TECHNICAL PROPOSAL

WARRIOR ANTI-DRONE AIR DEFENSE COMPLEX
ZARYA

2021

Control means of Anti-Drone Air defense complex ZARYA

The means of control provide for increased efficiency of the combat use of Anti-drone complexes on small-sized air targets and unmanned aerial vehicles (UAVs) with different purposes.

The increased accuracy of fire stems from the reduction of errors in measuring the target coordinates and the speed of the algorithms for solving the ballistic tasks **thanks to the automatic control and targeting of the fire means**.

During the development of the control means the modern tendencies in anti-aircraft artillery armament and real life experience were taken into account, using leading technologies in the field of radar systems and automated control systems, digital algorithms of data processing and ballistic calculations.

Purpose and composition of the control means

Warrior Anti-drone complex **ZARYA is one of the most effective systems worldwide with a very high efficiency in the destruction of small aircraft**, such as drones and unmanned aerial vehicles.

The Anti-Drone complexes ZARYA with the means of control are intended for air defense of stationary and sedentary objects. They can be added to the composition of anti-aircraft artillery units, mixed anti-aircraft missile and artillery units, as well as in the composition of units designed to combat UAVs.

The purpose of the system is: detection, recognition, targeting, direction and positioning, firing and defeating enemy drones and UAV's.

Composition of the control tools:

№	Name	Qty
1	Anti-aircraft artillery unit command post: 3D pulse radar with signal compression and electronically generated elevation angle diagram for detection of low-flying air targets and ground targets	1
1.1	Command control point - Radar machine No 1	1
1.2	Antenna - radar part - Radar machine No 2	1
1.3	Power supply system - Diesel power plant with central distribution box with cable network	1
1.4	Automatic controlled 14.5mm Anti-aircraft, twin-barrel cannons Warrior ZU-14.5-2	6
1.5	Warrior Air-burst Anti-drone 14.5mm cartridges WABAD 14.5x114mm *Minimal recommended quantity per complex of 6 fire units:* *- 14400 pcs 14.5x114mm WABAD cartridges in position at fire units* *- 3600 pcs 14.5x114mm API cartridges in position at fire units* *- 28800pcs 14.5x114mm WABAD cartridges- in readiness up to 6 km from the fire units* *- 7200 pcs 14.5x114mm API cartridges - in readiness up to 6 km from the fire units*	Unlimited

