Istanbul Gelisim Univ J Soc Sci 2024:11(2);450-461
DOI: 10.17336/igusbd.1290003

ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA

A Conceptual Framework for Studying the Effectiveness of Ballistic Missile Defence System (BMDS) and a Proposed Model

Balistik Füzelere Karşı Savunma Sisteminin Etkililiğinin İncelenmesine Yönelik Kavramsal Bir Çerçeve ve Öneri Bir Model

[1]Kenan ÖZDEN
[2]Orhan AKZADE

Abstract

The Ballistic Missile Defence System (BMDS), like any system, has its effectiveness, which must be studied, because it determines the extent to which the goal of this system's existence is achieved. In general, the effectiveness does not yet have a specific methodology to be calculated. This study provided a conceptual and theoretical framework for how to think about the effectiveness of BMDS, the factors which affecting them, and how they will be formulated and calculated. It also provided a proposed equation to calculate this effectiveness, and sources of information to obtain the elements of this proposed equation. Due to the difficulty to find this effectiveness by one person, this study suggested a multidisciplinary committee and its members to perform this task, due to BMDS's specificity and overlapping objectives.

Keywords

Ballistic Missile Defense System, BMDS, Effectiveness, Ballistic Missiles, Systems Engineering

[1]Prof., PhD, Istanbul Gelisim University, Department of Industrial Engineering, Istanbul, Türkiye.
✉ kozden@gelisim.edu.tr

[2]M.Sc. Graduated, Istanbul Gelisim University, Department of Industrial Engineering, Istanbul, Türkiye.
✉ orhanakzade@gmail.com

Geliş/Received: 09.05.2023
Kabul/Accepted: 28.05.2024

Öz

Balistik Füzelere Karşı Savunma Sistemi (BFKSS), herhangi bir sistem gibi, üzerinde çalışılması gereken etkililiğine sahiptir, çünkü bu etkililik sistemin var olma amacına ne ölçüde ulaşıldığını belirlemektedir. Genel olarak, etkililiğin henüz hesaplanacak belirli bir metodolojisi yoktur. Bu çalışma, BFKSS'nin etkililiği, onu etkileyen faktörler ve bunların nasıl formüle edilip hesaplanacağı hakkında nasıl düşünüleceğine dair kavramsal ve teorik bir çerçeve sağlamıştır. Ayrıca, bu etkililiği hesaplamak için önerilen bir denklem ve bu

Kenan Özden, Orhan Akzade, "A Conceptual Framework for Studying the Effectiveness of Ballistic Missile Defence System (BMDS) and a Proposed Model", Istanbul Gelisim University Journal of Social Sciences, 11 (2), October 2024, pp. 450-461.

önerilen denklemin öğelerini elde etmek için bilgi kaynakları sağlamıştır. Bu etkililiği bir kişi tarafından bulmanın zorluğu nedeniyle, bu çalışma, BFKSS'nin özgüllüğü ve örtüşen hedefleri nedeniyle, çok disiplinli bir komite ve üyelerinin bu görevi yerine getirmesini önermiştir.

Anahtar Kelimeler

Balistik Füzelere Karşı Savunma Sistemi, BFKSS, Etkililik, Balistik Füzeler, Sistem Mühendisliği

Introduction

The use of cruise and ballistic missiles was began in parallel with the events of World War II, with advent the cruise missile (V1), and the ballistic missile (V2), which were developed by Germany. Despite of these missiles sometimes deviated from their track; they caused many losses for the Allied countries, when the air defenses were weak in that time. By the time, the interest in acquiring arsenals of cruise and ballistic missiles started, developments and improvements began to take place too, especially in the injury accuracy and the quality of warheads carried on missiles. The missiles are characterize by their ability to reach targets that may be difficult for aircraft of all kinds to reach. Ballistic missiles were one of the deterrence elements possessed by countries due to their ability to carry various warheads of mass destruction such as nuclear and chemical warheads, etc., in addition to difficult to jam and stop it (Seren, 2015:11-13).

According to Oxford Dictionary; "Ballistic; is the scientific study of things fired into the air, such as bullets and missiles" and "A ballistic missile is a missile fired into the air at a specific speed and angle to hit the targeted location" (Oxford Learner's Dictionaries, 2011).

