ANALYSIS OF DESIGN FEATURES AND ASSESSMENT OF THE EFFECTIVENESS OF COMBAT USE OF VARIOUS MODIFICATIONS OF S-125 TYPE ADAM

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INTRODUCTION

This expert analysis of design features and combat capabilities of various modifications of the S-125 type air defense system has been prepared for based on an agreement between the 2nd Central Research Institute of the Ministry of Defense of the Russian Federation and the Federal Agency for legal protection of the results of intellectual activity of a military man, special and dual purpose under the Ministry of Justice of the Russian Federation Federation No. 46-s dated November 14, 2002.

The purpose of the expert analysis was to prepare initial data for determining the general level of constructive continuity of the anti-aircraft missile system S-125M2A.

Expert analysis was carried out in accordance with the requirements for legal protection of results intellectual activities, determined by Decree of the Government of the Russian Federation No. 1132 of September 29 1998 “On priority measures for legal protection of state interests in the process of economic and legal circulation of the results of scientific-research, development and technological work military and dual-use."

CONTENT

1 OVERVIEW OF TERMS AND DEFINITIONS RECOMMENDED FOR APPLICATIONS IN SCIENTIFIC AND TECHNICAL RESEARCH EXAMINATIONS OF VARIOUS MODIFICATIONS OF SAM TYPE S-125

1.1 List of terms and their abbreviations (abbreviations) in alphabetical order

ABC	antenna-waveguide system
ADA	automatic drifting balloon
ADC	aerodynamic target
APP	automatic starter
FOOD	automatic tracking
ASURK	automated missile control system complexes
AUS	subscriber communication center
AFU	antenna-feeder device
BT	fighting tube;
BC	ballistic target
BCH	combat unit
VDM	ignition-detonation mechanism
VIKO	remote all-round indicator
DES	diesel power plants
Zrdn	anti-aircraft missile battalion
SAM	anti-aircraft missile system
HUGE	anti-aircraft guided missile
IKO	all-round indicator
MIPC	gear ratio change mechanism
MP	masking post
NRZ	ground radar interrogator
OES	optical-electronic system

PSU	front dosing device
PIM	safety-actuator mechanism
PKZ	control and cover area
PKU	mobile control unit
PKU	mobile control unit
PRD	powder rocket engine
Road accident	mobile transformer substation
PU	launcher
RD	radar range finder
RLK	radar channel
PKK	radio command transmitter
RS	manual support
RUiV	radio control and sighting equipment
SDC	moving target selection equipment
SNR	missile guidance station
SP	starting position
SRC	reconnaissance and target designation station
SSP	synchronous servo drive
SUA	antenna control system
SUS	launch control system
SCK	klystron frequency stabilization system
SES	power supply facilities
TVC	TV channel
etc	technical division
TZM	transport-charging machine
TP	technical position
TPK	thermal imaging channel
TST	technological docking trolley
UEC	command generation device

UOC	coordinate determination device
USU	universal selection device
CU	celeukazanie

1.2 Dictionary (thesaurus) of terms with definitions and comments

Due to the current lack of generally accepted terminology in the field of anti-aircraft missile weapons, the main terms are outlined below and definitions adopted during the examination.

Anti-aircraft missile system (SAM) - a combination of functional and technically related combat and technical means providing performing missions to fire and destroy air targets with anti-aircraft guided missiles (SAM).

Air defense missile systems - structurally and functionally complete products that carry out operations to fire and destroy air missile defense targets. For S-125 type air defense systems, combat assets include:

- missile guidance station (MRS), which carries out detection and tracking of targets, as well as detection and tracking SAM in flight. In addition, SNR communicates with external subscribers, control of other air defense systems, and also control of missiles in flight;
- launchers (PU) preparing for start and start of the missile defense system according to the commands from the SNR.

In addition, when conducting an examination of combat air defense systems SAMs are also included.

SAM technical means - constructively and functionally finished products that carry out preparation, testing, filling and transportation of missiles, loading launchers, as well as power supply, transportation, surveying, maintenance and repair of military equipment.

Basic set of air defense systems - the usual number of combat and technical ones funds included in the air defense system. To complete tasks more efficiently The air defense system is supplemented with additional equipment to its basic kit.

Additional air defense systems - structurally and functionally finished products attached to air defense systems in addition to the basic set in options for its configuration. Usually additional funds represent are specific products that increase the efficiency of combat and SAM technical equipment.

SAM combat kit - the normalized number of SAMs established for the basic configuration of the air defense system.

Additional set of missiles - non-standardized number of missiles, included in the system in addition to the basic configuration of the air defense system.

Target channel – a set of radio engineering devices, designed to detect, track and determine current target coordinates.

Rocket channel – radio engineering devices intended for launching, capturing and guiding one missile to a target.

The affected area (ZZ) of an air defense system is part of the airspace, in any point which, under certain shooting conditions, is ensured hitting one missile against a single target of a certain type with a probability no less than specified. There are ordinary POs, implemented POs and guaranteed salaries. In addition, there is a PO towards the goal and a PO after it. The main characteristic of the zone is the location of its nearest and far boundaries relative to the point where the air defense system is located, as well as the upper and lower boundaries relative to the surface of the earth.

Missile control system - a set of devices determining the position of the missile and target and ensuring production commands to control and point the missile at the target at all times flight until meeting the target.

The fire unit is the main element of missile defense, solves the problem of fire destruction of air (ballistic) targets. As a rule, the fire unit is an anti-aircraft missile division.

Reconnaissance and target designation station (SRTS) - a radar that conducts reconnaissance and identification of air targets, the data of which is used for target directions.

Missile guidance station (MRS) is an element of an air defense system designed for tracking targets and targeting missiles at them. For S-125 SNR type air defense systems is more than just a radar. As a radar you can consider only its antenna system and several units in the cabins, and the rest of the equipment is intended for preparing and conducting firing missiles, as well as evaluating its results.

SNR antenna system - target and missile sighting antennas and antenna radio command transmitter mounted on the UNV cabin.

SAM firing is a set of operations on an air defense system carried out with the participation of operators (automated operations) or without them (automatic operations) to prepare for launch BIG, launch BIG, guidance BIG, detonation warhead of the missile defense system and assessing the results of the detonation.

Launch device - the main operation on the air defense system (automatic) at the stage preparation for the launch of missiles, which consists in determining the coordinates and time the predicted meeting point of the missile defense system with the target. For S-125 type air defense systems this the operation is automatic and is performed by a so-called automaton rifle accessories (APP).

SAM guidance is the process of controlling the SAM velocity vector by impact on its management system.

The missile guidance method is a given law for the proximity of the missile to the target, which, depending on the coordinates and parameters of the target’s movement, determines the required movement of the missile, ensuring its meeting with the target.

Three-point guidance method ("three-point") - a guidance method when in which the missile defense system is on a straight line during the entire flight to the target, connecting the SNR to the target (on the line of sight).

The lead method is a guidance method in which the missile defense system is the flight time to the target is found with some angular advance relatively straight line connecting the SNR to the target.

Operators - persons from the combat crew of the air defense system who carry out automated operations at automated workstations (AWS), consisting of *indicators* and control panels (units).

Indicators are means of displaying information that carry out converting electrical signals into visual ones, which allows operators to establish their presence and determine (evaluate) parameters, necessary for analyzing the situation or making decisions.

2 ANALYSIS OF THE STRUCTURE, OPERATING PRINCIPLES AND FEATURES OF VARIOUS DESIGN MODIFICATIONS OF SAM TYPE S-125

2.1 Analysis of the general structure of the S-125 type air defense system

2.1.1 Purpose and general structure of the S-125 type air defense system

C-125 Mobile Anti-Aircraft Guided Missile System "Neva", designed to destroy low-flying targets, was developed in accordance with the Resolutions of the Council of Ministers of the USSR 1957 and 1959 years.

Lead organization for the development of the C-125 system as a whole and development of a radar guidance station is KB-1 GKRE (TsKB "Diamond"). General designer RASPLETIN A.A.

The lead organization for the development of the 5V24 (5V27) rocket is OKB-2 GKAT ("Torch"). General designer P.D. GRUSHIN

Joint tests were carried out from July 1960 to March 1961.

All modifications of the S-125 type air defense system were developed within the framework of a single systems (S-125 systems) based on technical solutions implemented with development of the S-75 and S-25 systems. The purpose of this work was to create effective small mobile complexes capable of carrying out combat against low-altitude targets.

The S-125 type system is understood as a complex of equipment, providing assembly, transportation, testing, preparation, start-up and guiding missiles to the target.

The main tactical fire unit of the S-125 type system is anti-aircraft missile division. The system is designed to combat aerodynamic targets flying at extremely small (from 60m) and medium (up to 18 km) altitudes with speeds up to 560 m/s, and provides defeating air targets at ranges of 3.5 – 28 km with an effectiveness of up to 0.98 when firing two 5B27 anti-aircraft guided missiles (SAMs) (5B24). In exceptional cases (in self-defense or in the absence of other means of combat) the division may be involved in the destruction ground (surface) radar-observed targets.

The division is armed with a transportable anti-aircraft missile complex (SAM) type S-125 and reconnaissance and target designation equipment (SRC).

For centralized control of the combat work of several (up to twelve) the air defense system complex can be interfaced with an automated fire control system for missile systems, which provides automatic target designation (transfer of data on target coordinates) and aiming the SNR at the selected target from the unit command post or ZRV connections.

2.2 Analysis of the purpose of fixed assets included in the S-125 type air defense system (standard assets) and in the composition of combat support assets (attached assets)

Missile guidance radar CHP-125

The CHP-125 missile guidance radar is designed to detect a target, determine its current coordinates, control anti-aircraft missile launchers determining current coordinates missiles fired at the target, generating control commands and transmitting them to rockets.

Station SNR-125 carries out:

- target detection in a given search sector (according to system data directions);
- automatic target tracking;
- manual tracking of a single or group target;
- guidance of missiles to the target.

The station provides target tracking and missile guidance to the target (including the jammer) in conditions of organized active and passive interference, as well as random interference from weather factors and local items.

The station equipment is designed for continuous round-the-clock work with a general one-hour break.

The control room of the station houses the fire command post complex. The command post is equipped with:

- fire complex control means;
- internal (speaker-phone) and external (telephone) means communications;
- signaling means about the operating modes of the SNR-125 station and about readiness for firing launchers and missiles.

The SNR-125 station structurally consists of two units:

- equipment cabin UNK;
- UNV antenna post.

Cabin UNK

The equipment cabin is made in the form of a trailer, inside which The main radio equipment of the station is located, consisting of:

- - synchronizer and indicators;
- antenna position control devices;
- receiving devices;
- moving target selection devices;
- devices for determining coordinates;
- command generation devices;
- command transmission devices;
- functional control devices and simulators;
- control panels

The device equipment is mounted in cabinets with pull-out units. Most of the blocks are made on printed circuit boards. Cabinets in trailer placed in two groups along the sides of the trailer with separate cabinets, containing indicators and control panels in a separate group - so called the “command post” of the air defense system.

The UNK cabin is electrically connected to the antenna using cables UNV post, launchers and power supply system.

Antenna post UNV

The antenna post consists of antenna devices, high-frequency radio equipment and power drives arranged on the artillery cart.

The antenna post includes:

- transmitting antenna;
- receiving antennas;
- command transmitter antenna;
- transmitting device;
- high-frequency part of the receiving device;
- power drive in azimuth;
- power drive according to the elevation angle.

Electrical connections between the post and the control cabin are made through rotating contact device.

Assembly and disassembly of the antenna post is carried out using own lifting mechanism and use of the crane is not required. Antennas are transported on a special cart.

Rocket 5B24 (5B27)

The 5V24 (5V27) rocket is made according to a two-stage design with an axial accelerator. For the first time in domestic practice on an anti-aircraft controlled the rocket uses both launch and propulsion engines on solid fuel.

The second stage of the rocket is made according to the “Duck” aerodynamic design. Wings and rudders of the second stage, as well as accelerator stabilizers arranged in an "X" shape.

Starting equipment

Launch equipment for the C-125 system fire complex ensures the execution of missile transportation operations to the firing range position, loading (or unloading) launchers, pre-launch preparing and launching a missile at targets accompanied by a guidance station.

Power supply to the starting equipment is carried out autonomously from a mobile power station or from an industrial network.

The starting equipment includes:

- 4 launchers;
- 8 transport-charging vehicles;
- means of transporting launchers.

2.3 Classification of modifications of S-125 type air defense systems

Anti-aircraft missile system C-125 "Neva" with a 5B24 missile, single-channel for target and two-channel for missile, adopted for service ZRV air defense in 1961.

In 1970, a modernized air defense missile system was adopted complex C-125M "Neva-M" with a 5P73 launcher and a 5V27 missile.

In 1971...1979, further research and testing was carried out to improve the characteristics of the C-125 and C-125M air defense systems. In 1978 The modernized C-125M1 "Neva-M1" complex with a new modification of the 5V27D missile defense system.

Based on modifications of the C-125M "Neva-M" and C-125M1 "Neva-M1" air defense systems modifications of the Pechora air defense system and the air defense system were developed for delivery abroad "Pechora-2" respectively.

2.4 Analysis of life cycles and nature of continuity of modifications of S-125 air defense systems

2.4.1 Life cycles and continuity of the main range of modifications of the S-125 type air defense system After the adoption

of the S-125 air defense system with the 5B24 missile into service by the test site together with leading design organizations continuously research and testing work was carried out, which allowed to significantly improve its basic tactical and technical characteristics.

During testing of the S-125 complex, insufficient perfection of the 5V24 missile radio fuse. In addition, the affected area for a two-stage missile defense system weighing almost a ton already seemed obvious insufficient. The decision of the military-industrial complex to modernize missile defense systems and equipment SNR-125 was adopted in March 1961.

In 1970, a modernized air defense missile system was adopted complex C-125M, providing the ability to track targets TV optical channel, higher performance firing due to the introduction of quadruple launchers into its composition 5P73 (instead of twin 5P71) and 5V27 missiles with reduced time preparation for launch (0.5 min instead of 2 min) when they are turned on for preparation from a cold state. The 5P73 quad launcher provided use of 5V27 and 5V24 missiles.

In 1971...1979, further research and testing was carried out on improving the characteristics of the C-125 and C-125M air defense systems in countering potential enemy aviation based on the following main directions:

reduction of horizontal range to the near boundary of the zone destruction from 6 km to 3.5 km and ensuring docking with equipment training of air defense control command crews (list of modifications 1M for the C-125M and lists 23, 26 for the C-125 air defense system);

increasing the accuracy of missile guidance to maneuvering targets in conditions of absence of interference by 2...2.5 times (introduction of a wide contour band control), increasing the efficiency of pursuit shooting (introduced modernized 5V27D rocket), providing the possibility of manual tracking of low-altitude targets in MB mode (introduction of the method PC-MB tracking), ensuring fire on targets flying below the level starting position (up to - 2°) in MV2 mode and ensuring combat work complex in the “Long Range” mode with the SDC system turned on (list 4MR for the C-125M air defense system and list 25 for the C-125 air defense system);

improving the conditions for conducting combat work by air defense crews due to introduction of the KM air conditioner (list 7MR for the C-125M air defense system and list 24 for the C-125 air defense system);

ensuring protection of the complex from active interference by introducing GShN equipment (list 2MR for the C-125M air defense system);

increasing the survivability of the complex when used by the enemy anti-radar missiles due to the introduction of protection equipment complex from the PRR (product 5M99, list of protective equipment for the C-125M air defense system);

increasing the reliability of SNR equipment, docking with new power supply system DES 5E96-A and RKU-N (lists 1P, 6M for air defense systems C-125M);

increasing the noise immunity of the radio control channel and radio sighting of missiles by increasing the power of the missile defense system, reducing time bringing the SNR to combat operation for up to 2 minutes, increasing the survivability of the missile defense command post for due to its removal from the UNV post by 100 m, improving the conditions for conducting combat work on the calculation of salary due to the redistribution of management bodies and signaling between the workplaces of combat crew personnel, reduction manual operations and automation of the selection of a number of operating modes of the control system (list of 8MR for the C-125M air defense system);

ensuring identification of nationality of aircraft and ships through the introduction of a ground-based radio interrogator type 75E6 (list 9MR for the C-125M air defense system and list 9MA for the C-125 air defense system).

In 1978, a modernized complex was put into service C-125M1 with a new modification 5V27D, the main characteristics of which similar to the characteristics of the C-125M air defense system, modified according to the 1M lists, 2MR, ZMR, 4MR, 6M, 7MR and 1P. This complex can also be further developed according to lists 8MR and 9MR.

Main characteristics of the C-125, C-125M and C-125M1 complexes are given in Table. 2.1.

Table 2.1

No.	Name of characteristics	SAM C-I25 with lists 23, 24, 25, 26, 29, 9MA with addition	SAM C-I25M with lists IM, 2ÿÿ, ZMR, 4MR, 6M, 7MR, 1R, SAM S-125M1 s list 9MR
1.	Height of the lower border of the zone lesions, m,	20	20
2.	Maximum heading angle target flight in the affected area at altitudes above 500 m (less than 500 m), town.	160 Mode "Dogan" (75)	160 Mode "Dogon" (25)
3.	Horizontal range to the closest border of the affected area, km,	3,5	3,5
4.	The upper limit of the affected area, km, RLC, without interference, Vc •300 m/s; RLC, active interference, Vc •420 m/s RLC, passive interference, SDC-2, Vc •560 m/s; TVC	18 8 8 11	18 10 (GSHN) 8 11
5.	Maximum horizontal range to the far boundary of the zone defeats, km Radar without interference, TVK; RLC, active jamming; Radar radar, passive interference, SDC-2.	17 13,2 13,2	17 17 (GSHN) 13,2

6.	Maximum targets speed hit, m/s Radar, without interference, towards (to catch up); RLC, active jamming or TVK; Radar, passive interference.	700 (300) 420 560	700 (300) 420 560
7.	Possibility of defeats maneuvering targets	Available, nc • 6 units. "ShchP" mode, without interference	Available, nc • 6 units. "ShchP" mode, without interference
8.	Equipment for protecting the complex from interference when using radar	SDC, MARU, switching frequency, averaging circuit, ARU-1, memory, logic	Same with the equipment. GSHN
9.	Anti-radar from missile defense	Tactical ways perestroika radiation parameters SNR	Same with the equipment. 5M99P
10.	Acquaintance state of accessory blocking purpose and of missile launch circuits by to their planes	With the help of NRZ SRC and NRZ 75E6	Same
11.	Possibility of hitting targets, flying under negative viewing angles, as well as ground and surface targets.	Mode "MV-2" (min = -2•) Earth Mode	Same
12.	Number and type of launchers installations	4-5P71 (twin)	4 – 5P73 (quadruple)
13.	Preparation time for launch, s	30	30
14.	Possibility of pairing with SRC	Available (P15 radar, P12, or P19, P18)	Same

2.4.2 Life cycles and continuity of missiles included in the composition SAM type S-125

The S-125 air defense system uses 5V24 and 5V27 missiles of various types modifications.

The 5V24 rocket (basic for all modifications) became the first Soviet solid fuel missiles. Its appearance is shown in Fig. 2.1.

Rice. 2.1 5V24 missile defense system of the S-125 complex on the launcher

Resolution of 1961, along with the adoption of the missile 5B24, the development of its improved model was officially ordered, designated 5B27. The main areas of work on missile defense systems were development of a new radio fuse and main engine at a fundamentally new high-impulse mixed fuel with increased density, which was supposed to increase its energy levels, ensuring expansion of the affected area of the complex while maintaining dimensions HUGE. Resolution of the USSR Council of Ministers No. 479-199 of May 29, 1964 rocket 5B27 was adopted.

The main differences between the new missile defense system and the previously created 5B24 were the new main engine with an insert charge of mixed fuel weighing 151 kg, fuse, safety-actuating mechanism and warhead weighing 72kg. Externally, 5V27 missiles were easily identified by 2 aerodynamic surfaces installed on the transition connection compartment behind the upper right and lower left consoles, providing a reduction in the flight range of the accelerator after its departments. After the steps were separated, these surfaces unfolded, which led to intense rotation and braking of the accelerator with a separation all or several stabilizer consoles and its random fall

The following modifications of the rocket were created:

- 5V27G - sealed;
- 5V27GP - sealed, with a close boundary of up to 2.7 km affected areas;
- 5V27GPS - sealed, with an approximate near zone boundary defeat, with a selection block that reduced the likelihood triggering of a radio fuse by reflections from local objects when shooting at low-flying targets;
- 5V27GPU - 5V27GP rocket with accelerated pre-launch preparation, which was achieved by supplying increased voltage but on-board equipment from a ground power source in pre-launch mode warming up the equipment (corresponding modifications have also been made pre-launch preparation equipment in the UNK cabin).
- 5V27D missile defense system with increased flight speed (provides fire goals "to catch up").

2.5 Analysis of the principles of constructing the basic modification of the S-125 type air defense system (S-125M1 air defense system)

2.5.1 General principles for constructing an air defense system

The air defense system of the S-125 (S-125M) type includes:

- ground-based missile guidance radar station SNR - 125 (SNR - 125);
- ammunition for anti-aircraft guided missiles;
- starting equipment;
- power supply system.

Block diagram of the S-125 air defense system and interacting means are presented in Fig. 2.2.

Rice. 2.2. Block diagram of the S-125 air defense system

Block diagram of the S-125M(M1) air defense system and interacting means are presented in Fig. 2.3.

Rice. 2.3. Block diagram of the S-125M (M1) air defense system

S-125(M, M1) air defense systems can fire 5V24, 5V27 missiles various modifications (see section 2.4.2).

2.5.2 Principles for constructing the S-125 missile guidance station

2.5.2.1 Purpose and composition of the S-125 missile guidance station

The S-125 missile guidance station (MSR) performs the following main functions: Features:

- based on data from external target designation means, detects a target;
- performs manual or automatic target tracking;
- launches, captures and automatically tracks a missile;
- puts the missile on a trajectory and points it at the target;
- transmits a remote cocking command to the missile radio fuse.

The SNR has the following main devices:

- synchronizer;
- transmitting device (target sighting radio transmitter);
- antenna-feeder system;
- receiving device;
- moving target selection equipment. Selection equipment moving targets (MTS) is designed to protect the station from interfering effects of signals from local objects and artificial passive dipole interference in all modes combat operation of the station, i.e. upon detection, manual and automatic target tracking. In SDC equipment the principle of coherent-pulse selection is used;
- system of indications;
- remote all-round visibility indicator;

• system for controlling the position of antennas and launchers;

• device for determining the coordinates of targets and missiles;

• low altitude mode support device;

• device for generating control commands and starting device;

• control command transmission device and radio transmitter missile sighting;

• intra-divisional communication and signaling equipment;

• operational control equipment;

• station power supply equipment;

• control panels.

All station equipment is located at the UNV antenna post (Fig. 2.4) and in the UNK cabin (Fig. 4, 5).

Rice. 2.4. a) CNV antenna post. view 1.

1- raster head of the UV10 antenna; 2 - UV10 antenna; *3* - UHF antenna; *4* - UV12 antenna feed; 5 — UV12 antenna

Rice. 2.4. b) CNV antenna post. view 2

1 - cabinet UV40M; *2* - UV20 cabinet; *3* — block UV561; *4* — UV100 block

The UV20M transmitting device is located at the antenna post, high-frequency part of the UV40M receiving device, transmitting antenna UV10 target channel, receiving antenna of target and missile sighting channels UV11, radio control antenna UV12 and angle power drive elements place and azimuth.

The UNK cabin contains a synchronizer and main signal amplifiers targets and missiles, control center equipment, display system, manual control units target tracking and missile control, automatic determination of target and missile coordinates, command generation device control, radio control command transmitter and starter device, radio transmitter for sighting missiles (request transponders).

Rice. 2.5. Cabin UNK

The location of the main equipment in the UNK cabin is schematic shown in fig. 5.

Rice. 2.6. Cabinet layout
in the UNK cabin

Power conversion and distribution equipment is installed in cabin UNS, part of the division.

The UNV antenna post is installed on the KZU-16 artillery carriage. For bringing into the stowed position and transporting the antenna post The CNV is divided into the UV500 antenna head and a carriage with a truss and azimuthal column using a special mechanism, installed on the antenna post. The UV500 head is transported by trailer UV600.

To transport the station, tractors and cars are used appropriate traction and maneuverability.

2.5.2.2 Station functional diagram

The composition and functional diagram of the station (Fig. 2.7) are calculated for work on only one target with the possibility of targeting one or two missiles at the same time.

The station in tracking mode adopts the space survey method using two flat beams scanning in two mutually perpendicular planes located at an angle of 45° to the surface Earth.

Rice. 2.7. Functional diagram of the SNR

Both beams (directional patterns) are formed by two receiving target and missile sighting antennas, mechanically rigidly connected and aligned so that the line of intersection of their scanning planes coincides with the bisector of the viewing angles of each antenna. Both antennas have common irradiator, which provides alternate scanning of two beams of receiving antennas with a frequency of about 16 Hz.

