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Evaluation of a Light Machine Gun Using Analytic Network Process

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ABSTRACT

The light machine guns are among the significant fire support guns for the infantry. While the rapid advances in technology are improving the quality, these are also increasing the diversity, increasing the research carried out in the existing institutions and organisations.This is making the decision problem faced during the process complicated as well. To solve such problems, multiple criteria decision making methods are used. In this study, the selection of the light machine guns has been dealt as a multiple criteria decision making problem. To decide about the best machine gun, selection criteria of the best light machine gun is evaluated within a systematic feedback and a model pertaining to using Analytical Network Process (ANP) in the selection of the weapons has been developed. The criteria pertaining to the alternative weapons have been determined, the necessary polls have been prepared and applied, and the results have been achieved using the Super Decisions 1.6.0 package program.

Keywords: Military application, analytic network process, multi-attribute decision-making (MADM)

1. INTRODUCTION

In the future battlefield, long-range guns equipped with command control systems will play an effective role. The infantry will play the leading role in securing and controlling a region.

The most effective fire supporting gun which may be continuously possessed by the infantry is the machine gun. Changing of the battlefield and the rapid advances in technology day by day have also affected the development of the machine guns. Nowadays, machine guns which are portable, having a high hitting capacity, and an ergonomic usage, etc are being developed for use effectively by the infantry.

In literature, a number of studies pertaining to the selection of the gun systems are available. Mon and his colleagues (1994) used fuzzy AHP approach in the base of entropy weight in the evaluation of gun systems[1]. Cheng and Mon (1994) used AHP approach in the fuzzy scales base[2]. Chen (1996) presented a new method in the performance assessment of the weapon systems using fuzzy arithmetic operations[3]. Cheng (1996) proposed a new algorithm using fuzzy AHP in the base of grade value of membership function in the assessment of naval tactical bullet systems[4]. Greiner and colleagues (2003) set forth a new approach consisting of the hybrid of the AHP and integer programming approaches in order to screen the weapon systems projects[5]. However, when the literature is researched, there have not been any studies using ANP in the assessment of the weapon systems. On the other hand, it is obvious that in the selection of the weapon systems the determined criteria are not independent and there is an interaction and feedback loop with each other and with the other criteria. Due to this reason, it is perceived that ANP could give better results in the selection of the weapons.

In the study, attempt has been made to determine the most suitable light machine gun for the infantry among the alternatives using ANP[6] which is one of the Multi Attribute Decision Making (MADM) methods[7,8].

2. THE PROPOSED MODEL IN SELECTION OF LNG

2.1. Criteria for Consideration

The criteria which must be taken into consideration in the selection of machine gun have been achieved by consulting a group of specialists making studies and analysis and refering to the literature. The mentioned Specialist Group was created from Infantry Branch Officers who were experienced in using light weapons, and technicians capable of analysing the weapon systems technically. Furthermore, the knowledge and experiences of this Specialist Group were utilised in the creation of the network structure in which the interactions between each criterion have been shown. These criteria have been classified under four clusters. These are:

(i) Tactics,
(ii) Technique,
(iii) Logistics, and
(iv) Improvability

The criteria within every criterion cluster have been grouped. In Table 1 the criteria clusters and sub-criteria belonging to the criterion clusters are shown.

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2.1.1. Tactics cluster

Maximum Range: It is the longest distance, where the bullet leaving the gun from the muzzle of the weapon falls down after going a while in the air, by losing its speed due to gravity and resistance of the air. It is suggested that the maximum range should be as long as possible.

Effective Range: The distance where the desired effect on the target is achieved is called effective range. In order to determine the effective range, the international standards relating to the effect on the target are available. It is also suggested that the effective range should be long as in the case of maximum range.

Ergonomic usage of the weapon: The suitability of the usage of the weapon by the shooter is related to whether the ergonomic design is good or not. The length of the barrel, the distance between the trigger and handle, the distance between the handle and the butt and their sizes should be suitable to the body of the user and in an easy using state. The weapon shall have a suitable hand grip but unnecessary lugs shall not be available on its right and left. The weapon should be easy to use, portable and simple in terms of users. The mechanism of the weapon should not be complex and should be learnable by a beginner who can be trained without much effort. The reset of the weapon shall be made simple. Besides, the weapon should have iron sights and a binocular, which simplifies aiming the weapon and may be used continuously. The disassembling and assembling of the parts should be as simple as possible and should not require special apparatuses. The ergonomic structure of the weapon is very significant to increase the hitting percentage by the user.