A ballistic missile is a missile that has a ballistic trajectory over most of its flight path, regardless of whether it is loaded with any weapons (FAS, 2000).

Ballistic trajectory; It is the path followed by a bullet that moves only under the influence of gravity and possible atmospheric friction, its course cannot be changed and no propellant is given (Collins Dictionary, 2005).

Ballistic missiles can be classified into Short Range Ballistic Missile (SRBM), Medium Range Ballistic Missile (MRBM), Intermediate Range Ballistic Missile (IRBM) and Intercontinental Ballistic Missile (ICBM) (Akzade, 2023).

Ballistic missiles have been a subject of controversy between major countries and countries seeking to develop this type of missile (Egeli, 2014:40-43). This was noticeable at many times when following news bulletins, as condemnations from America and some European countries for ballistic experiments, and for countries seeking to develop their ballistic arsenal, Such as North Korea, Iran and sometimes Russia.

At the same time, studies and researches on ballistic missile defense systems (BMDS) were being conducted despite the difficulties encountered in the success of these systems performing their tasks, but countries and armies sought to develop or obtain them out of show and as a symbol of strength (Bowen, 2009).

Defense systems against ballistic missiles mainly consist of five processes that harmonize with each other to form this system and these processes are search, monitoring, pursuit, engagement and interception, and finally evaluation. These systems can be classified according to the stage that during it the interception is made into, pre-launch, during launch, ballistic stage and during the fall stage (Jian, Qiwang & Weiping, 2015:678).

BMDS; It is classified according to the intercept phase, the deployment of the interceptor, the method of neutralizing the target, and the types and locations of sensors used to track the target (Gansler, 2010).

As an example of these systems: Terminal High Altitude Area Defense (THAAD) used by USA, Iron Dome and David's Sling used by Israel, S-400 used by Russia and HQ-19 used by China.

Here an important question arises, to what degree are these systems effective? Of course, a question of this kind has no simple answer; two opposing opinions appear about the effectiveness of

these systems. The first opinion thinks that the values of effectiveness that are declared by countries are not reflect reality, especially since these systems were not subjected to a real war experience and all experiments which the results were based on were planned. The other opinion believes that these systems are effective and that experiments prove this effectiveness (Lewis, 2017:1).

The first opinion may supported by:

- The wars are usually random and unpredictable operations (Green & Stracener, 2019:125).
- The emergence of a difference between what was declared about the effectiveness of Iron Dome and the Patriot system during the testing phase, and what appeared on the ground when these two systems entered into a real war, where the results were below the level that was declared. (Wilkening, 1998; Lewis & Postol, 2000; Lewis, 2017).

The importance of the effectiveness term appears as an indicator to determine the extent to which systems are able to achieve their goals. This paper will provide a conceptual framework for studying the effectiveness of BMDS by putting forward a set of points:

1. Goals of BMDS.
2. Effectiveness term and its importance.
3. Types of the effectiveness.
4. Effectiveness of BMDS.

In the end, presenting a proposed equation to calculate the effectiveness of BMDS.

2. Goals of BMDS

BMDS is one of the important and sensitive elements in the national security system of any country, as it enables it to protect the infrastructure from population centres, industrial, political and historical sites. In addition to its role in providing a deterrent force, enhancing the diplomatic and political efforts of the state, and saving time for decision makers during crises (Geller, 2021:503-504).

The goals of countries from possessing anti-ballistic missile defence systems can be classified into:

1. Military goal: to ensure the state's military superiority over its surroundings and potential enemies.
2. Defensive goal: to protect population centres and vital facilities in the country from destruction and collapse by ballistic strikes.
3. Political goal: to give the state strong negotiating advantages in regional and international affairs; the existence of these systems allows decision makers enough time to think and consider the available options, and gives them confidence and boldness in making sovereign decisions regarding national security.

3. Effectiveness Term and its Importance

According to Özden, effectiveness is a performance indicator that measures the level of achievement of the objectives of a specific action (activity), and it can be expressed as the ratio of the outputs achieved to the expected or planned outputs (Özden, 2021: 25).

