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INTEGRATION OF THE VSHORAD MISSILE WITH THE SMALL CALIBER ANTI-AIRCRAFT GUNS - A WAY FOR AN INCREASING EFFICACITY

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Abstract: *Battlefield is a dangerous zone for the ground troops, even outside of the fight actions. The aerial threat imposes to every unit to take air-defense measures. That refers to much type of targets, against which the weapons hit / kill probability are so different. Most actually solutions are based on small caliber anti-aircraft guns or on VSHORAD missile systems. All these systems have engagement peculiarities and some efficacy limitations result. By integration of guns and missiles in mixed air-defense systems, the characteristics of both equipment can be optimal used, allowing to the troops much coverage and efficacy. The paperwork presents some basic considerations of the mixed-AD systems theory and two Romanian developments also.*

Keywords: *missile, gun, probability, efficacy, integration, target*

1. INTRODUCTION

The East-European zone was longtime connected to doctrines, tactics and battle technologies considering the possibility of an open major conflict between the military blocks. In these conditions the air-defense in all aspects were constantly preoccupied the Romanian military thinking, confronted mainly with the relatively Western air superiority.

In our country the production of the AD (air-defense) equipment has a tradition begining before the WW2, when licensed a.a. (anti-aircraft) guns were produced (Vickers cal.75mm and Rheinmetal cal.37mm), as well as the indigenous designed centralized fire-control equipment and the ammunitions also.

Concerning the ADMS (air-defense missile systems), in period of the '60 –'70 years few repair and maintenance facilities were founded, following the R&D, design and production capacities, especially for short-range air-defense missiles.

Representative for this category were the CA-94 and CA-95 systems, destined to the close defense of ground troops, using IR-homing missiles, together their school, training and checking devices.

Fig. 1 The CA-94 system

The CA-94 system is a MANPAD using an IR-homing AD missile with the following characteristics:

	U/M	A-94
Caliber	mm	72
Ceiling	m	2,300
Range		4,200
Target velocity	M	0.75
Average speed		1.5
Warhead	kg	0.8 HE
Weight		10
SSKP		0.22

The self-propelled CA-95 system uses an IR-homing fire-and-forget short-range AD missile, and allows a.a. coverage for the mechanized ground forces.

Fig. 2 The CA-95 self-propelled system

The A-95 missile has the following characteristics:

	U/M	A-95
Caliber	mm	120
Ceiling	m	2,800
Range		4,200
Target velocity	M	0.9
Average speed		1.5
Warhead	kg	2.8 HEF
Weight		30
SSKP		0,33

The systems are in use with Romanian Ground Forces.

2. NEW OPERATIUONAL TRENDS AND SYSTEM REQUIREMENTS

The international engagements impose a new mission profile for a different operational theatre. For the AD that means the direct a.a. protection allowed to small size units, tactical disposals and civilian objectives against aggressor low altitude aircraft.

Concerning the short-range air defense (SHORAD), the modern battlefield has as main characteristics:

- high density of the attacks
- increasing level of coordination
- intensive use of ECCM to blind or to fox the enemy systems
- communications network disturbances
- use of ELINT systems to locate the AD means and C^3I centers

These features impose AD configuration concordant with the menace evolution.

Aerodynamic vector requirements – Surface-To-Air Missile:

- the storage, transport, and release to be made to /from sealed container;
- preparing of missile launching from launch facility takes no more than 10 sec.;
- the protection of proximity fuse against the active and passive jamming;
- facility to work with solid fuel engines ;
- the initiation of warhead owns at least 3 levels of safety, of which no more than one stage to stand before startup missile;
- standard operation life of the missile to be at least equal to standard operation life of the system as a whole (without replacement of more than 5 % of components in terms of value);
- the level of probability of false alarm proximity fuse to < 0.01% in both presence of active and passive jamming;
- do not require special storage conditions and outdoor storage shorten not more than 30% specific service life cycle where maintenance would be done in enclosed storage.

Gun component requirements:

- have small caliber (20-40 mm);
- have several barrels (2-4);

- hit probability ≥ 0.9 to 10 projectiles;
- have high rate of fire (≥ 500 lov . / min / barrel);
- be able to use all types of anti-aircraft projectiles, proximity fuses;
- be able to use projectiles with submunitions, prefragmentate elements etc.

Generally, the a.a. automatic guns allow the fire volume, rapid reaction and self-defense capability, while the missiles allow a higher engagement envelope, direct SEAD tactics inhibition and edge range efficacy.

Mixed systems can reject the saturation attacks, when the enemy concentrates a large number of aerial assets (including UAV) against of a high value target. The density of defensive riposte continuously graduates when the target approaches by the objective.