Table 1. Criteria determined for the selection of machine gun

Criterion clusters	Criteria
1. Tactics	Maximum range
	Effective range
	Ergonomic usage
	Reliability
2. Technique	Weight
	Rate of Fire
	Angular Spread of Shots
	Damage
	Muzzle velocity
	Working principle
	Volume of Continuous Fire
	Barrel
3. Logistics	Easiness of Maintenance
	Durability
	Spare part
4. Improvability	Modular structure
	Kinds of Munitions

Reliability: The possibility of injuring the shooter due to the usage of the weapon should be minimal. For example; the weapon should not cause injury to the shooter's shoulder or face due to a sudden recoil and should not be automatically fired by mistake during its maintenance or when it falls down. Its barrel should be resistant to wear by long duration of serial shots and should not lead to barrel splits which may cause injury to the shooter.

2.1.2. Technical Cluster

Weight: The weight of the weapon should be to an extent permitting the user to carry and manage it easily and should be as light as possible. However, matters such as the requirement of decreasing the recoil, resistance of the barrel and addition of the tripod in order to achieve a balanced shooting position increase the weight of the weapon.

Damage: The machine guns are used in the battlefield against diverse targets. These targets may be an enemy group, a light armour vehicle, a blockhouse or a shelter. The weapon should be effective against these targets at certain measures.

Rate of Fire: It is the number of rounds which can be fired per minute by the weapon. For example; the shooting speed of the MG-3 machine gun is 1100-1300 rounds/min. As the shooting speed affects the target positively, it may also affect the percentage of the hit negatively. It is suggested that the rate of fire of the gun should be high.

Muzzle Velocity: It is the speed at the moment when the bullet core comes out of the gun muzzle. The first bullet speed of the MG-3 machine gun is 820 m/s. The high primary speed of the bullet increases the maximum range, effective range, and the effect on the target. It is also suggested that the primary speed of the bullet should be high.

Angular spread of shots: The angular value of the standard deviation (depending on the distance) per minute after the core of the bullet comes out of the barrel is called angular spread of shots. It's unit is called Minute of Angle (MOA). It is required that the distribution should be as less as possible. When it is more, it will decrease the hitting percentage, and hence, the effect on the target. The spread on the target by 7 consecutive shots at a distance of 1000 m of the MG-3 machine gun is 13,75 MOA. The shots should be taken within a circle[9] with a dia of 40 cm.

Working Principles: There are new working systems of machine guns which are being developed by the military organisation. Different recoiling systems, locking mechanisms are being developed and each system has some advantages over the another. The working principles of the weapon affects the shooting speed, hitting percentage, and recoiling.

Volume of Continuous Fire: It is the maximum number of shots that can be fired while the trigger of the weapon is kept pushed. The high value of the volume of continuous fire depends on the durability of the barrel. A high volume of continuous fire is suggested.

Barrel: One of the most important parts of the weapon is the barrel. The length, durability, the structure of its interior surface, its reaction to heat and vibration, are important for the weapon. A barrel irresistible to heat may crack after certain number of shots and become nonfunctional. The sensitivity against the vibration decreases the high barrel hitting percentage.

2.1.3. Logistics Cluster

Easiness of Maintenance: For an effective and efficient working of the weapon, its maintenance should be carried out regularly. The easy maintenance of the weapon will extend the economical life of the weapon and help it work more productively. Connected to the easy maintenance, it is necessary that the number of the parts be small and the raveling installation operations be easy.

Spare Part: It is suggested that the number of the spare parts of the weapon should be small. High number of the spare parts will affect the durability of the weapon and it's ease of maintenance. The import of the spare parts will increase the cost and the dependency on external sources. After obtaining the patent of the weapon, the production of the spare parts should be done within the country.

Durability: The weapon should be made from durable material against the impacts, shocks, and similar situations. It should be efficiently used in all kinds of battle conditions and should not be affected by mud and water to a large extent. The weapon should be designed in such a way that it does not jam even in the hard conditions, specially when its maintenance cannot be carried out regularly.