In some systems, it may be difficult to measure the achieved outputs realistically and truly, due to the difficulty of experimentation and/or its high cost. BMDS is an example for this systems. Therefore, the effectiveness calculation is resorted to using probability, and this means that:

$$\mathbf{0 \leq E \leq 1} \qquad (1)$$

Effectiveness defined as a measure of the rate at which a system performs the required functions under specified conditions. Knowing the value of effectiveness helps in the process of designing and analysing the system, whereby modifications may be made to the system to increase its success rate in achieving its goals (Dordick, 1965).

The conditions specified in the definition may viewed as constraints that define the solution area to search for the optimum effectiveness value; this conditions may be physical values such as time, speed, temperature etc.; it may be an economic or political conditions that has been converted into quantity values that can be measured.

Based on the definition of effectiveness, knowing its value gives a clear indication about the capabilities of the system in performing its tasks and achieving the goals of its existence. In other words, effectiveness answers important question: is the system correct and how its suitability to achieve the goals?

Knowing the effectiveness of systems plays an important role in the analysis and design of systems, through which it is possible to identify the various factors that affect the effectiveness, and work to improve this effectiveness by modifying the design, either partially or completely.

Effectiveness allows decision makers to compare multiple options to make the best decision. It may be a comparison between systems or techniques to choose the best one to achieve certain goals.

4. Type of Effectiveness

By reviewing the papers that talked about effectiveness, and given the objectives of effectiveness, effectiveness can be classified into:

a. Applied effectiveness: That effectiveness expresses the extent to which the system achieves goals that can be observed directly by the final user of the system.

b. Systemic effectiveness: It is that which expresses effectiveness from the perspective of system engineering.

c. Whole effectiveness: That effectiveness that expresses the entire system and includes systemic effectiveness, applied effectiveness, and effectiveness related to other goals, political and other.

5. The Steps to Calculate the Effectiveness

To calculate the effectiveness, there must be systematic, sequential steps to be followed until reaching the effectiveness value that suits its goal. These steps can be formulated as follows:

1. Determine the objective of calculating the effectiveness.
2. Choosing the criteria for measuring effectiveness.
3. Define hypotheses and constraints.
4. Create a model to study and analysis of effectiveness.
5. Solve the model within the framework of the hypotheses and constraints.

6. The Effectiveness in BMDS

There are not many articles that have examined effectiveness of BMDS. Some of them directly researched this topic, such as Lewis, Jian, Wilkening and Akzade. But their studies revolved around applied effectiveness, specifically those related to the ballistic missile interception method (Salvo, Shot-Look-Shot (SLS)).

Some of them mentioned the topic within the context without talking about it directly, such as Holland & Wallace.

The whole effectiveness of BMDS has not been studied so as to take into account the other goals of BMDS, and systemic effectiveness, as well as the impact on political effectiveness.Calculating the whole effectiveness of BMDS is not a simple matter, this paper is only an introduction, and a framework that can depended on, expanded and detailed, in order to calculate the whole effectiveness of BMDS.

6.1. Determining the Objective of Calculating the Effectiveness

First, it is necessary to determine the goal of calculating the effectiveness of BMDS, and these goals may be:

- Comparison of two or more BMDS for purchasing one.
- Developing a specific system to increase its effectiveness by making a modification in the structure of the system itself or by using certain techniques in the same system, to achieve a certain goal.
- The choice between installing a BMDS, and building a ballistic arsenal with an offensive or defensive objective.

Based on determining the purpose of calculating the effectiveness, the type of effectiveness to be calculated, and the elements included in the equation can be determined.

6.2. Choosing the Criteria for Measuring Effectiveness

There is still no systematic way to choose a criterion for measuring effectiveness, which can be applied to all systems; most of what has been published are qualitative methods that do not fulfil the purpose. It is possible to describe the effectiveness: a quantitative value, probabilistic value, dimensionless value, a value based on the reliability (Green & Stracener, 2019:126).

This proposition is logical due to the different nature of the systems, their goals, and the criteria for measuring the achievement of these goals; it can be said that effectiveness should be subject to the scientific approach.