The proposed basic tactical unit is mixed AD battalion, which assures some facilities, like:

- increased level of defensive automation
- enhanced C^3I/C4I facilities
- ECM resistance growth
- short reaction time
- multiple-targets engagement capacity.

3. THEORETICAL CONSIDERATIONS

For the gun-based AD systems may be observed that the hit probability severe decreases by range.

A good approximation for the hit probability in case of the barreled artillery Systems [1] is obtained by Raleigh formula:

$$HP_1 = 1 - \exp(-kxT_a/(\Delta xX)^2) \quad (1)$$

where Ta represents target area perpendicular projected on shooting plan, Δ is a total error in mRad, X is the range in km and k a correction coefficient.

For a burst fired with a single tracking and aiming data set [11], can be writing:

$$HP_S = 1 - \exp(Sx\ln(1 - HP_1)) \quad (2)$$

where S represents number of shoot in burst.

$$KP = HPxZ_1 \quad (3)$$

where Z_1 represents single shell kill probability, and the reliability coefficient for AD artillery ammunition is practically 1.

Contrary, a missile system has an impractical close zone, but keeps a relative efficiency just to the maximum range.

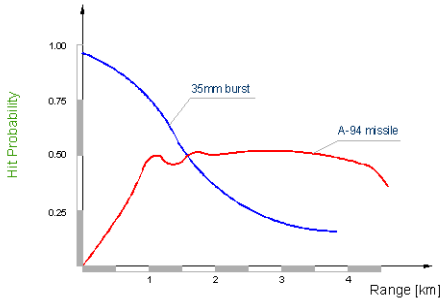

Fig. 3 The aspect of HP curves for a gun and a missile

Considering a standard data set about target and fire units type GDF003 and CA95M (T_a = 9, elliptic dispersion centered on target with 1,8/3,6 mRad deviation, aiming error 2 mRad, Z_{1M} - 0,45, Z_{1G} - 0,15) the hit and kill probability was calculate if a 35 mm HEI burst and a A95M missile will fired [2].

In the case of multi-missile use, the hit probability [5] is determined like follow:

$$HP_N = 1 - (1 - HP_1)^N \quad (4)$$

where N represents number of the missiles. Kill probability cumulates the hit

probability, the reliability and the shot efficacy on target [6].

$$KP_N = 1 - (1 - Z_1 HP_1)^N \qquad (5)$$

In rapport to the gun type, the results obtained by running a specialized program show the superiority of the missile starting with ranges over 1500 to 2500 m.

