where the first column is the rank of alternatives and the first type is decision makers. Then, the second matrix is formed where the decision makers are in the left-wing column of the alternatives and in the first row, and the cells - fields of the matrix are filled by assigning the value 0 to the last ranked alternative for each decision maker, the second ranked alternative from the back the value 1 and the best placed alternative An the value n -1. Finally, the vector W is obtained in the new right column where the values by species are summarized. The best placed alternative - the most acceptable alternative is the one that has the highest value of the vector W.

If it happens that two alternatives have the same rank, then the following is examined: the independence of the irrelevant alternative (the rank of the third alternative is changed and it is monitored whether it affects the two that have a higher rank); the group agreement (which is the order of ranks of two equally ranked alternatives among all decision makers); and non-dictatorship (check whether the result was obtained as the opinion of one individual).

Description of the alternatives and the criteria

Multi-criteria decision making was implemented for four alternatives in accordance with four criteria:

Alternative 1 - Preparatory shooting at serial number one with a 12.7 mm long range rifle M-93 from the 2020 provisional Instructions and Programs of Shooting with Infantry Weapons temporarily at a distance of 400 m, with 3 + 4 = 7 bullets at target number 1 with the aiming point - black circle with a diameter of 10 cm. It is necessary to go to the target twice for one executor, which is 800 m and requires 40 minutes to execute the shooting. If the rifle is not accurate and precise, it may happen that the entire 1x1 m target is missed, and the accuracy and precision of the rifle must be tested additionally, which increases the time required for shooting, as well as the amount of ammunition.

Alternative 2 - Testing the accuracy and precision of the rifle at a distance of 400 m with 4 + 4 = 8 bullets. It requires a time of 40 minutes and consumes one bullet more and is carried out at the same target number 1 with the aiming point - black circle with a diameter of 10 cm. It is favorable that both optical sights, M-93 and M-94, can be tested, and unfavorable that it may happen that there are no hits on the target.

Alternative 3 - Testing the accuracy and precision of the rifle at a distance of 100 m with 4 + 4 = 8 bullets. It requires a time of 10 minutes and consumes one bullet more compared to A1 and is carried out at the same target number 1 with the aiming point - a black circle with a diameter of 10 cm or some other aiming point on the target. It is favorable that the distance is 100 m, but it is unfavorable that the optical sight M-94 has a minimum aiming distance of 400 m, and it is necessary to define a control point in relation to the elevation of the bullet path at 100 m, because the aiming point and the control point do not coincide, which requires another target.

Alternative 4 - Proposal for preparatory shooting on regular color 1 at a target for testing accuracy and precision with the aiming point and control point 400 at 30 cm above the aiming point and control point 800 at 72 cm above the aiming point, at a distance of 100 m (with prior optical sight rectification) with 4 bullets at one of the control points. A distance of 200 m is covered, which is four times less compared to A1, 4 bullets are used and fired at the same target on which rectification is performed.

The criteria are as follows:

Criterion 1 - The time for which the shooting procedure ends, which is directly related to the shooting distance and the number of bullets. It is preferred to be the minimum value;

Criterion 2 - Ammunition consumption ranging from 4 to 8 rounds. A minimum value is also desirable;

Criterion 3 – The target is determined by type and it can be: target number three with a black circle aiming point with a diameter of 10 cm; a target with a crosshair as an aiming point; a target for testing accuracy and precision into which both rectification and shooting are performed. In the target for accuracy testing, we perform two actions, but it must be sketched, while target number 1 exists, and the second in order should be sketched or the aiming point marked on a clean target support. The criterion is of a linguistic type and depends on the choice of an alternative. The maximum value is preferred; and

Criterion 4 - Fatigue of personnel, which carries weights from 1 to 4 and is directly related to the shooting distance, shooting time, and the number of bullets. It is preferred to be the minimum value.

