The gunner's trainer of 9A35 "Strela-10" air defense combat vehicle

Characteristics

- The high fidelity of a gunner's workplace. Turret circular rotation 360°
- Implementation of algorithms of all 9A35 combat vehicle systems of operation in the simulator program, including the mathematical model of an anti-aircraft guided missile flight
- The high-quality visualization of an air and ground environment
- 3D models of different areas, including real sites specified by the Customer
- Air, jamming, and ground environment editor with wide options
- Combat work and simulated firing from a static position, on move, and afloat
- The reproduction of 3D and 2D launching and air targets impact zones during the gunner’s combat work at the instructor's workstation
- Automated evaluation of gunners’ actions during a combat work with detailed errors analysis
- System for diagnostics of simulator’s equipment operability
- Wide spectrum of scenarios for exercises and training events
- Training session results recording and archiving
- Possibility of integration into the combat crew simulator of the 9A35 (9A34) combat vehicle of the “Strela-10”

The simulator purpose and capabilities

The TO-9A35 simulator is designed to educate and train operators of BM 9K35 (9K34) combat vehicles of the Strela-10 air defense system indoor to shape and consolidate sustainable skills in visual reconnaissance and identification of air targets; determining target range, preparing for firing, choosing a firing mode, determining the moment of launch, launching an anti-aircraft guided missile, observing the missile's flight and evaluating the results of firing in various air, jamming and ground conditions, day and night, from a halt, on the move, and afloat

Educational and methodological capabilities of the TO-9A35 simulator.

Education and training capabilities of the simulator to train gunners:

- The individual training of the "Strela-10" air defense system gunners (technical, reconnaissance, combat work)
- Execution of the full list of the Gunnery Course exercises with the automated assessment of
- trainees' actions and analysis of violations of the «Shooting and combat work rules»
- Conducting simulated firing under a complex air and jamming environment in various ways (using photo-contrast and infrared channels of the missile homing head), on different terrain, from a static position, a halt, afloat
- Control of the 9A35 combat vehicle movement from the instructor's station
- Target designation to a gunner from the instructor's station

The simulator's capabilities to develop conditions for training:

- Selecting terrain types - moderately rugged terrain, mountainous, desert (3D 8x8 km terrain models of any locations can be developed, subject to a customer request)
- Time of a day and year selection
- Selecting meteorological conditions - sunny, cloudiness, rain, snow, wind
- Input/dismiss of the "Strela-10" air defense system equipment failures and malfunctions

Air and jamming environment generating capabilities:

- Plotting of aircraft, helicopters, and UAVs flight routes, as per their maneuver in direction, height, and speed
- Generating (dismissal) of a complex background environment
- Reiteration (if necessary, multiple) of air strikes

The simulator structure

The TO-9A35 simulator structure:

- instructor's work station
- the functional turret mock-up mounted on a circular rotation platform

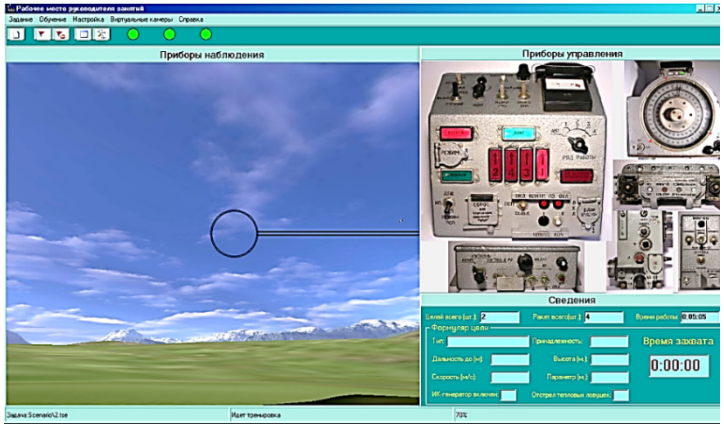
The general view of the Instructor’s workstation

The general view the functional turret mock-up mounted on a circular rotation platform

