REQUIREMENTS FOR GROUND-BASED AIR DEFENSE INTEGRATED SYSTEMS

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Abstract. The Air Defense (A.D.) represents a really support for any military operations. Between the A.D. assets, Surface-to-Air Missiles are the most important features in endowment, allowing dealing the rapid evolution of enemy's air assets. The paperwork presents the basic requirements focused on integrated systems - missiles and cannons. Important distinctions between the missile's and system's requirements are made. The conclusions are useful for all the military managers who have the responsibilities concerning the maintenance and acquisition plans regarding this kind of equipment.

Keywords: missile, air defense, range, efficacy, upgrade

1. Introduction

According to current and future threats, the most important capabilities of ground-air means to be developed are:

- combat missiles, ballistic and cruise;
- destruction of air targets with high speed remote inland appeals to objective in conditions of electronic warfare and use of anti-radiolocation missiles;
- simultaneously control a large number of aerial targets which attack on the same direction or close directions;
- quick reaction under stable integration of control systems, communication systems, computers and information systems (C4I) of army components;
- compatible communication protocols and data links between different types of weapon systems (fire unit) and command and control structure immediately above;
- high possibilities of manoeuvre and disposability.

The system is designed to combat air targets (airplanes, helicopters, missiles, etc.), which flies at high and very high speed, in wide range of heights, in numerous formations, under the usability of intense jamming, in all weather conditions specific to our country's climate, day and night.

2. Requirements and conditions for Surface-to-Air Missile systems (SAMS)

2.1. General requirements

In order to achieve the goals in the fight against the aerial threat, SAMS are incorporated in operational and tactical systems, which must meet the following requirements:

- systems can operate independently or can be integrated in unit type structures (mixed group) for which you can purchase the equipment needed for automated guidance of C3I or C4I;
- system components to be self-propelled or self-tracked with organic resources, on wheels and to allow movement in any type of roads with an tilt of at least 30^0;
- autonomy of movement of at least 500 km and running in groups of at least 24 h;
- system components to be loaded and transported on railways, seaways and airways;
- permit the supply of both industrial network power and their own groups, being able to make the transition from one way to another without disconnecting the system (in terms of continuing warfare);
- have technical measures for the protection of personnel from weapons of mass destruction.

Figure 1. The CA95M ADM system.
A product of Electromechanical Plant of Ploieşti

Table 1. The CA95M characteristics

Weight	9 t
Traverse speed	36^o/s
Tracking error	$\leq 1^o$
Reaction time at fire request	8 s

2.2. Requirements for the radio control station

Radio control stations are composed of devices which produce electromagnetic energy emitted into space by the antennas. These devices required [1]:

- uninterrupted average time of good working > 100 h;
- to ensure the required shot kill probability of targets that attack from all directions in an area defined by the following sizes and values:
  - minimum height ≤ 50 m;
  - maximum height ≥ 25 km;
  - minimum range ≤ 3,5 km;
  - maximum range ≥ 75 km;
- maximum speed of targets that can be controlled ≥ 2200 m/s;
- receiving single radar image of the upper echelon (by radio or wire connection) and synthetically display of the air situation with standard symbols;
- continuous reception, mission display and automatic data processing task that prepare its execution;
- automatic real-time analysis of the threat, the combat ways of targets, tasks and presenting proposals received accordingly;
- active jamming protection (noise, response etc.) and passive one of the target's and missile's sightlines and the guidance lines;
- protection against antiradiolocation missiles and self-directed rockets on other types of broadcast (if applicable) and the possibility of fighting with them;
- possess identification friend or foe (IFF) system in the national code and the facilities to adapt to other systems;
- be compatible electromagnetically with other radio means - military and civilian - in endowment when purchasing systems;
- duration of the transition from the battle position to march position and backwards ≤ 30 min;
- response time (the period between the receipt of the mission until the first rocket launch) ≤ 10 s;
- time for crossing from idle state to ready for launch (coupling technique and testing them) ≤ 3 min;
- can be recharged the launching installations while another is launching;
- shooting can be performed on land targets and targets on water surface;
- possess protection measures for the objectives and for their troops.

2.3. Requirements for the antiaircraft missile

Missile as aerial vector, is in fact component of the struggle within SAMS. Aerodynamics shapes and warhead ensures flight's trajectory toward the target and its destruction. Therefore missiles must meet the following requirements:

- storage, transport and launch must be done a sealed container;
- preparing to launch the rocket on launcher must last no longer than 10 seconds;
- radio warhead must be protected from active or passive jamming;
- the explosive charge must be initiated from both the radio warhead and the commands from the ground;
- the probability of false alarm at the radio warhead must be < 0.01% in the presence of both active and passive jamming;
- must not require special storage conditions and storage outdoor should not shorten with more than 30% the standard duration of developing in the case of enclosed storage.

2.4. Requirements for means of research of system airspace

It is a permanent mission carried out for the purpose of aerial situational awareness in real time and is done by the discovery, tracking and identification of the means currently in national airspace and military strategic interest.