The alternatives and the criteria are evaluated by decision makers, experts in the field of weapons with shooting training who work at the Military Academy with many years of teaching experience and experience in the troops, and experts in the field of weapons with experience of working in the Serbian Army units.

Ranking results

The first and the second decision maker used the AHP method of individual multi-criteria decision making, for the third decision maker (DO3) the alternative ranking method is unknown and the rank is (the best is A1; the second place is A2; the third place is A3, and the last place is the A4 alternative), while the fourth decision maker used the VIKOR method of multi-criteria decision making.

The first decision maker ranked the alternatives as follows:

Table 3 – Ranking of alternatives in accordance with the time criterion

Time	A1	A2	A3	A4
A1	1	0.5	0.5	0.3333
A2	2	1	0.25	0.25
A3	2	4	1	0.2
A4	3	4	5	1

Decision maker 1 works as follows: The first matrix is filled in with respect to (1), while the second is filled in based on the first, and so on for all four criteria. It can be concluded that for alternative A4, the criterion "time" has the greatest importance, then for alternative A3, and for A2, and for A-1 it has the least importance.

Table 4 – Ranking of alternatives in accordance with the ammunition criterion

Ammunition	A1	A2	A3	A4
A1	1	2	2	2
A2	0.5	1	0.8	0.8
A3	0.5	1.25	1	1
A4	0.5	1.25	1	1

From the above tables, it can be seen that the ammunition is the most important for A1, the target for A4, while the fatigue of the executor is equal for A3 and A4 because the shortest distance is covered.

Table 5 – Ranking of alternatives in accordance with the target criterion

Target	A1	A2	A3	A4
A1	1	1	2	0.5
A2	1	1	0.5	0.5
A3	0.5	2	1	0.5
A4	2	2	2	1

Table 6 – Ranking of alternatives in accordance with the fatigue criterion

Fatigue	A1	A2	A3	A4
A1	1	1	0.25	0.25
A2	1	1	0.25	0.25
A3	4	4	1	1
A4	4	4	1	1

The following tables check the importance of the criteria "ammunition", "target" and "fatigue", according to Satie's scale of comparison of Tables 4 - 6. The procedure is identical to the previous case and requires attention when filling out the initial matrix.

Now it is necessary to check the consistency of the matrix and the consistency ratio CR (2), by ranking the criteria in Table 7. The procedure is identical to the previous two cases and requires attention when filling out the initial matrix.

Table 7 – Ranking of the criteria and determining the weighted sum of the criteria

	K-1	K-2	K-3	K-4
K-1	1	0.33	0.33	1
K-2	3	1	0.25	4
K-3	3	4	1	5
K-4	1	0.25	0.2	1

The mean values of other matrices represent the initial values for the initial decision matrix, Table 8.

Table 8 – Formation of the initial matrix and the priority vector - weighting W

	Time	Ammunition	Target	*Fatigue*
A-1	0.1097	0.3992	0.2381	0.1
A-2	0.1331	0.1788	0.1699	0.1
A-3	0.2328	0.2110	0.2066	0.4
A-4	0.5244	0.2110	0.3854	0.4
W	0.1156	0.2645	0.5267	0.0932

Table 9 – Matrix consistency check

A*w	λmax	CI	RI	CR
0.47	4.09	0.078	0.9	0.087
1.12	4.22			
2.4	4.55			
0.38	4.08			
	4.23			

From Table 9, it can be concluded that the CR=0.087, which is less than 0.1, the matrix is consistent, and the alternatives are then ranked using the same procedure.

Table 10 shows that, for decision maker 1 (DO1), A4 was ranked best, followed by A1, then A3 and the lowest ranked one was A2.

Table 10 – Final ranking of the alternatives with weighted sums for DO1

A-1	0.2530	2.
A-2	0.1615	4.
A-3	0.2288	3.
A-4	0.3567	1.

In the same way, the second decision maker, DO2, with the help of the AHP methods, arrived at the final decision-making matrix and ranked the alternatives as in Table 11.