The scientific method is intended to be objective, free of personal opinions; calculations, assumptions, information, and judgments are based on obvious facts; based on mathematical sciences; quantitative and experimental (Özden & Gül, 2014: 12).

The above supports what was mentioned previously, that the value of the effectiveness will be between zero and one. (See paragraph 3)

Based on the foregoing, during the study of the effectiveness of BMDS, the goals must be clear, specific in time and place, measurable, and quantitative techniques must be followed in measuring these goals. Some criteria can be proposed to measure the effectiveness of BMDS based on their objectives:

- Probability of repelling a ballistic attack.
- The probability of puncture.
- The system readiness probability when the attack is happen.
- The probability of gaining a military advantage over a potential enemy.
- The probability of influencing an unresolved political issue of a national security nature.

Thus, each criterion needs to be elaborated, studied the surrounding factors, and transformed into a quantitative value that can be measured and monitored.

6.3. Defining Hypotheses and Constraints

Defining hypotheses and constraints are important matters in determining the criteria for measuring effectiveness, as criteria cannot be absolute without limits and restrictions. For example, some hypotheses and considered limitations can be mentioned when measuring the effectiveness of BMDS:

- The range of ballistic missiles used in the potential attack (short-range, long-range, intercontinental).
- The number of warheads in the potential attack.
- The number of decoys in the attack.
- The number of interceptor missiles assigned to each attacking warhead.
- Temperature.
- Radar detection range of moving targets.

Moreover, other assumptions and restrictions which cannot be mentioned here, but each case can be studied by itself.

6.4. Creating the Model

As previously indicated, one of the conditions of the scientific approach based on mathematical sciences, the effectiveness must have a mathematical model that describes the equation of effectiveness and expresses the assumptions, determinants, and restrictions in quantitative values that can be dealt with and understand its significance.

The model is defined as a simplified mathematical form that simulates a real situation, and the model can be one of three types: physical, graphical, or mathematical. The model consists of four main elements: Controllable variables (decision variables), parameters (uncontrollable variables,

natural states), constraints and limits, in addition to the objective function (Özden & Gül, 2014:20).

The model presented in this study can be applied on any BMDS when some information, data and characteristics are known, this means that the model is general not special for defined a system.

In BMDS:

a. **Decision variables:** They are those variables that can change the value of objective function, such as: the ability of the interceptor to destroy the target, the speed of the interceptor, the response speed of the system, the sensitivity of the radars, the number of radars and their spread, the number of interceptors assigned to each attacking warhead.

b. **Parameters / uncontrollable variables:** They express facts on the ground that cannot be controlled, such as the geographical nature of the country, the possession of a certain type of weapons by neighboring countries.

c. **Constraints:** They express the range of sources that can be taken by changeable variables, and are often related to financial limits, or technical difficulties such as: the number of interceptors assigned to each attacking warhead, the number of sensors that can be installed, the number of interceptor platforms.

d. **The objective function:** It expresses the equation of the whole effectiveness of BMDS.

6.5 Solve the Model

The creation of the model for the effectiveness of BMDS is considered the middle of the road in reaching the optimal solution; depending on the model that was built, its complexity, and its difficulty, the appropriate solution method can be chosen, either the numerical method, the analytical method, or simulation by computer.

7. Factors Affecting the Effectiveness of BMDS

There are some factors that may affect the effectiveness of BMDS; the most important of these factors can be mentioned:

a. **Potential attack size (number of warheads):** By increasing the number of warheads in an attack, the effectiveness of the BMDS would decrease as shown in Table 1 (Akzade, 2023:44). Although the effectiveness that studied by Akzade is part of the defensive effectiveness, but increasing it means increasing the whole effectiveness under study.

b. **Single Shoot Probability of Kill (SSPK) of interceptor:** By increasing SSPK of the interceptor missile, the effectiveness of the BMDS would decrease (Akzade, 2023). These data was founded by simulation as explained by Akzade.

c. **Interception techniques:** The Table 1 shown that SLS technique in more effectiveness in BMDS.

d. **The number of interceptor missile allocated for each warhead in the attack:** By increasing this number the effectiveness of BMDS would increase as shown in Table 2 (Akzade, 2023). These data was founded by simulation.