The space is irradiated by the transmitting antenna. Due to reception of signals reflected from the target and the transponder signal is carried out by each plane in turn, the receiving path of the station is common to signals received by an antenna scanning both in the F1 plane and in plane ÿ2.

Separation of signals across scanning planes required for generation of control commands is carried out in a coordinate-computing device.

Possibility of targeting two missiles simultaneously at one target is ensured by the presence of two sets of the following equipment: missile transponder signal receivers, coordinate determination units missiles, units of the device for generating missile control commands, as well as the ability of the radio command transmitter (RPK) to transmit two simultaneously independent groups of commands for each rocket (two control commands missile flight and one remote cocking command radio fuse in each group).

Both sets of equipment for missile signal receivers, coordinate blocks (UOK.) and control units (UVK) are the same

The responders installed on the missiles have the same working frequencies. Therefore, transponder signals from various missiles aimed given station, are selected only by range. For this purpose the second start rockets are fired approximately 4.7–5 s after the start of radio control the first rocket.

2.5.2.3 Synchronizer

Station synchronizer (reference voltage device) designed to generate reference voltages along the distance and in the corners, necessary to synchronize the operation of all main elements of the station.

The range reference voltage is a continuous series pulses, the repetition rate of which determines the sending frequency stations. Reference angular voltages are voltages whose frequencies equal to the scanning frequency of the antennas, and the temporary location is rigid associated with the position of the antenna radiation patterns in space.

The station synchronizer is divided into two functionally complete node: range synchronizer (UK77 and UK78 units) and synchronizer corner systems (UK79 block).

The main units of the range synchronizer are two tracking systems for periods T1 and T2, master oscillator, frequency divider and forming cascades that generate pulse voltages with the necessary parameters. It is used as a master oscillator LS generator.

A feature of the design of the range synchronizer is that the repetition period of range pulses is not determined by the device itself reference voltages, and the delay value of ultrasonic lines moving target selection equipment. In other words, the tracking period range pulses are adjusted to the size of the ultrasonic line delays. The range synchronizer generates stabilization pulses with variable repetition rate, which are supplied to the block of lines SDC delays. Stabilization pulses, passing the short and short delay lines long repetition periods (variable repetition rate) are received to the input of two tracking systems. To the tracking system of periods T2 and T1 impulses that have passed through the long and short arms arrive respectively delay lines. In addition, the tracking systems receive strobes stabilization generated by the coordinate determination device range from stabilization pulses passing through the direct channel of the device SDC.

The corner systems synchronizer (UK.79 block) is used to form angular reference stresses.

The block contains circuits for generating reference stresses of planes F1 and F2 and the circuit for generating local synchronization pulses.

To run angular reference voltage generation circuits pulses generated by antenna induction are used sensors. The use of antenna sensor pulses provides a rigid connection between the generated reference stresses and a certain angular the position of the corresponding antennas in the scanning sector. This eliminates the need for periodic monitoring and adjustment of the position of these voltages relative to the true position of the antennas, mandatory when any indirect formation method, which facilitates operation equipment and improves the accuracy of its operation.

The angle system synchronizer contains:

- generators of sawtooth voltages of planes ÿ1 and ÿ2;
- key voltage generator F1 and F2;
- reference pulse generator Fo;
- generators of F1 and F2 forms;
- headmistress pulse generator;
- blank generator e (25 *Hz).*

The starting voltages of the generators listed above, except form generator e and directrix pulse generator are rectangular voltages of the auxiliary generator or pulses, obtained by differentiating this voltage.

2.5.2.4 Transmitting device

Transmitting device of the target sighting channel

Transmitting device for target sighting channel (UV20M cabinet) designed to generate short-term high-frequency high power pulses.

The transmitting device is single-channel and is loaded by UV10 transmitting antenna.

Included in the transmitting device of the target sighting channel (UV20M) includes:

- modulator (blockUV21M);
- high-frequency block (UV23M1 block);
- magnetron;
- antenna equivalent (blockUV26);
- unit for automatically adjusting the frequency of the magnetron - APFM (unit UV24M);
- magnetron frequency tuning unit (UV25M1 unit);

• low-voltage rectifiers (UV121M1 unit);

• high-voltage rectifier (UV122M1 unit);

• external fans (unit UV27).

A simplified functional diagram of the transmitting device is shown in Fig. 2.8.

Rice. 2.8. Simplified functional diagram of the transmitting device

Missile sighting transmitter

The missile sighting transmitting device (UK20I cabinet) is used for generating sighting pulses and transmitting them via radio link to the board rockets.

The UK20I cabinet includes:

• pulse modulator (blockUK28);

• sighting transmitter (blockUK26);

• automatic frequency control system (UK24 unit);

• low-voltage rectifier (blockUK122);

• high-voltage rectifier (blockUK124).

The operation of the UK20I cabinet is controlled using a control oscilloscope (UK22 block) and wave meter located in the block automatic frequency control (AFC).

In addition to the units located in the UK20I cabinet, the transmitting sighting devices include an equivalent antenna (UK14 unit) and addition device (UK12 block).

Block UK 12, included in both the transmitting sighting device missiles, and into the transmitting device of control commands, provides the possibility of simultaneous operation of these devices on a common antenna.

The missile sighting transmitting device uses a system automatic frequency adjustment, similar to the AFC system radio command transmitter.

High-frequency pulses from the output of the sighting transmitter (block UK26) are supplied to the antenna switch, switching output transmitter for two types of loads: addition device (UK12 block) and antenna equivalent (UK14 unit). Between the output of the sight transmitter and the high-frequency switch turns on the coaxial insert, on which contains the diode heads of the power indicator and indicator envelope of high-frequency pulses, as well as two capacitive coupling probes, with the help of which part of the high-frequency energy is branched off from high-frequency path and is fed to the AFC panel mixer and wave meter.

Simplified functional diagram of the transmitting device missile sighting is shown in Fig. 2.9.

Rice. 2.9. Simplified functional diagram of the transmitting device missile sighting

To power the units, the UK20I cabinet has a power supply (UK122). The UK122 unit consists of three separate rectifiers:

- stabilized rectifier +250 *V,*
- stabilized rectifier -250 *V,*
- stabilized rectifier +150 *V.*

To power the modulator (UK28 unit) with a voltage of +850 V and smoothly With an adjustable voltage of 2-4 kV, the UK20I cabinet contains a UK124 unit.

2.5.2.5 Antenna-feeder system

The antenna-feeder system of the SNR-125 station consists of three individual antenna devices:

- transmitting and receiving antenna (UV10), intended for radiation high-frequency energy of the transmitter and reception reflected from the target signals in search and tracking mode;

- receiving antenna (UV11), designed to receive reflections from the purpose of signals and signals from the on-board transponder and channeling them to station receiver in tracking mode;
- antennas (UV12) for transmitting commands and transponder request signals (missile sighting channel).

The transmitting and receiving antenna and the command transmission antenna are attached to receiving antenna. Together they make up the antenna head and are installed on the base of the antenna post. Receive-transmit the antenna forms a needle-shaped radiation pattern with a width about 1.5° in both planes. The level of side lobes does not exceed 20 dB in the ±3° sector and 17 dB in the ±5° sector. SWR no more than 1.6. Coefficient gain 10,000. Polarization of the electric field vector is vertical.

The transmitting and receiving antenna consists of the following components:

- reflectors;
- bracket;
- raster head;
- waveguide path.

The receiving antenna device consists of two identical antennas, the radiation patterns of which are scanned in the F1 and F2 planes. Both The antennas are combined into one device - the UV11 antenna.

2.5.2.6 High-frequency part of the receiving device

High-frequency part of the receiving device of the SNR-125 station designed to receive signals from targets and missile transponders, their frequency selection, amplification and conversion of radio frequency pulses, blanking and gain control.

The high-frequency part of the receiving device is structurally designed in the form of a UV40M cabinet included in the UNV antenna post. Closet UV40M includes the following systems and blocks:

1. Receiving target sighting channel, which includes:

- high frequency amplifier (UV42FM unit);
- input device (blockUV43F);
- intermediate frequency preamplifier (block UV51-1).

2. Anti-fading target receiving channel, which includes:
   - input device (blockUV43M);
   - intermediate frequency pre-amplifier (UV51-block P).

3. Circuit for stabilizing the target local oscillator frequency with the device fast automatic adjustment of the klystron frequency (BAK), in which includes:
   - BAPC waveguide block (UV47 block),
   - electronic unit BAPC (blockUV48M).

4. Receiving channel for sighting the rocket, which includes:
   - high frequency amplifier (UV42FM unit);
   - input device (blockUV43F);
   - high frequency amplifier (UV42R unit);
   - input device (UV43RM block);
   - video signal pre-amplifier (UV52M unit).

5. Control and functional control scheme, in which includes:
   - waveguide control unit (UV342 unit);
   - electronic control unit (blockUV341).

6. Blanking and ASU schemes (blockUV341).

7. Power supplies UV141 and UV142M.

The high-frequency part of the receiving device has two receiving path: main receiving path (target sighting channel and channel sighting of missiles), working with a receiving-transmitting (UV10) and receiving

(UV11) antennas, and an anti-fading channel that works only with an antenna UV10.

Signals from the UV10 transmitting and receiving antenna are transmitted to high-frequency device through a ferrite separator (block ÿÿ23ÿ1), located in the transmitting device.

The UV23M1 block is designed for transmitting high-frequency energy transmitter into the transmitting antenna while protecting the receiving antenna devices from powerful pulses of the transmitter, for transmission to the receiving device for received signals, isolation between the transmitting device and antenna-feeder path, as well as for switching high-frequency energy from the transmitting antenna to the equivalent.

As power supplies for the high-frequency part of the receiving The device uses UV141 and UV142M blocks.

2.5.2.7 System of indications

The SNR-125 station display system includes three types indicator blocks:

- all-round visibility and launch zone indicator - UK31M unit;
- guidance and manual range tracking indicator - block UK32;
- indicators of manual tracking by angular coordinates F1 and F2 — two blocks of UKZZ.

In the cabin of the UNK there is also a remote circular indicator overview (VIKO), operating from a target detection station.

The UK31M unit, which is part of the UK60 cabinet, is intended for observation in modes of detection and guidance of target video signal marks, in tracking mode - marks of the far and near boundaries of the zone range damage, target trajectory marks and marks range to the missile's meeting point with the target. The block serves:

- to detect targets and point the antenna device at selected target in azimuth;
- to establish the possibility and determine the moment of start based on data from the launcher.

The UK32 unit, included in the UKZO cabinet, is intended for monitoring targets in detection, guidance and tracking modes and serves for perform the following functions:

- pointing the station's transmitting antenna at the selected target by the corner of the place;
- guidance of tracking systems of coordinate blocks on the selected a different target in terms of elevation and range;
- visual quality control of passive compensation fur and signals from local objects;
- manual tracking of targets by range;
- control of automatic target tracking for all three coordinates;
- monitoring the flight of the rocket and determining the results its launch;
- monitoring the position of the waiting gates by range.

UKZZ units included in UK30F1 and UK30F2 cabinets, used in manual target tracking mode. This mode used in a station in difficult conditions (presence of interference, group targets poorly resolved by the station, etc.), when tracking targets manual operator may be more reliable than automatic accompaniment. Observing target marks and using the steering wheels of the control units, combining these marks with vertical marks, the operator ensures that the system receives control the position of voltage antennas characterizing the angular target coordinates in a relative coordinate system.

All-round visibility and launch zone indicator (UKZ1M unit)

The all-round visibility and launch zone indicator performs two independent functions:

- displays target markings in detection and guidance;
- according to the launcher data in target tracking mode carries out indication of marks of boundaries of the affected area according to range, target trajectory and range mark to meeting point of the missile with the target.

Guidance indicator (UK32 unit)

The UK32 unit contains two cathode ray tubes with a magnetic deflection of rays - tubes I1 and I2, working as indicators television type with range (vertical) and angle sweeps (horizontal).

Manual tracking indicators (UKZZ blocks)

Two identical UKZZ units operate simultaneously in the station which are television-type indicators with sweeps range (vertical) - angle (horizontal). One of them is used for tracking targets along the F1 angle, the other - along the F2 angle.

The raster sizes of these indicators are: along the range (vertical) - 80 mm and along the angle (horizontal) -25 mm. The indicators use a tube with electrostatic beam deflection.

Remote all-round indicator (VIKO)

The remote all-round display indicator (VIKO) is designed for visual observation of targets within the station's coverage area target detection, to determine slant range and azimuth detected targets and to distinguish friendly aircraft from aircraft enemy by identification signals. The remote indicator works in complex with a target detection station.

VIKO includes:

primary repeater unit UK34;

all-round visibility indicator UK35;

tracking system amplifier unit UK36;

UK133 power supply.

VIKO equipment is located in the UKZOI cabinet of the UNK cabin.

Start pulses, pulses are supplied to the UK35 unit from the P-15 station distance and azimuth marks, identification signals and target signals.

2.5.2.8 Antenna position control system

The antenna position control system is designed to be installed antennas to specified angular positions in search and line alignment modes sighting of antennas with direction towards the target in guidance, manual and automatic tracking.

The combat operation of the station provides the following main modes operation of the antenna position control system:

- regime request objectives;
- guidance mode (H);
- manual tracking mode (MS);
- automatic tracking mode (AS);
- guidance mode in oblique planes (K);
- low altitude mode (LA).

In the search (guidance) mode, the space is reviewed by scanning the directional beam of the UV10 transmitting antenna operating for transmission and reception, in the vertical plane (scanning along e) and by rotating the antenna in azimuth and elevation. Antennas turn power drives.

Transmission (setting) of the angle is carried out using a single-scale selsyn connection. The drives are controlled from the UNK cabin steering wheels • and • guidance operator unit UK62.

Azimuth drive control also allows automatic carry out inspection of the space in all-round viewing modes (CR), large sector search (LSS) and small sector search (SME). The operation of the control system in these modes is ensured by the search mechanism. Search modes are switched by the search mode knob of the UK62 block. The antennas are swung in the sector search mode according to the sine law with with an amplitude of 10° and a period of 6.5 s (BSP) or with an amplitude of 1.5° and a period of 2.5 with (SMEs).

In all-round view mode (CR), the position control system antennas ensures antenna rotation in azimuth at a speed of 18 degrees/s.

In guidance mode (H), the antenna position control system provides the ability to roughly align the line of sight of antennas with direction towards the target with precision, allowing you to switch to tracking (manual or automatic).

In manual tracking mode (PC), drive control carried out from manual tracking units UK68 and UK68M. At accompanied by a mismatch between the direction to the target and the line sighting is determined by scanning the directional beam of two UV11 receiving antennas in the so-called oblique planes F1 and F2. Manual support operators evaluate this mismatch by indicators in the coordinates “F1—range” and “F2—range” and by turning the steering wheel you select it.

For the convenience of operators, the control system provides control from each of the RS blocks simultaneously by two power drives in such a way that the total rotation of the line of sight antennas occurs in the corresponding oblique plane. This opportunity control provides the presence of a coordinate converter.

Drive control in manual mode semi-automatic and carried out according to speed, adjusted for position.

In automatic tracking mode (AC) of the control device the position of the antennas ensures automatic line tracking sighting the antennas at the target position. In this mode the drives controlled by signals generated by angular coordinates blocks. The magnitudes of these signals are proportional to the mismatch between line of sight and direction to the target in oblique planes F1 and F2. Since this mismatch is worked out by rotating the antennas drives in the p and e planes, signals from the coordinate systems arrive at drive inputs through a coordinate converter.

In low altitude (LM) mode, the antenna system by elevation angle set to a constant angle determined by the MV selsyn setting block UK.92. Tracking with an antenna in elevation a target flying under sighting angle +1°, produced by the RS F1 helm. Azimuth drive is in AC mode.

The antenna position control system equipment includes the following cabin blocks UNK:

- guidance operator block (blockUK62);
- RS operator units (UK68 and UK68M units);
- voltage conversion and amplification unit (UK69M unit);
- power drive amplifier block (UK64M block).

In addition, the UK92 block contains a switching circuit and a synchronizer low altitudes, and at the UNV post there are blocks UV103M, UV210B, UV210E, UV250 F1 and F2 and two electric machine amplifiers included in antenna position control system.

Their purpose is to amplify the power of the control signal, coming from the UK64M unit, rotating the antennas in azimuth and elevation and generation of feedback voltages.

2.5.2.9 Launcher position control system

When tracking a target, the angular coordinates of the launchers contain the following components produced by the station equipment SNR-125: current coordinates of sighting antennas, lead corrections, parallax and sagging. Transfer of angle from the UNK cabin to each of launchers are produced using a two-scale synchro connections for each of the angular coordinates (• and •).

A complete set of launcher control systems, including which includes devices for generating current azimuth coordinates and elevation angle of sighting antennas, devices for generating lead angles • control and • control and devices for generating parallax angles of launchers, processes the coordinates of launchers in the form of rotation angles giving selsyn launchers.

The equipment of the launcher position control system includes installations include:

- block of amplifiers for drives of current coordinates of sighting antennas and lead drives (UK66 unit);
- parallax drive amplifier block (UK65 block);
- commander's block, in which electromechanical elements of all instrument drives (UK61M unit);
- unit for reverse control of the position of launchers (unit UK61A).

UK66, UK65, UK61M units are located in the UK60 cabinet. UK61 block located in the cabin (on the starboard side) near the fan cabinet.

Since the coordinates of the launchers must be generated station equipment in the form of rotation angles of the rotors of the producing synchronizers, in electromechanical stations are used to produce these angles tracking systems.

Devices for generating current coordinates are instrumented synchronous-following drives that work out rotation angles sighting antennas. The angle is measured using a synchro communications. To improve the accuracy of angle measurement in current drives coordinates, a two-scale connection with a gear ratio is applied between rough and fine selsyns 1:15.

Input data for controlling current coordinate drives are formed in accordance with the angles of rotation of the giving synchros, kinematically connected to the antennas.

Sync mismatch signal after pre-amplification the amplification stage of the UK66 block is supplied to the actuator (engine type ADP-123), which rotates the rotors kinematically the synchronous receivers associated with it in the direction of decreasing the angle mismatch. At the same time, the engine turns the synchronous sensors launchers.

The quality of operation of current coordinate drives is assessed by mismatch voltage of the synchronizers of the exact reference.

2.5.2.10 Coordinate determination device

Coordinate determination device (DOC) intended for generating data on the slant range and angular coordinates of the selected to hit a target and two missiles aimed at this target.

The target coordinate determination device includes the following: blocks:

- target range determination unit (UK71M unit);
- block for determining target angles (block UK73);
- installation and control unit (UK75 unit).

The rocket coordinate determination device includes the following: blocks:

- missile range determination unit (UK72 unit);
- rocket angle determination unit (UK74 unit).

The Low Altitude Mode Support Device (LAM) includes: the following blocks:

- block for generating target angular selective pulses and error watchdogs (block UK91);
- unit for forming angular rocket blanks and delaying them pulse directorate (block UK92).

Data on the coordinates of the target and two missiles is generated in the form pulses, the temporary position of which is relative to the reference The pulse voltage of the station determines the position of the target and the missile in relative station coordinate system.

Source of information about the position of the target and missile in space are the reflected target signals and the missile transponder signals, entering the coordinate device from the output of the receiving device stations. The nature of the target and missile signals is determined by the survey method space accepted in the station.

2.5.2.11 Device for generating control commands

The command generation device, which is part of the UNK cabin, intended for generating control commands K1, K2 for rocket flight when pointing it at a target, a one-time remote cocking command radio fuse KZ and command K4.

Commands K1, K2, KZ and K4 are transmitted to the rocket by a radio transmitter commands (UPK). The control commands K1, K2 and K4, through the autopilot, influences the rocket rudders, and the remote command arming of the radio fuse KZ ensures the activation of the radio fuse missiles are on alert.

The command generation device contains two identical sets blocks. The presence of two sets of blocks makes it possible aiming up to two missiles at one air target simultaneously.

Each kit includes blocks:

- block for generating error signals (blockUK81);
- lead block (blockUK82);
- command generation unit (UK83 unit);
- block for compensating for coordinate twisting (block UK86);
- voltage generation unit Fts±6 (UK89 unit), common to both command generation devices.

In addition to the indicated blocks, the set of command generation devices includes UK381M unit (control unit).

Two sets of UK.81, UK82 and UK83 units along with a power supply UK181 are located in the UK80 cabinet. The UK86 unit is located in the UK70TS cabinet, the unit UK381M is in the UK70 cabinet, and the UK89 unit is in the UK90 cabinet.

Control commands are formed through appropriate operations above the input data displaying angular coordinates and slant target and missile ranges, as well as target angular speeds.

The command generation device provides the ability to point missiles at a target using two methods: the lead method and the covering method goals (three-point method).

2.5.2.12 Command transmission device

The device for transmitting commands and requesting the responder performs the following functions:

- transmission of commands on board the rocket that control the movement of the rockets;
- transmission of one-time cocking commands to the missiles radio fuse;
- transmission of the transponder's request signal to the missiles.

In this case, control commands and transponder request signals are transmitted simultaneously on two missiles flying towards the same target. One-time command arming of the radio fuse is transmitted to both missiles sequentially.

Control commands are received at the input of the command transmission device in in the form of constant voltages, slowly varying within ±85V. By Only commands corresponding to the input signals are transmitted to the radio link. voltages from -50 to +50V. Voltages beyond these limits limited.

The transponder request signals are transmitted in the form of high frequency pulses synchronous with the probing pulses of the channel transmitter goals. Relative time arrangement of high-frequency pulses transponder request and probing pulses of the target channel are determined delay values in the paths for generating request and response pulses pulses and probing pulses of the target channel.

The command transmission device is located in two cabinets - UK20N (continuous transmitter of control commands) and UK20I (pulse responder request transmitter).

The UK20N cabinet includes the following units:

- encoder and modulator (blockUK23);
- command transmitter (blockUK25);
- automatic frequency control unit (UK27 unit);
- control decoder (blockUK21);
- high-voltage rectifier (blockUK121).

In addition, the command transmission device and the transponder request includes:

- equivalent (2 pcs.) - block UK14;
- addition device - UK12 block;
- antenna equivalent - UK15 unit.

2.5.2.13 Rocket launch device

The automated starter device is designed to determine the ability to fire at a selected target and automatically issue commands "Launch" of a rocket. The missile launch command is issued automatically or manually by the operator at the moment when the missile meets the target is located in the station's affected area. The rocket launch problem is solved based on determining the current range to the meeting point and the boundaries of the affected area. Current distance to the meeting point, as well as near and far boundaries affected areas are displayed on the all-round visibility indicator (block UK31M) in the form of concentric circles, the radii of which are proportional to the projections of the corresponding slant ranges onto horizontal plane. In addition, the indicator screen displays horizontal range of the target in the form of a point that leaves a trace when it moving.

Thus, the target's trajectory can be observed on the screen in the form of a line segment, which allows you to determine the course of the target.

The current value of the target parameter, speed and altitude is marked corresponding pointer instruments installed in the UK62 block.

The rocket launcher consists of five blocks:

- block for determining the range to the meeting point and target flight altitude (UK84M unit);
- block defined moment starts (block ÿÿ85ÿ);
- block for determining target course speed and target parameter (block UK87);
- block for determining the current slant range to the target in the mode "Three-point" (block UK88);
- all-round display and launcher unit (UK31M unit).

The UK84M and UK85M units are located in the UK70 cabinet, the UK87 unit is in cabinet UK30F1, block UK88 - in cabinet UK30F2 and block UK31M - in cabinet UK60.

The basis for solving the problem of meeting a missile with a target in the affected area based on the hypothesis of a uniform, straight flight of the target at at a constant altitude at a constant speed as you approach the station. It is assumed that the rocket moves uniformly to the meeting point, rectilinearly, with speed Vÿ, the value of which depends on the distance to meeting points.

To determine the moment of rocket launch, ensuring the meeting missiles with a target in the affected area, the device decides the result based on hypotheses, a formula for the distance to the meeting point and a series of equations, taking into account the limitation of the affected area.

2.5.2.14 Station power supply system

Conversion and distribution equipment located in the cabin UNS receives electricity of three-phase voltage 220V 50 Hz from standard power plants or from an industrial network. Part of it is transformed into high-frequency electricity of 400 Hz.

Energy of primary power supplies (220V 400 Hz, 220V 50 Hz) in cabin UNS division is distributed among consumers.

During the deployment and collapse of the station, as well as during breaks Between the main work, the switchgear receives energy from auxiliary power plant and issues it to consumers to ensure routine maintenance and for powering own needs (lighting, heating, ventilation, etc.), as well as for continuous heating of on-board batteries rockets.