Table 11 – Formation of the initial matrix and the priority vector - weighting W

	Time	Ammunition	Target	*Fatigue*
A-1	0.1339	0.4	0.2	0.1
A-2	0.1339	0.2	0.2	0.1
A-3	0.2054	0.2	0.2	0.4
A-4	0.5268	0.2	0.4	0.4
W	0.1981	0.2748	0.3873	0.1397

For decision maker 2 (DO2), the CR is 0.045, better than for DO1. Since this is less than 0.1, it means that the matrix is consistent, Table 12.

Table 12 – Final ranking of the alternatives with weighted sums for DO2

A-1	0.2279	3.
A-2	0.1729	4.
A-3	0.229	2.
A-4	0.3702	1.

Decision maker 4 (DO4) used the VIKOR method and formed the initial decision matrix as in Table 13.

Table 13 – Initial decision matrix

L max-min	min	min	max	min
	K1	K2	K3	K4
A1	40	7	1	4
A2	40	8	1	4
A3	10	8	2	1
A4	10	4	2	1
MAX	40	8	2	4
MIN	10	4	1	1

Then in Table 14, the field of the previous matrix is multiplied with the weight vector from the AHP.

Table 14 – Normalized decision matrix

W	0.1953	0.35007	0.21867	0.2758
L max-min	min	min	max	min
	K1	K2	K3	K4
A1	7.812	2.450	0.219	1.103
A2	7.812	2.801	0.219	1.103
A3	1.953	2.801	0.437	0.276
A4	1.953	1.400	0.437	0.276
MAX	7.812	2.801	0.437	1.103
MIN	1.953	1.400	0.219	0.276

Table 15 – Second normalized decision matrix

	K1	K2	K3	K4	**S**	**R**	**R***	**Sn**	**Rn**	**Q**
A1	0	0,.5	0	0	0.25	0	0.0025	0.0625	0.0625	0.0625
A2	0	0	0	0	0	0	0	0	0	0
A3	1	0	1	1	3	0	0.03	0.75	0.75	0.75
A4	1	1	1	1	4	1	0.04	1	1	1
				min	0	0	0			
				max	4	1	0.04			

Then, in accordance with (5) and (6), he formed a normalized decision matrix, Table 15. From there, he determined the strategies S and R, then R*, then with formulas (7) and (8).

The strategies Sn, Rn and finally the compromise strategy Q, for the probability v = 0.5, a simple comparison of which leads to the ranking of the alternatives, if certain conditions of sufficient advantage and a sufficiently firm position of the first-ranked alternative compared to the second-ranked alternative are met.

The complete procedure for calculating the strategies is described in the text above.

Table 16 – Checking the sufficient advantage of the first-ranked alternative

	Q	**Rang**
A1	0.0625	**3.**
A2	0	**4.**
A3	0.75	**2.**
A4	1	**1.**

In accordance with (9), DQ = 1 - 0.75 = 0.25. In accordance with (10), the sufficient advantage of the first-placed alternative A4 in relation to the second-placed alternative A3 is 0.33333 ≥ 0.25. Further, from Table 17, it is checked whether one of the three conditions is fulfilled, so that the first ranked alternative satisfies the condition of a sufficiently firm position.

Table 17 – Checking a sufficiently firm position

	v=1	**v=0**	**v=0.75**	**v=0.25**
A1	0.0625	0.0625	0.0469	0.0156
A2	0	0	0	0
A3	0.75	0.75	0.5625	0.1875
A4	1	1	0.75	0.25

Although only one of the three conditions needs to be met, in this case all three conditions are met. It is concluded that the first-ranked alternative maintains a strong enough position in relation to the second-ranked alternative both when v=0 and when v=1 and when v=0.75 and 0.25. It can be concluded that the individual methods of multi-criteria decision making, the VIKOR and the AHP, gave similar results. In certain cases, the use of one of the methods does not give the expected results, and it is necessary to change the method.