Table 1. Effectiveness changes in relation to the number of warheads per attack. (SSPK=0.8, interceptor/warhead = 5)

Number of heads	Effect. Salvo	Effect. SLS
1	0,987	1,000
2	0,974	0,999
3	0,961	0,999
4	0,949	0,998
5	0,937	0,998
10	0,877	0,996
20	0,769	0,992

Table 1. Continued		
Number of heads	**Effect. Salvo**	**Effect. SLS**
30	0,675	0,988
50	0,519	0,980
60	0,456	0,976
70	0,400	0,972
80	0,350	0,969
90	0,307	0,965
100	0,270	0,961

Table 2. Effectiveness changes in relation to the number of warheads per attack. (SSPK=0.8, warhead/attack = 1)

Interceptor / Warhead	**Interception Technique**	
	Salvo	**SLS**
1	0,800	0,800
2	0,899	0,955
3	0,950	0,992
4	0,974	0,998
5	0,987	1,000

e. The number of decoys in the attack: The presence of the decoys in the attack may lead to the loss of a number of interceptors, and increase the chance of warheads reaching their target, and causing damage. It will also lead to a decrease in the number of interceptors allocated to each warhead, and this will reduce the effectiveness of BMDS (See Table 2).

f. Type and range of attacking ballistic missiles.

g. System response speed: As the system response speed is increasing, the chance of interception the warheads will increase.

h. The speed and spread of the interceptors: The more the interceptors spread in a way that enables them to intercept the attack in the ballistic stage (which is the longest stage of the ballistic missile's flight), the effectiveness of BMDS will increase. The relationship between the interceptor speed and the effectiveness of BMDS is a positive relationship.

i. Saturation point of BMDS: It expresses the number of warheads that BMDS can handle, before it gets out of control. The greater value meaning BMDS has the ability to repel a larger attack, and more effectiveness (Akzade,2023).

j. Spread and sensitivity of radars and sensors: Whenever its spread is close to the sources of the threat, this helps in early warning and early response of BMDS, and probability of intrception the attack will be large.

k. The human factor in terms of training and security reliability.

l. The quality of weapons of potential enemies.

m. The security and political conditions surrounding the country.

n. Geographical nature of the country.

o. Reliability, sustainability, and durability of the system.

p. The financial capabilities of the country.

q. Percentage of local contribution to the system industry.

8. A Proposed Equation to Calculate the Whole Effectiveness of BMDS

Based on the military and defensive goals of BMDS, the equation must express these goals, with the addition of the participation rate of each goal based on the priority determined by the decision maker considering the circumstances of each country, and therefore the equation can be written in the following form:

$$E = (a.M + b.S). E_S \quad (2)$$

Where:

E: The value of the whole effectiveness of BMDS.

a: The weight of the military effectiveness in the value of the whole effectiveness.

M: The military effectiveness of the system.

b: The weight of the defensive effectiveness in the value of the whole effectiveness.

S: The defensive effectiveness of the system.

E_s: Systemic effectiveness.

The political effectiveness (**P**) is not included in the whole effectiveness equation, because it is not independent variable, it is a function of the whole effectiveness value. Since high military and defensive effectiveness of BMDS will necessarily lead to some political power. The political power does not depend on military and defensive effectiveness of BMDS only, but it may have other factors that enhance it.

$$P=f(E,F) \quad (3)$$

Where:

F: The other factors that boost the political power.

Thus, the effect of BMDS effectiveness on the political effectiveness can be studied as a separate topic or article.

Because the effectiveness is a probabilistic value then the condition below is fulfilled:

$$0 \leq M, S, P, E, E_S \leq 1 \quad (4)$$

The term (**b.S**) of the equation (2) represents the participation of the defensive effectiveness in the value of the whole effectiveness of BMDS; while the term (**a.M**) represents the participation of the military effectiveness.

The absence of one of this two terms mentioned above does not mean that the effectiveness of BMDS is zero.