The conversion and distribution equipment includes the following elements:

• frequency converter VPL-50 for converting three-phase voltage 220V 50 Hz to voltage 220V 400 Hz;

• voltage regulation unit BRN. The block works in conjunction with generator of the VPL-50 converter and serves for installation and maintaining generator voltage at a given level with precision ±2%;

• equipment for receiving electricity (cabinet 1), consisting of automatic machines AV1, AV2, AVZ and AV5 for connecting the main power plants and networks, automatic AB4 for connecting auxiliary power plants, control and measuring equipment, control equipment for diesel power plants and signal lamps;

• equipment for connecting and starting the motor of the VPL- converter 50 (magnetic starter unit) for connection to the network and step starting the converter in order to reduce inrush currents;

• power distribution equipment (cabinet 2), consisting of switches AB7 - AB12 to turn on the power to the cabin, post and PU at 50 Hz (of which AB8 is a backup), contactors KA1 - KAZ for turning on the power supply of the cabin and the post at 400 Hz (of which KAZ is a backup), start buttons, intermediate relays, signal lamps and control and measuring equipment.

During autonomous operation of the station in field conditions, the equipment conversion and distribution receives power from one or two main diesel power stations ESD-100. Enable and disable of power plants is carried out manually by automatic machines AB1 and AB2.

When operating from two ESD-100 power plants, the AB5 sectional machine can be in the on or off position. In the last In this case, power plants operate separately. guidance station, the converter and antenna post are powered from the second bus section, and launchers - from the first busbar section of cabinet 1.

Turning on the power supplies of the entire station, as well as raising the high voltage can be produced remotely (from the UNK cabin from the remote control unit UK.61M) or from the front panel of the corresponding rectifier.

All rectifiers are dry-type and air-cooled.

2.5.2.15 Communication system

Communication between all elements of the anti-aircraft fire complex missile division S-125, as well as the central communications post (UNK cabin) with the command post is carried out via the GTS system (loud-speaking connection). The central communication post is the UNK cabin.

GGS amplifiers, power supply to them and relays switching subscribers division, located in block UK63 of the UNK cabin.

The GGS system uses single-channel communication with the central amplifier. The operation of the GGS system is possible through one channel, the second channel is a spare (emergency). In this regard, in block UK63 there are two amplifier with corresponding rectifiers that are powered from the mains 220V 50 Hz.

2.5.2.16 Control panels

The station control panels contain elements allowing:

- control the readiness of the station equipment for centralized inclusion;
- centrally turn on and off the station and transmitter;
- establish modes of combat operation and control of the station;
- carry out centralized functional control video tract, RPK, SDC and radio tract;

• turn on the missiles for preparation and select the launcher installations;

• choose the desired guidance method;

launch missiles and return coordinate coordinates to their original state rocket and UVK blocks.

The front panels of the units are used as control panels UK161, UK61M, UK63 (UK60 cabinet), UK62, UK47 (UKZO cabinet).

2.5.2.17 Structural design of SNR-125

Antenna post UNV

The CNV antenna post consists of two devices: the base of the post UV550 and block heads UV500.

The base of the UV550 post includes the following assemblies and blocks:

• frame mounted on a KZU-16K carriage;

• farm UV554;

• lifting mechanism UV556 for raising and lowering the head blocks;

• azimuthal base with azimuthal placed on it reducer UV210B;

• current collector UV110;

• rotating platform with folding platforms;

• BlockUV561;

• input and output boxes UV101, UV102 and block UV103M;

• UV504 base with UV210E angle reducer, two spring shock absorbers and support.

A block head is attached to the upper part of the base of the UV550 post UV500, which includes:

• transmitting/receiving (anti-fading) antenna UV10;

• receiving antenna UV11;

• transmitting antenna UPK UV12;

• high-frequency part of receiving devices - UV40M cabinet;

• transmitting device - UV20M cabinet;

• simulator of missile transponder signals - UV343M unit;

• distribution box UV100;

• UV250 damping gyroscopes along planes F1 and F2.

Block head using azimuth gearbox UV210B has the ability to rotate in azimuth along with the rotating part of the UV110 current collector and the rotating platform. By elevation, the head can rotate within the working sector. At reaching the boundaries of the sector, the angle gear motor UV210E stops.

To balance the head when turning it in elevation, use spring shock absorbers. To level the base of the post, use jacks placed on the KZU-16K frame. Leveling is done by levels. When the post is in combat position, the folding platform and the ladder are down.

During routine, emergency and other work related to the need to inspect or repair equipment, head, folding the platform and stairs rise, their locking mechanisms are activated contacts. In this case, the power drives are automatically turned off. For routine maintenance of UV20M and UV40M cabinets is necessary pre-install the head in such a position in elevation, when in which the UV10 antenna is directed to the zenith. In this case, cabinets UV20M and UV40M occupy a position convenient for their maintenance.

When transporting the UNV post, the head of the UV500 blocks is lowered to trailer SMZ-925B using a lifting screw mechanism, established on the basis of the post.

Before laying the block head on the trailer, the antennas are removed from it UV10 and UV12, a waveguide connecting the UV10 antenna to the UV20M cabinet, and artillery panorama.

UV553 base with azimuth column and platform transported directly on a KZU-16K carriage.

The air filling system consists of a UV561 block fixed based on UV550, and the air supply path to the UV10 antenna and transmitter UV20M. Excessive pressure is created in the raster head of the UV10 antenna, in the waveguide path connecting the raster head of the UV10 antenna with cabinet UV20M, as well as in the UV23M1 block of the UV20M cabinet.

The UV561 block is located on the farm and is a cabinet with hermetically sealed doors. The cabinet contains two cylinders with dried with compressed air.

UNK coordinate-computing cabin

The UNK cabin equipment is mounted in a semi-trailer. Part The equipment located in the UNK cabin includes the following cabinets and blocks:

- cabinets UK30F2, UKZO, UK60, UKZOI, UK90, UK50, UK20N, UK20Y (on the starboard side);
- cabinets UK30F1, UK40, UK70, UK70TS, UK70R, UK80, UK 10 (according to left side);
- UK100M unit on the left side in the front part of the cabin;
- UK61A unit on the starboard side near the fan cabinet;
- blocks UK12, UKD4, UK15 in a compartment in the floor of the rear part of the cabin.

The cabinets in the cabin are mounted on a stand that serves as an air duct in cabinet ventilation system. Installed above the cabinets on the sides air ducts Cabinet ventilation system allows for pick-up and disposal air from both the cabin and outside.

To cool the cabin, four exhaust vents are installed in the roof. fan, and on the sides in the front of the cabin there are two windows for air intake into the cabin.

To connect the cabin with the antenna post and the system power supply there are four input boxes) located in the floor front of the cabin. Entrance boxes have hinged lids down, on which the connectors are marked.

UK14, UK15 blocks and the addition device are located in a compartment in the floor rear of the cabin.

The cabin has ten white lamps and two blue lamps, the activation of which is blocked with the opening of the doors. Provided emergency lighting with two lamps from a 12V battery.

List of the main equipment of the SNR-125 station, indicating functional name, code and quantity per set are given in Table 2.2.

Table 2.2

List of main equipment of the SNR-125 station

	Designation	Code	Quantities oh on set
ANTENNA POST I. Post		UNV	
base 1.	Base 2. Azimuth	UV550	1
	gear 3. Current	UV553	1
	collector 4. Block 5. Compressed	UV210B	1
	air block 6. Electric	UV110	1
	machine	UV103	1
	amplifier Block head 1.	UV561	1
	Antenna 2. Raster head 3. Antenna 4.	EMU-12AZa	2
II.	Scanning head 5.	UV500	1
	Antenna 6.	UV10	1
	Angle gearbox 7.	UV10-1	1
	Damping	UV11	1
	gyroscope 8. Junction box	UVP-8	1
		UV12	1
		UV210E	1
		UV250	2
		UV100	1

	Designation	Code	Quantities oh on set
III Sighting channel transmitting device	aims 1. Modulator 2. High-frequency unit 3. Antenna equivalent 4. Automatic frequency control unit magnetron - APFM (node 1, node 2, block power supply UV124) 5. Magnetron frequency adjustment unit 6. Low-voltage rectifiers 7. High- voltage rectifier 8. Fan unit	UV20M ÿÿ2ÿ UV23M1 UV26 UV24M UV25M1 UV121M1 UV122M1 ÿÿ27	1 1 1 1 1 1 1 1 1
IV High-frequency part of the receiving device	1. Receiving high frequency amplifier missile sighting channel 2. High frequency receiving amplifier target sighting channel 3. Anti- fading input device channel 4. Receiving channel input device missile sighting 5. Receiving channel input device target sighting 6. Waveguide frequency stabilization unit 7. Electronic frequency stabilization unit 8. PUCh target channels 9. Video signal pre-amplifier rocket channel 10. Power supply 11. Power supply 12. Waveguide control and monitoring unit 13. Electronic control and monitoring unit	UV40M UV42R UV42FM UV43M UV43RM UV43F UV47 UV48M UV51 UV52 UV141 UV142M UV342 UV341	1 1 1 1 1 1 1 1 2 1 1 1 1 1
IN.	Regulatory control unit	UV343M	1
COORDINATE COMPUTING CABIN I Manual control cabinet		UNK	
	1. Starting automatic block 2. Manual tracking indicator 3. Manual tracking block 4. Rc T/T determination block 5. Power supply	UKZ0F2 UK67A1 UKZZ UK68M UK88 UK132M	1 2 1 1 1 1

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	Designation	Code	Quantities oh on set
II. Guidance operator cabinet		UKZ0	1
	1. Power drive amplifier unit 2. Functional control panel 3. Guidance indicator 4. Guidance operator unit 5. Coordinate conversion unit 6. Power supply	UK64M UK47 UK32 UK62 UK69M UK131	1 1 1 1 1 1
III. Commander's closet		UK60	1
	1. Drive amplifier block 2. Communication block 3. All-round visibility and launch zone indicator 4. Commander unit 5. Parallaxer drive amplifier unit 6. Power supply	UK66 UK63 UK31M UK61M UK65 UK161	1 1 1 1 1 1
IV.	Cabinet for remote all-round display	UKZ0I	1
	1. Primary repeater unit 2. All-round visibility indicator 3. Tracking system amplifier 4. Power supply	UK34 UK35 UK36 UK133	1 1 1 1
V. Low altitude mode support cabinet		UK90	1
	1. Signal generation unit ÿÿ±•	UK89	1
	2. Formation block corner selective target impulses and sentry impulses error signals 3.	UK91	1
	Block for forming rocket corner blanks and pulse delays of directrixes 4. Power supply	UK92 UK191	1 1
VI. SDC cabinet		UK50	1
	1. Coherent local oscillator block 2. Phase detector block 3. Delay line block 4. First subtraction stage block 5. Second subtraction stage block 6. Selector block 7. Power supply	UK52 UK53 UK54 UK55 UK51 UK56 UK151	1 1 1 1 1 1 1
VII. Cabinet UPK		UK20N	1
	1. Decoder 2. Modulator and encoder 3. Command transmitter 4. AFC unit 5. High-voltage rectifier	UK21 UK23 UK25 UK27 UK121	1 1 1 1 1

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	Designation	Code	Quantities oh on set
VIII. Missile sighting transmitter cabinet	1. Switching panel 2. AFC unit and wave meter 3. Transmitter 4. Modulator 5. Power supply 6. High-voltage rectifier	UK20I UK22 UK24 UK26 UK28 UK122 UK124	1 1 1 1 1 1 1
IX. Manual escort cabinet	1. Automatic starting block 2. Manual tracking indicator 3. Manual tracking block 4. Vu and P determination block 5. Power supply	UKZOF1 UK67A1 UKZZ UK68 UK87 UK132M	1 2 1 1 1 1
X. Functional control and simulator cabinet	Stress generation block 1. intermediate frequency and interference signals 2. Target video signal generation unit 3. Target angle signal generation unit 4. Range signal generation unit targets 5. Rocket signal simulation unit 6. Coordinate conversion unit 7. Power supply	UK40 UK41 UK42 UK43 UK44 UK45 UK46 UK141	1 1 1 1 1 1 1 1
XI. Control and recording equipment cabinet	1. Block of matching devices 2. Power supply	UK10 UK18 UK19	1 1 1
XII. Cabinet definition coordinate rack	1. Missile range determination unit 2. Missile angle determination unit 3. Main missile signal amplifier 4. Power supply	UK70R UK72 UK74 UK59 UK171	1 2 2 2 1
XIII. Cabinet defined coordinate goals	I. Installation and control unit 2. Target range determination unit 3. Target angle determination unit 4. Automatic frequency switching 5. Main target signal amplifier 6. Torsion angle compensation unit 7. Power supply	UK70C UK75 UK71M UK73 UK57M UK58M UK86 UK171	1 1 1 1 1 1 1 1
XIV.	Reference voltage cabinet 1. Control panel 2. Block for determining the range of the meeting point 3. Block for determining the moment of launch 4. Range synchronizer 5. Angular systems synchronizer 6. Power supply	UK70 UK381M UK81M UK85M UK77, UK78 UK79 UK173	1 1 1 1 1 set 1 1

	Designation	Code	Quantities oh on set
XV.	Command generation cabinet 1. Error signal generation unit 2. Preemption signal generation unit 3. Control command generation unit 4. Power supply unit	UK80 UK81 UK82 UK83 UK181	1 2 2 2 1

2.5.3 Principles of constructing anti-aircraft guided missiles (SAM)

Purpose

Two-stage anti-aircraft guided missile 5V24 (5V27) is included in composition of the S-125 (S-125M, M1) anti-aircraft missile system and is intended to destroy manned and unmanned air attack weapons, flying at subsonic and supersonic speeds in the ranges of low and average altitudes on oncoming and catching courses. Hitting targets carried out by the high-explosive fragmentation action of the missile warhead.

The 5V24 (5V27) rocket is made according to a two-stage design with an axial accelerator. For the first time in domestic practice on an anti-aircraft controlled The rocket uses both starting and propulsion engines on solid fuel.

Composition, layout and basic data of the rocket

Rocket composition.

The rocket includes the following main functional parts: airframe, starting engine, propulsion engine, combat equipment, equipment flight control, air system, electrical system, source power supply

The rocket airframe includes the body, wings, rudders, stabilizers, braking planes, control mechanisms for rudders, ailerons and gear deployment of stabilizers. The glider serves to accommodate all onboard rocket systems and forms the required aerodynamic shape. Individual parts of the missile body are the warhead housing, the radio fuse and engines.

The starting engine ensures the launch of the rocket from the launcher and its rapid acceleration to supersonic speed, which ensures required efficiency of aerodynamic flight controls rockets.

The main engine provides a further increase in speed rocket flight, allowing you to obtain the required altitude and flight range at specified time to hit the target.

The missile's combat equipment ensures destruction of the target and consists of warhead, radio fuse and safety-executive mechanism (PIM).

The high-explosive fragmentation warhead hits the target with fragments, and when detonated at close range, it also has a high-explosive effect.

Radio fuse of pulse operating principle when a missile approaches target ensures the issuance of a trigger signal to the PIM.

PIM ensures, based on the activation signals of the radio launcher, the detonation of the warhead at the target, and in official handling protects against accidental ground and in-flight PIM has three independent stages of protection.

Flight control equipment ensures controlled flight missiles to the meeting point with the target in accordance with the chosen method guidance The equipment consists of radio control equipment and vizirovanija (RUiV) and autopilot.

RUiV radio equipment receives request pulses and commands guidance station control, transmits signals to the guidance station, allowing you to determine the position of the rocket in space, and converts guidance station commands into control electrical signals, which go on autopilot.

The autopilot converts control signals from the control devices into signals control of steering gears that deflect the rudders, which leads to performing a missile maneuver in accordance with commands from the guidance station.

Guiding the missile at the target is ensured by controlling it in two mutually perpendicular planes coinciding with the planes wings, which are called planes I and II control channels. The autonomous channel for stabilizing the missile in roll is conventionally called channel III.

The air system provides air supply to the steering gears autopilot and turboelectric generator during the entire flight. The air system consists of an air-reinforcement unit, distribution units, air ducts and consumers.

The rocket's electrical system integrates all onboard equipment into a single automated complex providing power, switching of electrical circuits during preparation, launch and flight of a rocket. The electrical system consists of switching equipment, pyrotechnic devices, on-board electrical network with electrical connectors and contact pads.

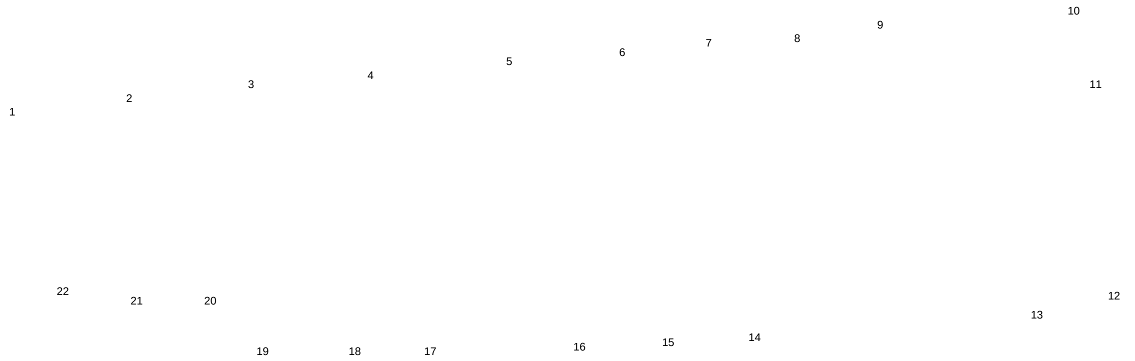
The power source on the rocket is a turboelectric generator, driven by compressed air energy.

Rocket layout.

The rocket is configured according to the “Duck” aerodynamic design, i.e. rudders are located in front of the wings. The wings and rudders are located in an X-shape under an angle of 45° to the vertical plane. On two wings, upper right and lower left in flight, there are ailerons to stabilize the rocket in go.

The starting engine (accelerator) is located behind the main engine engine on the same axis with it. The booster separates mid-flight. General form The rocket in a fully assembled state (first stage) is shown in Fig. 2.1.

The layout of the rocket without an accelerator (second stage) is shown in Fig. 2.10.



Rice. 2.10. Rocket layout without accelerator (second stage)

1 — transmitting antenna of the radio fuse; 2 — steering wheel; 3 — safety-actuating mechanism; 4— central distribution box; 5 - ampoule battery; 6 — block of radio control and radio imaging equipment; 7 — wing; 8 — rigging unit; 9 — transmitting antenna of radio control equipment; 10 — aileron; 11 - air-reinforcement block; 12 — nozzle of the main engine; 13 — detachable electrical connector to the accelerator; 14 — main engine; 15— aileron control rod; 16 — aileron control mechanism; 17 - reception

antenna radio fuse; 18 — autopilot unit; 19 - converter; 20 - warhead; 21 — steering mechanism; 22 – radio fuse block.

The body of the second stage of the rocket, which houses the combat equipment, flight control equipment, aerial and electrical The system is divided into five compartments.

Compartment No. 1 is a radio fuse. Front of the case radio fuse is made of radio-transparent material, it contains the transmitting antenna is located. Receiving antennas are located along the rocket body and are connected to the RV unit by high-frequency cables.

Compartment No. 2 is intended for installation of rocket rudders and mechanisms steering wheel controls. The mechanism consists of two independent kinematic circuits providing separate control of each pair of steering wheels, located in the same plane. In addition, the compartment contains radio fuse selecting block, short circuit device and delay block, which are not shown in the figure. At the rear end of the compartment on a special A safety-actuating mechanism is installed on the board.

Compartment No. 3 is the warhead. After joining compartments No. 2 and 3 the PIM detonator is located at the intermediate detonator of the warhead, which ensures reliable detonation of the warhead when the PIM is triggered. Before installation of warheads, the missile is equipped with a false shotgun section that simulates warhead in terms of dimensions and docking points.

Along the outer surface of the warhead body under the upper fairing an air duct to the steering gears, electrical wiring harnesses to radio fuse, steering gears and PIM. Under the side fairings the cables of the receiving antennas of the radio fuse are located.

Compartment No. 4 is designed to accommodate radio control equipment and sighting, autopilot unit, turboelectric generator, main part electrical equipment, air valve unit and control mechanism ailerons connected to the ailerons by external rods. For comfort installation and operation, electrical equipment elements are assembled in a block relay and central junction box. In addition, in the compartment housing No. 4, an on-board electrical socket is installed, through which electrical communication is carried out with ground control devices readiness for rocket launch. Along the sides of the compartment in special recesses The radio fuse receiving antennas are installed under the fairings.

Compartment No. 5 is the main engine. In the motor housing the powder charge is installed. Main engine nozzle is closed fairing.

The wings are attached to the engine body, two of them have ailerons. On the left upper wing (along the flight) there is a transmitting antenna and receiving antenna of RUiV radio equipment. For aerodynamic symmetry at the ends of the other three wings there are simulators transmitting antenna, and a plate is riveted on the right lower wing symmetrically to the receiving antenna. Along the main engine housing wiring harnesses connecting the electrical system components have been laid second stage with accelerator. The harness going to the accelerator on the left side of the flight, ends with a tear-off connector. Located under the right fairing limit switch. The rigging is welded on the top and bottom of the MD body ear.

The accelerator layout is shown in Fig. 2.11. Main part The accelerator is a starting engine equipped with a powder charge.

Rice. 2.11. Accelerator layout

1 - thrust cone; 2 — overload indicator; 3 — braking plane; 4 - screed; 5 - stabilizer; 6 - damper; 7 — rear cone; 8 — roller support; 9 — yoke; 10 — starting motor; 11 - pusher; 12— locking mechanism; 13 - tear-off connector

In addition to the starting engine, the accelerator includes stabilizers, rear cone, thrust cone.

The thrust cone serves to connect the accelerator to the second stage rockets. The cone rests with seats on the body shell and nozzle main engine. Shear bolts securely hold the second stage and accelerator in docked state.

On the thrust cone in the plane of the lower left and upper right wings have rotary brake planes with spring pushers and locking mechanisms. Installed outside on a cone overload indicator under the protective casing and breakaway connector plug.

Stabilizers are mounted in hinge joints on the rear bottom of the hull starting engine. They are pivotally connected to hydraulic dampers attached to the starting engine housing. For decreasing dimensions of the rocket until it leaves the launcher; stabilizers are folded and secured with a tie. On the engine housing rocket support units are located on the launcher: a front yoke and two rear roller bearings.

Basic weight data and geometric dimensions of the rocket

Weight	955 kg
including:	
second stage	425 kg
accelerator	530 kg
Length of the first stage (with stabilizers folded) 5948 mm;	
Second stage length	4132 mm
Position of the center of mass of the loaded rocket (from the toe)	3984 mm

2.5.4 Principles of construction of starting equipment

Starting equipment for the fire complex of the C-125 system (S-125M, M1) ensures the execution of missile transportation operations to the firing range position, loading (or unloading) launchers, pre-launch preparing and launching a missile at targets accompanied by a guidance station.

Power supply to the starting equipment is carried out autonomously from a mobile power station or from an industrial network.

The starting equipment includes:

- 4 launchers;
- 8 transport-charging vehicles;
- means of transporting launchers.

Launcher

The launcher is designed to install two (PU 5P71) or four (PU 5P73) missiles, synchronous antenna tracking guidance station system and automatic launch cycle missiles at the command of the guidance station operator. General view of PU 5P73 presented in Fig. 2.1.

Basic tactical and technical data of the launcher

Installation weight in stowed position	12500 kg
Weight in firing position	9700 kg
Maximum length in stowed position	9125
Maximum height	3625 mm
Maximum width	2640 mm
The transition time from traveling to combat position is not more	1.5 cups
Loading angle	3°30’
Electric drive pointing angles:	
by the corner of the place	t 3° to 64°30
in azimuth	without limitations
Maximum guidance speed from electric drives:	
by the corner of the place	
in azimuth	5 city/s
	13 city/village

The launcher includes the following main parts:

- swinging part - for installing two missiles resting on their
yokes and accelerator rollers on the guides of the swing beams
parts;
- a machine with casings (rotating part) - for placing equipment and launcher mechanisms and support for the swinging part;
- horizontal machine platform;
- base - serving as a support for the installation in the combat position and by cart during transportation;
- running gears;
- gas deflectors - to protect the soil near the installation from erosion gas jet during rocket launch;
- electrical equipment.

Electrical equipment includes system equipment and cables rocket launch control and synchronous servo drive equipment.

The launch control system equipment includes automation units (BA), on-board simulators and ground power supplies for on-board equipment rockets. The launch control system also includes preparation blocks missiles located in the cockpit of the guidance station.

The launch control system equipment provides remote preparation and launch of missiles in the required sequence with any installation; in the event of random faults in the circuits rocket or launcher, launch control system equipment provides automatic shutdown of faulty equipment with the issuance of corresponding signals to SNR consoles.

