ASPECTS REGARDING ANTIAIRCRAFT FIRING EFFECTIVENESS

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DOI: 10.19062/1842-9238.2016.14.2.3

Abstract: *The threat to state security world is a very topical subject which is in constant evolution . Of the many factors that directly influence this development. I believe that the most significant are the global security destabilizing threat related to emphasizing regional crises, the importance of tactical ballistic missile, air -to-surface missile, antiradar missile, cruise missiles, and unmanned aerial vehicles. Evolution launch procedures ammunition by modern means of air attack and the aerial threat against land targets, involves the Air Defence systems improvement.*

Keywords: *Integrated Air Defence system shoot kill probability decisive criteria*

1. INTRODUCTION

The Integrated Air Defence systems will be strong requested by the air density and timing enemy attacks. Air opponent will use massive and diverse means specific electronic warfare in order to neutralize in the first stage, radar and communication systems ground based.

In this context, the factors, requirements and operational concepts of an integrated Air Defense system are very complicated. The most important objective will be to achieve the "Near Zero Leak" level (any area uncovered) for objective protection. This level of protection is best guaranteed by a mixed Air Defence system composed of Surface - to-Air Missiles (SAM) and Antiaircraft Artillery (A.A.A.).

The SA -7 SAM system falls into the category of short-range infrared homing without cooling photosensitive element, intended to destroy the air targets that fly at small altitude, handled by one person. Thus, in the Land Forces, A- 94 missiles are launched by the CA- 94 complexes.

The SA -9 SAM system is also part of the short-range infrared homing. This self propelled type is designed for mobile Air Defence units of the Army. The system is intended for the destruction of planes and helicopters flying at low altitudes through direct sighting . CA-9 5 is the local version of the Soviet system STRELA -1. Instead armored car BRDM -2 has been used ABC-79M vehicle, manufactured by the local arms industry. Antiaircraft modernized variant of this system, currently in the Romanian Army is called CA - 95 M.

The SA - 6 SAM system „KUB", belongs to the SHORAD category, to defend troops and objectives against aerial threats that fly at low and medium altitudes with subsonic / supersonic speed.

The SAM medium-range HAWK (Homing All the Way Killer) is capable of destroying maneuvering aerial targets with high speed and helicopters that fly at low and medium altitudes. Originally the system has passed through three stages of modernization ending with HAWK XXI type . By adding external facility " tail chase " it has gained the capability to engage the Tactical Ballistic Missile (TBM).

Aerial vectors have a streamlined arrow aerodynamic configuration with delta wings and rudders, rectangular ailerons. Homing heads are equipped with phased array antennas networks conducted in numerical processing technologies. A primary objective is the integration of specific equipment HAWK PIP III with 3D cameras, SENTINEL type and distribution centers (control) fire (FDC).

The SA - 2 SAM system „VOLHOV" fall in the medium -range and is designed to combat aircraft, wings missile, automatic gas balloons drift, and other types of aerial targets in all weather conditions, time and season. In some cases, it may be used for the destruction of land or surface of water targets. The system entered the service in 1964 and underwent three successive modernizations, until the 80s . The system is equipped with own radar for searching airspace, conjugated to a radio altimeter and radar to guide the missile by radio commands . In the presence of jamming, the missile guidance to the target can be done visually, using a television system.

The Automatic Anti-aircraft gun S-60) is a road-transportable, short-range, single-barrel system. The gun is intended to destroy the different kind of targets that fly at low altitude (4800–6000 m) and land or surface of water targets up to a 2500 m distance.

The 30 and 35 mm size Anti-aircraft guns are weapons designed to attack aircraft. Such weapons commonly have a high rate of fire and are able to fire shells designed to damage aircraft. They also are capable of firing at high angles, but are also usually able to hit ground targets as well in a direct fire role.

2. DECISIVE CRITERIA OF AIR DEFENCE INTEGRATED SYSTEMS

For a decision to extend the resource, revitalization and modernization of air defense systems are commonly applicable to the following criteria :

- system performances;
- requirements for interoperability with NATO similar systems;
- the used technology;
- financial resource.

2.1 The performance criteria are a defining element to make the life extending decision of the Air Defense systems. The ability of these systems to carry out its mission successfully is determined by the following technical and tactical characteristics:

– single shoot kill probability;
– the rate of fire;
– the maximum and minimum altitude;
– the targets speed;
– the different kind of targets;
– the number of targets tackled simultaneously;
- the number of concentrated shooting against one target;
– the efficiency range;
– reaction time;
– the deployment.