Some countries do not have a real ballistic threat, have a financial surplus, and seek to possess these systems to show strength and superiority over their neighbors and surroundings, which enhances their presence and power. These countries attach great importance to military effectiveness, which is to term (**a.M**).

On the other hand, some countries have a real ballistic threat and want to equip themselves with BMDS as a defensive strategy in the first place, and here the term (**b.S**) will be a priority.

Some countries may be in the middle and therefore follow a balanced policy between the military and the defensive, so the weights (**a, b**) will have values between zero and one, and the condition below is fulfilled:

$$a+b = 1 \quad (5)$$

The weights (a, b) are determined from decision makers and experts based on the priority of goals.

Systemic effectiveness was entered into the equation as a factorial because it expresses the readiness of the system, its reliability, its sustainability, and its ability to protect itself.

Whereas, if the systemic effectiveness is equal to zero, this means that the whole effectiveness will be zero.

This systemic effectiveness differs from one writer to another, and includes several elements such as reliability, sustainability, capacity, availability and other elements (Barringer 1997).

Given the nature of BMDS, the following elements will be adopted in the systemic effectiveness equation:

a. Reliability: It expresses the ability of the system to operate during the required time without failure (Barringer 1997:5). The human factor, in terms of skill, training, and ability to deal with the system, can be included in the calculation of reliability here, in addition to the technical factor related to equipment and its quality, which has the greatest role. It can be expressed as the ratio of the number of successes in the task to the total number of trials.

b. Readiness: The probability that the system is ready and stand by to respond when requested. It is expressed over a specified period, let it be a full year, in proportion to the time during which the system is valid and ready to enter the execution of a task to the total time (year). This item includes maintenance periods, breakdown periods, and the period required for repair.

c. Durability: It expresses two things, the first is the system's ability to protect itself from penetration and interference, and the second is its ability to continue in the performance of its tasks. This element includes several factors that must be taken into account:

1. The probability of the exceed puncture or interference if it happen, and continuing to perform its mission and make it successful. It is measured by the ratio of the number of times the system succeeds in performing its tasks successfully if the puncture or interference is happened, to the number of times a puncture or interference is happened. If the matter is discussed in terms of probability, it can be said that it is the product of the probability of the system succeeding in performing its tasks when the puncture occurs, in the probability of the puncture itself.

2. The probability of the system penetration, including technical penetration, and human penetration; in other words, the integrity of the selection procedures, the appointment of persons within the system, and the authorization granted to them.

3. The percentage of dependence on external sources in the maintenance, repair operations, spare parts and high technologies, and the extent of confidence in these sources.

The equation of resilience can be formulated as follows:

$$\mathbf{D} = \frac{1}{2}\left[\mathbf{P_{(e/p)}}.\mathbf{P_p} + (\mathbf{1}-\mathbf{d}).\mathbf{R_s}\right] \qquad (6)$$

Where:

D : The probability of system durability and continuity.

$\mathbf{P_{(e/p)}}$**:** The probability of exceed the puncture if it occurs and performing the task successfully.

$\mathbf{P_p}$ **:** The puncture probability.

d : The percentage of dependence on external sources in the maintenance, repair operations, spare parts and high technologies.

$\mathbf{R_s}$ **:** Trusting external sources.

Based on the foregoing, the systemic efficiency equation can be formulated as follows:

$$\mathbf{E_S = R_e \,.\, R_n \,.\, D} \qquad (7)$$

Where:

$\mathbf{R_e}$**:** Reliability.

$\mathbf{R_n}$**:** Readiness.

D: Durability.

Accordingly, the equation for the whole effectiveness of BMDS is:

$$\mathbf{E = (a.M + b.S).\ R_e.R_n.D} \qquad (8)$$

The elements of equation (8) can be obtained from:

- System test results and manufacturer data.
- Simulation results that can be performed on the system after preparing its model.
- Engineers, military experts, and politicians.

- The contracts for manufacture, purchase, maintenance and repair.

The final model of effectiveness can be formulated as below:

$$\mathbf{Max\ E} = \frac{1}{2}(\mathbf{a}.\mathbf{M} + \mathbf{b}.\mathbf{S}).\mathbf{R_e}.\mathbf{R_n}.\left[\mathbf{P_{(e/p)}}.\mathbf{P_p} + (\mathbf{1} - \mathbf{d}).\mathbf{R_s}\right] \quad (9)$$

Subject to:

Some of constraints that relate to the terms of the objective function and the budget allocated to BMDS.