Synchronous servo drives provide remote guidance of all launchers from the UNK cabin in the required direction direction and returning the settings to the original charging position after launch of the last missile or when the readiness mode is removed from it.

Interlock circuits make it impossible to launch a rocket when mismatch between the launcher and the SNR antenna post by values of more than 25' and in the zone ban.

Transport-charging machine

The transport-loading vehicle ensures the transportation of missiles and loading (or unloading) the launcher with them.

The transport-charging machine is mounted on a vehicle all-terrain chassis. Rockets are mounted on the left and right beams the front part in self-gripping carriages, the rear part with grippers on beam trolleys.

In the transport position, the beams are secured with special ties; the entire vehicle with stowed missiles is covered with an awning, allowing carry out loading and discharging operations without removing it.

For charging, the transport-charging machine drives onto access bridges located near the launcher and strictly fixing the position of the TPM relative to the launcher.

The maximum speed for transporting missiles on highways is up to 50 km/h and dirt roads up to 30 km/h.

2.5.5 Principles for constructing energy supply facilities

The means of the system's fire complex can be provided power supply as autonomous from a special mobile power station, and from an industrial power supply network with a voltage of 220V and a frequency of 50 Hz.

In accordance with this, the composition of power equipment the complex includes:

- power distribution cabin;
- diesel power plant (ESD-100).

Distribution and power cabin UNS

The UNS distribution and power cabin performs the functions switchgear and power converter station for supply of fire complex equipment.

Power received from the network or diesel power plant 220V 50Hz through the cabin the ONS is distributed to various consumers (SNR, launchers, etc.). Using a VPL-50 three-phase converter current 220v 50Hz is converted into three-phase current frequency 400Hz for guidance station equipment and synchronous drives of launchers.

The remote control allows you to start and stopping the ESD-100 power plant and adjusting the voltage and frequency.

When collapsing and deploying the complex, power supply to its means can be carried out from an auxiliary power station with a capacity of 30 kW, also located in the UNS cabin.

Diesel power plant ESD - 100

Diesel power plant ESD-100 is the main source power supply of the fire complex; it is mounted in a special body on a MAZ-5207V low-bed trailer.

The station has two departments - diesel and operator's department.

A diesel-electric unit is installed in the diesel department power 100 kW, diesel control panel, two heaters type OV-65 and auxiliary equipment.

The control room houses control equipment and monitoring the operation of a diesel-electric installation. There are two installed here tank with fuel, ensuring the possibility of continuous operation of the diesel engine in for 12 hours without refueling. ESD-100 can operate in parallel with similar stations and industrial network.

2.6 Analysis of the principles of operation of the basic modification of the S-125 air defense system (S-125M1 air defense system)

2.6.1 General principles of operation of the air defense system

2.6.1.1 ADMC as an automatic control system

A complex is used to guide anti-aircraft missiles to a target. equipment that makes up the control system. All control systems anti-aircraft missiles according to the basic principle of operation are systems automatic control (AVR), i.e. closed-loop systems management. To explain the high efficiency of such systems, let us compare principles of operation of two main types of control systems - with open and closed loop control. Structural diagrams of these systems are shown in Fig. 2.12.

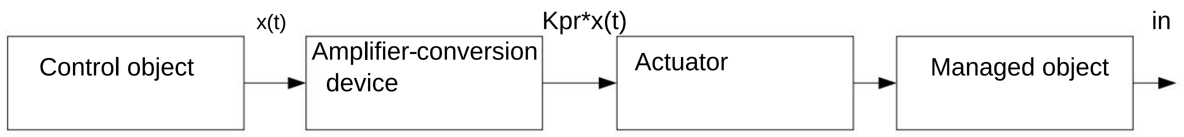
Any control system includes a control object (setting device) and the controlled object (load). The control object specifies input signal of the system *x(t)* is the law according to which it should control the load - change its controlled parameter. Actual the current value of this parameter during the control process is the result control - called the output signal of the system *y(t).* Management goal always consists in achieving the equality *y(t) = x(t).* Under the entrance and exit control system signals x(t) and y(t) are understood as non-physical signals at the input and output of the system, but only the information contained in them respectively about the required law and the actual result of management.

In a system with an open control loop (Fig. 2.12, *a)* the input the signal enters an amplifying-converting device, where is amplified and transformed to the form *Kprx({),* where *Kpr is* the coefficient transformations. This type of signal is necessary for control actuator (drive) of the system. Executive the device acts on the controlled object, changing it accordingly controlled parameter.

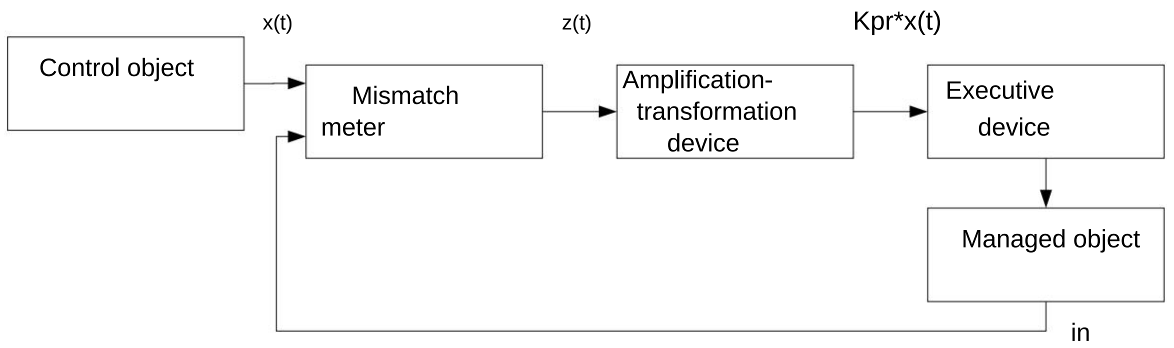
In a system with a closed control loop (Fig. 2.12, *b)* there is also mismatch meter, which is a comparing device (discriminator) of the system. For one meter input mismatch, an input signal is received, and the second input in the circuit negative feedback is the output signal of the system. In the meter mismatch, both signals are automatically compared, resulting in a mismatch signal (error signal) is generated equal to their differences:

$z(t)$ = x(t)-ÿ(t).

Feedback in the system is negative, since when Upon receiving an error signal, the output signal is subtracted from the input signal - weakens its effect.



a)



b)

Rice. 2.12 Block diagrams of control systems a) with an open control loop; b) with a closed control loop.

Mismatch signal through amplifier-converter and the actuator acts on the controlled object.

The presence in systems of the second type of mismatch meter and circuit negative feedback that closes the control loop and leads to a fundamentally new quality of management.

Indeed, in open-loop systems, control is produced only under the influence of the input signal *x(t),* i.e., without taking into account actual control result *y(t).* If for some reason control occurred with an error (the output signal as a result of control will not match the input), then *this* will not affect the behavior in any way systems. Therefore, precise control with this type of system possible only in ideal conditions, when there are no reasons for occurrence of control errors: if all elements of the system by themselves work absolutely accurately and are not affected by any external disturbing factors - interference.

In closed loop systems, control is carried out under influence of the error signal *z(t) = x(t) - y(t),* i.e., taking into account the actual control result *y(t).* Therefore, while this result is not corresponds to the input signal *x(t),* the control process continues and ends only when the error signal goes to zero, i.e. the control goal is achieved: *z(t)* = 0 at *y(t)* = *x(t).* Thus, if open-loop systems are indifferent to control error, then in In closed loop systems, it is the control error that is responsible for essentially the cause of control.

The air defense system is a closed-loop control system. The control object in this system is the goal, the input signal is its current coordinates (•ts, •ts, Dts), the controlled object is a rocket, the output signal is its current coordinates (•ÿ, •ÿ, *ÿÿ).* Meter mismatch and amplification-converter device are performed usually as a computing device for generating commands, executive the device is the rocket autopilot, which controls its rotation angles rudders. If control commands are transmitted to the rocket via a line telecontrol, then the actuator means all this line.

The current coordinates of the target and the missile are determined by radar methods and are entered into a computing device. In the latter happens continuous comparison of the same coordinates of the target and the missile, as a result what determines the mismatch signals for each coordinate •• = •ts - •r; •• = •ts - •r; •D = Dts - Dr. These signals, in accordance with accepted by the guidance method are converted into control commands, which, through the actuator acts on the rocket's rudders. Turning the steering wheels rocket changes the direction of its flight in such a way that the signals mismatches tend to zero (•••0; •••0; •D•0 at •c • •r; •c • •r; Dc • Dr), i.e. the missile is aimed at the target. Moreover, even unforeseen changes in input signal (target maneuvers) or output signal (demolition rockets by wind, changes in rocket motion parameters due to changes operating mode of its engine, atmospheric density, etc.) in principle not reduce the accuracy of missile guidance, since they only lead to corresponding changes in error signals, under the influence which continuously control the rocket.

Anti-aircraft missile control systems

Systems are used to control anti-aircraft missiles radio remote control, homing systems and combined systems.

There are also autonomous control systems that ensure the flight of the rocket according to a given program (pre-calculated trajectories) and are used to control ballistic missiles ground-to-ground class. Autonomous control of anti-aircraft missiles impossible, since when shooting at a moving air target The rocket's trajectory cannot be determined in advance. However, elements of autonomous controls are often used when guiding anti-aircraft missiles for stabilizing the position of the rocket in flight and setting its trajectory to the initial section.

Some elements of the control system are necessarily on board missiles, some may be located at the ground control point and called a missile guidance station.

1. Radio remote control systems

In radio telecontrol systems, the rocket is controlled using commands generated by the missile guidance station and transmitted to the missile via radio telecontrol line. Management commands are formed based on comparison of the current coordinates of the target and the missile aimed at it. These coordinates are determined using ground-based target sighting radars and rockets.

The most common command systems today are radio remote control and radio beam guidance systems.

a) Radio-television command system

This type of control system consists of:

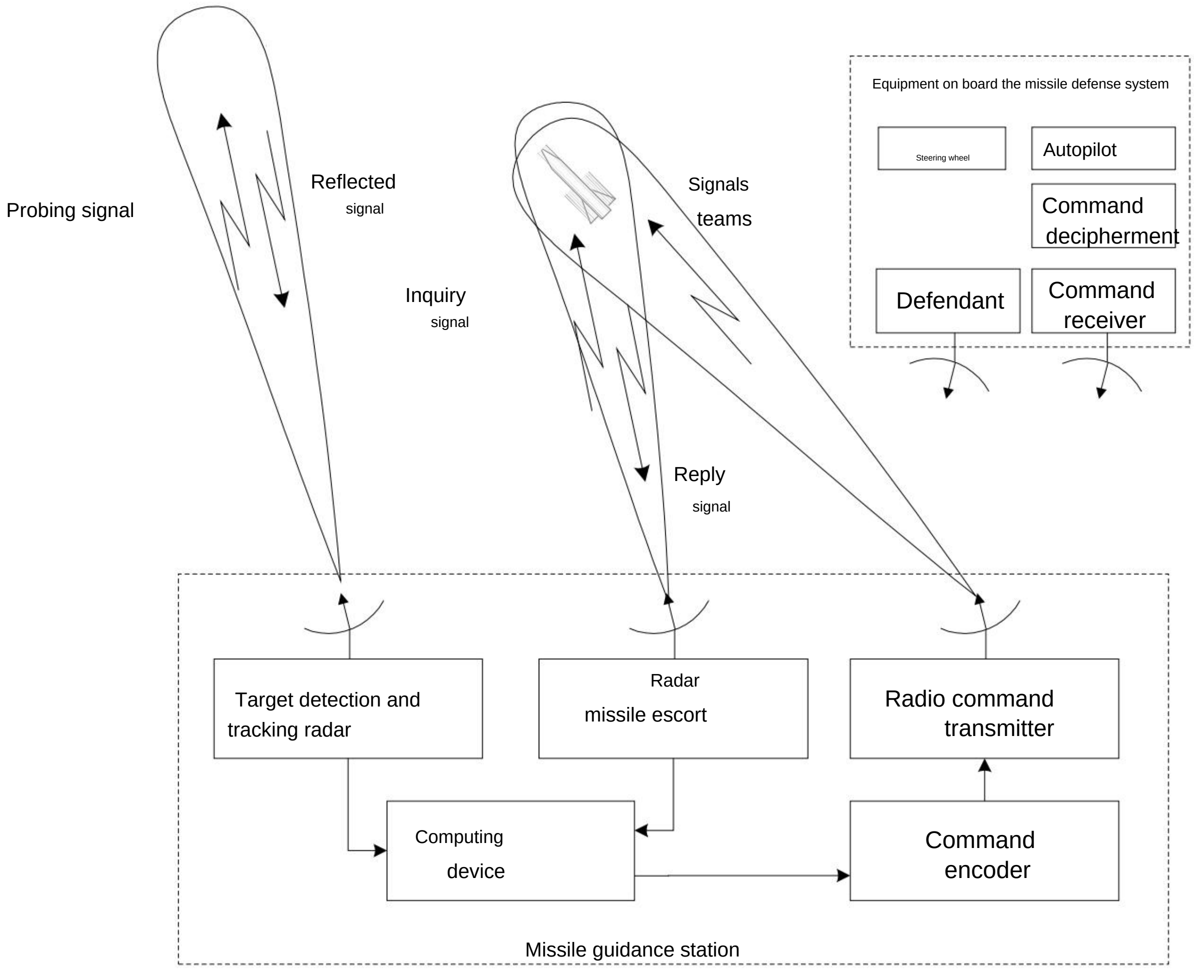
— radar sighting channel (determining coordinates) purposes;

- missile sighting radar channel;

— computing device;

- missile telecontrol radio lines.

The block diagram of the system is shown in Fig. 2.32.



Rice. 2.13 Block diagram of the command system radio remote control

The target viewing channel includes a ground-based radar with a passive response, which automatically accompanies the target to determine its current coordinates Using the same radar, a preliminary search is carried out and selecting a target, as well as determining the moment of missile launch.

The missile's sighting channel includes a second ground-based radar, which automatically accompanies the rocket to determine its current coordinates. Since the effective reflective surface of the rocket is small, it confident support on it is usually installed radar transponder. In this case, the missile sighting channel is an active response radar system. For ensuring selectivity (selection) on request and response and increasing noise immunity of this channel, request and response signals can be encoded and have different carrier frequencies. Typically, radar target tracking and missiles operate in pulse mode.

Commands must be transmitted via the radio telecontrol line simultaneously at all currently aimed missiles, and for controlling the trajectory of each missile requires two commands (current in two mutually perpendicular planes in which the rudders are located rockets). Therefore, the radio telecontrol line must be multi-channel.

To transmit information on the contents of commands (their sign and magnitude) command voltages generated by the computing device must be converted into radio command signals carrying this information. Information is transferred to radio signals through their modulation of command voltages. To separate line channels telecontrol and ensuring its immunity to radio signals commands, as a rule, are encoded - they are given additional encryption qualities.

In accordance with this, the radio telecontrol line includes:

at the missile guidance station

— a command encoder in which the selected method is implemented transmission of information about the contents of commands on board the rocket (carried out selected type of signal modulation by command voltages) and coding command signals;

— a radio command transmitter that generates radio signals; the envelope of which corresponds to the selected modulation method coding;

- a directional transmitting antenna through which radio signals commands are emitted in the direction of the rocket;

on board the rocket

— a receiving antenna that receives radio command signals;

- radio command receiver that amplifies and detects received radio signal;

- command decoder, in which commands are decoded (analysis of received signals for their compliance with the established code) and their demodulation (determining the content of commands by converting decoded signals into command voltages similar to the voltages on output of the computing device);

— autopilot, through which, under the influence of command voltages, the rocket's rudders are rotated accordingly.

Instead of two separate target and missile tracking radars in the system command radio telecontrol it is possible to use one radar, which must simultaneously accompany the target and the missile aimed at it. This the problem can be solved using the linear scanning method two fan rays in mutually perpendicular planes.

Radio command and control systems can provide simultaneous guidance of one missile at one target (be single-channel on target and missile), several missiles on one target (to be single-channel targets and “multi-channel” for a missile), several missiles for several targets (to be multi-channel by target and missile). Increasing the channel capacity of the system on a missile and especially on a target is associated with a corresponding complication missile guidance stations mainly due to an increase in the number radar sighting channels and radio telecontrol channels.

b) Radio beam guidance systems

In radio beam guidance systems, the missile is aimed at the target with using a control radio beam (“radiotropes”), on the axis of which it automatically kept in flight. This eliminates the need for formation of special management teams.

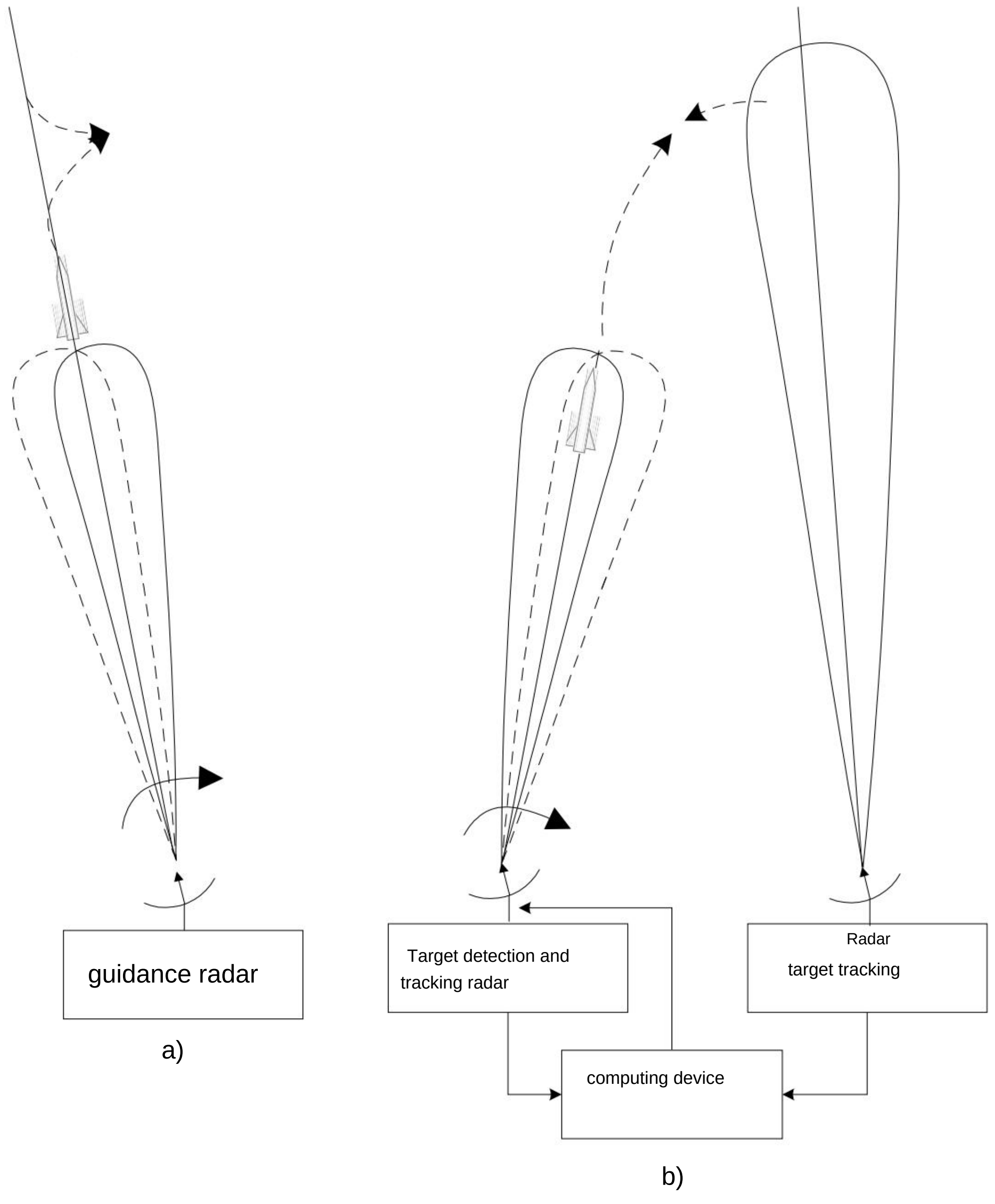
The radio telecontrol line of the system includes a radio transmitter guidance with a transmitting antenna that creates a control radio beam, and sensitive equipment on board the rocket that responds to deviation rockets from the axis of the radio beam. To receive the control radio beam it is usually the equal-signal method with conical development is used directional patterns.

The control equipment on board the rocket includes a signal receiver radio beam with receiving antenna, measuring (analyzing) device and autopilot.

The missile control loop error signal is used envelope of the amplitude of the radio beam signals received on the rocket, which contains information about the magnitude and sign of the missile's deviation from its axis radio beam - equal-signal direction. Error signal voltage is allocated in the measuring device, where it is then converted into two controlling in mutually perpendicular stress planes. The latter influence the autopilot, which turns the rocket's rudders so that it returns to the axis of the radio beam (in this case the error signal and control voltages tend to zero). Because the rocket is automatically kept on the axis of the radio beam, then the necessary changes the directions of its flight are provided by the angular movements of the radio beam, i.e., by rotating the antenna in azimuth and elevation.

To determine the necessary movements of the radio beam in the system there is a target sighting channel that can be combined with the channel management or separated from it.

In a system with a combined target sighting channel (Fig. 2.14, a) In principle, a single radar can be used, which automatically accompanies the target using an equal-signal method. Probing signals of this The radars simultaneously form a control radio beam. In progress automatic target tracking geometric axis of the antenna (equal-signal direction) is automatically aligned with the direction to the target, than At the same time, missile guidance is provided. This system is different its simplicity, but allows you to aim the missile only using the three-point method (the missile is kept on the target's line of sight at all times). Besides disadvantages inherent in this method, here the possibility arises irreversible departure of the missile from the radio beam (loss of control) during its sudden movements during automatic tracking of a maneuvering target.



Rice. 2.14 Radio beam guidance system: a) with a combined target sighting channel; b) with an autonomous target sighting channel

This possibility is practically eliminated in a system with autonomous target sighting channel, the presence of which allows you to guide the missile by the proactive method. Such a system has: target tracking radar, Missile tracking and guidance radar and computing device (Fig. 2.14, b). The first radar automatically tracks the target, the second - the missile, simultaneously creating a control radio beam for it. Information about the current coordinates of the target and the missile from the output of both radars are entered into computing device. The computing device solves the problem of the point where the missile meets the target and control voltages are generated, which affect the tracking radar antenna control system and missile guidance and set its elevation angle •a and azimuth •A. Turns the antennas of this radar provide the necessary movements of the controller radio beam to guide the missile to the meeting point. In this case, the combination of the axis control radio beam directed towards the target occurs only at the moment missile meeting target. In the process of guidance, since accompaniment targets are tracked by an autonomous radar, the control radio beam can move slowly and smoothly enough to prevent loss rocket control. There are no radio beam guidance systems devices for generating commands and a radio command transmitter at the point management. This is due to their simplicity compared to command commands. radio remote control systems. In addition, the system with combined target sighting channel (Fig. 2.14, a) allows without any complications of ground-based equipment to direct one at a time - control a radio beam has a fundamentally unlimited number of missiles. However, according to compared with command telecontrol systems, guidance systems radio beam have less immunity to interference, since they there is no coding of control signals, and the encryption quality radio beam signals is the conical deployment frequency, which easily scouted by the enemy. In addition, the enemy can use the control radio beam to guide it to the station guidance of their air-to-ground missiles.