Aerial surveillance requirements are as follows:

- discovery distance of targets with actual surface reflectance of targets: for a 0.1 m^2 surface, distance is > 20 km;
- the number of targets that can be simultaneously tracked more than 100;
- the number of targets which can provide the necessary parameters for calculating the drag elements more than 40;
- pointing precision of targets to control station (lighting) < 10;
- protection for anti-radar missile, and, if needed, other types of self-guided missiles on other types of transmission;
- summary display of information about aviation situation;
- compatible IFF system with the civil codes system and the possibility of implementing the alliance IFF system;
- minimum height tracking targets with actual surface reflectance: for a surface of 0.1 m^2 minimum height is < 50 m;
- pack-unpack duration ≤ 30 min.

3. Requirements and conditions for mixed missile-cannon systems

Air Defense with SHORAD (Short Range Air Defense) means aims to achieve immediate action, firm and decisive of ground-air systems for the

direct antiaircraft defense of airfields, operational elements of device (PC), of required crossing points and other small targets against an air enemy acting on small and medium heights, using manoeuvre and intense jamming in all weather conditions, day and night.

Figure 2. The GEPARD-R mixed SPAAG/Missile [2]

For the gun air defense systems can be observed that the target hitting probability dramatically decreased by range. The Raleigh formula [2] offers a good approximation for this parameter in the case of the barrelled artillery systems:

$$HP_1 = 1 - \exp\left[-k \cdot \frac{T_a}{(\Delta \cdot X)^2}\right] \quad (1)$$

where T_a represents the projection of the target surface into the firing plan, Δ is the total error expressed, in mRad, X is the range, in km, and k is a correction coefficient.

For a burst shots with a single acquisition data set, may be write:

$$HP_S = 1 - e^{S \cdot \ln(1 - HP_1)} \quad (2)$$

where S represents the number of shots into the burst.

$$KP_S = HP_S \cdot Z_1 \quad (3)$$

where Z_1 represents the target destruction probability with a round, and the reliability coefficient (good functioning) is practically 1 for the anti-aircraft ammunition.

Contrary, a missile system has a closed zone with zero probability, but conserves a relatively high efficacy until the maximum range of engagement [3].

Reported to the gun type, the results obtained by the use of a specialized calculus program show the superiority of the missile at the ranges starting of 1,500 till 2,500 m.

Given the current endowment of artillery and anti-aircraft and missile troops and objectives of the Partnership assumed by Romania, the achievement of anti-aircraft systems and performing MANPAD (Man Portable Air Defense) and SHORAD is a priority.

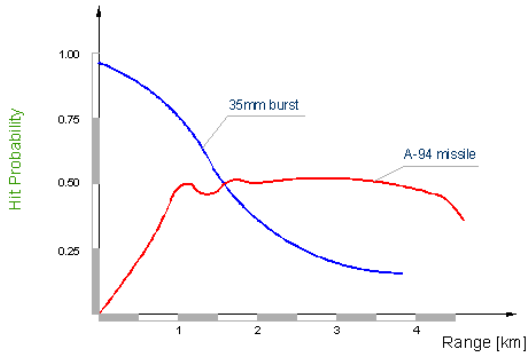

Figure 3. The aspect of hit probability for a gun and a missile system [2]

For direct air defense of small targets, the most important capabilities of ground-air means to be developed are:

- destruction of aerial targets in direct ways of attack at the objective in electronic warfare and the use of anti-radar missiles;
- simultaneously control of a large number of aerial targets attacking in the same or close direction;
- rapid reaction under stable integration of command system, control, communications, computers and information (C4I) of Staff of the Air Force.

3.1. General requirements for anti-aircraft system

Anti-aircraft Artillery (A.A.A.) units are organised into battalions (battery), with 6 cannons and radar short research (SRR-around 40 km.). Each battalion consists of 3 batteries (platoons), shooting fire units (FU), with two cannons. Each FU will receive information about the SRR and the targets of its own acquisition system and shooting.

General requirements for this kind of units consist of:

- the systems can be integrated into the unit (large unit) type to be able to purchase the needed equipment to conduct automated command of C3I or C4I, compatible with similar systems of NATO;
- the fire entity must act autonomously;
- the system components must be auto- propelled;
- the system components must be loaded and transported on railways, ships or by air;
- must have technical measures for the protection of personnel that use weapons of mass destruction.

3.2. Requirements for means of research of airspace system

Radar data transmission is done in classical system (vocally). Radar may be used to direct their own fighters to intercept and indicate the targets, in the case of air-ground systems utilisation.