As it is clear the model is non-linear, this increases the difficulty of the solution. This model can be solved using simulation by computer programs.

What is noticeable is the extent of the multiplicity of sources of information to calculate this equation, and this rises from the multiplicity and complexity of the system objectives and therefore it is difficult for a particular person to accomplish this task. Therefore, it is suggested that a multidisciplinary committee should undertake this task so that it includes at least:

1. One or more military experts.
2. Expert in defense systems against ballistic missiles.
3. One or more political experts.
4. Systems engineer.
5. Expert in operations research.
6. Administrative expert.
7. Legal Expert

This committee will undertake some of the sequential tasks as the following order:

1. Receipt of defensive, military and political goals from the concerned authorities.
2. Identification of Key Performance Indicators (KPI).
3. Determine ways and means to measure the achievement of goals.
4. Study the environment surrounding the country.
5. Review documents related to the technical specifications of BMDS.
6. Study the terms of the contracts.
7. Examine the local contribution in BMDS manufacturing.
8. Study the human factors in BMDS (procedures and policies of employment, authorities, work procedures etc.) and quantify.
9. Mirror all information to the model.
10. Find a solution for the model.
11. Issuance of the final report with recommendations to the concerned authorities.

9. Conclusion

Effectiveness is a probabilistic value that depends greatly on the reliability, readiness, and durability of the system, and these terms may be defined differently according to the nature of the studied system, as well as the nature of the objectives of the studied system.

The Ballistic Missile Defense System is characterized by having a special nature in which the military, engineering, security, political and administrative disciplines overlap because the objectives of this system are multi-field, and the terms of the effectiveness equation of this system has been defined according to its nature, in order to build the equation for the overall effectiveness of this system.

It was clarified that the political effectiveness of BMDS is follows to the military and defense effectiveness and does not enter into the calculation of the overall effectiveness of BMDS because it is not a major factor influencing its value, as the increase in the military and defense effectiveness of BMDS will naturally lead to an increase in the value of the political effectiveness.

The value of effectiveness is not only related to technical matters, but also related to the human factors in terms of training and its immunity against penetration by unfriendly intelligence agencies.

Calculating the whole effectiveness of BMDS is not an easy thing that can be known and studied by one person, due to the complexity of the elements of effectiveness, and their relates to different military, political, administrative, technical, engineering and security disciplines; it is imposed by the nature of the system itself and its multiple and overlapping goals.

Therefore, it is appropriate to form a committee to calculate the effectiveness of BMDS. This committee will monitor the targets, formulate them in a measurable manner, set the appropriate criteria for each target; then it deduces the elements of the equation of whole effectiveness, build the mathematical model, analyzes this model and extracts information. The last step, the committee submits the information, data and suggestions to the person with the authority to make the appropriate decision.

References

AKZADE, O. (2023). Balistik füzelere karşı savunma sisteminde etkililik. İstanbul: İstanbul Gelişim Üniversitesi, Lisansüstü Eğitim Enstitüsü, Endüstri Mühendisliği Anabilim Dalı, Mühendislik Yönetimi Bilim Dalı (yayınlanmamış yüksek lisans tezi).

Collins Dictionary. Harper Collins Publishers. Erişim adresi: https://www.collinsdictionary.com

DORDICK, H. S. (1965). An introduction to system effectiveness. RAND Corporation. Erişim adresi: https://www.rand.org/pubs/papers/P3237.html

EGELİ, S., "Füze tehdidi ve NATO füze kalkanı: Türkiye açısından bir değerlendirme", Uluslararası İlişkiler, Cilt 10, Sayı 40 (Kış 2014), p. 39-73.

FAS, Federation of American Scientists. (2000). Missile. Erişim adresi: https://fas.org

GANSLER, J. S. (2010). Ballistic missile defense - Past and future. Washington, Operational Test and Evaluation Office of the Secretary of Defense. Erişim adresi: https://apps.dtic.mil/sti/citations/ADA527876

GELLER, P. J. (2021). Index of US military strength: Ballistic missile defense. The Heritage Foundation. Erişim adresi: https://www.heritage.org/military-strength.

