System for counteracting large groups of low-flying targets

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Abstract: *The material offers a description of a type of system for counteracting large groups of low-flying targets, established at the Institute of Metal Science, equipment, and technologies with Center for Hydro- and Aerodynamics “Acad. A. Balevski” at the Bulgarian Academy of Sciences-BAS. Data on its structure, the main tactical and technical characteristics and functions of its main modules and some test results are presented.*

Keywords*: LOW-FLYING TARGETS, SYSTEM FOR PROTECTION, MODULAR PRINCIPLE, FLEXIBILITY*

1. Introduction

The development of aviation in the last decade has led to the possibility of massive actions of large groups of air vehicles by flying at low and extremely low altitudes. Typical cases in this direction are the use of dozens of helicopters or dozens of drones in missions in which they fly at altitudes of several tens to several hundred meters. This is a serious challenge for the protection of military sites and critical infrastructure [1,2,3], and in addition to detecting and identifying these types of targets, their widespread use creates problems for the system to neutralize them.

For this purpose, the Institute of Metal Science, equipment, and technologies with Center for Hydro- and Aerodynamics “Acad. A. Balevski” at the Bulgarian Academy of Sciences-BAS (IMSETHC-BAS) has created a system for combating low-flying objects [4-7], designed to counter mass intrusions helicopters and tactical drones.

Counteraction is carried out by interfering with their means of satellite navigation and control, as well as by kinetic effects with fragmentation munitions.

2. Results and discussion

The system is a modular type, and each of the modules can be used alone or in combination with other modules.

The main modules of the system are:

- For kinetic impact;
- For electronic counteraction;
- Communication and information module (Module C3I)

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KINETIC IMPACT MODULES

The modules for kinetic impact are of two types - for impact against helicopters (anti-helicopter mines - AHM) and for impact against unmanned aerial vehicles - drones (anti-drone mines ADM). Both types of mines use a warhead located on the earth's surface, which forms a stream of fragments as the target flies over it. The area for effective destruction of the modules is in the form of a cone with a tip at the point of the warhead, with a height of 350 m. The warheads can be located at a distance of more than 10 meters, which makes it possible to ensure the overlap of their zones of destruction by simultaneously detonating several warheads.

In addition to warheads, the kinetic impact modules include a safe fuse, sensor unit (for AHM - acoustic and radar, and for ADM - radar and optical), radio module for two-way communication, GPS positioning device, control and self-diagnostic unit, power supply , spare parts and tools – for installation and dismantling or leveling device on the ground and transport packaging.

The main samples of AHM and ADM are as follows:

- AHM / S -100 and AHM-200;
- ADM-100 and ADM-200

The AHM/S-100 and ADM-100 are mines with up to 15 warheads controlled by a common device, including sensors, a radio module for two-way communication and a GPS positioning device (Figure 1). The AHM-200 and ADM-200 are mines with a single warhead, over which is mounted a control device including sensors, a radio module for two-way communication and a GPS positioning device (Figure 2).

Fig. 1. *General view of AHM/S-100 and ADM-100*

Fig.2 *General view of AHM-200 and ADM-200*

At the request of the client it is also offered:

• Simulations of both types of mines - without a warhead and without or with a limited number of other components designed to create fake minefields.

• Training samples of both types - safe, designed for staff training.

• AHM and ADM mines can be part of the low-flying countermeasures system or used autonomously.

In autonomous mode, these mines are placed in position and within three months (of which one month - in combat mode) they explode and hit with fragments the low-flying objects flying above them.

The main characteristics of the AHM / S-100 and AHM-200 are presented in Table 1, and of the ADM-100 and ADM-200 are presented in Table 2.

ELECTRONIC MODULES FOR COUNTERMEASURES

The electronic counter-modulus (ADM) modules have an open architecture and are based on interference emitters in a certain frequency range.

Table 1. *Main characteristics of AHM-100 and AHM-200*

Characteristic	Parameter	Parameter
Mine type	AHM/S-100	AHM-200
Number of warheads	1-15	1
Body material	plastics/metal	plastics/metal
Total weight, kg	up to 39	up to 57
Diameter, mm	360	
Main charge, kg	16	22
Explosive type	TNT/RDX 50/50	TNT/RDX 50/50
Fragments number	up to 1500	up to 1380
-dimensions, mm	12x12x12	12x12x12
- weight, g/pc	up to 13.6	13.6
Effective range, m	up to 300	up to 150
Fragments pcs/m^2 – 100 m	30-50	1.7
Deployment	manual	manual
Operating temperature range, ^0C	from - 40 to +70	from - 40 to +70
Turning into armed state	Controlled by cable or radio channel	Controlled by cable or radio channel