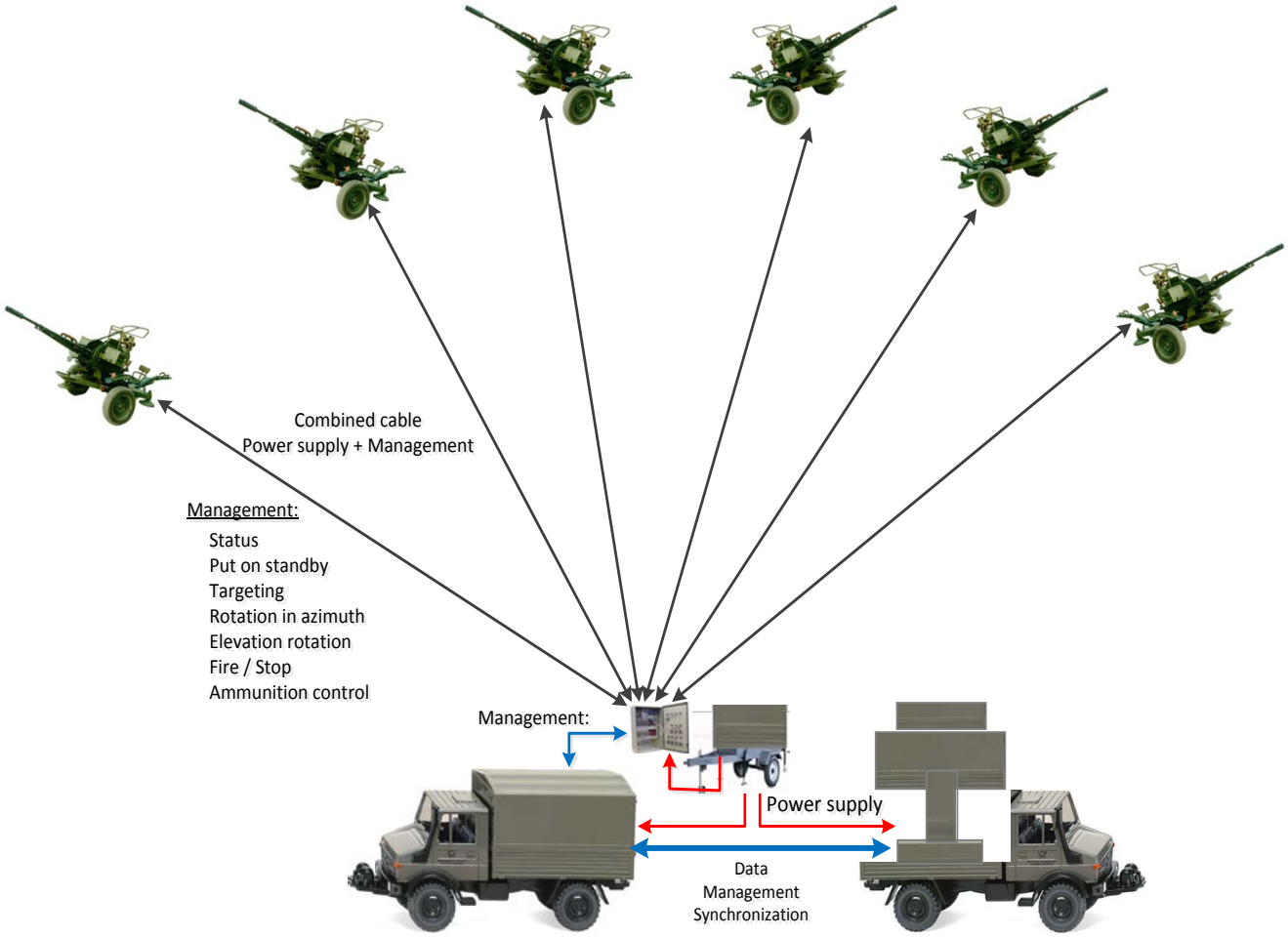


Figure № 1: Block diagram of the control means in the composition of the complex ZARYA

1. **Capabilities**
   - **Automatic detection and tracking** of UAV's and other air and ground objects with small reflecting surface.
   - **Recognition and identification of the targets.**
   - Visualization of the air situation on the background of a geographical map.
   - **Automatic direction at azimuth and elevation** and **firing** of the cannons.
   - Detection, tracking and **simultaneous firing at one or different targets** with each cannon.
   - Automatic stop of the firing when the target is shot down and direction of the cannons to start firing at the next target.
   - **Automatic control of ammunition consumption**. The sensors on the cannons ensure operation stop when all the cartridges have been fired.
   - Defeating of targets at **different distances up to 4000 m**.
   - Rate of fire with 6 Canons Warrior ZU-14.5-2 – 7200 rounds/min, which create a dense cloud of 144000 (one hundred forty-four thousand) sub-projectiles per minute when firing with 14.5x114mm WABAD Cartridges.
   - Modular design allowing adding additional equipment.
   - Capabilities for multiple system integration.

2. **Characteristics of the control means**

3.1. 3D pulse radar

3D pulse radar with signal compression and electronically generated elevation angle diagram for detection of low-flying air targets (UAVs, aircraft, helicopters) and ground targets.

3.1.1. Radar Type Index

Radar PX – 04 – C – 01

3.1.2. Purpose of the radar

The radar is designed for automatic detection and tracking of highly maneuverable air targets with a small reflecting surface (UAV, aircraft, helicopters) as well as ground targets (people, machines) against the background of ground reflections. The radar is mobile and can change its position quickly. The radar is designed to target air defense and anti-missile systems.