2. Homing systems

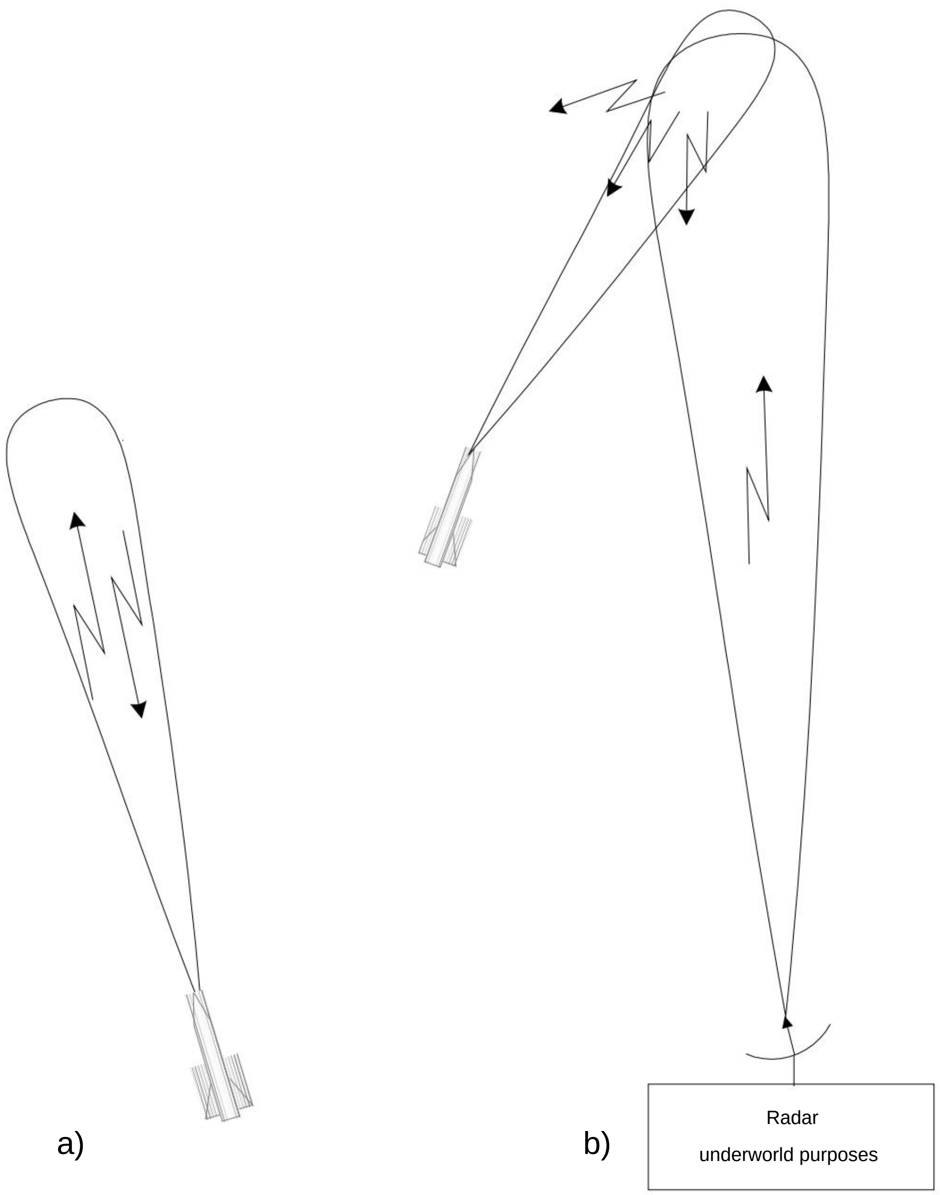
In homing systems, the missile is controlled using signals coming from the goal itself. These signals are perceived by the sensitive control equipment located on the rocket and called the head homing, which directs the missile to the target. Thus, homing is based on the difference in the physical properties of the target and the background (on target contrast).

Excessive sources can be used as control signals targets sound vibrations, light waves, infrared (thermal) radiation, electromagnetic oscillations of radio frequency.

The most common radar homing systems are in which radio waves are used as control signals, reflected by the target as a result of its irradiation. To the homing equipment missile radar systems include: target reflected receiver radio waves with a receiving antenna directed forward (toward the target); measuring device in which the angle between the direction is determined missile-target and either the missile's velocity vector, or the longitudinal axis of the missile, or some direction in a fixed coordinate system and control voltages are generated; autopilot, which is under under the influence of control voltages, turns the rocket rudders, directing it to the target in accordance with the selected guidance method.

At the location where the radio transmitter is installed, irradiating the target, radar homing systems are divided into active and semi-active. It is also possible to use passive systems (heads) homing, using as control signals the target's own (natural or artificial) radio emission. Since such systems do not artificially irradiate the target, which can be detected by the enemy, they are characterized greatest targeting secrecy

In active systems, the transmitter that irradiates the target is also located on a rocket. Consequently, in this case, there is placed on board the rocket entirely miniature radar that irradiates the target and receives reflected its signals (Fig. 2.15, a).



Rice. 2.15 Active (a) and semi-active (b) homing systems

In semi-active systems, the transmitter irradiating the target is located at on the ground, and on the rocket there is only a receiver of signals reflected by the target (Fig. 2.15, b). For continuous and effective irradiation of the target in this In this case, a ground radar transmitter (target illumination station) is used, which automatically tracks the target with its antenna. According to this

The radar can select the moment and initial direction of the missile launch, and The process and result of homing are also monitored.

Active systems are characterized by complete process independence homing from ground equipment. However, semi-active systems such as As a rule, they are more profitable in economic and energy terms. Indeed, firstly, in semi-active systems on a rocket less equipment is installed and, therefore, perishes along with it (no transmitter) than in active systems. Secondly, power and Directional coefficient of the antenna of the ground transmitter illumination stations can be much higher than for a miniature radar, located on the rocket. Therefore, the range of semi-active systems more than active ones. However, active systems become energetically more advantageous at short distances between the missile and the target due to approaching the target of the irradiating transmitter. Therefore use active systems is advisable if homing begins at a large distance from the missile launch point and a short distance from the missile to the target, i.e. on the final part of the rocket's trajectory.

3. Combined control systems

A comparison of telecontrol and homing systems shows that Each type of control has its own advantages and disadvantages. Yes, range the actions of telecontrol systems are greater than the range of even systems semi-active homing because the sensitivity of the receiver ground radar target sighting can always be made higher sensitivity of the receiver on board the rocket. Interference immunity of systems telecontrol (especially command) is higher than homing systems: telecontrol commands are encoded, which makes them difficult to reconnaissance enemy and the creation of effective targeted interference (in particular, falsification of commands), and the receiving antenna of the on-board equipment of the rocket directed “backwards”, towards the control point, which weakens the impact interference emitted from the target. When homing, the ability to encode control signals are very limited, and the receiving antenna of the equipment homing is directed “forward”, towards the target, which makes it easier creating interference for the enemy, in particular false targets (decoys). Finally, in telecontrol systems (especially in radio beam guidance systems) the equipment on board the rocket is simpler than in systems homing (especially active ones). However, the accuracy of telecontrol decreases with increasing distance to the target (mainly due to reducing the accuracy of automatic target tracking and increasing errors guidance). Homing accuracy increases as the missile approaches targets regardless of the distance to the target from the control point. According to these reasons, combined control systems are often used, in in which the advantages of different control systems complement each other.

A typical combination of methods for controlling anti-aircraft missiles is: telecontrol on the main and homing on the final section of the rocket's trajectory. This combination provides greater control range inherent in telecontrol and high probability hitting a target, which is ensured by homing. good noise immunity of such a system in the main part of the rocket trajectory is determined by the noise immunity of the telecontrol system, and the creation interference with the homing system is made difficult by the fact that this system is turned on only in close proximity to the target.

It should be noted that the combination of telecontrol and homing leads to a significant complication of the equipment on board the rocket.

2.6.2 Basic principles of operation of ground-based air defense systems

2.6.2.1 Basic principles of operation of the air defense system

The operating principle of the S-125 complex is shown in Fig. 2.16.

Rice. 2.16. Operating principle of the S-125 complex

The SNR-125 missile guidance station has four antennas: one receiving transmitting antenna UV-10, two receiving antennas UV-11 and one antenna UV-12 radio controls.

The UV-10 transceiver antenna is powered by the transmitter radioimaging. SNR-125 using the UV-10 transceiver antenna provides an overview of the space in the sector in elevation and azimuth. Indication of the air situation is carried out using an indicator all-round viewing with a radially circular scan, and an indicator guidance, on the screen of which the elevation angle is shown horizontally, and along vertical - slant range.

If a target appears in the viewing sector, a reflection will occur from it radio waves The signals reflected from the target are received by the transceiver antenna that forms a narrow directional pattern needle type.

After the target is detected, the guidance mode is carried out bisector of the viewing sector of the transceiver antenna at the target. After implementation of the guidance mode, the target is transferred to manual mode or automatic tracking. In this case, scanning (swinging) the beam The transmitting and receiving antenna is turned off, and the scanning of the receiving beams UV-11 antenna is turned on.

Receiving antennas form knife-shaped beams, width whose half power is equal to: in the scanning plane 1° and in plane perpendicular to the scanning direction, about 5°. Rays receiving antennas are scanned alternately in planes inclined to horizon at an angle of 45°, which reduces the influence of the earth on the formation beams and improves the conditions for separating signals reflected from targets, and signals reflected from the ground and local objects.

In target tracking mode (PC or AC), the needle-shaped receiving beam The transmitting antenna is held in the direction of the target. Reflected from target signals are received by the transceiver and receiving antennas. The signals received by the transceiver antenna are used to determining the range to the target, and the signals received by the receiving antennas — to determine angular coordinates in “oblique” planes.

This antenna operation scheme in tracking mode allows:

—avoid strong reflected signals from local objects, since they can only be irradiated by the side lobes of the diagram directivity of the UV-10 transmitting antenna;

—reduce distortion of the envelope of a packet of signals reflected from the target and missile responders;

— have the required viewing sector of the station along the missile sighting channel;

—increase the station’s potential along the target viewing channel.

Reflected signals from the target from the output of the antennas enter the receiving system

The signals received by the transceiver antenna are supplied in the form a continuous series of pulses to the input of the antifading receiver. Signals, received by receiving antennas are bursts of pulses, repeating the beam shape of receiving antennas. These signals are input main receivers.

In the receiving system, the reflected signals are converted and amplified and then go to the indicator device and determination device target coordinates.

Picture of the air situation in target tracking mode displayed on the screens of guidance indicators, manual tracking and all-round view.

When tracking a goal, its spatial coordinates in a relative coordinate system: slant range rts, angular coordinates ÿ1 and ÿ2.

To hit a target, it is necessary that the area where missiles meet it was in areas of controlled missile flight, where it is ensured high pointing accuracy. This area is part of the viewing area station and is called the affected area.

To ensure that the missile meets the target in the affected area, the missile is launched produced while the target is in a region of space called missile launch zone.

The SNR-125 station has an automatic start-up device that solves the problem meeting and determines the far and near boundaries of the affected area, as well as pre-emptive slant range to the point where the missile meets the target. The boundaries of the affected area and the lead range are displayed on the screen all-round visibility indicator in the form of concentric circles. Except In addition, the target course line is displayed on the PPI screen.

These images make it possible, using a tablet, installed at the PPI screen, select the moment of rocket launch.

When the target enters the launch zone, the missile is launched. Around SNR-125 station at a distance of approximately 70±10 *m* from the UNV antenna post there are four twin launchers connected synchronously servo drives with antenna system. This connection provides firing a rocket into the moving scanning sector of the SNR-125.

After launch, the rocket moves with the help of a powder accelerator, which resets around the 2nd second. After about 3 seconds the rocket enters the irradiated sector. Using radio control antenna The UV-12 emits request pulses from the onboard missile transponder. Wherein The missile transponder is periodically launched during its irradiation impulses of request. The missile's response signals are received by receivers UV-11 antennas. Missile transponder signals after conversion and gains by the receiving device are sent to the guidance indicators and device for determining rocket coordinates. When combined in time transponder signals with missile tracking pulses (waiting strobes) coordinate blocks “capture” rocket signals, and its automatic tracking begins.

During missile tracking, its spatial coordinates similar to the coordinates of the tracked target.

Device for generating commands SNR-125 based on difference data the same coordinates of the target and the missile aimed at it forms control commands.

The rocket's flight is controlled by two commands (K1, K2) in two mutually perpendicular planes.

From the output of the command generation device, control commands are issued to a command transmission device, where they are encoded and converted into radio signal.

Device for transmitting commands using a UV radio control antenna 12 emits radio control commands via a radio communication link to the rocket. Commands are received by on-board equipment, amplified and decrypted and go on autopilot. The autopilot processes control signals and, acting on the rudders, changes the direction of the rocket's flight in such a way so that the deviation of the rocket from the kinematic trajectory is minimized.

Missile control begins after automatic signal acquisition transponder tracking system of the coordinate determination device.

At the first stage of controlled flight, the rocket is launched onto the trajectory method, then the guidance process is carried out. Guidance process ends with the explosion of the missile warhead. Detonation of a warhead carried out by a radar fuse, which operates in pulse mode. To prepare a radio fuse for action on a missile a one-time command for remote arming of the radio fuse is given.

One-time command for remote arming of a radio fuse generated in the command generation device, converted by the device transmission of commands and the UV-12 antenna is radiated onto the rocket.

In the S-125 complex it is used depending on the shooting conditions two guidance methods: the method of half straightening the trajectory (method lead) and the three-point method (target covering method).

With these guidance methods, the formation of control commands (K1 and K2) rocket flight is carried out on the basis of mismatch signals h• and h•, representing the instantaneous values of linear deviation missiles from the trajectory of the guidance method in two mutually perpendicular planes. These error signals are generated in blocks devices for generating commands based on the differences between the target coordinates of the same name and missiles aimed at it: •r, •F1, •F2.

The radio fuse is triggered at a time when the distance (miss) between the missile and the target does not exceed 20 meters, and undermines the warhead a missile that hits a target with its fragments

2.6.2.2 Basic principles of operation of SNR-125

The SNR-125 station has two modes of viewing the space:

- search and detection of targets;

- pointing the viewing sector director and range gates at target;
- target tracking (manual, semi-automatic and automatic);
- launch and automatic tracking of the rocket.

Search and target detection

The space survey is carried out in a relative coordinate system (Fig. 2.17).

Rice. 2.17. Relative coordinate system of the SNR-125 station

In detection and targeting mode, overview of a given sector space is produced by a circular beam (transmitting beam) wide 1.5ÿ1.5° at half power level. The beam is deployed in the sector 10±x20° in elevation angle by uniform rotation of the raster irradiator heads, and in azimuth - by swinging the antenna column in a sinusoidal law. It is possible to perform circular rotation of the antenna post but azimuth.

The antenna post drive allows you to install the antenna head in within the range from minus 1 to 80° in elevation and in any direction in azimuth. Elevation and azimuth drives are controlled by guidance operators or manual support. In automatic tracking mode the drive can be controlled by station coordinate blocks. Control the drive is carried out from the UNK cabin.

The transmitting device located at the UNV antenna post produces short high-frequency pulses that are emitted target sighting antenna. Part of the energy of these pulses, reflected from target, received by transmitting and receiving antennas sighting of the target and through the receive-transmit switch goes to inputs of receiving devices. Here the target signal is converted into intermediate frequency pulses that are pre-amplified and are issued to the UNK cabin, where they are further strengthened. The amplified intermediate frequency target signal is fed to the detector directly or through moving target selection equipment.

From the output of the detector, target signals (video pulses) are sent to indicator and coordinate blocks.

The guidance operator searches and detects the target.

Goal search can be of three types.

1. *All-round view.* The antenna column rotates uniformly in azimuth at a speed of 18 degrees/s. In this case, there is an overview of the space within ±5° in elevation and 360° in azimuth.

2. *Sector search.* The antenna column swings in the direction specified by the operator guidance sector. The swing sector can be changed from ±10 to ±1.5°. In this case, there is a review of the space ±5° in elevation angle within swing sector in azimuth,

3. *Manual search.* The direction of the antenna system is determined position of the steering wheel • guidance operator unit. At the same time it may there is a view of the space within ±5° in elevation and arbitrary review (at the discretion of the guidance operator) in azimuth from speed not exceeding 18 degrees/s.

The target is detected by the all-round visibility indicator and the indicator guidance

In detection mode, the surround view indicator may have radial-circular or sector scan "azimuth - range" in depending on the search mode, and the guidance indicators are “angle elevation - range roughly" and "elevation angle - range exactly".

Aiming the viewing sector director and range gates at the target

The guidance operator, controlling the azimuth drive, sets specified sector, aligns the target mark with the center of the sweep sector "azimuth - range" of the all-round visibility indicator during sector search or achieves maximum brightness of the target mark on the indicators all-round visibility and guidance during manual search.

By controlling the angle drive using the handwheel • and position range gates using the steering wheel D, guidance operator guidance indicators with “elevation angle - rough range” sweeps and “elevation angle - range accurately” points horizontal and vertical sighting marks on the target mark. In this case, the vertical mark guidance indicator and position of the beam of the all-round visibility indicator characterize the position of the scanning sector director, and horizontal mark of the guidance indicator - position of the strobes range.

By aligning the crosshairs of the sighting marks of the guidance indicator with marking the target, the guidance operator stops scanning transmitting beam in elevation and azimuth (the beam stops at director of the review sector) and transfers control of the sector position scanning receiving antennas and range strobes for manual operators tracking (RS mode) or to coordinate blocks (AS mode).

In tracking mode, the target is irradiated by the transmitting non-scanning beam. Reflected target signals are received by the transmitting and two receiving antennas. Missile transponder signals are being received the same two receiving antennas.

Maximum radiation patterns of receiving antennas in the plane electric field vectors (in a wide plane) are shifted relative to bisector of the scanning sector of receiving antennas at a certain angle in side of the director's sighting.

The directrix of sight is a straight line shifted to vertical plane at an angle • below the bisector of the scanning sector receiving antennas. The receiving-transmitting beam stops on this straight line. antennas in target tracking mode.

When you stop scanning the transmitting beam or when you switch to or another tracking mode launching angular sweeps of indicators guidance is translated into pulses from receiving antenna sensors.

During manual tracking, each RS operator tracks the target along one angular coordinate using indicators with increased scale 3.5° along the angular coordinates of the F1 and F2 planes. Corner scans of RS operators along angular coordinates are triggered by pulses receiving antenna sensors. Manual guidance operator targets performs the functions of an operator of manual target tracking along range.

When aiming, manual and automatic target tracking coordinate blocks (UNK cabin) generate impulses to which target sighting marks (vertical marks) are rigidly attached to indicators. The location of these pulses (UOK pulses) relative to reference pulses associated with the mobile viewing sector of the receiving antennas, characterizes the coordinates of the target in the relative coordinate system, which is shown in Fig. 2.17.

Target tracking

From PC mode, the target can be transferred to automatic tracking, for which, by combining the sighting marks with the target mark, RS operators enable automatic target tracking. Wherein UOC impulses are disconnected from manual tracking organs and are connected to tracking systems of coordinate blocks, which carry out accurate automatic tracking along the coordinates rts, f1ts, F2C. However, in this mode and with automatic goal support, managing the position of the sector director scanning is carried out by operators of manual support according to F1 and F2. They hold the target together with the sighting marks on the headmistress scanning sector, i.e. in the beam.

In fully automatic tracking mode, drives controlled by station coordinate blocks. In the presence of passive interference and reflections from local objects the guidance operator enters into operation of moving target selection equipment, with the help of which the masking effect of interference and reflections from local items.

The station has a low altitude mode (LA), which serves for reducing the influence of the “mirror” signal on the tracking of low-flying aircraft aims.

In MV mode the following are performed:

- installation of the antenna system in elevation at a constant angle of 1° (angular coordinate blocks in AC mode, azimuth drive in AC mode);
- blanking of mirror signals through target and missile channels;
- introduction of angular “guard” strobes along the target channel.

After the target crosses the line of sight of the target (directress) the comparison circuit is triggered and prepares the switching circuits for control of the angle drive using the RS F1 steering wheel.

To eliminate active interference, a stepwise restructuring of the operating frequencies of the target sighting channel. Due to the operating frequency for planes ÿ1 and ÿ2 is the same, then the tuning for of these channels is produced simultaneously. Perestroika may be at the discretion of the guidance operator, both manual and automatic. If at work on the aircraft - active noise interference producer perestroika frequency does not lead to the desired result, then the guidance operator includes a noise smoothing circuit that allows perform accurate target tracking according to angular coordinates as manually (RS) and automatically (AS).

Launch and automatic tracking of a rocket

The starter device issues start permission, indicating ability to launch at the moment.

To determine the launch moment, the guidance operator is guided by information about the current coordinates of the target on the drive scales of the current coordinates (UK61 block), according to guidance indicators (UK32 block), indicator starting device (UK31M unit), as well as by instruments on the operator's console guidance (UK62 unit).

Having completed these operations, the guidance operator selects method of aiming a missile at a target.

The guidance operator can launch two missiles at intervals between starts, which is determined by the time from the moment of start to the moment the launched missile is captured. When firing in one gulp, the guidance operator launches a rocket from one of the channels, the second rocket is launched automatically upon the first capture signal.

Missiles are captured and guided automatically.

2.6.3 Basic principles of operation of missile defense systems

Rocket preparation modes

During the pre-launch preparation of a loaded rocket, located on the launcher, its onboard equipment can be in one of the following modes, which are provided ground automation and pre-launch preparation console:

- long standby mode;
- on-call mode;
- combat mode.

The indicated modes characterize the degree of readiness of the missile for combat use and differ in the number of on-board circuits live equipment. Availability of standby mode ensures accelerated preparation of the missile for launch in a combat situation, allowing at the same time to moderately consume the resource of the onboard equipment.

The time the missile spends in long standby mode is not limited. The time it remains in standby mode is limited operating life of the on-board equipment in partial switching mode, which is about 200 hours. Finding the missile in combat mode allowed for no more than 25 minutes, after which the missile must be transferred into long standby mode for 20 minutes.

When transferring a rocket from long standby mode to standby mode the first 1.5 minutes lasts for the equipment to enter the new mode. After that during the rest of the standby mode, the missile is in readiness mode No. 2. When transferring a missile from readiness mode No. 2 to combat mode, the onboard equipment enters the mode within 30 seconds, after which the missile is in readiness mode No. 1, allowing launch it immediately. Thus, in preparation for launch missiles from the long standby mode require at least 2 minutes, from ready mode No. 2 - 30 sec, from ready mode No. 1 start can be produced immediately.

Long standby mode

In long standby mode on the rocket from ground devices 26 V voltage is supplied for monitoring the safety circuit and for heating batteries. The passage of current through the safety circuit indicates serviceability of the safety-actuating mechanism of the radio fuse (about the presence of all stages of protection). In case of a circuit break Security automatically issues a missile malfunction signal.

The safety chain is monitored continuously until the missile is launched. If The ambient air temperature is below +5°C, then the battery is heated by all training modes; in this case, the battery temperature is adjusted according to within the range from plus 5 to 30°C with thermal relays installed in it, according to signals which open or close the heating circuit.

Standby mode

In standby mode, the filament lamps of the radio fuse are supplied with voltage 3.15V (half filament voltage); simultaneously on radio fuse is supplied with 26V voltage to lock the executive circuit providing initiation of the PIM electric detonator. This prevents its accidental operation.

The radio control equipment is supplied with a voltage of 6.3V to the filaments submodulation tube and transponder magnetron, requiring long warming up for about 1.5 minutes.

Battle mode

The missile is transferred to combat mode after at least 1.5 minutes: after turning on standby mode. At the same time, all radio equipment lamps control and radio fuse, filament voltage is supplied, the glow and anode voltage of the autopilot.

The autopilot gyroscopes are supplied with a voltage of 3x36V.

After 30 s of combat mode on the pre-launch preparation console the READY display No. 1 lights up and the START button is voltage +26V. At this point, the autopilot enters mode, and radio control equipment and radio fuse are prepared for rapid exit to mode (only anode voltages are not applied). If a rocket launch will not be carried out immediately after the READY number 1 indicator lights up, combat mode continues automatically and can last 25 minutes. By After this time, the ground equipment automatically transfers rocket into long standby mode. Return if necessary missile equipment from combat mode to long standby mode can be done manually by the operator.

Pre-launch preparation and rocket launch

The rocket is launched only from combat mode by pressing a button START. At the same time, automatic preparation of the rocket and control are carried out pre-launch operations; the starting circuit is closed only if execution.

After pressing the START button when the safety circuit is working radio fuse on board the rocket, the following operations are performed.

A voltage of 26V is supplied to the pyrochargers of the air-reinforcement unit. Air fills the pipeline system and enters the steering gears and ampoule battery. The electrolyte from sealed ampoules is squeezed into electrodes. The battery enters mode and produces a voltage of 26V. From battery voltage starts and enters on-board mode converter. When the converter voltage reaches 90V, The rocket equipment switches to onboard power supplies. At the same time, the anode voltage of the radio fuse is turned on and The free gyro of the autopilot will be released. When uncaged the gyroscope closes the block contacts through which the voltage is 26V prepares the circuit for turning on the PIM clock mechanism (the first one is removed protection stage) and the chain of squibs and propulsion engines. Simultaneously with these operations, a ready-to-start signal is issued, to which a voltage of 26V is supplied to the squibs of the starting engine. The engine starts and the rocket leaves the bow launcher. At the moment of descent the autopilot is switched to the “integral” mode and the anode voltage to the radio control equipment unit. All starting operations with the moment the START button is pressed until the missile leaves the launcher are completed in a time of 0.5-1 s.

When a missile leaves the launcher, the tie rod is crossed wire holding the stabilizers in the folded position. Under stabilizers “open” due to the action of inertial forces - rotate relative to the hinge point. Speed opening is limited by hydraulic dampers, impact at full opening is softened by a crushable aluminum pin. Disclosure stabilizers occurs in no more than 0.25 s.