Table 2. *The main characteristics of ADM-100 and ADM-200*

	ADM - 100	ADM - 200
Number warheads	1-15	1
Body material	plastics/metal	plastics/metal
Total weight, kg	up to 34	up to 37
diameter, mm	360	
height with adjustable legs, mm	From 400 to 600	From 400 to 600
Main charge, kg	16	22
Explosive type	TNT/RDX 50/50	TNT/RDX 50/50
Fragments number	up to 2700	up to 1600
-dimensions, mm	8x8x8	10x10x10
- weight, g/pc	up to 4	up to 7
Effective range, m	up to 300	up to 200
Penetration - 100 m	up to 2 mm mild steel	up to 5 mm mild steel
	20 mm pine wood	40 mm pine wood
Penetration - 200 m	1 mm mild steel	2 mm mild steel
average Fragments pcs/m2 - 100 m	50-100	40-75
average Fragments pcs/m2 - 200 m	15 -25	10-15
Deployment	manual	manual
Operating temperature range, ^0C	from - 40 to +70	from - 40 to +70
Turning into armed state	Controlled by cable or radio channel	Controlled by cable or radio channel

The ability to create effective interference with different powers and frequencies up to eight gigahertz has been mastered, which allows the construction of specialized modules for electronic counteraction at the customer's request.

The available standard modules for electronic interference are four types - two portable systems with short range (ADM 1000-3 and ADM 1000-5) and two types of mobile systems for electronic interference - with medium range (ADM - RSRI - 1 and ADM - RSRI - 2).

ADM 3000/3, ADM 5000/3, ADM 8000/3 and ADM 3000/5, ADM 5000/5, ADM 8000/5 are transported manually or with light transport equipment and can be powered by batteries, generators or mains power supply. They provide interference on three (in the standard version - for satellite navigation) and five (in the standard version - three for satellite navigation and two for control) frequency channels, and the frequency channels can be selected at the request of the customer. Their range is respectively 3 km, 5 km and 8 km.

ADM-RSRI-1 and ADM-RSRI-2 are transported with light transport equipment and can be powered by generators or mains power supply. They have twenty channels, the frequency channels can be selected at the customer's request, and their range is up to 10 km.

In addition to interference emitters, the electronic countermeasures modules include a radio module for two-way communication, a GPS positioning device, a control and self-diagnostic unit, a power supply, spare parts for assembly and disassembly, a ground leveling device and transport packaging.

Electronic countermeasures modules can be part of the low-flying countermeasures system or used autonomously.

In stand-alone mode ADM 3000/3, ADM 5000/3, ADM 8000/3 and ADM 3000/5, ADM 5000/5, ADM 8000/5 are deployed for a period of three months (of which one month - in combat mode) to create interference within up to 5 minutes when low-flying objects are flying over them.

In stand-alone mode, the ADM-RSRI-1 and ADM-RSRI-2 can run 24 / 24-7 / 7 continuously for six months or be switched on according to a pre-set program.

General view of the ADM 3000/3 and ADD 3000/5 is shown on Figure 3.

The main features of ADM 3000/3, ADM 5000/3, ADM 8000/3 and ADM 3000/5, ADM 5000/5, ADM 8000/5 are shown in Table 3.

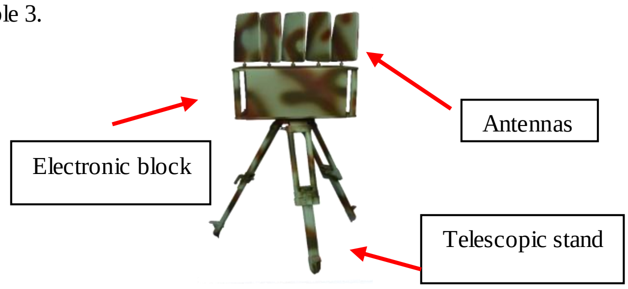


Fig. 3 General view of ADD 3000/5

Table 3 *Main features of ADM 3000/3, ADM 5000/3, ADM 8000/3 and ADM 3000/5, ADM 5000/5, ADM 8000/5*

Jamming bands	ADM 3000/3, ADM 5000/3, ADM 8000/3 - L1, L2, L5 of GPS,GLONASS,GALILEO and BDS.ADM 3000/5, ADM 5000/5, ADM 8000/5 - L1, L2, L5 of GPS,GLONASS,GALILEO and BDS, 2.4 GHz, 5,8 GHz
Jamming operation capability	50 sessions with 5 min duration

Jamming distance	ADM 3000/3, ADM 3000/5 – up to 3 000 м. ADM 5000/3, ADM 5000/5- up to 5000 м. ADM 8000/3, ADM 8000/5 – up to 8000 м.
Weight	25 kg.
Power Supply	Accumulator and/or 220Voptional

The appearance of ADM-RSRI-1 and ADM-RSRI-2 is identical and is shown on Figure 4.