2.1.4. Improvability Cluster

Modular Structure: The gun shall give the possibility that reserve equipments, such as night-sight binocular, thermal weapon binocular, easily sighting apparatus, carrying handle, laser marker may be quickly mounted and with ease. The improvement of the modular structure may decrease its durability, increase it's weight and complicate its maintenance. However, it is suggested that the weapon be as modular as possible.

Kinds of Munitions: The machine guns can fire munitions having diverse features. Training shell used for training purposes, drill cartridge used in the operations, tracer which leaves a track while the bullet goes to the target, bullet with steel core which can be used against the light armoured vehicles are some of the kinds of the munitions. Besides these equipments, which can be mounted on the weapon, and special munitions aimed to provide effects such as mist, lightening, and chemical are available. In order to increase the effect on the target and make it serve the aim, it should be able to fire different types of munitions[10].

2.2. Creating the Network Structure

Before creating the structure of the network, the control criteria have to be determined[11-17]. In this study, only a single control criterion has been taken into consideration. This control criterion has been accepted as "benefit criterion". The structure of the network has been created taking opinions of the specialists in different areas related to the light weapons. The Specialist Group can perform assessments on the weapons in terms of tactics, technique, logistics, and improvability.

The criteria clusters and interactions between the criteria have been shown with arrows in the structure of the network. Dependencies from a criterion cluster to another criterion cluster are called as exterior dependency and the influence by a criterion cluster to the criteria itself is called interior dependency. In Fig. 1, the structure of the network configured in the Super Decisions 1.6.0 Package Program is shown. When the structure of the network is generally analysed, it is seen that the tactics, technique, and logistics criteria clusters have both the internal and external dependency and the improvability criteria clusters doesn't have internal dependency but only exterior dependency.

In Table 2, the interactions between the criteria have been given.

2.3. Pair-wise Comparisons Matrices and Priority Vectors

The 1-9 scale proposed by Saaty is used to perform the pair-wise comparisons. This comparison scale enables the decision-maker to incorporate experience and knowledge intuitively and indicate how many times an element dominates the other wrt. the criterion.

The pair-wise comparisons have been dealt within three fundamental stages:

(i) cluster comparisons,
(ii) comparisons of criteria, and
(iii) comparisons for alternatives.

These paired comparisons are used to derive eigenvectors and form a super matrix.

In the first stage, the weights of the criterion clusters have been calculated. In this stage, it is considered that there is no interaction between the clusters. The quantitative significance of the clusters related to the objective has been determined wrt each other. The pair-wise comparison matrices of the clusters assessed in terms of objective have been shown in Table 3. On the condition that the consistency rate is l<0.1, it shows that the comparison is consistent. When the Table 3 is analysed, it is seen that the consistency is 0.0101. Since this rate is nearly equal to 0.1, the comparisons can be treated as consistent. Furthermore, according to the values resulted from Table 3, it is seen that best light weapon selection criteria related to the objective is the technique cluster with the maximum value 0.497, and the improvability cluster has the least value 0.099.

In the same way, the resulted cluster weights have been calculated based on the other criteria clusters and the consistency rate of every matrix has been < 0.1. Calculated weight values of the comparisons have been shown in Table 4.

Comparison of criteria is dealt in two groups as: (i) Comparison of sub-criteria within the domain of a criterion~Interior dependency, and (ii) comparison of sub-criteria over the domain of different criteria~Exterior dependency. In the first group, the interaction (interior dependency)

Table 2. The interactions between the criteria

1.1. Criteria affecting the maximum range	**1.2. Criteria affecting the effective range**	**1.3. Criteria affecting the ergonomic usage**
1.2. Effective Range	1.1. Maximum Range	1.4. Reliability
2.5. Muzzle Velocity	2.4. Damage	2.6. Working Principle
2.6. Working Principle	2.5. Muzzle Velocity	2.8. Barrel
2.8. Barrel	2.6. Working Principle	4.1. Modular Structure
4.1. Modular Structure	2.8. Barrel	
4.2. Kinds of Munitions	4.1. Modular Structure	
	4.2. Kinds of Munitions	