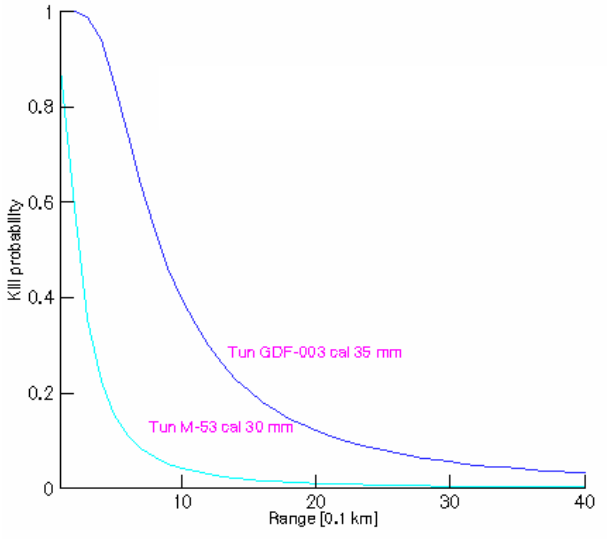

Fig. 4 The kill probability for M-53 and GDF003 guns

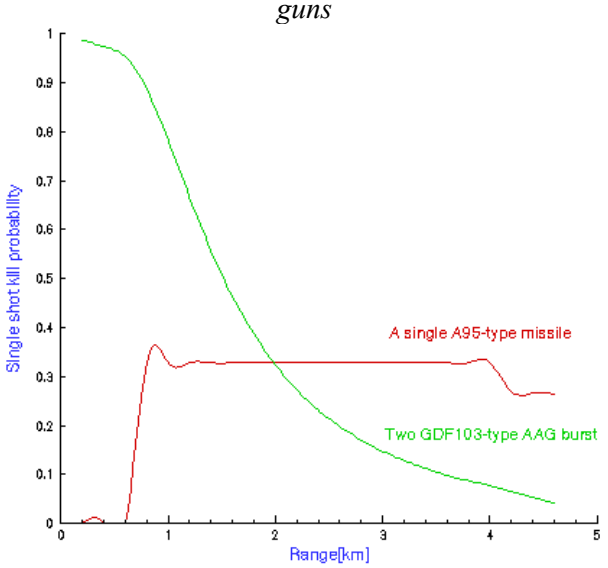

Fig. 5 The kill probability for a GDF003 battery and a CA-95 system

4. THE MIXED GUN-MISSILE SYSTEM GEPARD-R

In the years 2004-2005, the companies SC Electromecanica Ploieşti SA and Krauss Maffei Wegmann have developing a common project based on the Romanian Gepard SPAAG and the CA-94 IR-homing VSHORAD MANPADS missile system.

The Romanian partner was responsible for missile, launcher, FCS with missiles, crew training and field-range test organization, while the German partner was responsible for FCS integration, supply, special maintenance facility and logistics.

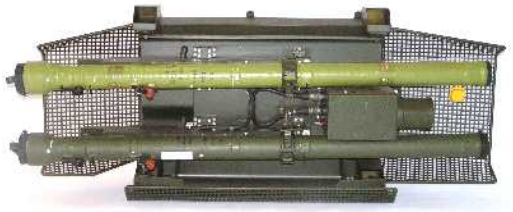

Fig. 6 The IL A94-G for Gepard-R side weapon station

Fig. 7 The GEPARD-R mixed SPAAG/Missile

The mixed integrated system was designed, realized and was performed a testing program. The results out passed the initial requirements.

Fig. 8 Gepard-R field-range test

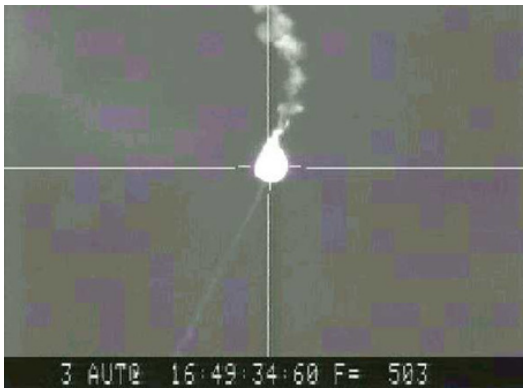

Fig. 9 A missile shot registration result

Practically, in field-range test the missile ripple fire can be executed against two different targets, before the guns opening fire.

Both missile shots were accurate, despite little angular difference between targets and their remnant IR trace.

The mixed system combines the advanced searching and tracking capacity of the basic SPAAG with the A-94 missile performance, a high mobility and increased fire-power system resulting.

5. THE INTEGRATED GUN-MISSILE SYSTEM 35mm AAG / CA-95

The small caliber automatic 35mm GDF003 gun system [3] with their associated searching/FCS equipment (SHORAR low altitude radar station and GSN optical tracker) can be integrated with the CA-95 self-propelled missile system, resulting a high effective mixed AD battery. This experiment was performed by SC Electromecanica Ploieşti SA together ACTTM Bucureşti at the prototype level and tested in Capu Midia field-range.

The system architecture is based on SHORAR battalion's command point (BCP).

Fig. 10 SHORAR command post

The emission can be stopped in 3 sectors with variable limits to protect the shelter against anti-radiation missiles. The radar search and made IFF interrogation in the same time with target tracking (track while scan capability).

Searching zone is covered by 2 electromagnetic fascicles (for low / medium altitude), which computer automatic and adaptive commute.

Searching zone Range Altitude Elevation	 D=25 km H= 3 km ε= 45°
Scan rate	57/38 rpm
Emitter pick power	1,8 kW
Work frequency	X band
No. of pursued targets	20
No. of tracked targets	10
Power input	8.5 kW

Fig. 11 The Oerlikon GDF003 2 x 35 mm gun

Max. effective range	4 km
Rate of fire	1100 rds/min
Vertical firing field	–5° ÷ + 92°
Ready to fire ammo	2 × 56
Muzzle velocity	1175 m/s
Traverse rate	120°/s
Elevation rate	60°/s

The battalion commander assures operation control by means of tactical console, located in BCP. This console shows:

- tactical scenario display
- aerial situation display
- menace evaluation
- targets distribution towards batteries.

The BCP connected in radar data-link network generates in real time the aerial situation image and is informed about the targets which will enter in their own search and fire zone.

The information about targets concerns location, identity (friend/foe), classification (plane/helicopter), direction, speed, engagement envelope.

Because of multiple sources, which don't be simultaneously jammed/destroyed, the network is more stables than any individual search asset and the weapon systems don't be detected when execute active search.