Part of decisive performances are presented in table 1 for missiles systems and in table 2 for cannons.

Table 1 – The technical and operational performances of missile systems

System/measure units	VSHORAD		SHORAD	MRAD		
	SA-7	SA-9	SA- 8	SA- 6	HAWK	SA -2
Max altitude (Hm.)	23	23	50	140	≈ 25	300
Range (km.)	5	5	10	18	30	50
Missile weight (Kg.)	≈ 10	≈ 30	≈ 130	≈ 630	≈ 640	≈ 2400
Missile speed (mps)	500	500	550	950	800	759-800
Guidance	Self propelled IR		Radio command	Self propelled semi-active terminal homing		Radio command
Warhead weight (Kg.)	≈ 0,4	1	6,5	30	74	≈ 200
Single Shoot Kill Probability (SSKP)	≈ 0,3	≈ 0,4	≈ 0,8	≈ 0,8	≈ 0,6	≈ 0,7
Life cycle (years)	≈ 10	≈ 10	≈15	≈ 20	≈ 12	≈ 25

Table 2 – The technical and operational performances of artillery systems

System/measure units	VSHORAD		
	2 x 30 mm.	2 x 35 mm	S-60
Max altitude (Hm.)	30	35	50
Effective range (Km.)	≈ 3,5	≈ 4,2	≈ 6
Rate of fire (rounds/min.)	500 - 1000	1100	50 – 60
Velocity speed (mps)	1050	1175	1000
Single Shoot Kill Probability (SSKP)	≈ 0,0023	≈ 0,0023	0,0032

2.2 The requirements for interoperability with NATO similar systems. As a result Romania's accession to NATO, the ex-Soviet systems had some incompatibility with similar NATO ones (especially on the command and control area). Consequently the romanian modernization systems became priority to achieve interoperability with similar systems within the Alliance. Command and control outside the unique scope and will integrate in decision-making levels electronic assisted and complex expertised. These levels could be:

- political decision;
- military decision;
- the feed-back.
- execution;
- the operation leadership;
- the raising of defects rate.

2.3 Financial resources. Like any technical system the Air Defense ones have a limited technical resource (usually of the order of 10 to 30 years depending on the type of technique). With the passage of time the systems become older from physically and morally point of view. The end of systems operational life is usually accompanied by the following symptoms:

- the depreciation of special rocket fuels and powders in their shipments.
- depletion of stocks and accessories and the impossibility of renewing their (there is no equivalent on the market due to the age of technological parts).

2.4 The used technology. A more economical alternative than purchasing new systems is the upgrading the old ones, (by maintaining main equipment that were not affected by age system and replacing aging equipments). This process is performed mainly by replacing electronic components, communications/ IT, technologically obsolete. The up-grade decision is influenced heavily by a number of capabilities available to the recipient at a time, such as:

- the existence and functioning of a military group program management;
- the existence of a scientific panel of the policy areas;
- existence of industrial facilities for: machining; rockets engines loading / testing; load/ testing components of combat; assembly/ ground testing for missiles; antiaircraft firing range; electro-mechanical assemblies; replacement/ repair car equipment;
- availability of trained crews capable to signal some weaknesses;
- existence of tactics consultants to steer the program to the specific requirements of troops or imposed conditions on the ground.

3. SHOOT KILL PROBABILITY (SKP)

The possibilities of destruction are expressed by the number of destroyed or damaged air assets , from the total countered targets during an air attack carried out by the enemy (in a given period of time) and depend on:

- number of basic drawing subunits that compose fire system;
- the technical and tactical combat characteristics of equipment from the endowment subunits (rate of fire, effective shooting range, single shoot kill probability (SSKP);
- mission period of time;
- characteristics and vulnerability of air assets;
- action mode of aerial enemy;

For Antiaircraft Artillery the kill probability depend on the number of shooting projectiles against the target and SSKP. The SKP will be calculate tacking into account the formula:

$$P_{N(D)/A} = 1 - e^{-N \cdot P_1} \tag{1}$$

where:

$P_{N(D)/A}$ - probability of destruction of the aerial target using ,,n" projectiles (SKP);
P_1 - probability of annihilation (destruction) aerial target with one projectile (SSKP) ;
N - number of strokes executed ;
e - 2.71828.