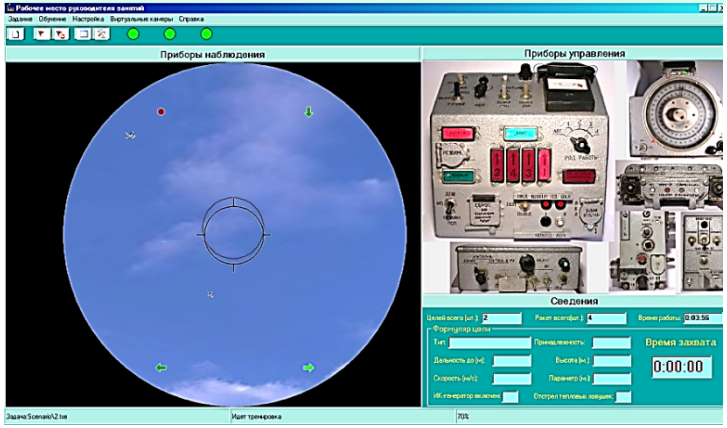
The instructor’s workstation

- ON/OFF Control
- development an exercise (selection of air targets, routes and flight times, terrain, time of day, weather conditions, interference)
- controlling of the 9A35 combat vehicle movement over terrain
- monitoring of a gunner's current field of view in the 9SH127 optical sight and in the turret protective glass
- monitoring of the current state of controls and indicators at the gunner's workplace
- monitoring of trainees actions and their errors in the course of an exercise
- target designation to a gunner to simulate a command post actions
- two-way communication between an instructor and a gunner being trained, simulating faults in the operation of an equipment
- automated generation of exercise evaluation results as per the Gunnery Course standards
- documenting results of an exercise, output the results for printing

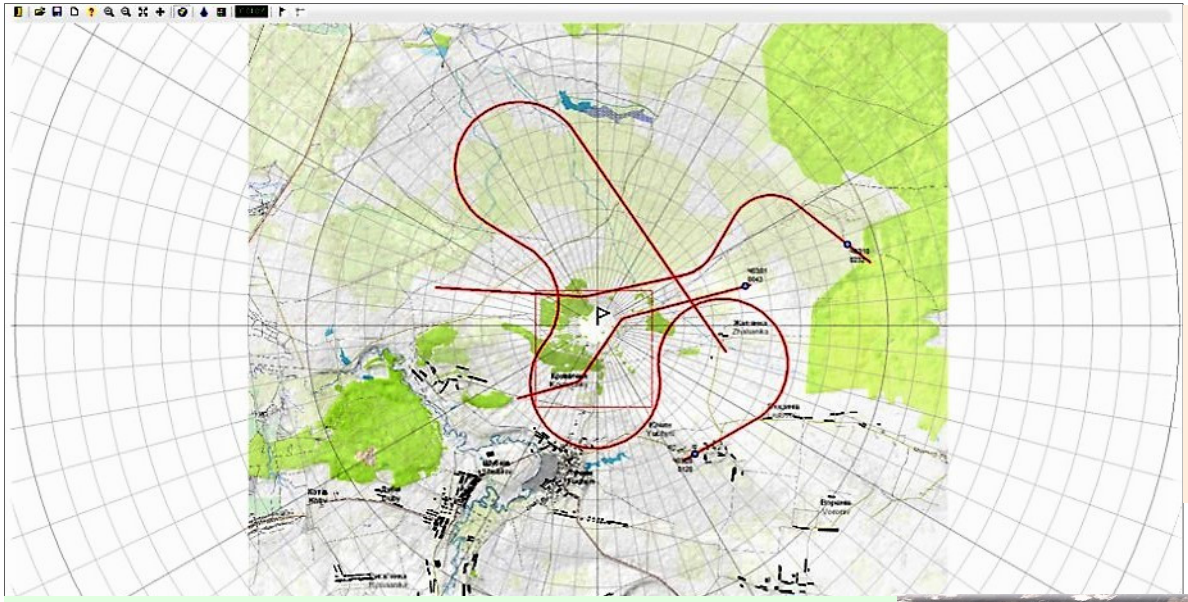
Duplicated gunner's field of view



Duplicated field of view of the 9SH127 sight



The instructor's workstation capabilities in the development of an air situation and displaying the launch and impact zones



The air situation editor built into the instructor's interface allows to:

- generate flight routes for single and group targets
- set a speed and altitude of single and group targets on different parts of the route
- set the areas of application (shooting) of false thermal targets by airplanes and helicopters

The current position and configuration of a launch zone and an engagement zone of an air target are displayed at the instructor's workstation and on the screen for collective use. This makes it possible to visually demonstrate to a group of trainees the following:

- real spatial dimensions of a launch and impact zones of various air targets
- changing the position and size of a launch and impact zones of air targets while maneuvering in a course, altitude, and speed
- the need for accounting changes in the position and size of the launch and impact zones when firing against maneuvering air targets

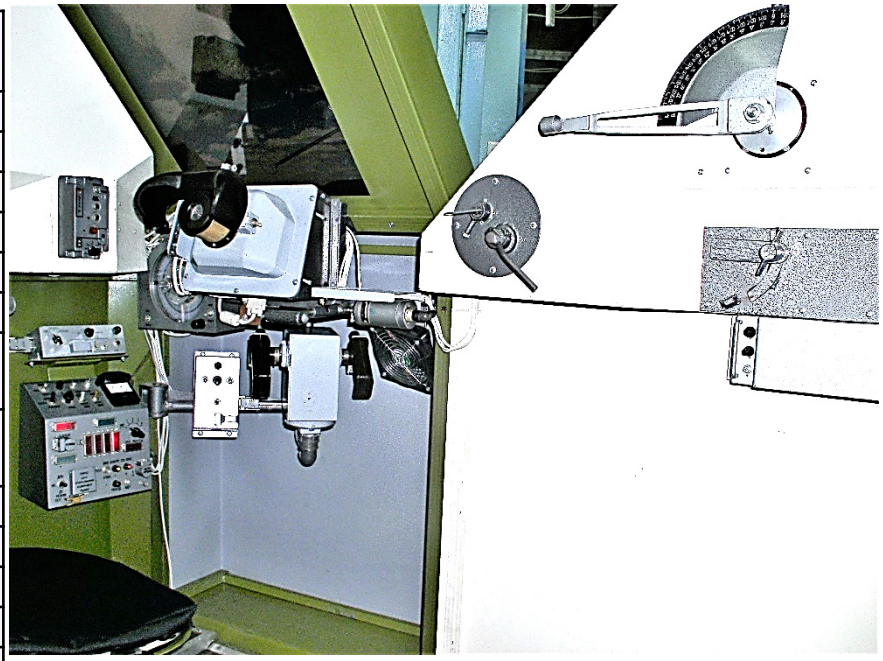
The turret functional mock-up

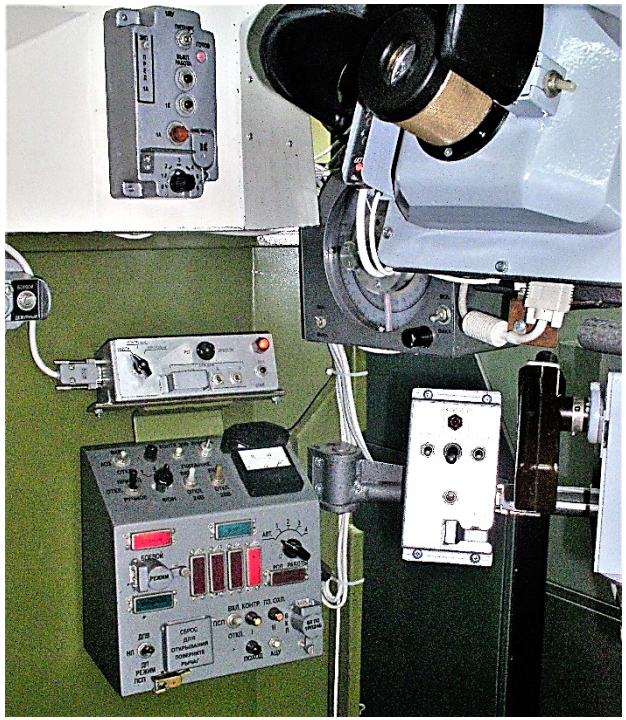
The functional turret mock-up is a frame structure made of steel profiles, fully corresponding to the dimensions of the operator's workplace in a combat vehicle. The devices' and assemblies' mock-ups are placed at the gunner workplace. A side door provides entry and exit for a gunner being trained. Removable cover plates provide access to equipment and components of the simulator.

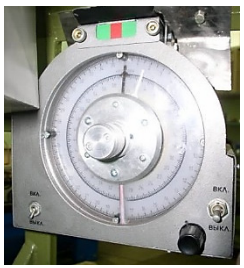
The mock-up is mounted on a circular rotation platform, which is controlled by a guidance control unit and provides rotation of the mock-up around an axis with a speed proportional to the angle of rotation of a control unit.