1.4. Criteria affecting the reliability	**2.1. Criteria affecting the weight**	**2.2. Criteria affecting the rate of fire**
1.3. Ergonomic Usage	1.1. Maximum Range	2.5. Muzzle Velocity
2.8. Barrel	1.3. Ergonomic Usage	2.6. Working Principle
4.1. Modular Structure	2.5. Muzzle Velocity	4.1. Modular Structure
	2.6. Working Principle	
	2.8. Barrel	
	3.2. Durability	
	3.3. Spare Part	
	4.1. Modular Structure	
	4.2. Kinds of Munitions	

2.3. Criteria affecting the angular spread of shots	**2.4. Criteria affecting the damage**	**2.5. Criteria affecting the muzzle velocity**
1.1. Maximum Range	1.1. Maximum Range	2.2. Rate of Fire
1.2. Effective Range	2.2. Rate of Fire	4.2. Kinds of Munitions
2.1. Weight	2.3. Angular Spread of Shots	
2.2. Rate of Fire	2.5. Muzzle Velocity	
2.5. Muzzle Velocity	2.8. Barrel	
2.6. Working Principle	4.1. Modular Structure	
2.8. Barrel	4.2. Kinds of Munitions	
4.1. Modular Structure		
4.2. Kinds of Munitions		

2.6. Criteria affecting the working principle	**2.7. Criteria affecting the volume of continuous fire**	**2.8. Criteria affecting the barrel**
	2.6. Working Principle	2.1. Weight
	2.8. Barrel	2.7. Volume of Continuous Fire

3.1. Criteria affecting the easiness of Maintenance	**3.2. Criteria affecting the durability**	**3.3. Criteria affecting the spare part**
1.3. Ergonomic Usage	2.1. Weight	1.3. Ergonomic Usage
3.3. Spare Part	2.7. Volume of Continuous Fire	1.4. Reliability
4.1. Modular Structure	3.3. Spare Part	2.2. Rate of Fire
	4.1. Modular Structure	3.1. Easiness of Maintenance
		3.2. Durability
		4.1.Modular Structure

4.1. Criteria affecting the modular structure	**4.2. Criteria affecting the kinds of munitions**	
1.3. Ergonomic Usage	1.1. Maximum Range	
2.4. Damage	1.2. Effective Range	
3.1. Easiness of Maintenance	2.4. Damage	
3.2. Durability	2.7.Volume of Continuous Fire	

between the criteria found in the same criterion cluster and in the second group, the interaction (exterior dependency) of the criteria within different clusters have been tackled.

For the comparison of the alternatives, the alternatives wrt all the criteria should also be compared.

2.4. Creating the Super Matrix and Achieving the Limit Super Matrix

The super matrix in ANP is similar to the Markov transition matrix[18]. The columns of the super matrix are composed of the local priority vectors. A super matrix is a partitioned matrix that each entry represents a relationship between two nodes (components or clusters) in a system. One constructs the supermatrix of the network in Fig. 1 as shown in Eqn. (1). Since there are four clusters in this network, the super matrix in this equation has four columns and four rows. The numbers adjacent to the supermatrix represents each cluster. For instance, number 1 is assigned for the tactics cluster. Here the W_{ij}, (i=1,..,4, j=1,..,4) terms show the sub-matrices and they are equal to zero if there