From Table 18, it can be concluded that for the first, second and fourth decision maker, the best alternative is A4, while the opinion of the third decision maker deviates and for him the best alternative is A1 and the lowest ranked alternative is A4. Regardless of everything, his opinion is taken into consideration even if he does not agree with the others.

Table 18 – Results of the individual multi-criteria decision-making methods

METOD	AHP	AHP		VIKOR
RANG	DO 1	DO 2	DO 3	DO 4
1.	A4	A4	A1	A4
2.	A1	A3	A2	A3
3.	A3	A1	A3	A1
4.	A2	A2	A4	A2

When the alternative rankings of all four decision makers are entered in Table 18, the following results are obtained. From the aforementioned table, a new Table 19 is formed, which represents the summarization and ranking of the results of all decision makers while respecting the rule that the worst-placed alternative is assigned 3, the second-placed 2, the third-placed 1, and the last or fourth-placed 0. In Table 19, a simple sum of the ranks leads to the best ranked alternatives to A4.

Table 19 – Use of the Borda method in the ranking of the alternatives

	DO 1	DO 2	DO 3	DO 4	W	RANG
A1	2	1	3	1	7	2.
A2	0	0	2	0	2	4.
A3	1	2	1	2	6	3.
A4	3	3	0	3	9	1.

The Borda method gives the final ranking of alternatives A4, A1, A3, and A2. The best alternative is A4, while the least favorable is A2.

Conclusion

Individual multi-criteria decision-making methods AHP and VIKOR can give different results or be less favorable for a certain problem. In this case, the decision makers obtained favorable results by applying two different methods. Using the VIKOR method, the first-ranked alternative A4 satisfied the criterion of sufficient advantage and sufficiently solid position for all three conditions, out of which only one is sufficient to be fulfilled in relation to the second-ranked alternative A3. The third decision maker only presented the results without explaining the method used. All four decision makers had an equal right to vote in the decision. By applying the Borda group decision-making method, their results were summarized and the most favorable alternative was selected, which is the fourth alternative, A4.

The paper presents a model of the application of multi-criteria decision-making methods for solving a specific problem in the field of weapon use for the purpose of training and realization of the first initial preparatory shooting at serial number one with a 12.7 mm long range rifle, through the selection of the most favorable conditions for shooting. The mentioned procedure combines three actions into one, rectification of the sight - without the use of ammunition, testing the accuracy and precision of the rifle and at the same time the implementation of preparatory shooting, i.e., checking the sniper's training in uniform aiming and firing. The rectification procedure is the product of the author's experiment and for the first time in any official literature in Serbia it is shown here; it was tested in practice where it gave positive results. The idea for the procedure was taken from the shooting with the 30 mm Automatic Grenade Launcher M-93, where the preparatory shooting at serial number one is also the shooting for testing accuracy and precision and checking the operator's training in proper aiming and firing.

The results show that there is a need for a justified change in the conditions for the execution of preparatory shooting with a long range rifle, and the mentioned procedure can be used to select any other four alternatives with four criteria in any field with the ranking of alternatives and criteria by experts in that field.

Multi-criteria decision-making methods have shown results and are used in all areas, both in natural and social spheres of life, in order to obtain maximum product performance. The proposal for future research is that before purchasing and putting weapons into use, multi-criteria optimization methods should be used, the existing and new systems should be compared with the proposed procedure, and the results and the opinions of experts should be followed when purchasing or modernizing assets. Through the aforementioned procedure, the performance of the M-19 modular rifle or the M-20 modular machine gun can be compared with the existing rifles and machine guns or the Kornet EM anti-armor system with the existing anti-armor weapons.