3.1.3. Principle of radar operation

The radar is pulsed with signal compression, scans in a circular mode from 0° to 360^0, with electronic formation of an elevation diagram with 8 sections at 8 different frequencies and with different degrees of signal compression. The processing uses 11 or 7-bit Barker code, FFT for earth reflection (Doppler effect) and vector analysis of complex RF signal.

3.1.4. Tactical and technical data of the radar

Pulse radar with signal compression and electronically generated elevation angle diagram.

Each beam of the electronic diagram is emitted at a different frequency. The signal compression coding is frequency-based with phase conjugated frequencies.

The antenna is active with an electronically scanning elevation angle diagram.

At each new angle of transmission and reception, the carrier frequency is different, as may the transmission and reception code. This makes the jamming of the radar harder.

Receiving is performed in parallel on all sub-diagrams forming the main diagram.

The height is measured with two receiving antennas placed at an appropriate distance of their phase centers for unambiguous calculation of the angle at the place Ѳ relative to the axis of the antenna for each detected object.

The radar also has a subsystem for diagnostics and control during operation.

The radar has the appropriate accuracy of capturing the coordinates of the targets and for targeting active means of protection.

It has an output with TCP/IP and ASTERIX protocol to C2 systems and remote control.

Tactical and technical characteristics:

№	Technical parameters	Dimension
1	**Implementation**	
	Capability	High-precision tactical 3D radar for detecting objects at long distances with the ability to target weapon systems
	Dimension	3D (Range, Azimuth and Height)
	Distance range	60 km
	Height	12 000 m
	Azimuth coverage	360°
	Elevation angle coverage	32º
	Distance accuracy	15 m
	Azimuth accuracy	0,08º
	Elevation angle accuracy	0,1°
	Distance resolution	150 m
	Azimuth resolution	1,4º
	Signal processing	Signal compression Observation of the background of reflections from the earth's surface
	Pulse power	4 kW
	Diagram	Adaptive in elevation angle
	Scan speed (data refresh)	1 second / 2 seconds
	Power Consumption	5 kW;
	Power Supply	3 x 380V/50Hz;
	System diagnostics and control and remote control	YES

№	Technical parameters	Dimension
	Detection of a distance from an object with an Effective Reflecting Surface (ERS) as follows:	
	Drone, rocket with ERS about 1 m^2	21 km
	Air targets at low altitudes, cruise missile with ERS about 4m^2	35 - 48 km
	Air targets with ERS over 4 m^2	Not less than 60 km
	Automatic processing "plot" and "track" Automatic tracking (processing).	YES
	Detection probability (100 NM target), PFA of 10^{-6}	≥ 0,9
	MTBCF (Mean Time Between Critical Failure)	≥ 3100 hours
	MTTR (Mean Time To Repair)	≤ 30 minutes
	BITE Performance	100%
2	**Antenna**	
	Antenna technology	AESA and Full Digital
	Gain (transmit and receive)	transmit – 36 dB, receive – 36 dB
	Operating frequency	C Band
	Beam types	Multibeam independent system 8 transmitting and receiving beams of different frequencies.
	Rotation speed	60 / 30 RPM
	Electronic antenna tilt (down)	- 0°
	Electronic antenna tilt (up)	+0°
	Formation of the diagrams	Digital
3	**Transmitter**	
	Transmitter type	Solid State
	Cooling type	Air
4	**Receiver processing**	
	Moving Target Detection (MTI / MTD) Deployment / Capability	Available - MTI / MTD with vector signal processing (vector signal analysis) and Fast Fourier Transform (FFT)
	Application of pulse compression	YES (Digital signal compression)
	Application of frequency change	YES (Pulse to pulse)
	Implementation of non-automatic initiation (NAI)	YES
	Implementation of Clutter Automatic Processing (CAP)	YES (automatic frequency change other than interference)
	Implementing a permanent false alarm (CFAR)	YES
	Sensitivity time control (STC) or implementation of equivalent processing	YES
5	**Computer, display and data processing**	
	Display monitor	21"