Operation of onboard equipment in flight

At the starting part of the trajectory, the autopilot input is disconnected from the output radio control unit and a fixed zero command is sent to it (DC voltage 13V from voltage divider). During the time from before the rocket is launched, the autopilot stabilizes the rocket before the booster is reset relative to a fixed coordinate system, i.e. supports it constant position in roll and in the direction of the shot, improving “shooting” a missile into the beam of a guidance station.

When the rocket leaves the launcher and acceleration increases the inertial contactor of the safety-actuating device is triggered mechanism (the second stage of protection is removed). Through the closed contacts, the electric igniter is undermined, triggering the PIM clock mechanism. WITH At this point, the rocket's flight time begins to count.

At the launch site of the flight at the entrance of the onboard sighting unit radio control equipment begins to receive request pulses from ground station; The sighting unit transmitter sends to the ground response impulses. Thus, the rocket transmits data about its position in space before the accelerator is reset.

At the end of the accelerator operation, when the thrust of the starting engine drops and the longitudinal acceleration of the rocket decreases, the alarm goes off overload. In this case, the main engine squib circuit is supplied with voltage 26 V, the autopilot switches from the mode "integral" to "scale" mode, the autopilot input is connected to the output radio control equipment. At the same time, a command to turn on is given radio fuse transmitter modulator. To hide the work radio fuse before approaching the target, the transmitter modulator operates on equivalent. In this case, the radio fuse receiver is closed, which eliminates it triggered by active interference and other unforeseen reasons. IN At the end of the accelerator operation, the third stage of protection is also removed PIM (from voltage 26V in the safety actuator the electric igniter is triggered, ensuring the alignment of the axes of the transmission charge and electric detonator; after that upon initiation electric detonator, the entire PIM detonation circuit is triggered).

From a voltage of 26V, the squibs of the main engine fire, the engine starts and the second stage quickly separates rockets from the accelerator. In case of failure of the overload alarm the accelerator will begin to separate before the main engine starts, since it aerodynamic drag is greater compared to aerodynamic resistance of the second stage of the rocket. At the same time, the launch of the march engine and performing other operations listed above are provided by a limit switch, which is connected in parallel contacts of the overload alarm and closes at the beginning of separation accelerator

On the cruising leg of the flight to the receiving antenna of the equipment radio control continuously receives high-frequency command signals and ground guidance station request pulses. Request pulses start transmitter of the radio imaging unit, which through the transmitting antenna The on-board radio control equipment transmits response pulses to the ground. Command signals are converted into DC voltages, proportional to the required rudder deflection angle. These voltages through the autopilot they influence the rudders, deflecting them in the desired direction.

In case of loss of request pulses in the on-board equipment radio control, the "zeroing" circuit is triggered and the autopilot receives zero commands. When request pulses appear, it is restored normal operation of the radio control line.

Near the target, a long-range command is sent via radio link from the ground arming the radio fuse. This command is via on-board equipment radio control enters the radio fuse, providing switching transmitter modulator from the equivalent to a high-frequency generator and opening the receiver. When a target irradiated by a radio fuse hits area of space within the radiation pattern of receiving antennas radio fuse, high-frequency transmitter pulses reflected from targets, fall on the receiving antennas and enter the receiver radio fuse. Received impulses accumulate up to a certain level and open the executive circuit of the radio fuse.

The accumulation time of reflected pulses, called time delay and equal to several milliseconds, obtained by the corresponding selection of parameters of the executive circuit and along with the shape of the diagram directivity of the receiving antennas of the radio fuse ensures optimal coordination of the radio fuse with the warhead. After the start During long-range cocking, the missile manages to accumulate impulses fly such a distance and take such a position relative to the target that when the warhead is detonated, the best target coverage is ensured fragments.

When the executive circuit is unlocked, the radio fuse emits direct current pulse to the PIM electric detonator, which, through the transfer charge and detonator bomb undermines the warhead.

If a meeting with the target does not occur, then the PIM clock mechanism initiates the electric detonator at ÿpolmax±2 from the flight, after which it occurs self-destruction of the rocket (Tpolmax - maximum flight time of the rocket certain modification).

2.7 Analysis of the features of the principles of construction and operation of modifications of the S-125 type air defense systems supplied for export (Pechora-2M and Pechora-2A air defense systems)

2.7.1 Analysis of the features of the operating principles of construction and the Pechora-2M air defense system

Modernized anti-aircraft missile system "Pechora-2" with anti-aircraft guided missile 5V27D (5V27DE) - "Pechora-2M" is intended to combat low-flying and other types of targets, including made using Stealth technology, in simple and complex jamming environment.

The main elements of the Pechora-2M complex are assigned the following indices:

- missile guidance station SNR-125-2M;
- antenna post UNV-2M;
- equipment cabin UNK-2M;
- launcher (PU) 5P73-2M - for self-propelled version;

Modernization of the Pechora air defense system is carried out by updating bulletins of the means included in its composition (antenna post UNV, launch installation of 5P73) and replacement of the equipment cabin UNK (M) with a new one the UNK-2M control cabin being developed.

As part of a modernized anti-aircraft missile system "Pechora-2M" includes:

- modernized missile guidance station SNR-125-2M;

- missile battery SM-RB-125-2M;

The SNR-125-2M missile guidance station consists of a modernized antenna post UNV-2M and upgraded equipment cabin UNK-2M.

In a modernized missile guidance radar SNR-125-2M provides the ability to connect to one modernized equipment cabin, two modernized antennas posts

Modernization of the export version of the anti-aircraft missile system (SAM) "Pechora" and its modifications, carried out in order to improve it tactical, technical and operational, can be roughly represented by two in stages.

The first phase of development is currently underway modernized short-range air defense system "Pechora-2M" includes a list work performed in accordance with the Technical Specifications approved Commander-in-Chief of the Air Force January 5, 2000, cooperation of developers (customer - OJSC "Defense Systems", the main developer is JSC KB Kuntsevo) in the following areas:

- increasing operational reliability and resource recovery complex by transferring most of the equipment to modern element base;
- expansion of the affected area in conventional and complex jamming environment;
- automation of control of the technical condition of the complex;
- increasing the mobility of the complex facilities by installing fixed assets of the complex on automobile chassis (in self-propelled version);
- more convenient maintenance of complex facilities, reduction volume and time of maintenance work complex, reducing the number of service personnel;

• improving the ability to provide spare parts in over a long period of time;
• increasing the secrecy of the complex's operation by introducing a new teleoptical system (day/night);
• reduction in the number of inter-cabin connections, transition to telecode communication system;
• organization of digital exchange of information with means target designation and higher command posts;
• reducing the deployment (collapse) time of the air defense system.

At the first stage, the anti-aircraft guided missile system is also being modernized 5V27D rocket in order to improve its flight performance and increasing firing efficiency (index of modernized missiles - 5V27DE) and the radio-technical protection complex (KRTZ) with the purpose of protecting the SNR from attacks by Harm-type anti-radar missiles.

The second stage of modernization is planned after completion work of the first stage and aims to further build up combat capabilities of the modernized Pechora-2M air defense system through the introduction new technical solutions, also increasing its survivability in conditions the enemy's use of modern and advanced reconnaissance and WTO by implementing the mobile properties of the complex in combination with using special means of disguise and imitation.

The first stage of modernization of the Pechora-2M air defense system provides modification of the SNR-125-2M missile guidance radar and missile battery SM-RB-125-2M.

The modernization of the missile guidance station involves an antenna post (UNV) replacement:

input receiving device (UV-40M cabinet), made on lamp devices, on a microwave module made of solid state technologies;

television optical equipment 9ÿ38-1, on electronic optical system (day/night), providing automatic target tracking;

mechanism for lifting the antenna using a hydraulic mechanism;

control system for the drive of the antenna system, made on lamp devices, for equipment made on a new modern element base.

In addition, the antenna post provides for the introduction of modern element base:

target detection and tracking channel receiving device;

receiving device for the missile acquisition and tracking channel;

devices for tracking and determining the coordinates of targets and missiles;

devices for generating missile control commands;

transmitter of missile control commands and missile request;

station synchronizer;

digital moving target selection system;

equipment for protection against special types of interference;

equipment for automatic compensation of active noise interference covering side lobes of the radiation pattern of the UV-10, UV-11 antennas;

telecode communication equipment for exchanging information with modernized equipment cabin of the complex;

functional control equipment;

target range determination devices (laser range finder);

means of autonomous power supply (for UNV-2M).

The following are not subject to modernization at the antenna post:

radio transmitting equipment;

antenna system;

current collector;

drive actuators.

The first stage of modernization involves the introduction of modernized radar station, new equipment cabin on based on the KK.6 container body with new equipment consisting of:

automated workstation for anti-aircraft missile commander division;

automated workstation for launch officer;

automated guidance officer workstation;

telecode communication equipment for exchanging information with modernized antenna post, modernized launchers installations, detection and target designation means, higher command posts;

operator training equipment;

life support systems;

set ZIP-0 and ZIP-1;

means of autonomous power supply.

When connected to one upgraded hardware cabin, two modernized antenna posts, it is additionally equipped automated guidance officer workstation.

Modernization of the missile battery includes:

equipping 5P73 launchers with preparation devices and ensuring the launch of missiles on a new element base;

equipping 5P73 launchers with digital communication channels information with the coordinate-computing cabin UNK;

installation of modernized 5P73 launchers for two missiles type 5V27D on off-road wheeled chassis;

equipping 5P73 launchers with autonomous means electricity supply

Modernization of the 5P73 launcher in self-propelled and container option provides for the introduction into the modernized launch installation of the following tools, made on modern elemental base:

digital equipment for starting automation;

telecode communication equipment for exchanging information with modernized equipment cabin of the complex;

functional control equipment;

launcher drive control processor.

The following are not subject to modernization on the launcher: current collector; actuators of the launcher control drive; secondary power sources for missile defense systems.

Upgraded self-propelled launcher 5P73-2M placed on a vehicle chassis with an autonomous source electricity supply When upgrading the 5P73 launcher for self-propelled version excludes two guide beams.

Self-propelled launcher installation 5P73-2M provides transportation of missiles.

Modernization of the 5V27D anti-aircraft guided missile provides for:

- modernization of the SAM launch accelerator;
- modernization of the warhead of the missile defense system;
- modernization of the SAM radio fuse.

Modernization of the 5V27D missile defense system is carried out according to a separate technical task. The index of the modernized missile defense system is 5V27DE.

Management of assets of the modernized air defense system "Pechora-2" carried out from a modernized control cabin (UNK-2M).

The UNK-2M control cabin provides:

signaling the readiness of air defense systems for centralized activation and operating modes of air defense systems;

centralized inclusion and shutdown funds modernized air defense system;

alarm system for centralized switching on and off of funds modernized air defense system;

transferring the air defense system from standby mode to combat mode and back;

selection and indication of synchronization with any of the 8 modernized launchers;

signaling the execution of commands for preparing missiles and finding the line firing of launchers in prohibited sectors;

control of missile preparation and launch;

control of missile guidance and firing results.

The equipment of the modernized Pechora-2 air defense system will include telecode and voice communications. Communication lines must provide transmission of alarm, operational command and technological information. Between the means of the modernized air defense system there must be communication via radio (wireless) and wired (cable) is provided.

The modernized Pechora-2 air defense system provides for the adoption of measures protection against organized interference. Radar and optical means The Pechora-2 air defense system will provide detection and destruction of weapons air attack by the enemy under the influence of active and passive interference of cover and self-cover.

The modernized Pechora-2 air defense system provides technical measures to increase noise immunity, including through the introduction automatic active interference compensators operating along the side lobes, digital system for selecting moving targets and equipment for protection against special types of interference.

The modernized air defense system will provide the ability use funds radio engineering protection from anti-radar shells.

A distinctive feature of the Pechora-2M air defense system is the presence in it two antenna posts. This technical solution will provide tracking up to two targets and up to four missiles simultaneously. Besides, it will be possible to provide distance measurements to the director active noise interference, which is accompanied by two antennas posts according to angular coordinates. Determining the range to the PAP can carried out using the triangulation method.

Ways to modernize the Pechora-2M air defense system:

- use of ECO as an independent support channel goals.
- shelling of group targets using optical channel data.
- increasing the accuracy of missile tracking at the final stage flight.
- use of a thermal imaging station as part of the air defense system target detection operating in the far IR range.

Analysis of the features 2.7.2 operating principles of the Pechora-2A air defense construction and system

Modernization of the Pechora air defense system carried out by OJSC Central Design Bureau Almaz, aimed at extending deadlines operation, increase operational and tactical and technical characteristics modernized S-125M1 "Pechora" air defense system based on replacement of the analogue one equipment to digital.

Name of the modernized model - S-125M2A air defense system ("Pechora-2A")

Modernization of the Pechora air defense system is carried out through modernization missile guidance radar (SNR) and anti-aircraft guided rocket (LARGE) 5B27D.

Modernized anti-aircraft missile system "Pechora-2A" with modernized anti-aircraft guided missile 5B27E is designed for combating low-flying targets and massive modern and promising means of air attack, including made using Stealth technology, in various interference environments, in any time of day, in various climatic and meteorological conditions conditions.

Modernization of the SNR is carried out in the following directions:

- extension of service life;
- improving the operational characteristics of the system, including:
- improving combat crew training equipment
- partial automation of the combat crew work process;
- increasing reliability;
- reducing the volume of routine maintenance;
- reducing electricity consumption;
- expansion of the affected area due to modernization of methods missile guidance
- increasing missile guidance accuracy and probability of destruction targets, including at low altitudes;
- increasing detection and tracking capabilities targets in conditions of intense passive interference and reflections from underlying surface;
- increasing detection and tracking capabilities targets in conditions of intense active interference;
- introduction of automatic target acquisition and tracking in TV channel;

At the preliminary design stage, the possibility of further modernization of the Pechora air defense system in the following areas:

- improving the operational characteristics of the air defense system due to replacement microwave electrovacuum devices (TWT, etc.), main amplifiers target and missile signals to solid-state ones, as well as replacing other components (relays, connectors, EVP, etc.);

- further improvement of missile guidance methods and overview of the space.
- increasing the survivability of the combat crew of air defense systems due to the introduction remote workstation (remote control) with remote control means of air defense systems;
- increasing the survivability of air defense systems by reducing the background of the diagram directivity of the SNR antenna and unmasking signs in IR and visible ranges of light waves;
- integration with the S-300P air defense system of various modifications and air defense systems "Volga" into a single complex in order to increase noise immunity and mutual cover;
- increasing the characteristics of the complex under application conditions intense active interference and PRR due to the introduction of laser rangefinder, day and night TV channel and/or thermal imager for detection and tracking of targets at night;
- increasing system mobility by reducing cable communications and placement of air defense systems on transported (towed) platforms;
- introduction of the modernized 5V27E missile defense system;
- deeper consistent modernization of the remaining SNR equipment and the introduction of a new missile.

Modernization of the 5V27D anti-aircraft guided missile (individually TTZ) is carried out for the purpose of:

- extension of its service life;
- improvement of flight performance;
- increasing the efficiency of hitting targets.

Composition of the Pechora-2A air defense system

The Pechora-2A air defense system includes:

- modernized missile guidance radar

  SNR-125M2A consisting of:

  - o CNV antenna post;
  - o modernized equipment cabin UNK-M2;
- rocket battery consisting of:
- up to 4 launchers 5P73P;
- up to 8 transport-loading vehicles PR-14AM;
- power supply system (power station 5E96A and

  distribution and conversion cabin RKU-N).

The Pechora-2A air defense system is being created on the basis of the Pechora air defense system by modifying it according to the ballot. The cabin included in the SNR is undergoing modifications. UNK-M1. The name of the modernized cabin is UNK-M2

Modification of the UNK-M1 cabin is carried out by:

a) replacement of analog equipment:

- target and missile coordinate determination devices (UOK),
- command generation devices (CDD),
- starting device (PP),
- station synchronizer, simulator (TR),
- subtracting devices SDC,
- antenna position control systems (APCS),
- control and indication devices SNR,
- functional control equipment (FC)

for digital equipment;

b) improvements to the equipment that provides low altitude mode (MB);

c) retrofitting the UNK-M1 cabin with digital devices:

- coherent accumulation of radar signal (CS),
- a device for determining target coordinates in a TV channel (POK),
- special computers (SV),

• equipment for in-station measurements (ISI) and documentation (AD);

The Pechora-2A air defense system will provide automatic (or on command operator) capture and automatic tracking of a television target optical channel.

The Pechora-2A air defense system will have NLC tracking errors in conditions there are fewer specular reflections from the underlying surface than air defense systems "Pechora". Target tracking errors for these conditions are clarified during tests.

At the preliminary design stage, proposals for reduction of systematic and fluctuation errors of automatic tracking targets and missiles, including against the background of reflections from local objects and passive interference, as well as NLC in mirror conditions reflections from the underlying surface.

Errors in target tracking in TV mode of a modernized air defense system "Pechora-2A" compared to the "Pechora" air defense system will be reduced.

The Pechora-2A air defense system is expected to have an increased level of automation processes of combat work of combat crews, including through improvement display of combat information.

The modernized air defense system will include measures to elimination of missiles in emergency situations (in case of “non-capture” of a missile or loss missile control), as well as in case of “non-explosion” of the warhead at the target, taking into account security of ground facilities.

In the modernized missile guidance station of the Pechora-2A air defense system an on-site measurement system (IMS) is provided and the possibility of their documentation is provided.

A set of VSI and documentation tools will provide playback of recorded information, as well as receiving in any point in time of the necessary express information.

The launch device of the modernized missile guidance station will be provide automatic generation of the following information:

- the form goals (·,·,R,H,V,P);
- parameters of the affected area (RD, RB, RG RDG, RBG);
- current range to the missile meeting point (RB, RBÿ) with the target after capturing the target for tracking in no more than 2 - 2.5 s.

The modernized Pechora-2A air defense system will take protection measures against the following types of interference:

- active interference:
  - continuous noise (targeting, barrage, sliding, intermittent);
  - response noise narrowband and broadband;
  - response pulse multiple;
  - response pulse single (leading in range, speed and angular coordinates);
  - chaotic impulse;
  - misleading.
- passive interference.

3 ASSESSMENT OF THE EFFECTIVENESS OF COMBAT USE OF VARIOUS MODIFICATIONS OF S-125 TYPE ADAM

3.1 Analysis of the features of the combat use of air defense systems of the S-125 type

To assess the effectiveness of the combat use of various modifications of the S-125 type air defense system by conducting a simulation modeling requires knowledge not only of basic performance characteristics and principles functioning of the air defense system, but also knowledge of combat tactics.

In this area it was assumed that the main tactical fire The unit of the S-125 type system is an anti-aircraft missile battalion, capable of conducting independent combat operations.

The division is armed with a transportable anti-aircraft missile complex (SAM) type S-125 and reconnaissance and target designation equipment (SRC).

The S-125 anti-aircraft missile division is deployed at the launch site position that does not require special engineering structures and hard surface areas.

Preparing a position consists of leveling the platforms, preparing access roads, construction of shelters, etc. A section of terrain, intended to accommodate a C-125 division, must not contain natural obstacles and buildings. Start position closing angle should be no more than 1•.

UNK cabins are compactly located in the center of the starting position UNV antenna post, UNS and UND cabins.

At a distance of 70±10 m from the antenna post, CNVs are located launchers.

There are two main options for the location of launchers relative to SNR-125: fan-shaped and evenly around the circumference.

The fan-shaped version of the launcher allows you to hit targets coming from front, missiles of any launcher, since the launcher prohibition zone limiting shooting was mainly directed to the rear of the position, towards SNR-125.

The fan arrangement of the PU can be used with a closed (ring) defense of an object, when the target appears from the rear of the division excluded.

Option for uniform placement of launchers along circle allows you to hit targets coming from any direction, missiles launched from two or three launchers depending on the location of the zones ban.

This option can be used when defending a single object, when the direction of entry into the zone is unknown.

The S-125 anti-aircraft missile system has the following main combat properties:

— high firing efficiency;

— the ability to fire at high-speed and low-altitude targets;

- the ability to fire at targets with low reflectivity surface;

- the ability to fire when used by the enemy active and passive radio interference;

— the ability to fire at maneuvering and group targets;

- the ability to fire in any weather conditions and at any time Times of Day;

- the ability to move from one firing position to another.

High shooting efficiency

High firing efficiency is achieved:

- installation on a rocket of a powerful warhead, detonated at a certain distance from the target with a radio fuse;

— high accuracy of missile guidance to the target. Maximum the value of missile pointing errors at the target in this complex is not exceeds 20-30 *m.*

Possibility of shooting at high-speed and low-altitude targets

The S-125 complex ensures reliable target destruction, approaching it from any direction at speeds up to Vts = (420+ 14ÿÿ) m/s in an area limited by:

- heights Hts = 0.2 - 10 km;

— heading parameter P = 7 km;

- horizontal range du= 6-10 km;

— heading angle of meeting q = 60° (for Vÿ·300m/s ÿ=9km, q = 90°).

At high target speeds, tracking errors increase, the reliability of “capture” and automatic target tracking decreases.

The ability to fire at low-altitude targets is provided by:

1. The presence of a narrowly directed needle beam of the transmitting antenna, the width of which is equal to half power 1.5°.

The use of a narrow beam makes it possible to maximize press it to the ground and thus irradiate and detect targets flying at low altitudes. In addition, the narrow beam irradiates (illuminates) only target, which greatly reduces reflections from local objects, since they will only be irradiated by the side lobes of the beam.

The direction of the needle beam is shifted relative to the bisector scanning sectors of receiving antennas to the horizon by 5° and is called the director of sighting.

This, in turn, leads to the fact that when irradiated with a needle by the beam of a low-flying target, the beams of the receiving antennas will be torn off the ground. This also reduces the influence of the ground on beam formation.

For the same purpose, the maxima of the receiving antenna beams are shifted relative to the bisector of the scanning sector of the receiving antennas by 2° to horizon

2. Scanning the beams of receiving antennas in “oblique” planes. At scanning in “oblique” planes, the beams of receiving antennas are almost touch the ground, which significantly reduces the influence of the ground on them formation.

The use of scanning in “oblique” planes also improves conditions for separating direct target and missile signals and their mirror signals reflections in the ground plane.

3. Using a radio fuse operating in pulsed mode. The radio fuse is equipped with a time selector, which is gated by range selector pulses, which reduces the ability to receive signals reflected from the ground and local objects.

The duration of the selector pulses is approximately 0.7...0.8 ÿs. This pulse duration ensures that the radio fuse operates at altitudes of about 60 m.

4. Sequential (rather than simultaneous) replacement of capture strobes pulses of the missile transponder with tracking strobes (wide strobes narrow).

Simultaneous replacement of capture strobes with tracking strobes can lead to the fact that instead of the main direct signal of the missile transponder, the ground plane specular reflection signal can be captured.

All these, taken together, features of the S-125 complex allow effective combat against low-flying targets.

Possibility of shooting at targets with low reflectivity surface

Timely opening of fire and shelling of targets throughout the affected area possible if the maximum target detection range SNR-125 will have greater slant range to the far border of the launch zone to an amount that ensures identification, “capture” of the target and preparation initial data for shooting.

It is known that the target detection range also depends on the effective reflective surface of the target.

SNR-125 confidently detects targets with reflective surface equal to the reflective surface of a MIG-17 type aircraft on ranges:

— when the moving target selection equipment (MTS) is turned off — up to 41 *km;*

— with the SDC equipment turned on—up to 33 *km.*

SNR-125 includes a launcher that solves the problem meeting and determines the initial data for shooting in time, not exceeding 5 *s.*

All this makes it possible to fire at an air target that has small effective reflective surface, two missiles in any space of the affected area.

Ability to fire when used by the enemy active and passive radio interference

Success in solving a combat mission to destroy air targets in interference conditions depends on the noise immunity of the SNR-125 and the degree preparation and training of operators.

To combat active interference, missile guidance station SNR-125 has a jammer, which makes it possible to automatically or manually abruptly change the frequency of the magnetron generator and thus “tune out” from active interference. If the enemy uses broadband interference clogging the station on both frequencies, then the smoothing circuit is turned on, which forms an artificial packet goals. This allows you to more accurately follow the jammer. At This uses the three point method.

The radio fuse also has means of protection against active interference. The master oscillator of the radio fuse has a variable frequency, varying within •10%.

Changing the repetition rate of the radio fuse provides missile immunity to pulse interference. Besides, The radio fuse has an anti-jamming attachment that is used to combat with active noise interference.

Availability in the SNR-125 station of SDC, MARU equipment and chains with short time constant (MTC) allows you to effectively fire at the target in the presence of passive interference and reflections from local objects. Should note that the normal operating mode of the S-125 complex for low-flying The purpose is the mode with the SDC equipment turned on (SDC-1).

The radio fuse has a software signal amplification circuit, reflected from the target. The scheme allows you to highlight the target signal against the background passive interference.

Analyzing the above, it can be assumed that the C- complex 125 is capable of effectively destroying air targets in conditions the enemy's use of active and passive jamming.