The radar provides airspace researching, discovery and tracking of air assets and bi-dimensional data about these (azimuth and distance). Radar data from users is done in classical system (by voice). The radar can be used to guide its own fighters and to indicate the targets for Surface- to-Air missiles systems. The main requirements for means of aerospace researching are:

- the discovery distance of targets with actual surface reflectance; for a surface of 0.1 m^2 the distance is > 30 km;
- circular and sector horizontally searching;
- the number of targets that can be simultaneously tracked more than 40;
- the number of targets which can provide the necessary parameters for calculating the drag elements more than 10;
- protection for anti-radar missile, and, if needed, other types of self-guided missiles on other types of transmission;
- summary display of information about aviation situation;
- compatible IFF system with the civil codes system and the possibility of implementing the alliance IFF system;
- possession of IFF system that can operate in NATO code and country codes (military and civilian);
- minimum height tracking targets with actual surface reflectance; for a surface of 0.1 m^2 minimum height is < 10m.

3.3. Requirements for fire control station

Weapon systems are controlled from this station. One station can control any one weapons bay, but can only control one at a time. To control multiple bays, multiple fire control stations are required:

- the probability of destroying with one rocket to be greater than 0.7 for aircraft, in complex combat conditions (low altitude, high speed, jitter, handle);
- to ensure the destruction of an area sized and defined by the following values:
  - minimum height ≤ 10 m;
  - maximum height ≥ 5 Km;
  - minimum range ≤ 500 m;
  - maximum range ≥ 10 km;
- maximum speed of targets that can be controlled ≥1000 m/s;
- the number of targets that can be controlled simultaneously by one system with the probability of destruction required ≥ 2;
- continuous transmission at the control section of the upper echelon of the combat readiness of personnel and technology, of reports on the accomplishment of the fighting mission, control of targets in decentralized system;
- to achieve automatic and real-time analysis of the threat and determine ways to combat targets, comparing them to the missions received and the presentation accordingly;
- active jamming protection (noise, response, etc.) and passive sight lines of missiles and targets and control lines;
- to have passive sensors (TV, IR) for the operation on powerful jamming scenarios;
- antiradar missile defense and against self-directed missiles on other types of emission (if any) and the possibility of engaging battle with them;
- possession of IFF system that can operate in NATO code and country codes (military and civilian);
- to be compatible electromagnetically with other radio - military and civilian – means found in procurement when purchasing the systems;
- the system crossing time in marching position and inverse position ≤ 10 minutes;
- possession of protection measurements of objectives and their troops.

3.4. Requirements for antiaircraft missile

Basic characteristics of new means will be focused on increasing the effectiveness, electronic counter measures, for rapid reaction, mobility and working stability, in any conditions of time and weather. Antiaircraft missile requires:

- storage, transport and launch must be done a sealed container;
- preparing to launch the rocket on launcher must last no longer than 10 sec;
- proximity warhead must be protected against active or passive jamming;
- the engine plant must operate with solid fuel;
- the initiating system of the battle load must possess at least three-stage safety of which not more than one stage should raise before the missile is launched;
- the probability of false alarm at the proximity warhead must be < 0.01% in the presence of both active and passive jamming;
- standard duration of missile developing must be at least equal to the standard duration of the system as a whole (without change of more than 5% of the components in terms of value);

- must not require special storage conditions and storage outdoor should not shorten with more than 30% the standard duration of developing in the case of enclosed storage.

3.5. Requirments for the cannon structure

The cannons were effective in beating distance of about 4 km and height of about 3.5 km. The beating of the 35 mm cannons is no longer a decisive factor, so that the 30 mm became more important, due to the lower weight of the entire system, higher volume of transported ammunition and higher theoretically rate of fire. The cannon structure must comply with some requirements, such as:

- have small caliber (20-40 mm);
- have several barrels (2-4);
- annihilation probability ≥ 0.9 to 10 strokes;
- have high rate of fire (≥ 500 projectiles/min) for each barrel;
- can use at all kinds of anti-aircraft projectiles, proximity warheads;
- can use projectiles with submunitions, prefragmented elements, etc.

The twin GDF003 type gun is an automatic drive in recharging position. The piece is automatic based with three outriggers, it have optical aligning device and camouflage set incorporated.

Figure 4. The GDF003 35 mm a.a. gun, Electromechanical Plant of Ploieşti

Table 2. The GDF003 characteristics

Effective range	4 km
Rate of fire	1100 rounds/min
Ready to fire ammo	2 × 56 rds
Reloads	2 × 63 rds
Shell velocity	1175 m/s

4. Conclusions

The main goal is represented by the defense resources which in turn have to be included into an integrated system. This kind of system will allow their usage with maximum efficiency at the right moment for their foremost mission, in full interoperability with other similar systems belonging to the armed forces of the allied countries. The basic considerations of the mixed-AD systems requirements and two Romanian developments have presented. Some of the technical and operational performances of the presented systems have grouped into a summarizing table, according to the public sources.

These equipments cannot be replaced easily when their characteristics no longer keep pace with the progress of potential targets.

The cost of these systems can get a lot of many.

Up-grading of such a system becomes an option both to preserve the operational performance and to save funds in the current financial crisis, instead of buying a new system. Finally, an important conclusion supports the possibility and necessity of the A.D. integrated systems up-grade, when the threat characteristics were changed. 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.

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