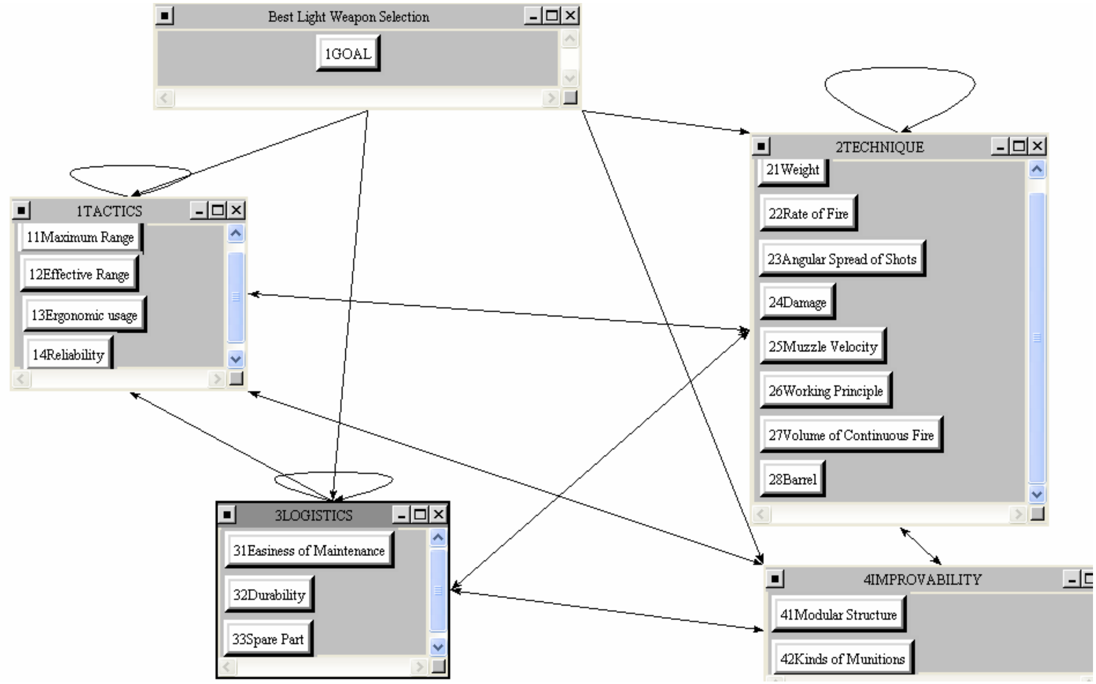

Figure 1. The best light weapon selection problem network structure and dependencies between the clusters.

is no interaction from cluster *j* to cluster *i* (as in W_{31} and W_{44}). Additionally, a positive W_{ij} means that cluster *i* depends on cluster *j*.

$$W = \begin{matrix} & 1 & 2 & 3 & 4 \\ 1 & W_{11} & W_{12} & W_{13} & W_{14} \\ 2 & W_{21} & W_{22} & W_{23} & W_{24} \\ 3 & 0 & W_{32} & W_{33} & W_{34} \\ 4 & W_{41} & W_{42} & W_{43} & 0 \end{matrix} \quad (1)$$

Table 5 shows the unweighted super matrix, which include the eigenvector values of the criteria wrt the objective and the eigenvector values of the criteria as a result of the interior and exterior dependencies. In an unweighted super matrix, the columns may not be column stochastic, which means the sum of the entries in that column is not equal to 1. However, the super matrix needs to be stochastic to have meaningful limiting priorities. For this purpose, one should obtain the weighted super matrix (Table 6) by multiplying the weights in Table 4 with the unweighted super matrix. For example, let one consider the maximum range and objective entry, which is 0.410, in Table 5. Note that the maximum range criteria is in Tactics cluster. The weight corresponding to this entry, which is 0.285, is taken from the intersection of tactics and objective in Table 4. The multiplication of these values, which is 0.117 (= 0.410*0.285), yields the maximum range and objective entry in Table 6. After that one raises the weighted super matrix to the power of a large number. The resulting limit super matrix is shown in Table 7.

The calculations in this study have been performed by using the Super Decision 1.6.0 Program. Finally, the

Table 3. The values of pair-wise comparison matrix of the criteria clusters related to the objective

	Tactics	Technique	Logistics	Improvability	Eigenvector
Tactics	1	1 / 2.15	2.45	3.45	0.285
Technique		1	4.0	4.24	0.497
Logistics			1	2.45	0.119
Improvability				1	0.099

Table 4. Calculated weights of the criteria clusters

	Objective	Tactics	Technique	Logistics	Improvability
Objective	0.000	0.000	0.000	0.000	0.000
Tactics	0.285	0.216	0.067	0.154	0.631
Technique	0.498	0.603	0.641	0.280	0.098
Logistics	0.119	0.093	0.167	0.503	0.272
Improvability	0.099	0.088	0.126	0.063	0.000