In order to use external sources for FCS (ASOC included), the CA-95 platform was extensively modified, a lot of data-processing and command equipment being accommodated.

Fig. 12 Inside of the CA-95 firing post

In basic mode the targets indication comes from GSN. The launcher is automatic driven in azimuth. The operator uses the optical sight and the joystick to acquire the target, which initiates the automatic track. Advance angles has predetermined values and are automatic introduces. The shot is fired at the operator initiative.

In reserve mode the target indication is received from BCP by digital data-link and autonomously detected.

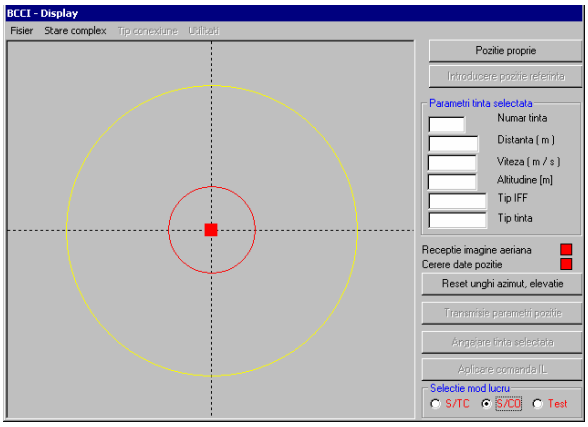

Fig. 13 The on-board data-control panel

Such equipment permits to build a mixed battery structure, with two guns and two missile stations, around a GSN FCS. Even a tracked derivative version of the CA-95 missile launcher can be easily obtained [4].

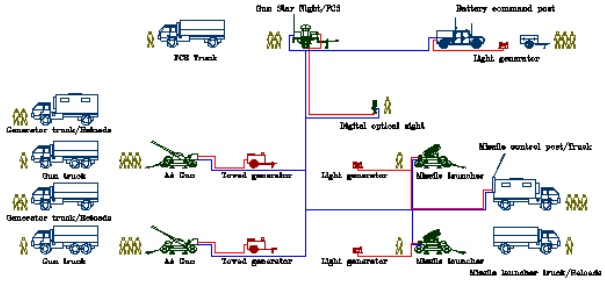

Fig. 14 The integrated AD Battery structure

Connecting three batteries with a SHORAR BCP an integrated mixed AD battalion can be obtained, allowing direct protection of small sized military and civilian objectives and tactical disposal elements against low altitude targets like fighter-bombers, hovering ground assault aircraft and helicopters, cruise missiles and drones.

At the unit level the AD performances exceed the possibilities of individual weapons, with few relevant characteristics [9]:

- Search range 25 km
- No. of pursued targets 20
- No. of tracked targets 10
- Kill probability 0.68 ÷ 0.96
- Effective AD coverage 17 km
- Simultaneously engaged targets 9

6. CONCLUSIONS & ACKNOWLEDGMENT

The system integration supposes the existence of an industrial infrastructure, capable to assure:

- platform upgrade
- board devices
- weapon systems and ammunition
- C^3I/C^4I hardware and software

In the same time the free access on market for some specialized devices (like solid-state computers, positioning equipment, data link, communication stations, GPS, INS, night vision equipment) is necessary [7].

A schedule for an industrial development of a mixed gun/missile system shows that an economy that was designed, was tested and was produced separately missiles, guns and platforms is more than capable to integrate this parts into a mixed AD systems [8], [10].

Another idea refers to the possibility to obtain a good result concerning the efficacy through a mixed system using even ageing weapons, but supported at the system level by the state-of-art equipment and software.

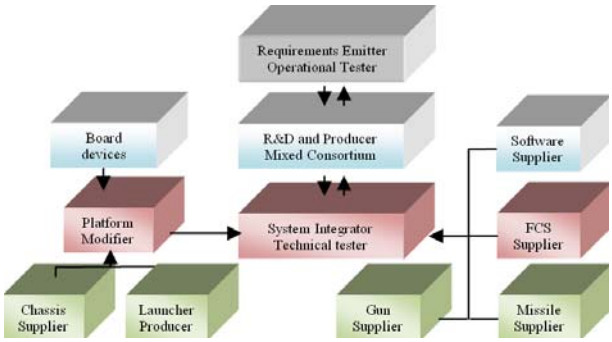

Fig. 15 Industrial development schedule

These can be a way of action for the armies disposing of the stocks of weapons from previous generation.

Not at least, the mixed AD systems allow grater engagement flexibility against the aerial targets and much stability for the general area defense.

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