№	Technical parameters	Dimension
	Maximum number of Plots	2 500 Plots
	Maximum number of Tracks	2 000 Tracks
	Monitoring and control console / Quantity of the workstation	2
	Ability to display a map	YES
	Ability to display a geographic network	YES
	Ability to display a map of the sea (air) route	YES
	Possibility to change the card by the operator	YES
	Traceability (target label, target identifier, target type, speed, altitude, direction and vector)	YES
	Ability to record / play data	YES
	Possibility for safety warning	YES
	Interface and protocol for integration format	YES
6	**ECCM Capability**	
	Frequency independence	Formation of a multibeam diagram
	Attenuation analysis / Attenuation extractor	YES
	Automatic selection of the least affected frequency	YES
	Silent mode / Emission control	YES
	Other ECCM features	YES
7	**IFF/SSR (optional MSSR)**	
	Modes	Modes 1, 2, 3/A, C, 4/5 и Mode S Level 2 per ICAO Annex 10
	Probability of detection	0,9
	Distance accuracy	≤ 50 m
	Azimuth accuracy	≤ 0.30°
	Maximum Plot Capability	1500 plots
	Detection distance	Up to 250 km

Basic modes of radar operation

1) Automatic detection of spots (marks) from radar targets - Plot;
2) Automatic survey of the coordinates of radar targets;
3) Automatic detection of a route for radar purposes - Track;
4) Automatic tracking of radar targets;
5) Automatic identification of radar targets by primary radar and secondary radar;
6) Automatic transmission of information to other systems;
7) Automatic archiving of data for radar purposes;
8) Display of raw primary radar information and after processing secondary information on a digital display.

System composition:

- Container off-road truck - 2 pcs.
- Container for workplaces and generators 20 feet - 1 pc.
- Container frame 20 feet with hydraulic jacks for antenna platform - 1 pc.

- Communication equipment*: VHF Radio, UHF Radio, HF Radio, Voice Communication System (VCS), radiotelephones* - 1 set.
- Set of cables for connecting the modules and cables for connecting to the mains supply - 1 set.
- Diesel generators - 1 pc.
- UPC with batteries for 10 minutes - 1 set.
- Set of grounding equipment 5Ω - 1 set.
- Lifting conical platform mounted on a container frame - 1 pc.

* *Communication equipment is an option*

Video monitoring system

Complex of day and night (infrared) cameras, with remote control for rotation, tilt and focus.

The cameras are controlled remotely by the radar operator by pointing the camera at the radar-defined coordinates of the monitored object. The video images are broadcast in the command center and displayed on the monitors of the workplaces against the background of a tactical map.

Using the Show Video Surveillance Camera menu, PTZ camcorders are guided by radar data. The values for latitude, longitude, altitude, azimuth angle (horizontal of the current title) and angle of elevation (current vertical position) are reported on the screen, which checks the correct positioning of the camera when automatically aiming at a specific target.

Using the Targets Toolbar menu, the operator identifies the targets and can enter a symbol to represent the target depending on the type of target and the level of threat.

Multiple cameras can be linked in C2 system.

Command post (CP) for management

Machine № 1 - Container with workplaces is a unified automated mobile control point for an air defense group, armed with anti-aircraft systems for close action, incl. anti-aircraft battery, anti-aircraft regiment, etc.

The hardware and software ensure the receipt of information about the situation both from the own radar and from neighboring radar formations and from the higher command post, connected in C2 network for data exchange, processing of the received information and transmission of the results in the form of information models and recommendations for combat use.

A command post provides a solution to the following main tasks:

- **Reception of information about the air situation** through the data exchange channels in the command radio network;
- Data exchange with higher and subordinate control points, incl. and receiving combat missions, command and control signals, and transmitting and receiving reports;
- Interface with other radar stations and systems;

- **Automatic information processing and data visualization**;
- Automatic reception of **information about the state (status) of the fire means** of the subordinate units connected in the system;
- **Assessment of the air situation and decision-making for the distribution of targets between the fire units (fire units);**
- **Preparation and assignment of tasks to subordinate units** in an automated manner by transmitting commands for control and signaling;
- **Targeting and control by means of automatic directing** (rotation in azimuth and elevation) of the fire units;
- **Ability to remotely control the firing of fire units**.
- Control of the performance by means of automatic receipt of data on the status and the mode of operation of the fire means, to include **control of ammunition consumption**.