Ability to fire at maneuvering and group targets

The very principle of rocket flight control contains the possibility firing at maneuvering targets.

However, this possibility significantly depends on the maneuverability properties air targets, the size of the affected area, as well as the flight time rockets to the meeting point.

The affected area of the S-125 complex is small, and maximum missile flight time to the far boundary of the affected area equals approximately 24 seconds.

It can be assumed that the above reasons make the target maneuver ineffective against shooting. Availability of a starting device in the complex, determining the initial data for shooting in 5s, improves conditions firing at maneuvering targets.

The ability to fire at group targets is ensured by the presence of SNR-125 manual method of target tracking.

3.2 Justification for the list of combat capabilities indicators SAM

To judge the combat capabilities of an anti-aircraft missile system in different conditions, compare different methods organizing combat operations when repelling a raid of several targets, methods of preparing and firing at one target, you must have quantitative characteristics, which are called combat indicators effectiveness of air defense systems.

Typically, the combat mission of a unit equipped with an air defense system is is to hit as many targets as possible from an airborne attack. This problem is solved by conducting a series of shooting at single and group targets.

Considering the random nature of the result of military operations, the most a complete characteristic of a random variable - the number of casualties in a raid goals - is the law of distribution of this quantity. However, the use This distribution itself is inconvenient. Therefore, in many in practical cases as indicators of combat effectiveness various numerical parameters associated with this are used distribution (mathematical expectation and dispersion of the number of affected targets, the probability of hitting a given number of targets from a raid, etc.).

Most widely used as an indicator of combat the efficiency of the complex received the mathematical expectation (ME) of the number (proportion) of targets hit per raid (average number of targets hit). MOJ number of targets hit allows us to characterize the degree of compliance results of combat operations to the assigned task and, therefore, is indicator of combat effectiveness. The convenience of this indicator is also in that it can be determined directly, without law distribution of the number of targets hit.

The mathematical expectation of the number of targets hit is equal to the sum probability of hitting each individual target. That is, to determine mathematical expectation of the number of targets hit must be able to determine the probability of hitting each target from the raid, taking into account possible shelling of a target with several missiles.

Evaluation of combat effectiveness indicators of combat use various modifications of the C-125 air defense system were assessed through simulation simulation of combat operations of an air defense group (system), consisting of

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several air defense systems centrally controlled from the command post of the group (system), to repel air strikes of various compositions (group and massive).

As the main indicator of reflection efficiency massive all-altitude strike of aerodynamic airborne missiles by a group Air defense used the relative coefficient of targets hit *KUNOTN,* average consumption of missiles per hit target *NzurSR.*

Relative coefficient of hit targets of the i-th variant *of KunOTNi* calculated using the following formula:

, (1)

where *i* is the number of the air defense missile grouping option;

Muni - MOR of the number of destroyed targets, averaged over several implementations. The maximum number of destroyed targets is determined based on the results simulation modeling;

Muno - MOR of the number of destroyed targets of the reference (basic) variant.

The average consumption of missiles per hit target *NzurSR* is determined by simulation results.

Can be used as an auxiliary indicator histogram of distribution of ranges of affected targets by zone depth fire, the values of which for each range interval Dj are determined by results of simulation modeling according to the formula

$$ÿ_j = M [Nun\ j] ,$$

Where

Dj - range intervals along the depth of the air defense missile zone, equal to 5 km;

M [Nstrj] - the number of destroyed targets for which the point missile encounter with the target lies in the j-th range interval (determined by simulation results).

3.3 Modeling system used for evaluation effectiveness of air defense systems

3.3.1 General principles for constructing a modeling system

Simulation system for performance assessment The air defense system consists of a model of combat operations of an air defense group, initial bases data, databases of modeling protocols, a set of training programs source data, displaying the progress of the simulation and processing the results modeling. Models of various means of air defense groups can connect operator workstations that allow you to monitor functioning of the simulated means and manage them. Imitation– the modeling complex can function both on a local computer and in a distributed computing environment.

Block diagram of the simulation system is presented in Fig. 3.18.

Rice. 3.18. Structure of the simulation system

The model of combat operations of an air defense group is a program that allows reproduce the dynamics of the functioning of air attack means and air defense groups. Essentially, it is a conversion operator source data into the simulation protocol. Preparation of initial data, display and reproduction of the simulation progress, processing of results modeling are being carried out separate programs, interacting with databases and not directly related to combat model program.

The initial data preparation program allows you to set the location means of air defense grouping, lay out flight routes for targets, plan enemy use of jamming and precision weapons by means of the air defense group. Deployment of air defense grouping assets and Target flight routes are displayed against the background of an electronic map.

Program for demonstrating the progress of repelling an anti-aircraft missile strike grouping allows you to display the current position and status of funds groupings, missiles in flight, airborne missiles, ballistic missile launchers, as well as a whole range reference and summary information.

In programs for preparing initial data and demonstrating progress impact reflection, electronic maps are used in the SXF format adopted in the Ministry of Defense of the Russian Federation.

The program for express processing of the simulation protocol allows evaluate the main indicators of the effectiveness of the group's combat operations Air defense (mathematical expectation of the number of destroyed targets, mathematical expectation of the number of missiles expended, mathematical expectation of the number destroyed system assets) and a number of additional indicators (distribution of the number of destroyed targets by type, by air defense missile system numbers, by range and altitude, time diagram of SAM operation by target, etc.).

More detailed processing of the simulation protocol allows obtain the data necessary to assess the damage caused by the enemy defended object: number, types and list of targets achieved task line, point of impact of enemy ballistic missiles, coordinates of missile defense meeting points with targets.

Access to databases by all programs included in the package modeling system is carried out using the interface ODBC application programming. To store source data and simulation results, you can use any DBMS for which ODBC drivers are available. Access DBMS is currently used, InterBase SQL Server ÿ MS SQL Server.

Workstations of grouping equipment operators interact with model of combat operations of an air defense group using the TCP/IP protocol.

Principles of constructing a model of combat operations of an air defense group

Model of combat operations of an air defense group according to classification belongs to the class of event-based object-process models with dynamic, decentralized managed structure and capability conditional event planning. The structure of the model is presented in Fig. 3.19.

Rice. 3.19. The structure of the model of combat operations of an air defense group.

The basis of the combat operations model of an air defense group is the core, responsible for initializing the model and dispatching processes during simulation time, and a system-wide library containing implementations methods of the base class on which all classes are based simulated processes. The next level is libraries common to all subject area. They implement systems transformation methods coordinates, functions of working with databases, process methods - containers, basic control algorithms, etc. On these libraries are based on and complement their libraries of basic simulation processes air defense grouping equipment and target libraries. And at the highest level - models of air defense grouping equipment that implement only processes specific to them. Responsible for the user interface model shell. Several shell options have been implemented for interactive and batch model launch, both locally and on remote computer.

The described simulation model belongs to the category of process-based oriented. The functional diagram of the model is presented in Fig. 3.20. Chronological sequence of events occurring in the model recorded in the database in the form of a model operation protocol.

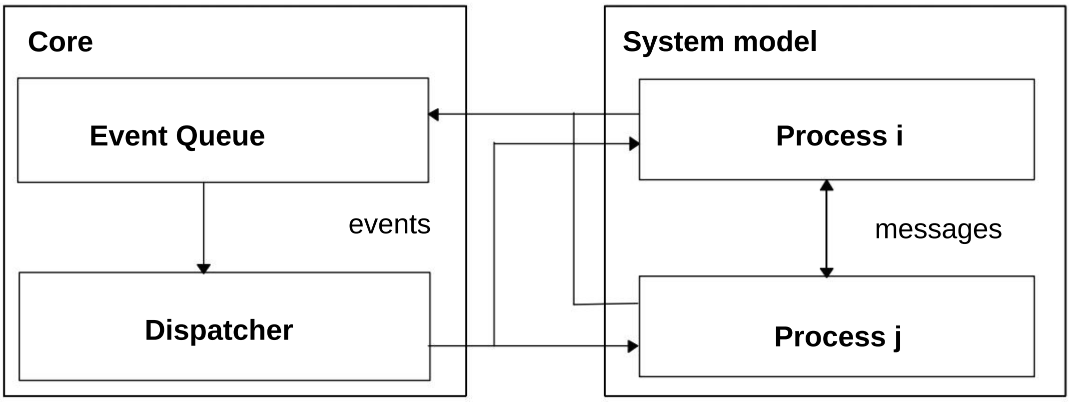


Fig.3.20. Functional diagram of the model

3.3.2 Principles of modeling air attack weapons (AEA)

The type of EHVs modeled in the modeling system is presented in Fig. 3.21.

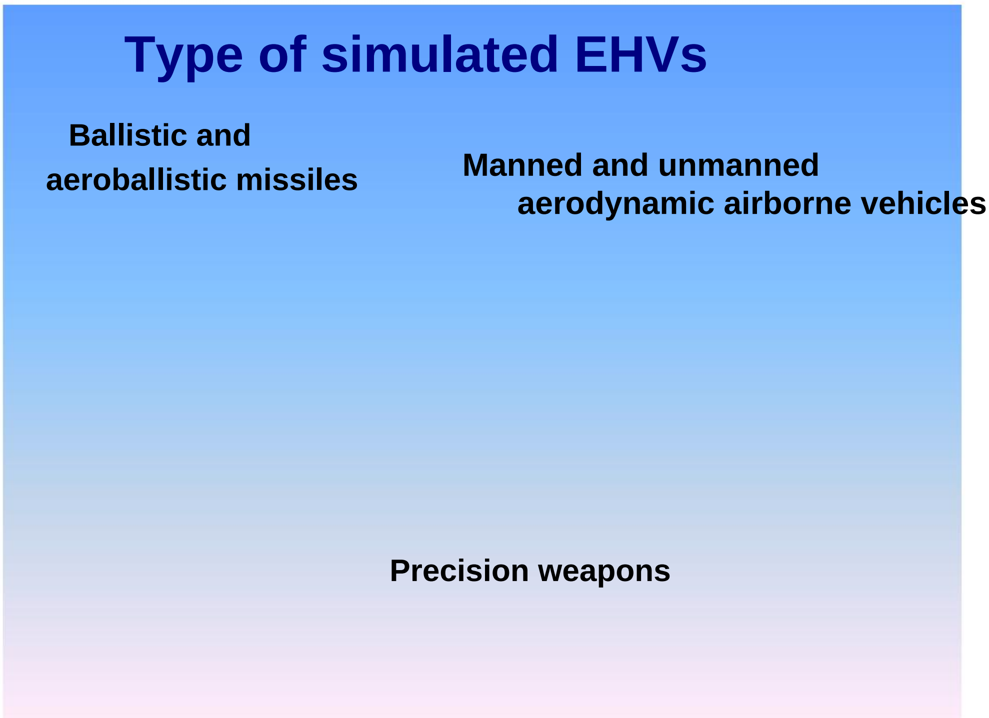
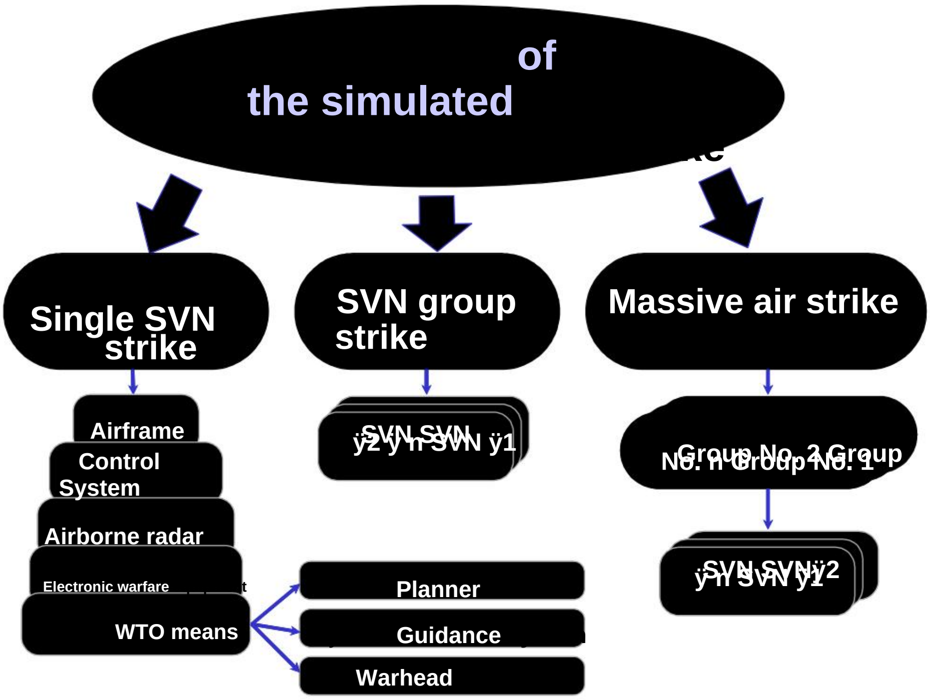


Fig. 3.21 Type of SVN

Based on these types of EHVs, EHV impacts can be generated in the model with different structures. Options for the structure of a simulated EHV strike are presented in Fig. 3.22.



Rice. 3.22. Structure of a simulated EHV impact

To evaluate the effectiveness of S-125 type air defense systems, only group and massive strikes of aerodynamic explosive devices.

All types of aerodynamic air pumps (hereinafter referred to as aerodynamic targets - ADC or aircraft aircraft) are modeled taking into account communications between the required speed V of the ADC flight, atmospheric pressure P and air density • at a given height, which for all ADCs is established by a relationship called the “energy equation”:

$$\bullet\bullet V^2/2 + ÿ = const$$

where the term $\bullet\bullet V^2/2$ - velocity pressure.

This takes into account the lift force, the total aerodynamic force, traction force. This allows you to simulate individual features in detail SVN flight, including the overloads acting on them.

Battle formations of a tactical group, intervals and distances between ADCs are determined from the conditions:

- mutual visual or radar control between ADC;
- mutual cover by interference;
- exclusion of radar resolution of RES BP of individual ADCs that make up the group;
- destruction of no more than one aircraft in a group when a combat bomb is blown up parts of an anti-aircraft guided missile.

The minimum tactical unit used in strikes is a pair of aerodynamic aircraft. An exception may be the Kyrgyz Republic. Based This aerodynamic aircraft is characterized by the following main types and formation parameters (distances, intervals and excesses between individual IN). As the main standard formations (battle formations) pairs aerodynamic aircraft, flight (detachment), tactical group, strike echelon The following structures are used:

1. bearing - a=0.2...5 km, b=0.2...2 km, c=0.05...0.15 km;

2. wedge - a=0.2...5 km, b=0.2...2 km, c=0.05...0.15 km;

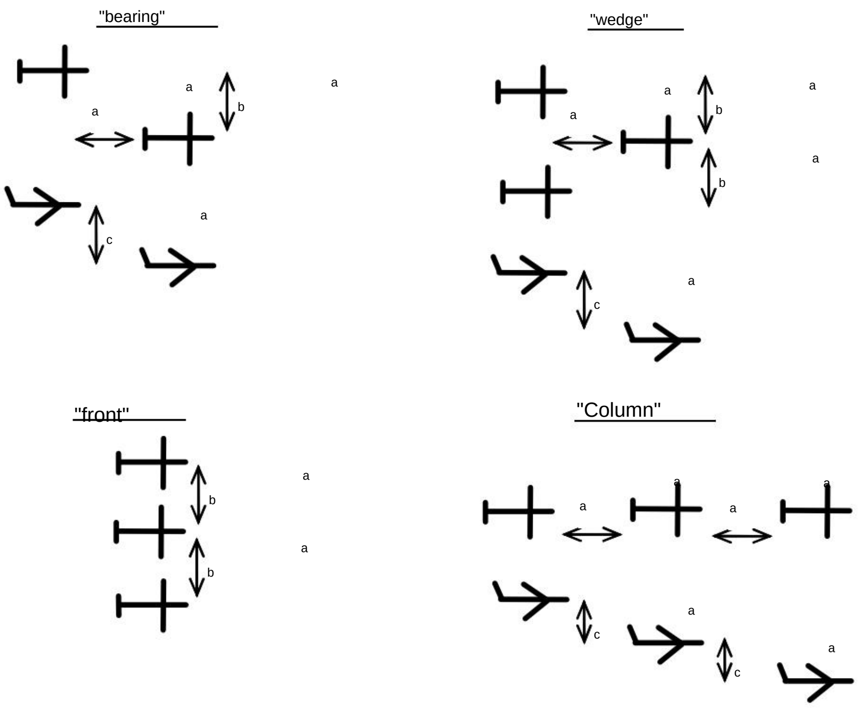
3. reverse wedge;

4. front - b=0.2...2 km;

5. column - a=0.2...5 km, c=0.05...0.15 km;

6. battle formation of a tactical group - a column of units (detachments) with time interval of 2...3 minutes.

The battle order (formation) of a pair, unit (detachment), with quantitative characteristics: distance (a); interval (b); excess (s), presented in Fig. 3.23.



Rice. 3.23 Parameters of the main formations of aerodynamic aircraft

3.3.3 Principles of modeling anti-aircraft missiles

The block of anti-aircraft missile models is designed to simulate combat operations of all possible types of air defense groups - with homogeneous and mixed composition of fire weapons. At the same time, in the simulated In groupings, the following types of fire weapons are possible (see Fig. 3.24):

- long-range anti-aircraft missile systems (DDS);
- medium-range anti-aircraft missile systems (SDMS);
- short-range anti-aircraft missile systems (ZRK MD);
- non-strategic missile defense fire systems (OK ABOUT);
- small and ultra-small complexes of means of protection against WTO (KSZ).

Rice. 3.24. Type of simulated air defense systems

S-125 type air defense systems belong to the MD class of air defense systems.

The model takes into account that MD air defense systems have a large number modifications that differ in composition, as well as characteristics and algorithms for the operation of the main elements of the complex.

All simulated modern air defense groups have hierarchical structure (Fig. 3.25):

two-level, when several air defense systems are centrally controlled from Group CP;

three-level, allowing that from the command post of the group centrally controls several control points (usually air defense control points), which, in turn, control the air defense system.

To assess the effectiveness of the S-125 air defense system, it was chosen taking into account approximations to real groups, two-level structure.

Thus, to implement a two-level control system The air defense system in the model block includes the KP zrbr (VKP) model and the KP model zrdn group (KPS).

Rice. 3.25 Simulated constellation control system

The model also provides that the command post and air defense missile system have their own sources of radar information about the air situation - autonomous target designation devices (ATCS). To do this, in the models block ASCS models of various types have been implemented. In addition, for CP sources of information may be neighboring checkpoints.

To assess the effectiveness of the S-125 type air defense system, it was taken into account that the composition The air defense system has ASCU radars of the P-15 (P-19) and P-12 (P-18) types, and at higher command posts There are circular radars with higher performance characteristics.

Principles of modeling command posts of a group

As a simulated group command post (ZRS command post) in the model a generalized type of command post was considered, capable of controlling several air defense systems by bringing them to the required degree of readiness, issuing target designation (TC) and coordination of air defense missile systems.

The CP model is called at a rate corresponding to the control cycle simulated types of air defense systems.

The model simulates the following operations performed equipment and combat crew of the command post:

receiving messages from ASCU KP;

receiving messages from air defense systems;

identification of information about radar images from various information sources;

formation and refinement of a single array of target traces (EMT);

analysis of the state of combat operation of the air defense system;

clarification of information for air defense missile systems about the control centers being developed;

issuing bans on air defense systems for certain purposes (release of the Central Committee);

selection of goals for the target area;

selection of air defense systems for the target missile;

preparation of initial data for the CR algorithm;

celeraspredelenie;

issuing target designations for air defense systems;

management of the working sectors of the air defense system.

Principles of air defense missile systems modeling

The air defense system is a complex technical system and has its own complex internal structure. Each element of this structure has a certain set of functions and is characterized by many parameters. IN the number of main elements includes: combat control point (CCU), radar target tracking and missile guidance (MTFRLS), launchers (PU), anti-aircraft guided missiles (SAM). Accordingly, the SAM model includes its composition:

1. PBU model;
2. MFRLS model;
3. PU model;
4. SAM model.

The enlarged structural diagram of the SAM model is shown in Fig. 3.26. On The figure also shows the SAM systems interacting with the model - model Group command post and SVN model.

Fig. 3.26

According to its functional purpose, the PBU model is control element of the air defense missile system model. The BSP processes the input information from the group command post, from other air defense systems, forms teams control for subordinate assets, reports for the group command post.

The functioning of the MFRLS, PU and SAM models is processing of appropriate control commands coming from the PBU and issuing reports on the progress of the execution of commands.

The list of functions performed by each model is determined functional purpose of the simulated air defense system.

The PBU model reproduces:

- receiving information (commands) from the group's command post;
- receiving messages from interacting means;
- receiving reports from repaired equipment (MFRS, launchers, missiles);
- issuing reports on the state of the air defense system, on the air stop and on the progress combat work of the air defense system at the group's command post;
- issuing control commands to subordinate means;
- issuing messages to interacting means;
- management of the working sector of the IFRLS;
- management of the development of target designations from the group's command post;
- management of target tracking modes;
- preparing data for shooting:
  - calculation of the coordinates of the missile's meeting point with the target;
  - determining the time to the meeting point;
  - determination of the time reserve for shelling a target within the zone defeat of air defense systems;
  - selection of the type and number of missiles to fire;
  - assignment of missile launch mode;
  - designation of the type of shooting;
  - determining the moment of missile launch;

• missile guidance;

• assessment of shooting results.

The MFRLS model reproduces:

• receiving control commands from the PBU;

• issuing reports on the status of the MFRLS, on detected and tracked targets on the MODU;

• overview of space and information processing;

• determination of nationality of goals;

• management of the position of the working sector.

The launcher model (PU) reproduces:

• receiving control commands from the PBU;

• issuing reports on the status and ammunition of missiles on the PBU;

• preparation of missiles;

• missile launch.

The rocket model reproduces:

• receiving commands from the control panel;

• receiving control commands from the PBU;

• rocket flight;

• issuing reports on the status and coordinates of the flight on the MODU;

• detection, acquisition and tracking of the target by the seeker;

• hitting the target.

A wide variety of functions performed determines the presence an extensive network of information and functional connections between blocks that implement these functions (functional blocks).

The basis of the functional relationships between the blocks of the air defense system model lies the operational processes occurring in the air defense system during its combat work by targets (cyclograms of the combat operation of the air defense system).

Cyclogram of the combat operation of the air defense system against one selected target (target channel) in a centralized mode of combat operation is sequence of performing the following functions (Fig. 3.27):

1. Reception of information.
2. Issuing commands (reports).
3. Selecting a target to capture.
4. Preparing rockets for launch.
5. Target acquisition for tracking.
6. Target tracking.
7. Preparing data for shooting.
8. Missile launch.
9. Missile guidance.
10. Issuing a command to detonate the missile warhead in the area of the point meetings.
11. Evaluation of shooting results.

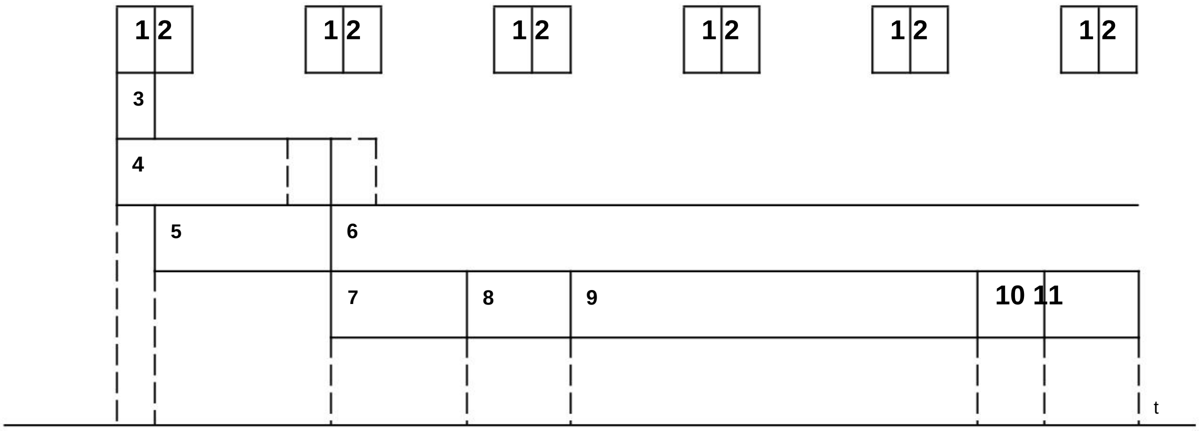


Fig. 3.27

Cyclogram of the combat operation of the air defense system against one selected target (target channel) in autonomous combat operation mode is as follows (Fig. 3.28):

1. Reception of information.
2. Issuing commands (reports).

3. Overview of the autonomous search sector and tracking of targets on aisle
4. Selection of targets for precise tracking.
5. Preparing rockets for launch.
6. Target acquisition for tracking.
7. Target tracking.
8. Preparing data for shooting.
9. Missile launch.
10. Rocket flight.
11. Issuing a command to detonate the missile warhead in the area of the point meetings.
12. Evaluation of shooting results.