GREEN, J. M. & STRACENER, J. (2019, May)., 15th annual acquisition research symposium. "A framework for a defense systems effectiveness modeling and analysis capability - systems effectiveness modeling for acquisitıon," Naval Postgraduate School, CA, United States.

BARRINGER, H. P. (1997). Availability, reliability, maintainability, and capability. Triplex Chapter of the Vibrationa Institute.

HOLLAND, O. T. & WALLACE, S. E. (2011, September). Using agents to model the kill chain of the ballistic missile defense system. Naval Engineers Journal, p. 141-151.

JIAN, Y., QIWANG, H. & WEIPING, W. (2015, September 9). Analyzing ballistic missile defense system effectiveness based on functional dependency network analysis. The Open Cybernetics & Systemics Journal, p. 678-682.

LEWIS, G. N. (2017). Ballistic missile defense effectiveness. AIP Conference. American Institute of Physics.

Oxford Learner's Dictionaries. Erişim adresi: https://www.oxfordlearnersdictionaries.com

ÖZDEN, K. & GÜL, S. (2014). Yöneylem araştırması - I. İstanbul: Nobel Akademik Yayıncılık Eğitim Danışmanlık Tic. Ltd. Şti.

ÖZDEN, K. (2021). Toplam kriz yönetimi. İstanbul: Nobel Akademik Yayıncılık Eğitim Danışmanlık Tic. Ltd. Şti.

SEREN, M. (2015). Türkiye'nin füze savunma sistemi (İhale süreci, temel dinamikler ve aktörler). Ankara: Siyaset, Ekonomi ve Toplum Araştırmaları Vakfı (SETA).

WILKENING, D. A. (1998). A simple model for calculating ballistic missile defense effectiveness. Californinia: the Center for International Security and Cooperation at Stanford University.

Özet

Etkililik, büyük ölçüde sistemin güvenilirliğine, hazırlığına ve dayanıklılığına bağlı olan olasılıksal bir değerdir ve bu terimler, araştırılan sistemin doğasına ve ayrıca incelenen sistemin amaçlarına göre farklı şekilde tanımlanabilmektedir. Balistik Füzelere Savunma Sistemi (BFKSS), hedeflerinin çok alanlı olması nedeniyle askeri, mühendislik, güvenlik, siyasi ve idari disiplinlerin örtüştüğü özel bir yapıya sahiptir, buna göre sistemin bütün etkililik denkleminin terimleri tanımlanmıştır. BFKSS'nin siyasi etkililiğin askeri ve savunma etkililiğe tabidir, bütün etkililiği değerini etkileyen bir faktör olmadığı için BFKSS'nin bütün etkililiğin hesaplanmasına girmediği sonuçlanmıştır. Etkililiğin değeri sadece teknik konularla ilgili değil, aynı zamanda eğitim açısından insan faktörleri ve düşmanca istihbarat teşkilatlarının sızmasına karşı bağışıklığı ile de ilgilidir. BFKSS'nin bütün etkililiğinin hesaplanması, etkililik unsurlarının karmaşıklığı ve farklı askeri, siyasi, idari, teknik, mühendislik ve güvenlik disiplinleriyle ilgili olması nedeniyle tek bir kişi tarafından bilinip incelenebilecek kolay bir şey değildir; sistemin kendisinin doğası ve çoklu ve örtüşen hedefleri tarafından empoze edilmektedir.

Bu nedenle, BFKSS'nin etkililiğini hesaplamak için bir komite oluşturmak uygundur. Bu komite hedefleri izleyecek, ölçülebilir bir şekilde formüle edecek, her hedef için uygun kriterleri belirleyecek; daha sonra tüm etkililik denkleminin unsurlarını çıkarır, matematiksel modeli kurar, bu modeli analiz eder ve bilgileri çıkarır. Son adımda, komite bilgi, veri ve önerileri uygun kararı verme yetkisine sahip kişiye sunmaktadır.