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Aplicación de los métodos AHP y VIKOR de toma de decisiones individuales y del método Borda de toma de decisiones grupales al elegir la forma más eficiente de realizar el tiro preparatorio al número de serie uno con un rifle de largo alcance M-93 de 12,7 mm

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CAMPO: matemáticas aplicadas, ingeniería mecánica, ciencias militares (tácticas con sistemas de armas)
TIPO DE ARTÍCULO: artículo científico original

Resumen:

Introducción/objetivo: El artículo presenta el método de aplicar métodos de toma de decisiones multicriterio para mejorar disparos y seleccionar las condiciones más favorables para disparos. Los expertos clasificaron las alternativas mediante los métodos individuales de toma de decisiones multicriterio AHP y VIKOR, y luego se seleccionó la alternativa más favorable utilizando el método Borda de toma de decisiones grupales. El objetivo del trabajo es seleccionar la forma más eficiente de disparar con el mínimo cansancio humano, consumo de objetos móviles y en el menor tiempo posible mediante una combinación de métodos de toma de decisiones multicriterio, que garanticen la exactitud y precisión del disparo del rifle para disparos posteriores y otras operaciones.

Métodos: El artículo presenta una de las formas de utilizar métodos multidisciplinarios de toma de decisiones multicriterio para un problema específico en el campo de la táctica con sistemas de armas. Los expertos en el campo de armamentos, utilizando los métodos AHP y VIKOR de toma de decisiones individuales según múltiples criterios, seleccionaron la alternativa más favorable de acuerdo con cuatro criterios dados. Luego, aplicando el método Borda de toma de decisiones en grupo, se eligió la alternativa más favorable: las condiciones más favorables para realizar el tiro preparatorio en el número de serie uno con un rifle de largo alcance de 12,7 mm. Las alternativas son cuatro tiros, a saber, dos modos de realizar el tiro preparatorio con un fusil de largo alcance calibre 12,7 mm número de serie uno, uno del actual Instructivo y Programa de Tiro con Armas de Infantería y el otro método recientemente propuesto, así como dos modos de realizar tiros para probar la exactitud y precisión de un rifle de largo alcance.

Resultados: La selección de las condiciones más efectivas para la ejecución del primer tiro preparatorio inicial en el número de serie uno con un rifle de largo alcance, que garantizará la máxima precisión del arma y el mínimo consumo de recursos: tiempo, municiones, objetivos y fatiga del personal.

Conclusión: La solución tiene en cuenta la optimización simultánea de varios criterios para seleccionar la forma más eficiente de realizar tiros preparatorios en el número de serie uno para garantizar personal descansado y capacitado, así como rifles de largo alcance precisos y exactos para tiros posteriores. lo que conduce al máximo ahorro de recursos, la satisfacción del personal y armas precisas.

Palabras claves: rifle de largo alcance, rectificación, tiro, AHP, VIKOR, método Borda.

Применение методов индивидуального принятия решений AHP и VIKOR и метода группового принятия решений Borda при выборе наиболее эффективного способа выполнения поподготовительных упражнений №1 по стрельбе из дальнобойной винтовки М-93 калибра 12,7-мм

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РУБРИКА ГРНТИ: 27.47.19 Исследование операций,
78.25.00 Вооружение и военная техника
ВИД СТАТЬИ: оригинальная научная статья

Резюме:

Введение/цель: В данной статье представлен способ применения метода многокритериального принятия решений с целью совершенствования стрельбы и выбора наиболее благоприятных условий для стрельбы. Альтернативы ранжировались экспертами на основании использования индивидуальных многокритериальных методов принятия решений „AHP“ и „VIKOR“, после чего лучшая альтернатива выбиралась методом группового принятия решений „Borda“. Цель данной статьи − выбрать наиболее эффективный способ стрельбы с минимальным утомлением человека, расходом вещей и в кратчайшие сроки, используя сочетание многокритериальных методов принятия решений, обеспечивающих точность стрельбы и оружия в последующих учениях и других действиях.