Fig. 4 General view of ADM-RSRI-1 и ADM-RSRI–2

The main characteristics of ADM - RSRI - 1 and ADM - RSRI - 2 are presented in Table 4.

Table 4 *Main characteristics of ADM - RSRI - 1 and ADM - RSRI - 2*

Jamming distance	ADM 3000/3, ADM 3000/5 – up to 3 000 м. ADM 5000/3, ADM 5000/5- up to 5000 м. ADM 8000/3, ADM 8000/5 – up to 8000 м.
Power supply	230V or 120V AC, 5kW
Jamming bands	**ADM-SSRI – 1**: L1, L2, L5 of GPS, GLONASS, GALILEO and BDS , 2.4 GHz, 1.840 GHz 2.140 GHz, 2.650 GHz,5.8 GHz, 910 MHz, 940 MHz. **ADM-SSRI – 2**: L1, L2, L1-H* of GPS, GLONASS, GALILEO and BDS , 433MHz, 868MHz, 900 MHz, 2.4 GHz и 5.8 GHz, IRIDIUM, INMARSAT, THURAYA(1550 MHz and 1630MHz).
Jamming operation capability	Preset work, no time limit
Jamming distance	Up to 10 000 m
Jamming channels	20 pcs. (10 main and 10 backup)
Jamming channels power	Up to 100 W/ per channel
Dimensions of the jammer unit:	H without antennas/with antennas: 1020 mm/2450 mm L: 1340 mm W: 720 mm
Weight	250 kg
L1-H* - simulated GPS signal	L1 of GPS, GLONASS, GALILEO and BDS

COMMUNICATION AND INFORMATION MODULE (MODULE C3I)

C3I modules consist of an information module, communication modules and control and command modules (C2 modules).

The information modules are designed to detect and identify low-flying targets and violators of the access zones to the respective components of the System. These include common and distributed components.

Distributed components are radars, optical means and sensors for approaching and / or attempting to manipulate a device from the System. They are integrated in the respective component of the System or are located near it.

The common component of the system is radar (Figure 6), capable of detecting drones at a distance of up to 5 km. The radar contains a radio module for two-way communication, a device for GPS positioning, a control and self-diagnostic unit, power supply, spare parts - for assembly and disassembly, a device for leveling the terrain, etc.

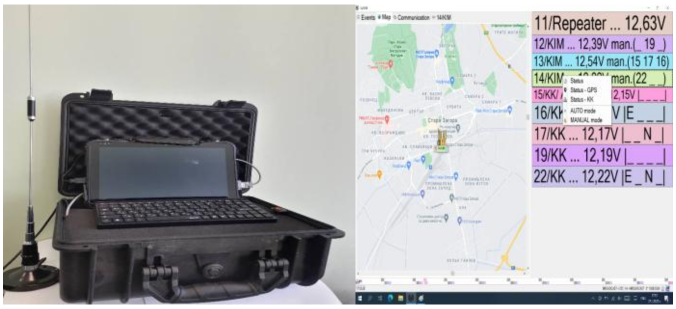
At the customer's request, other types of active or directional radars and optical devices can be integrated into the system.

General view of passive radar

General view of active radar

Fig 6. *Radars as a common component of C3I*

The communication modules provide exchange of status data and control commands between the C2 modules and the other components of the system and are of the type shown on Figure 7.



Command Centre

Repeater Communication and Information module

***Fig 7**. C3 modules*

They include common and distributed components, with the common communication modules integrated into the C2 modules of the System and the distributed components integrated into the other components.

In the standard version, ADM - RSRI - 1 and ADM - RSRI - 2 operate in the range of 868MHz, and the rest - in the range of 170 MHz.

The control and command modules (C2 modules) are mobile and stationary and function as classic command centers. They are designed to control and manage the other modules of the System by analyzing the data received from them and automatically or through an operator give commands to control their operating modes. They consist of a data analysis and management unit, a data archiving unit, a display device, a power supply, etc., and they contain a radio module for two-way communication, a GPS positioning device, a control and self-diagnostic unit, a power supply, spare parts and tools - for assembly and disassembly, ground leveling device and transport packaging.

Stationary C2 modules can be located in rooms or containers in which it is possible to place some mobile C2 modules (eg C2 radar module). The mobile C2 modules are located in portable suitcases.

Control and command modules may be integrated with command centers or control points of other air defense or airspace monitoring and control systems.

3. Conclusion

The general structure and the main characteristics of the System for combating low-flying drones and helicopters developed by a team from IMSETHC-BAS are presented. It allows for flexible adaptation and use of a specific set of modules depending on the conditions of its operation. The system has been tested under various conditions and has proven its effectiveness in the simultaneous takeoff of more than ten different types of drones. The developed software for data exchange and management is open access, which allows the system to be integrated with other similar systems, as well as if the user wishes to use other communication channels for data exchange.

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