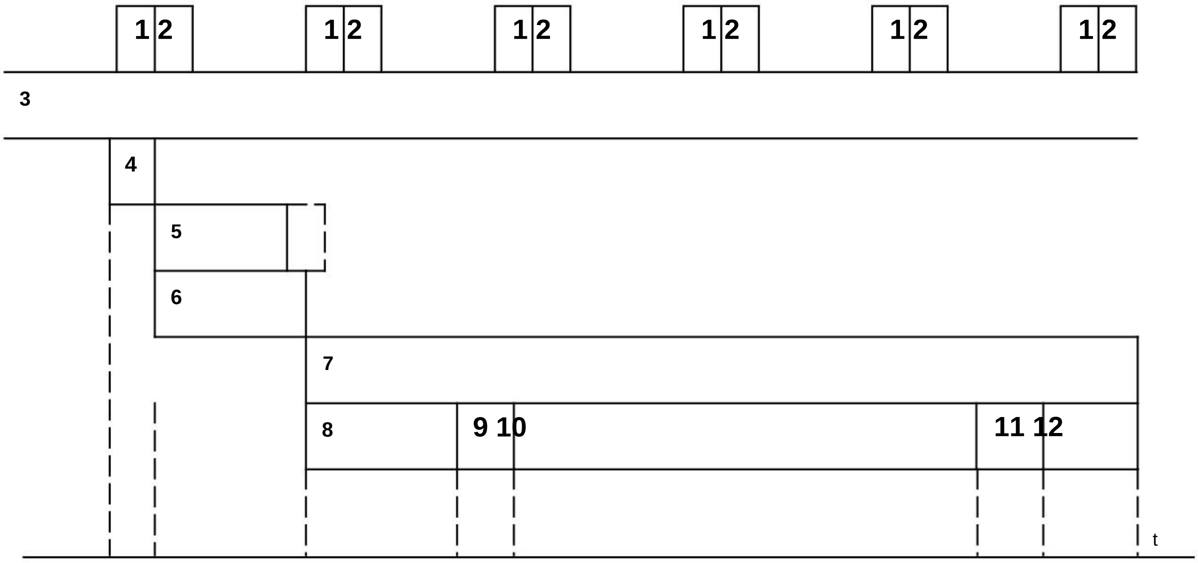


Fig. 3.28

That is, during the combat operation of air defense systems, even against one target at a time several functions are performed (survey of space, target tracking, issuing information, missile guidance, etc.). As the targets are loaded channels, the volume of parallel functions is significantly increases.

At each moment of time, the composition of simultaneously performed functions determines the state of the air defense system model. The change of such states occurs in strictly defined points in time, tied to the beginning or completion of a particular function. Time intervals between shifts states for the air defense missile system model do not play a significant role. Therefore imitation The functioning of the air defense system is carried out only during a change of state. State change times (start or end time of any functions) are calculated taking into account the actual situation, temporary characteristics of the combat operation of the air defense system and other characteristics of the air defense system, determining the logic of its work.

3.3.4 Principles for preparing source data

Preparation of initial data for the modeling system carried out by a special program for preparing initial data for simulation experiments.

The program is designed to develop initial data for conducting simulation experiments and storing them in the source database data.

The program solves the following tasks:

1. Forms an air enemy strike:

- enters, displays and changes reference data for goals.
- lays out flight routes for targets;
- assigns targets for fire and electronic suppression air defense systems;

2. Forms an air defense group:

- sets the coordinates of the air defense systems' points;
- sets the directions for the working sectors of the air defense systems;
- sets information links for air defense systems;
- sets the operating modes of grouping tools;

• installs missile ammunition on launchers of the appropriate type.

The coordinates of objects in the source data base are stored in geographic coordinate system (latitude, longitude, altitude). Height objects is set above the earth's surface, taking into account the relief (above the level sea, if a digital map of the area is not used).

To display and enter coordinates of objects in the program a rectangular relative coordinate system is also used, given by some reference point. Object position in relative coordinate system is determined by X, Y coordinates and relative height (excess). X and Y axes are directed parallel the corresponding axes of the Gauss-Kruger coordinate system. X coordinates and Y is defined as the difference between the corresponding coordinates of the object and the point reference in the Gauss-Kruger coordinate system. If the object and reference points located in different six-degree zones, object coordinates are recalculated into the reference point zone. The excess is defined as the difference between the heights of the object and the reference point.

The reference point of the relative coordinate system can be snapped to certain geographical coordinates, to some object or point in the trajectory of the object.

The program provides filling of the source data base in the format any DBMS for which ODBC drivers are available. Currently A database in Microsoft Access format is used.

The program provides the use of a reference database in format of any DBMS for which ODBC drivers are available and which provides the ability to store binary data.

An option for specifying the initial data for the F-16 type ADC is presented at Fig. 3.29.

Rice. 3.29. Option for specifying initial data for ADC type F-16.

An option for specifying the initial data for the S-125 type air defense system is presented at Fig. 3.30.

Rice. 3.30. Option for specifying initial data for S-125 type air defense systems

3.3.5 Principles for collecting and processing simulation results

Program for demonstrating the progress of repelling an anti-aircraft strike missile group

The program is designed to display the dynamics of the model combat operations by an anti-aircraft missile group. The program uses as the initial data, the protocol recorded by the model in the database. Information read from the database allows you to visually reproduce the progress modeling the process of repelling an attack by an anti-aircraft missile group SVN.

The program provides two operating modes: DEMONSTRATION 1, DEMONSTRATION 2:

• In DEMONSTRATION 1 mode they can be used as ready-made databases modeling results, and the database that is used in the current moment to record results of the simulation program modeling. In this mode, data is read from the database sequentially in time depending on the selected mode playback

• In DEMONSTRATION 2 mode, data from the database is read once opening the database. In this mode, it is recommended to use only ready-made Modeling results database.

The program provides a choice of one of three modes Playback: Playback (Normal), Fast Playback or synchronous playback (the latter only in DEMONSTRATION 1).

• ***Reproduction.*** From the database (in DEMONSTRATION 1 mode) or from memory (in DEMONSTRATION mode 2) sequentially with a clock cycle of 1 second the recorded current status data is selected and position of the simulated objects and their new position is displayed and state.

• ***Faster playback.*** Different from playback mode only speed. It is possible to change the playback speed in wide range.

• ***Synchronous playback.*** In this mode the demo program works simultaneously with the model and provides display of the latter information recorded in the database, i.e. synchronously reproduces the move modeling.

The program provides:

* display of grouping assets, missiles in flight, air defense systems, launchers institutions BR and others;

* selecting one of the projections for displaying the simulated air and ground situation: projection onto a horizontal plane (see Fig. 3.31); projections onto the vertical plane (see Fig. 3.32).

* displaying a terrain plan using electronic maps. IN The program has implemented wide functionality for working with electronic maps: scale and offset control, control composition of displayed objects, search for objects, construction of high-rise profiles, etc.

* various display control functions: shift, change of scale. Provides display of rectangular and geographic coordinate grid, movement trajectories of simulated airborne vehicles and SAM. At the moment of destruction of a surface-to-air missile or a grouping vehicle, or detonation of a missile defense system the corresponding symbol is displayed, this moment is accompanied by also a sound effect.

* receiving and displaying information about the selected object condition, name, type, number, spatial position and movement parameters, as well as background information about the purpose, performance characteristics and real appearance.

* calling programs to evaluate the results of simulated combat operations air defense groups, clearly representing numerous integral and private indicators of grouping capabilities for reflection simulated impact.

Rice. 3.31. Display of simulated air and ground situation on a horizontal plane.

Rice. 3.32 Display of simulated air and ground conditions
to a vertical plane.

Simulation results analysis program

The program allows, by processing the simulation protocol, to evaluate main and additional indicators of the effectiveness of combat operations air defense groups in simulation experiments.

The program can be used to analyze already completed experiments, as well as directly during modeling. In the last In this case, the calculated indicators can be updated automatically from at a given pace.

When processing the results of experiments consisting of several implementations, the program allows you to analyze both individual implementations, and so is the experiment as a whole.

For a clear presentation of the simulation results Charts and graphs are used. Below are the display forms some calculated indicators.

Main results

The form displays the main indicators of combat effectiveness actions of the group as a whole and for individual fire weapons.

Air defense group

The form displays the number of grouping funds, those involved in repelling the air strike, by type and number of weapons groups destroyed by the enemy.

SVN the opponent

The form displays the number of enemy air strikes by type and the number of airborne missiles destroyed when repelling the strike.

PAP opponents

The form displays the number of enemy air strikes - stagers active interference by type and number of PAPs destroyed during reflection strikes.

Distribution of enemy air strike weapons by type

The diagram displays the number of enemy air strikes of each type involved in the strike.

Distribution of destroyed targets by type

The diagram shows the number of enemy air strikes of each type, destroyed by an air defense group when repelling an attack.

Distribution of destroyed targets by range

The chart shows the number of targets destroyed fire weapons of the group at a certain range.

Distribution of destroyed targets by height

In the diagram, the vertical axis shows the height, along horizontal axis - number of targets destroyed in a given range heights

Distribution of destroyed targets over time

The chart shows the number of targets destroyed in specified time interval.

Distribution of destroyed targets by fire weapons

The chart shows the number of targets destroyed by each fire weapon of the group.

Distribution of destroyed targets by type and fire means

The diagram shows the number of enemy targets by type, destroyed by the group's chosen fire weapon.

Missile fire rate

On diagram displayed distribution quantities spent missiles on the group's fire assets.

The program for processing simulation results allows you to obtain separately for each of the fire weapons proposed in the list, diagrams described below.

Fire weapon operation time diagram

Displays the time intervals in which the weapon accompanies targets or directs missiles at them.

Trajectories of the selected target in various projections

The graphs display projections of the movement trajectory of the selected object

3.4 Initial data on options for constructing a simulated air defense grouping

The scenario was taken as the initial data for modeling combat operations between air defense and air defense systems, maximum close to real actions during the Arab-Israeli wars.

This is explained by the fact that the leadership of Egypt and Syria, at one time (in 1973 - 1982) took a number of measures to increase combat effectiveness and combat readiness of the air defense system and purchased a large number of air defense systems from the USSR, in including the Pechora and Pechora-2 air defense systems. Particular attention was paid air defense of troop groups and facilities in the border zone. Powerful zonal echeloned in depth were created groupings of air defense forces and means covering the most important objects and troop concentration areas. They ensured the destruction of air targets in a wide range of altitudes and in conditions of the use of electronic warfare equipment.

In Egypt, 4 air defense divisions were formed, numbering 22 anti-aircraft missile brigades, 13 anti-aircraft artillery regiments (57- and 37-mm anti-aircraft guns), 23 separate ZA divisions and three MANPADS battalions "Strela-2". Cairo was covered by three mixed anti-aircraft missiles brigades consisting of 18 divisions (S-75M, S-75, S-125).

The most powerful group of air defense systems was deployed to on the western bank of the Suez Canal, consisting of 8 anti-aircraft missile brigades (54 air defense systems S-75, S-125 and “Kvadrat”). It covered two armies, communications and airfields. This group had a continuous zone of anti-aircraft fire and strong direct artillery and missile cover.

Syrian air defense had 6 air defense brigades and 16 anti-aircraft artillery regiments, and also battalions (companies) of Strela-2 MANPADS. Three zrbr were mixed (zrdn S-75 and S-125) and three - homogeneous (ZRDN “Kvadrat”) composition. Zrbr "Square" was mainly covered by troops, and mixed brigades -

Damascus, important facilities, airfields and communications, while simultaneously deciding tasks of covering troops in the general air defense system.

Fragment of the conflict with the results of striking the means Syrian air defense in the Beqa Valley region (Lebanon) is shown in Fig. 3.16.

- destroyed air defense systems

Fig. 3.33

Option for a simulated air defense group

To cover objects, ground forces, as well as the cities of Zahla and Damascus deployed an air defense group consisting of three brigades "Square" and one mixed brigade of S-75 and S-125.

To assess the effectiveness of the combat use of various modifications of the S-125 type air defense system, an air defense group was built based on two “Kvadrat” brigades by replacing 9 “Kvadrat” air defense systems with 9 “Pechora-2A” air defense systems (Fig. 3.34)

Rice. 3.34 Air defense grouping based on the Kvadrat, S-75, S-125 air defense systems and on base of the "Pechora-2A" air defense system.

3.5 Initial data on SVN strike options

By 1973, Israel received about 170 aircraft from the United States. As of 10/01/73 the Israeli Air Force had about 480 combat and 100 transport aircraft, 80 helicopters. Modern aircraft (type F-4, A-4, Mirage) accounted for more than 60% of the entire fleet. On the territory of Israel it was equipped 14, and on the Sinai Peninsula - 11 airfields with runways ranging from 1200 to 3000 m. This allowed the Israelis to carry out several massive blows. The strikes were carried out using a variety of tactics techniques, weapons and under the guise of interference. They were staged on-board means of strike and special aircraft, as well as UAVs.

To reduce the effectiveness of enemy air defenses, anti-aircraft missiles were widely used, decoy missiles and UAB.

Fragment of an Israeli air strike during combat operations in the area Beqa Valley (Lebanon) is shown in Fig. 3.33. The basis of the aviation fleet consisted of TA aircraft such as F-4, A-4, and Mirage.

To assess the effectiveness of the combat use of various modifications of the S-125 type air defense system based on the specified fragment of the real EHV strike, initial data on EHV impact were generated for modeling, which included modern tools air attack, including TI, manufactured using technology "Stealth". Scheme of spatial construction of the massive variant all-altitude strike of the EOS is presented in Fig. 3.35.

Rice. 3.35. Scheme of the spatial construction of the SVN strike variant

The main idea of the simulated explosive attack, most likely when conducting military operations with NATO countries, consists of suppressing fire and information subsystems of the air defense group, striking objects. The IEV strike variant is characterized by a large quantitative composition and type of airborne attack systems, complex interference environment, combat the procedure and tactics for using air defense systems. The actions of the SVN are covered up active interference of individual, group and collective protection.

The strike option includes three echelons of aerodynamic explosive and support group.

The support group includes specialized aircraft jamming, providing cover for all attack echelons from loitering zones. Specialized aircraft E-8 "Jistars" designed for electronic reconnaissance of group assets Air defense and issuing information to the TI of fire suppression of air defense systems. The specialized E-2C Hokkai aircraft conducts air reconnaissance situation and controls the actions of various strike groups.

The first echelon consists of missile defense and technical equipment for suppressing the group's assets. The combat mission of the echelon is to conduct reconnaissance in force to overcome air defense groups in the interests of the second echelon and, if possible, destruction of elements of this group.

The second echelon consists of manned aircraft with PRR on board, intended for the final defeat of group elements air defense

The third echelon also consists of manned aircraft (Gr 6, 7). designed to inflict a specified degree of damage on the defended impact objects. The third echelon includes technical equipment manufactured according to Stealth technology.

3.6 Results of a comparative assessment of the effectiveness of combat actions of air defense groups based on S-125 air defense systems, including number of those supplied for export (Pechora-2M air defense system and "Pechora-2A")

3.6.1 Results of a comparative analysis of tactical and technical characteristics of the Pechora-2M and Pechora-2A air defense systems

As simulated S-125 type air defense systems in simulation experiments, the Pechora-2M air defense system and "Pechora-2A".

The main performance characteristics of these types of air defense systems are given in the table

TTX	Pechora-2M	Cave-2A
Type of targets hit	B-1B, B-2, F-111, F-16, F-117A, "Tornado", KR "Tomahawk" and ALKM, helicopters type AN-64, (RPA).	B-52, B-1B, FB-111, B-2, F-16, F-14, A-10, F-117A, KR "Tomahawk" and DPLA
Damage zone (when firing 5V27D missiles) - maximum slant range: at an altitude of 0.5 km at altitudes of 14-20 km - near border of the affected area - lower limit of the affected area - upper limit of the affected area - maximum heading parameter	 20 30 3.5 km 0.02 km 0.02 km to 20 km 20 km at least 16.5 km at least 18 km	 at least 18 km at least 28 km 3.5 km
Probability of defeat in the absence of radio and optical-electronic countermeasures with 5V27D missiles when firing at a target such as an F-16 aircraft with ESR = 2 sq. m, flying at a speed V<= 300 m/s (flight altitude more than 100 m)	not less than 0.72	not less than 0.72
Automatic capture and automatic target tracking television-optical channel	+	+
Time to bring deployed modernized assets		

complex on alert - from standby mode - from standby mode	no more than 5 minutes no more than 10 s	no more than 5 minutes no more than 30 s
Detection range of SNR SAM targets with a probability of at least 0.5: - with an EPR of 2 sq.m in conditions without interference: at an altitude of 7 km at an altitude of 350 m - with an EPR of 2 sq.m in conditions of interference (•=2 kW/MHz; Deq = 100 km) - with an EPR of 0.1-0.15 sq.m in conditions without interference at an altitude of 7 km at an altitude of 350 m	at least 69 km at least 30 km at least 35 km at least 30 km at least 25 km	at least 69 km at least 30 km at least 35 km at least 30 km at least 25 km
Noise immunity: - ensures the destruction of targets with an effective reflective surface of 2 square meters. m under the influence of ACP - according to PP of special types or PAP of self-covering barrages - in conditions of passive interference - determining the range to the PAP using the triangulation method	2 kW/MHz (Dekv=100km) + at least 5 packs at 100 meters ways +	2 kW/MHz (Dekv=100km) + up to 6 packs per 100 meters of path -
Total number of PU	4 (8 – in stock two antennas posts)	4
Characteristics of optical-electronic systems: - availability of day and night TV-channel - presence of a thermal imager for detecting and tracking targets - presence of a laser rangefinder	+ + +	+ + +

Analysis of the main tactical and technical characteristics of the Pechora air defense system 2M" and "Pechora-2A" shows that the Pechora air defense system, modernized as

JSC KB Kuntsevo and OJSC CDB Almaz will have almost identical fire capabilities.

A distinctive feature of the Pechora-2M air defense system is the ability connecting two modernized antennas to the UNK equipment cabin UNV posts and the presence in the air defense system of up to 8 launchers (with the mandatory presence of two antenna posts). The presence of two antenna posts allows for simultaneous firing of up to two targets with simultaneous guidance up to four missiles and determine the range to the PAP using the triangulation method. Given the advantage of the Pechora-2M air defense system can be considered conditional, since additional capabilities of the air defense system were achieved by simple increase the number of assets in the air defense system. Many years of development experience means of an air defense system shows that the cost of an air defense system is mainly determined precisely the cost of the antenna post and the cost of missile ammunition. That's why, built anti-aircraft missile groups based on (for example) 4 air defense systems "Pechora-2M" with two antenna posts and 8 launchers as part of each air defense system and on base 8 air defense missile systems "Pechora-2A" will have equal fire capabilities with the same cost.

Therefore, below are the results of the analysis of the effectiveness of only for an air defense group from the Pechora-2A air defense system.

3.6.2 Results of the effectiveness of the assessment of a massive by reflection air defense strike

The effectiveness of the combat operations of the air defense group was assessed, built on the basis of the Pechora-2A air defense system, when repelling a massive all-altitude EOS strike (Section 3.5) under the following conditions:

1) without electronic and fire countermeasures air enemy sides;

2) without electronic countermeasures and in fire conditions suppression of group assets;

3) in conditions of interference and without fire opposition from air enemy;

4) in conditions of electronic and fire countermeasures side of the air enemy.

To carry out the assessments, the modeling system included specially designed:

• model of air defense grouping;

• Pechora-2A air defense system model;

• PU model;

• model ZUR ZRK "Pechora-2A".

Principles of modeling the Pechora-2A air defense system

1. The combat operation of the air defense system was carried out in a centralized mode control from the group command post. Control from the group's command post consisted of coordination of combat operations of anti-aircraft missile divisions and in distribution of their efforts.

2. The combat work of the air defense system against the target began with the detection of its SRC. From the SRC, the Central Committee on the SNR was introduced.

3. SNR detected and captured the target for auto tracking *(various options taken into account during modeling):*

a) radar channel (RLC);

b) TV channel (TVC);

c) TP channel (TPC);

d) radar+TVK (detection + tracking);

e) radar + TPK (detection + tracking);

f) ECO (that is, the use of TV/TP channels and LD channel).

4. When only the EOS was operating, the range measurement was carried out LD channel.

5. The initial data was prepared automatically trigger device (data preparation time 2s).

6. 2 missiles were assigned to fire at targets. Repeated shelling of targets was also produced in a squad of two missiles.

7. In conditions of interference, the functioning of the means and algorithms for protection against active interference.

Main results

Results of the effectiveness of air defense group combat operations are given in Table. 3.3-Table 3.4 and are presented in Fig. 3.36-Fig. 3.39.

Table 3.3

Indicators of the effectiveness of combat operations of an air defense group during no fire suppression

Conditions	Indicators	
	Relative coefficient destroyed targets	Average consumption of missiles per one target hit
No interference	1,0 2,3	
In the presence of interference (RLK)	0,46	3,1
In the presence of interference (RLK+TVK)	0,75	2,6
In the presence of interference (RLK+OES)	0,92	2,1

The figures roughly show:

1. (RLK) – operation of only the radar channel;

2. (RLK+TVK) – joint functioning of radar and television channels;

3. (RLK + OES) – joint operation of radar channel and optical-electronic system SNR (TVK, TPK and laser rangefinder) in general.

Fig. 3.36

Fig. 3.37

Table 3.4

Indicators of the effectiveness of air defense group combat operations in conditions of fire suppression Indicators

Conditions	Relative	
	coefficient Average consumption of missiles on destroyed targets one target hit 1.0 2.3	
Without interference and without fire suppression (in accordance with		

Table 3.3)		
No interference	0,21	5,6
In the presence of interference (RLK)	0,13	7,67
In the presence of interference (RLK+TVK)	0,38	3,89
In the presence of interference (RLK+OES)	0,71	2,76

Fig. 3.38

Fig. 3.39

Analysis of results

1. Modernized air defense system "Pechora-2A", developed according to full program of technical specifications (including in terms of ECO), will have capabilities to combat modern air attack weapons.

Potential capabilities of SNR (radar channel and optical electronic system) allow you to fire at low-altitude missiles, TI type F-16 and Stealth aircraft - F-117. Probabilities of hitting a target with one missile will be at least 0.7-0.72. The presence of an IPS significantly increases noise immunity and survivability of air defense systems.

2. In conditions where the enemy uses interference (from areas loitering and from battle formations) when the SNR operates only radar The effectiveness of the group decreases sharply:

a) in the absence of fire suppression - by 54%;

b) in conditions of fire suppression - by almost 80%.

Application enemy tactics combined electronic suppression of the group's electronic warfare systems reduces the effectiveness implemented anti-jamming measures (detection range of SNR targets decreases by almost half) due to the lack of systemic measures counteraction from the air defense group.

3. The joint use of radar and TVK increases fire capabilities of the air defense system by expanding the capabilities of the SNR to detect and tracking targets in conditions of interference and fire suppression. Growth group effectiveness was:

a) in the absence of fire suppression - about 30%;

b) in conditions of fire suppression - 25%.

In conditions of fire suppression, air defense systems were also destroyed due to breakthrough of TI with guided missiles and bombs to the positions of divisions.

4. The joint use of RLC and EPS SNR as a whole can significantly increase the effectiveness of the air defense group. Growth group efficiency was:

a) in the absence of fire suppression - 46%;

b) in conditions of fire suppression - 58%.

Thus, in the absence of fire counteraction, comprehensive the use of radar and EOS SNR can ensure the full implementation of fire capabilities of the Pechora-2A air defense system. Effectiveness of grouping in complex jamming environment will be 92% of the effectiveness of the air defense group with repelling an air strike in simple conditions, and in conditions of fire suppression – 71%.

5. According to the modeling results, the average consumption of rockets per one the target hit ranged from 2.1 to 3.1 - in the absence of fire suppression; from 2.8 to 7.7 – in conditions of fire suppression. Availability of ECO significantly increases the stability of target tracking in complex interference environment, which reduces the loss of missiles due to guidance failure.

High consumption of missiles when repelling an air strike in conditions fire suppression is explained by the fact that, firstly, the air defense systems were destroyed after the launch of missiles against accompanied targets, secondly, unsuccessful attempts to fire at the PRR. The Pechora-2A air defense system is not provided ability to recognize target classes (ADC, BC). Initial data for firing at an accompanied PRR was prepared as for an ADC. After the launch of the missile defense system (in cases where the launcher issued permission to fire) according to the PRR Either the escort was disrupted, or the missile defense system left the affected area due to for the ballistic nature of the PRR flight path.