The hardware of the CP includes in its composition:

- Automated workplace of the radar operator;
- Automated workplace of the commander;
- Information processing equipment;
- System for target allocation and targeting;
- Documentation equipment;
- Communication system;
- Weather station;
- Power supply system.

Automated workstations, information processing equipment and documentation equipment are built on the basis of high-performance industrial computers integrated into a local area network.

The main tactical and technical characteristics are given in Table 2.

Characteristic	Value
Number of workstations	2
Number of simultaneously escorted air objects (AI)	up to 500
Coordinate update rate	6 seconds / 4 seconds;
Distance range	60 km
Height	12 000 m
Azimuth coverage	360°
Elevation angle coverage	60º
Distance accuracy	15 m
Azimuth accuracy	0,08º
Elevation angle accuracy	0,1°
Distance resolution	150 m
Azimuth resolution	1,4º

Characteristic	Value
Total number of conjugated sources and users of information, including:	Up to 12
superior CP	1
interacting CP	2
Radars / SAM	Up to 4
Number of objects to manage	Up to 6
Time for storage of the recorded information in a standard complete set	No more than 30 days
Supported form for data transmission	ASTERIX
Protocols for digital data transmission channels:	
physical level	10BASE-T, 100BASE-TX
transport level protocol	TCP
Power supply	380 V ± 10 %, 50 Hz ± 5%

Table 2

The target allocation and transmission system provides for:

- Visualization of the air situation on the background of a geographical map;
- Indication of the sectors prohibited for shooting;
- Visualization of data on the location and status of fire units;
- Assessment of the degree of danger of the accompanied means;
- Computer playback of options for action and decision support for fire impact;
- Automatic allocation and display of the plan of allocation on the screen of the commander's workstation and providing an opportunity for operational correction;
- Transmission of commands (signals) to bring the subordinate formations ready for combat operations;
- Automatic formation of commands for aiming the fire means in the form of calculation of the aiming angles, taking into account the ballistic deviations and the meteorological conditions of the firing according to the firing table of the anti-aircraft complex ZARYA. Reporting the type of ammunition with the possibility of contactless explosion of projectiles;
- Automated transmission of target targeting in the weapon control system (automatic rotation in azimuth, automatic rotation at an elevation angle), automatic tracking of targets.
- Possibility for remote detection of shooting (optional).

Type of control and targeting signals

№	Meaning
1	Number of the fire unit
2	Status of the fire unit
3	Prepare for combat
4	Targeting and support mode
5	Azimuth guidance commands
6	Elevation angle targeting commands
7	Start / Stop; Remote shooting control
8	Ammunition control – optional
9	Other signals

Meteorological station

The station measures atmospheric pressure, temperature and humidity of air, wind speed and direction in the area of the firing position of the battery in automatic mode. The measurement results are automatically transmitted to the Targeting and Targeting System.