Table 5. Unweighted super matrix

	1. Objective	1.1. Maximum Range	1.2. Effective Range	1.3. Ergonomic Usage	1.4. Reliability	2.1. Weight	2.2. Rate of Fire	2.3. Angular Spread of Shots	2.4. Damage	2.5. Muzzle Velocity	2.6. Working Principle	2.7. Volume of Continuous Fire	2.8. Barrel	3.1. Easiness of Maintenance	3.2. Durability	3.3. Spare Part	4.1. Modular Structure	4.2. Kinds of Munitions
1. Objective	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.1.Maximum Range	0.410	0.000	1.000	0.000	0.000	0.756	0.000	0.500	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500
1.2. Effective Range	0.415	1.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500
1.3. Ergonomic Usage	0.059	0.000	0.000	0.000	1.000	0.244	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.750	1.000	0.000
1.4. Reliability	0.115	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.250	0.000	0.000
2.1. Weight	0.350	0.000	0.000	0.000	0.000	0.000	0.000	0.087	0.000	0.000	0.000	0.000	0.500	0.000	0.885	0.000	0.000	0.000
2.2. Rate of Fire	0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.238	0.140	1.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000
2.3. Angular Spread of Shots	0.198	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.490	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.4. Damage	0.113	0.000	0.668	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.898
2.5. Muzzle Velocity	0.073	0.630	0.173	0.000	0.000	0.222	0.230	0.230	0.267	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.6. Working Principle	0.038	0.130	0.054	0.778	0.000	0.095	0.770	0.046	0.000	0.000	0.000	0.706	0.000	0.000	0.000	0.000	0.000	0.000
2.7. Volume of Continuous Fire	0.064	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.115	0.000	0.000	0.102
2.8. Barrel	0.110	0.240	0.105	0.222	1.000	0.683	0.000	0.400	0.103	0.000	0.000	0.294	0.000	0.000	0.000	0.000	0.000	0.000
3.1. Easiness of Maintenance	0.141	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.209	0.630	0.000
3.2. Durability	0.604	0.000	0.000	0.000	0.000	0.786	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.791	0.370	0.000
3.3. Spare Part	0.256	0.000	0.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.000	0.000	0.000	0.000
4.1. Modular Structure	0.882	0.846	0.145	1.000	1.000	0.818	1.000	0.709	0.149	0.000	0.000	0.000	0.000	1.000	1.000	1.000	0.000	0.000
4.2. Kinds of Munitions	0.118	0.154	0.855	0.000	0.000	0.182	0.000	0.291	0.851	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 6. Weighted super matrix

	1. Objective	1.1. Maximum Range	1.2. Effective Range	1.3. Ergonomic Usage	1.4. Reliability	2.1. Weight	2.2. Rate of Fire	2.3. Angular Spread of Shots	2.4. Damage	2.5. Muzzle Velocity	2.6. Working Principle	2.7. Volume of Continuous Fire	2.8. Barrel	3.1. Easiness of Maintenance	3.2. Durability	3.3. Spare Part	4.1. Modular Structure	4.2. Kinds of Munitions
1. Objective	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.1.Maximum Range	0.117	0.000	0.231	0.000	0.000	0.050	0.000	0.040	0.080	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.433
1.2. Effective Range	0.118	0.231	0.000	0.000	0.000	0.000	0.000	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.433
1.3. Ergonomic Usage	0.017	0.000	0.000	0.000	0.231	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.214	0.000	0.116	0.631	0.000
1.4. Reliability	0.033	0.000	0.000	0.231	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.039	0.000	0.000
2.1. Weight	0.174	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.000	0.000	0.000	0.000	0.500	0.000	0.293	0.000	0.000	0.000
2.2. Rate of Fire	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.183	0.108	0.836	0.000	0.000	0.000	0.000	0.000	0.280	0.000	0.000
2.3. Angular Spread of Shots	0.099	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.377	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.4. Damage	0.056	0.000	0.449	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.098	0.120
2.5. Muzzle Velocity	0.037	0.424	0.116	0.000	0.000	0.142	0.192	0.177	0.205	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.6. Working Principle	0.019	0.087	0.036	0.523	0.000	0.061	0.644	0.035	0.000	0.000	0.000	0.706	0.000	0.000	0.000	0.000	0.000	0.000
2.7. Volume of Continu ous Fire	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.038	0.000	0.000	0.014
2.8. Barrel	0.055	0.161	0.071	0.150	0.673	0.438	0.000	0.308	0.079	0.000	0.000	0.294	0.000	0.000	0.000	0.000	0.000	0.000
3.1. Easiness of Maintenance	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.105	0.171	0.000
3.2. Durability	0.072	0.000	0.000	0.000	0.000	0.131	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.398	0.101	0.000
3.3. Spare Part	0.030	0.000	0.000	0.000	0.000	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.698	0.595	0.000	0.000	0.000
4.1. Modular Structure	0.087	0.082	0.014	0.096	0.096	0.103	0.164	0.107	0.023	0.000	0.000	0.000	0.000	0.087	0.074	0.063	0.000	0.000
4.2. Kinds of Munitions	0.012	0.015	0.082	0.000	0.000	0.023	0.000	0.044	0.129	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 7. Limit super matrix