Методы: В данной статье представлен один из способов использования мультидисциплинарных методов многокритериального принятия решений по конкретной задаче в области тактики систем вооружения. Эксперты по баллистике выбрали наиболее выгодную альтернативу с помощью методов индивидуального многокритериального принятия решений „AHP“ и „VIKOR“ по четырем заданным критериям. Затем с применением метода группового принятия решений „Borda“ был произведен окончательный выбор наиболее благоприятного альтернативного варианта-условия выполнения подготовительных упражнений по стрельбе №1 из дальнобойной винтовки калибра 12,7 мм. Альтернативными являются четыре способа стрельбы, а именно два способа выполнения подготовительных упражнений по стрельбе № 1 из *дальнобойной винтовки калибра 12,7 мм, один способ согласно Инструкции и программе стрельбы из стрелкового оружия и второй − новый способ, а также два способа выполнения упражнений по стрельбе для проверки точности дальнобойной винтовки.*

Результаты: Выбор наиболее благоприятных условий для проведения первого подготовительного упражнения по стрельбе №1 из дальнобойной винтовки обеспечивает максимальную точность оружия и минимальный расход ресурсов − времени, боеприпасов, мишеней, усталости состава.

Выводы: Решение учитывает одновременную оптимизацию нескольких критериев с целью выбора наиболее эффективного способа выполнения подготовительных упражнений по стрельбе № 1 с целью обеспечения отдохнувшего и подготовленного личного состава и точности дальнобойной винтовки для последующих учений, что приводит к максимальной экономии ресурсов, удовлетворению состава и точности оружия.

Ключевые слова: дальнобойная винтовка, исправление, стрельба, AHP, VIKOR, метод Borda.

Примена AHP и VIKOR метода индивидуалног одлучивања и Borda метода групног одлучивања при избору најефикаснијег начина извршења припремног гађања на редном броју 1 далекометном пушком М-93 калибра12,7 mm

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ОБЛАСТ: примењена математика, машинство, војне науке (тактика са системима наоружања)
КАТЕГОРИЈА (ТИП) ЧЛАНКА: оригинални научни рад

Сажетак:

Увод/циљ: У раду је представљен начин примене метода вишекритеријумског одлучивања чији је циљ унапређење гађања и одабира што повољнијих услова за извршење гађања. Алтернативе су рангиране индивидуалним методама вишекритеријумског одлучивања AHP и VIKOR од стране експерата, након чега је најповољнија алтернатива одабрана применом Borda метода групног одлучивања. Циљ рада јесте да се *комбинацијом метода вишекритеријумског одлучивања одабере најефикаснији начин извршења гађања уз минималан замор људства, утрошак покретних ствари и за што краће време, који ће обезбедити тачност ипрецизност оруђа за наредна гађања и друга дејства.*

Методе: Приказан је један од начина употребе мултидисциплинарних метода вишекритеријумског одлучивања на конкретном проблему из области тактике са системима наоружања. Експерти из области наоружања су применом AHP и VIKOR методе индивидуалног вишекритеријумског одлучивања, према четири задата критеријума, извршили избор најповољније алтернативе. Затим је применом Borda метода групног одлучивања извршен коначан одабир најповољније алтернативе – услова за извршење припремног гађања на редном броју 1 далекометном пушком М-93, калибра 12,7 mm. Алтернативе су четири гађања – два начина извршења припремног гађања на редном броју 1, један из „Упутства и програма гађања пешадијским наоружањем” и други новопредложени начин, као и два начина реализације гађања за испитивање тачности и прецизности далекометне пушке.

Резултат: Изабрани су најповољнији услови за извршење првог почетног припремног гађања на редном броју 1 далекометном пушком, који ће обезбедити максималну тачност оруђа и минималан утрошак ресурса – времена, муниције, мета и замора људства.

Закључак: Решење узима у обзир истовремену оптимизацију више критеријума ради одабира најефикаснијег начина извршења припремног гађања на редном броју 1. На тај начин обезбеђује се одморно и обучено људство, као и прецизност далекометне пушке за наредна гађања, што доводи до максималне уштеде ресурса.

Кључне речи: далекометна пушка, ректификација, гађање, AHP, VIKOR, метод Borda.

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