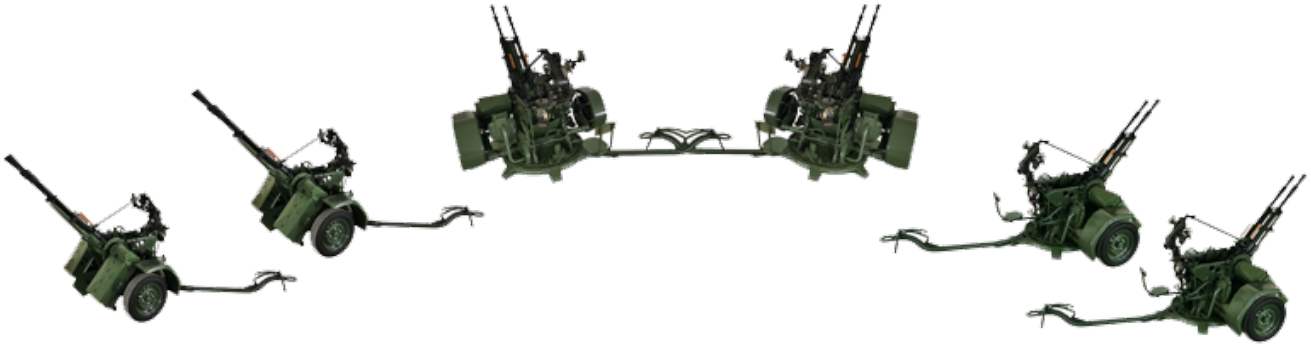
Power supply system and connection cables

Each anti-aircraft battery is equipped with a mobile diesel power plant, distribution box and cable network, providing power and control of fire means.

A cable for connection to the radar for transmitting the commands for control and targeting of the fire means is connected to the distribution box.

The use of a single multi-core combined cable for transmission of three-phase power supply and control and targeting signals is envisaged.

Radar guided /Automatic controlled anti-aircraft weapons Warrior ZU-2



There are three modes of operation of Anti-aircraft Cannons: Manually, Semi-automatic by joystick and fully automated control by the radar

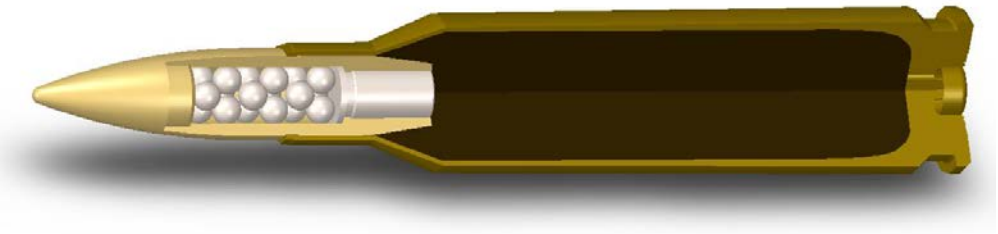
Functions of automatic control:

- Direction speed control;
- Position control, targeting and firing;
- Sending data to the control unit for the position of the cannon by GPS or manual input;
- Sending data about the position of the weapon in azimuth and elevation to the weapon control system;
- Sending information for the state of ammunition.

Technical characteristics

- Military standard is implemented – operational in severe climatic conditions;
- Target tracking speed – horizontally up to 56°/s, vertically up to 35°/s;
- Firing range – 4000m.
- Rate of fire of 6 Canons Warrior ZU-14.5-2 – 7200 rds/min, which create a dense cloud of 144000 (one hundred forty-four thousand) sub-projectiles per minute, when firing with 14.5x114 mm WABAD Cartridges.

Warrior Air-brust Anti-drone cartridge 14.5x114mm WABAD



The use of 14.5x114mm WABAD cartridges in the automatically controlled /Radar guided anti-drone air-defense system guarantees 100% efficiency of defeating small aircraft such as drones and UAVs, etc.

There are 14.5x114mm WABAD cartridges with air explosion at different distances.

After reaching the specified distance, a small charge in the projectile is activated and disperses a dense beam of spherical defeating elements – **20 sub-fragments**, which have an initial speed of 200m/s at a distance of 100 m. The sub-fragments penetrates aluminum sheet with thickness 4.5mm and steel sheets with thickness 1.8mm, which creates a dense deadly cloud.

Combining cartridges with scattering at different distances increases the depth of the barrage fire. Thus, when firing with 6 radar-guided cannons Warrior ZU-2, 36 000 fragments are released in 20 seconds, which form a large and dense cloud. This greatly increases the possibility of shooting at more targets and the probability for their destruction compared to other similar ammunition.

Even the smallest target cannot pass through this cloud of sub-fragments without being hit.