	1. Objective	1.1. Maximum Range	1.2. Effective Range	1.3. Ergonomic Usage	1.4. Reliability	2.1. Weight	2.2. Rate of Fire	2.3. Angular Spread of Shots	2.4. Damage	2.5. Muzzle Velocity	2.6. Working Principle	2.7. Volume of Continuous Fire	2.8. Barrel	3.1. Easiness of Maintenance	3.2. Durability	3.3. Spare Part	4.1. Modular Structure	4.2. Kinds of Munitions
1. Objective	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.1.Maximum Range	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
1.2. Effective Range	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
1.3. Ergonomic Usage	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
1.4. Reliability	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
2.1. Weight	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
2.2. Rate of Fire	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088
2.3. Angular Spread of Shots	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
2.4. Damage	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
2.5. Muzzle Velocity	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
2.6. Working Principle	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191
2.7. Volume of Continuous Fire	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078
2.8. Barrel	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122
3.1. Easiness of Maintenance	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
3.2. Durability	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
3.3. Spare Part	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
4.1. Modular Structure	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
4.2. Kinds of Munitions	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021

Table 8. Criterion weights resulted from limit super matrix

Number	Criteria	Weight
1	Maximum range	0.025
2	Effective range	0.019
3	Ergonomic usage	0.065
4	Reliability	0.021
5	Weight	0.094
6	Rate of fire	0.088
7	Angular spread of shots	0.010
8	Damage	0.020
9	Muzzle velocity	0.060
10	Working principle	0.191
11	Volume of continuous fire	0.078
12	Barrel	0.122
13	Easiness of maintenance	0.019
14	Durability	0.051
15	Spare part	0.058
16	Modular structures	0.056
17	Kinds of munitions	0.021

weights of the criteria are taken from the limit supermatrix and shown in Table 8.

2.5 Evaluation of Alternatives

To calculate the final priorities of the alternative machine guns, first a questionnaire to the specialist group regarding the one by one comparison of the alternative machine guns based on each criteria is applied. The values obtained from the questionnaire have been shown in Table 9. The final priorities of each machine gun in Table 10 have been calculated by multiplying the values in Table 9 by criterion weights in Table 8. The total rows in Table 10 is the sum of the final priorities of the corresponding alternative machine gun.

The resulting evaluation of the alternative machine guns according to the final priorities is illustrated in Fig. 2.

When Figure 2 is analysed, it is seen that the machine gun D is the best machine gun with the value of 0.257, machine gun A is the second with the value of 0.230, machine gun E is the third with the value of 0.133 and B, C, F machine guns take the values close to each other.

In the best light weapon selection, using ANP, the weights of the criteria, which may affect the selection, have been determined and according to these weights the scoring of every alternative machine gun has been made. The method dealt in this study may also be used efficiently in the selection of other weapon systems. From the results obtained, some comment and assessment may be made on many subjects and accurate information may be achieved.

3. CONCLUSION

Selection of a new weapon contains many detailed processes such as research on the weapon, analysis of the weapon, production of the weapon. Furthermore, the selected weapon is expected to be used efficiently as long as possible within the frame of the economical opportunities and maximum benefit from the system is expected to be achieved.

In some situations, in the selections of the weapons, the political or international relations may play an influencing role. In such cases, it is necessary that this factor be considered in their assessment. However, in this study the political factor has not been taken into consideration.