It is considered that a target will be destroyed or damaged, if performed felling probability ($P_{N(D)/A}$) equal to 0,8 (done safety drawing).

For Surface - to- Air Missiles the kill probability depend on the number of launched missiles against the target and single shoot kill probability SSKP. The SKP will be calculate using the formula:

$$P_{N(D)/R} = 1 - \prod_{i=1}^{N} (1 - P_1) \tag{2}$$

where:

$P_{N(D}$ - probability of destruction of the target aerial using „n" missiles (SKP);

P_1 - probability of destruction with one missile (SSKP);

N - the number of antiaircraft missiles. [2]

Using integrated systems against aerial threats by distribution of fire SKP will be calculate using the formula :

$$P(R \bigcup T) = P(R) + P(T) - P(R \bigcap T) \tag{3}$$

For the same case but using concentrated fire against aerial threats SKP will be calculate using the formula:

$$P(R \bigcap T) = P(R) * P(T) \tag{4}$$

Increasing the number of projectiles the SKP will increase as followed:

Using the relation (1) for different number of projectiles SKP will have the values:

$P_{50} = 0,147$

$P_{100} = 0,273$

$P_{150} = 0,380$

$P_{550} = 0,827$

From theoretical point of view, using the S- 60 system the target will be destroyed by shooting 550 projectiles.

The kill probability of SAM system that launch two and three missiles against the target will be:

$P_2 = 0,91$

$P_3 = 0,97$

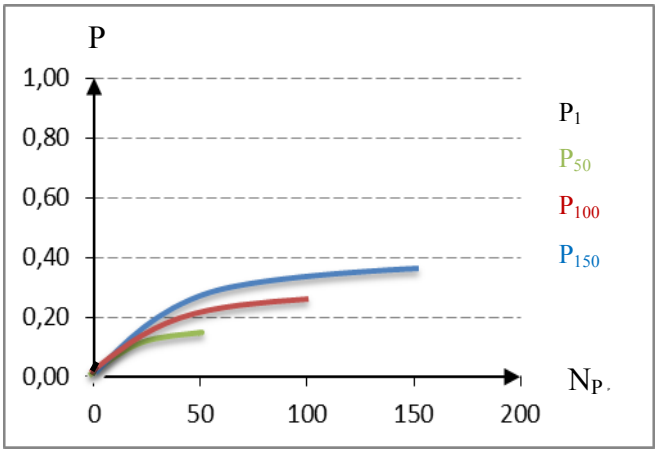
Using three missiles against the aerial threats, SKP will have the maximum value

Using integrated systems against aerial threats SKP will have the value between 0,78 and 0,98. The kill probability of integrated systems using 100 projectiles and one, two and three missile will be:

$P_{100/1} = 0,782$

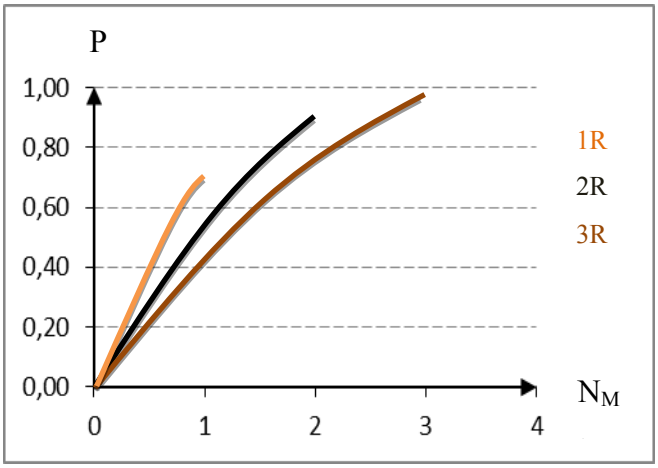
$P_{100/2} = 0,935$

$P_{100/3} = 0,978$



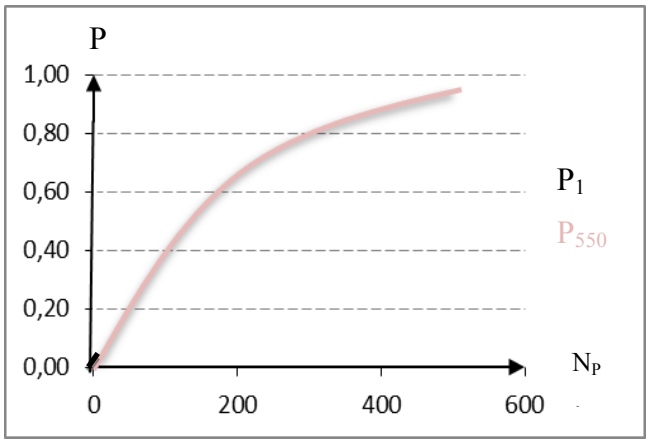
(a) (b)

FIG. 1. Comparative Gun shoot kill probability depending on number of projectiles case (a), using the S - 60 system (b)



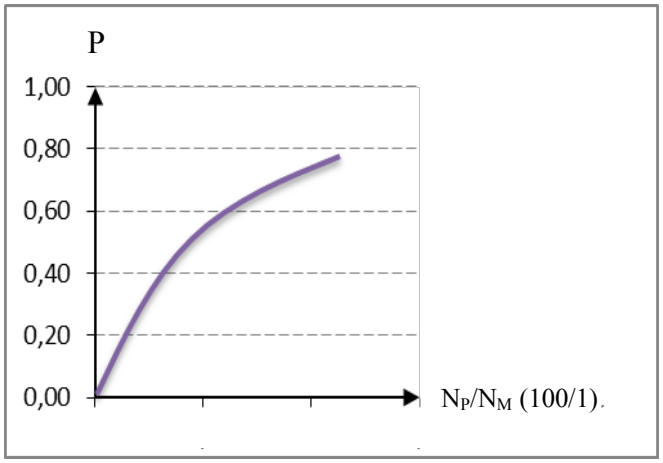
(a) (b)

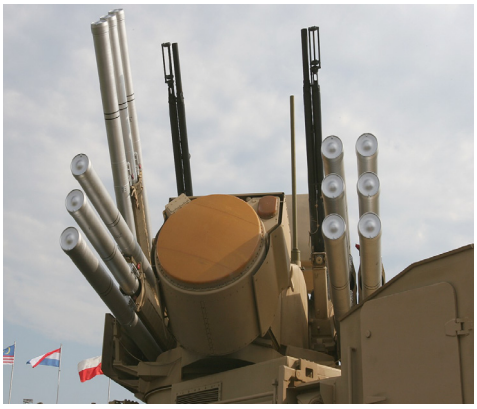
FIG. 2. Comparative missiles kill probability using one to three rockets case (a), with the SA - 6 system (b)



(a) (b)

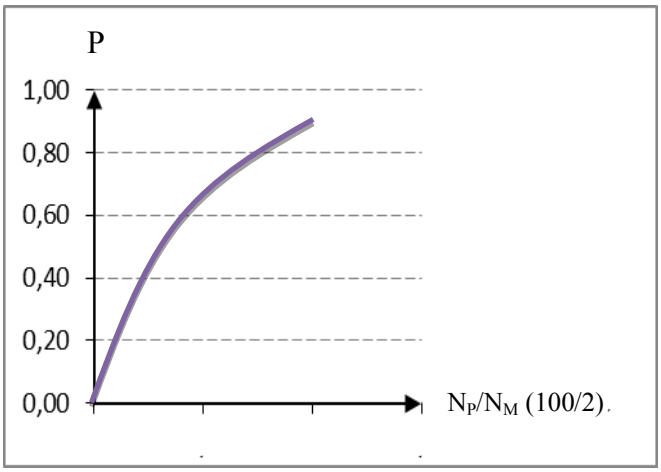
FIG. 3. Gun shoot kill probability using 550 projectiles case (a), with the 2x30 mm size system (b)





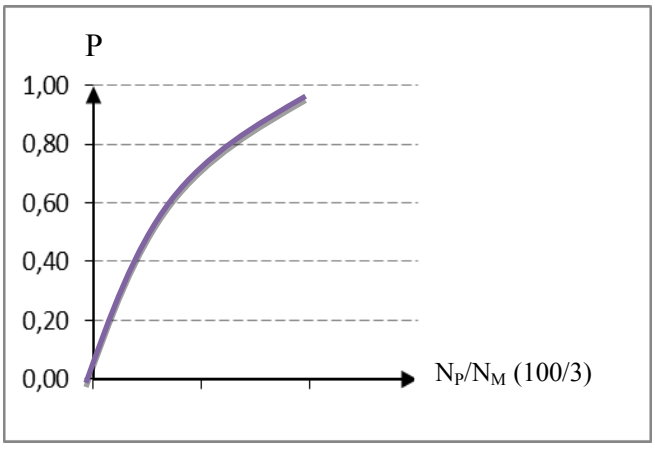
(a) (b)

FIG. 4. The shoot kill probability using 100 projectiles and one missile case (a), using integrated AD system SA 22 (b)



(a) (b)

FIG. 5. The shoot kill probability using 100 projectiles and two missile case (a), using integrated AD system (b)



(a) (b)

FIG. 6. The shoot kill probability using 100 projectiles and three missile case (a), using integrated AD system GHEPARD and SA 7 (b)

CONCLUSIONS

Tacking into account the issues analyzed in this paper it is clear that more data contribute to substantiate arguments for making a decision if need system up-grading. These take into consideration the following aspects:

- technical parameters and performance management imposed by the central structure (effective range, single shoot kill probability, system structure etc.);
- agility / versatility of main equipments (eg if the research radar can operate independently or integrated into ASOC - Air Sovereignty Operation Center);
- existence of industrial facilities domestic capacities;
- alliance policy;
- doctrine of armed forces regarding the unification of the equipment, tactics, and training for categories of forces;
- financial support available;
- strategic reasons that may require the deployment of some systems at a time.

In any case, an up-grading program for integrated Air Defense systems requires one to two years in the best logistical conditions. All these considerations are available in the case of a domestic system that lends itself to modernization (or previously acquired).

Reality of strategic environment shows that the armed that belong to relatively rich countries such as UK or United Arab Emirates as the powers that hold cutting-edge technologies in the field of Air Defense such as USA or Russian Federation not cast A.D. systems until their technical resource is consumed and up-gradation potential is fully exploited.

Finally the antiaircraft effectiveness increases with A.D. systems integration with reference to Surface-To-Air Missile and Antiaircraft Artillery arranged on the same chassis or different platforms. For both systems S.A.M. and A.A.A. the kill probability depend on the number of shooting /launching projectiles/missiles against the aerial targets and SSKP.

REFERENCES

[1] *** *Manual de probleme de tragere cu rachete antiaeriene dirijate,* Editura Militară, Bucureşti, 1969;
[2] Bălaceanu, I., Dumitru, D., şi Stuparu, G., *Evaluarea posibilităţilor de luptă ale mijloacelor de agresiune aeriană şi ale celor de ripostă antiaeriană*, Editura Singur, Târgovişte, 2003;
[3] Chelaru, Teodor Viorel, s.a., *Mathematical calculation model for guidance precision, target hit and target kill probability in the case of close range homing missile*, Journal of Battlefield Technology, Vol. 10, No 2, 2007;
[4] Rădulescu, Marius şi Şandru, Vasile., *Integration of the VSHORAD missile with the small caliber antiaircraft guns – A way for an increasing efficacy,* AFASES 2013, Braşov, 2013;
[5] Şandru, Vasile şi Maxim, Ionuţ. *Teoria tragerilor antiaeriene*. Editura Academiei Forţelor Aeriene ,,Henri Coandă", Braşov, 2013;
[6] Şandru, Vasile, *Emerging Aspects in the Process of Modernizing Integrated Aerospace Systems*, Review of the Air Force Academy, Vol X, No 2 (21)/ 2012, pp. 25-30, Braşov, 2012;
[7] Şandru, Vasile, *The Current Stage of Air Defense Systems' Structure and Performances. S.A.M. Systems Comparative Analysis in Romanian Inventory*, Review of the Air Force Academy, Vol XI, No 1(23)/2013, pp..107-112 Braşov, 2013;
[8] *** URL: http://rumaniamilitary.wordpress.com/sistemele-aa-ale-armatei [accessed 10 iunie 2016] ;
[9] *** URL: http://rumaniamilitary.ro/artileria-anti-aeriana-sovietica-tunuri [accessed 12 iunie 2016] ;
[10] *** URL: http://vatsaas.org/rtv/arsenal/teamrocs/gainful/sa6photos.aspx [accessed 16 iunie 2016].