The economic factor has also not been included in the assessment due to the fact that the safety of the country

Table 9. Priorities of the alternatives according to each criteria

Criteria	Machine gun A	Machine gun B	Machine gun C	Machine gun D	Machine gun E	Machine gun F
Maximum range	0,462	0,158	0,044	0,045	0,214	0,077
Effective range	0,401	0,253	0,089	0,062	0,149	0,046
Ergonomic usage	0,312	0,152	0,075	0,092	0,096	0,108
Reliability	0,394	0,107	0,258	0,038	0,068	0,135
Weight	0,151	0,144	0,041	0,424	0,077	0,163
Rate of fire	0,119	0,079	0,275	0,048	0,446	0,033
Angular spread of shots	0,164	0,068	0,372	0,108	0,245	0,043
Damage	0,057	0,096	0.036	0,159	0,395	0,257
Muzzle velocity	0,057	0,23	0,058	0,21	0,083	0,36
Working principle	0,386	0,07	0,164	0,233	0,047	0,1
Volume of continuous fire	0,148	0,093	0,062	0,434	0,221	0,042
Barrel	0,129	0,166	0,058	0,412	0,07	0,165
Easiness of maintenance	0,272	0,132	0,056	0,422	0,087	0,031
Durability	0,222	0,09	0,158	0,428	0,066	0,036
Spare part	0,166	0,035	0,083	0,447	0,212	0,057
Modular structures	0,393	0,093	0,272	0,036	0,056	0,15
Kinds of munitions	0,086	0,168	0,394	0,035	0,053	0,264

Table 10. The final priorities of the alternatives according to each criterion

Criteria	Machine gun A	Machine gun B	Machine gun C	Machine gun D	Machine gun E	Machine gun F
Maximum range	0.012	0.004	0.001	0.001	0.005	0.002
Effective range	0.008	0.005	0.002	0.001	0.003	0.001
Ergonomic usage	0.020	0.010	0.005	0.006	0.006	0.007
Reliability	0.008	0.002	0.005	0.001	0.001	0.003
Weight	0.014	0.014	0.004	0.040	0.007	0.015
Rate of fire	0.010	0.007	0.024	0.004	0.039	0.003
Angular spread of shots	0.002	0.001	0.004	0.001	0.002	0.000
Damage	0.001	0.002	0.001	0.003	0.008	0.005
Muzzle velocity	0.003	0.014	0.003	0.013	0.005	0.022
Working principle	0.074	0.013	0.031	0.045	0.009	0.019
Volume of continuous fire	0.012	0.007	0.005	0.034	0.017	0.003
Barrel	0.016	0.020	0.007	0.050	0.009	0.020
Easiness of maintenance	0.005	0.003	0.001	0.008	0.002	0.001
Durability	0.011	0.005	0.008	0.022	0.003	0.002
Spare part	0.010	0.002	0.005	0.026	0.012	0.003
Modular structures	0.022	0.005	0.015	0.002	0.003	0.008
Kinds of munitions	0.002	0.004	0.008	0.001	0.001	0.006
Total	0.230	0.117	0.130	0.257	0.133	0.120

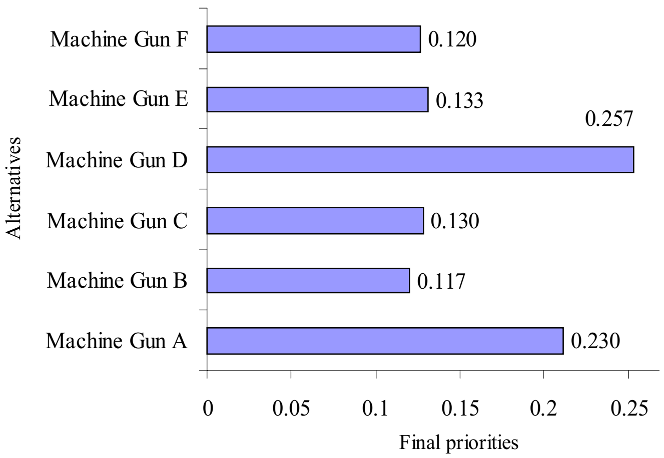

Figure 2. Final priorities of the alternatives

has got a primary preference. It suppresses consideration of alternative weapon costs in the defense industry over the other factors in selection of the weapon. The second reason why the economic factor has not been included in the assessment is that the information related to the costs of the alternative weapons are not certain and may be changing according to the agreements made.

As a result of this study, a method has been proposed, which can give the opportunity of joining the quantitative and qualitative factors and taking multiple criterion and interactions of these criteria with each other into consideration. It has been assessed that ANP approach can be effectively used in the selection of the weapon.

There are a number of methods to be used in comparing light machine guns such as fuzzy ANP, ELECTRE, DEA and TOPSIS. Further research may be the application of these multi-attribute evaluation methods to the weapon selection problem and the comparison of the results.

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