Equipment composition of the functional turret mock-up

№ seq.	Designation, title	Quantity, pcs.
Instruments' and assemblies' mock-ups		
1	A guidance system console	1
2	Launch equipment operator console	1
3	Launch equipment operator-2 console	1
4	coarse laying sight	1
5	9SH127 Optical sight	1
6	Operational control panel for zone assessment equipment	1
7	Control and monitoring unit - U of a zone evaluation equipment	1
8	1ZH2-3 Control unit of the direction-finding system	1
9	Direction finding system display circuit	1
10	Azimuth indicator	1
11	Display panel	1
12	1LU Control panel of ground radar interrogator	1
13	Summing amplifier of communication equipment	1
14	Protective glass of a turret	1
15	Hand wheel override of a shifter mechanism	1
16	Traversing guidance reducer	1
17	Turret traversing lock	1
18	Press-to-talk pedal	1
19	Launcher Stopper Pedal	1
Common equipment		
1	Terrain and airspace display system in the protective glass of a turret	1
2	Gunner's seat	1
3	Headset with a press-to-talk button	1
4	The audio system	1







Distinctive features of TO-9A35 gunner simulator

№	Characteristics	Hardware and software to ensure characteristics
1	Constructive adequacy of the functional gunner's workplace mock-up	Full compliance of dimensions of the functional gunner's workplace mock-up and placement of equipment mock-ups, controls, indication, and signaling means in it with those in the 9A35 combat vehicle. Full compliance of ranges of movement (moves) and efforts of simulator controls (control console, pedals laying, levers, switches) with the characteristics of the real 9A35 combat vehicle equipment. Adequacy of devices' and assemblies' mock-ups, correspondence of equipment illumination, instruments' scales, banners, and nameplates to a real 9A35 combat vehicle. Physical simulation of turret rotation during combat operations.
2	Functional simulator adequacy	The program for generating the 3D external environment (virtual battle space), in which an air adversary and the "Strela-10" air defense system operate
		Full implementation of the 9A35 combat vehicle systems' operation algorithms
		Mathematical model of an anti-aircraft guided missile flight by the method of proportional guidance
		A mathematical model for calculating the spatial parameters of the launch and impact zones of each air target
		A mathematical model of estimating the influence of background conditions on an operation of a missile homing head
3	High educational and methodical capabilities of the simulator	Built-in of air situation and interference conditions editor. A large number of options for an air environment. A wide range of air targets. Correspondence of flight technical characteristics of virtual air targets with the real ones
		Extensive capacity to supervise trainees' actions of operators being trained
		Wide capacity for training a group of gunners by demonstrating to them both the actions of a gunner being trained and the spatial zones of launch and impact
4	High quality of the visualization	The 3D environment generating software provides high-quality visualization of a landscape, infrastructure facilities, as well as air targets, clouds, sun, etc.
		Visualization of the current picture in a field of view of protective glass and in a field of view of an optical sight

Simulator's visualization scenes examples

The simulator’s software features

Serial №	Characteristics	Parameter's value
1	Aggregated simulator's adequacy coefficient (the degree of implementation of combat operations)	>0,8
2	Dimensions of the 3D training area model (length x width x height), km	8 x 8 x 5
3	Air targets types	Helicopters Mi-8, Mi-24, UH-60, AH-1, AH-64 Attack aircraft such as JH-7A, A-10, Su-24, Su-25 Fighters such as J-10, F-16, MiG-29, Su-27, F-18 Transport aircraft such as Y-8, An-26, An-12, Il-76, C-130H Unmanned aerial vehicles such as Wing Loong, MQ-1C, RQ-7 Cruise missiles such as AGM-86, AGM-158, 3M14
4	Number of air targets simultaneously present in the air	8
5	Types of air targets maneuver	By height, by course, by speed
6	Characteristics of air targets (speed, flight altitude, turning radius, maneuvering possibilities)	Following the flight characteristics of simulated air targets
7	Types of interference	Sun, background noise
8	Time of a day	Day, twilight

The capability to supervise trainees’ actions:

- as per the current state of controls and indication means at the Instructor's workstation
- as per a duplicated field of view in the protective glass of a turret
- as per the duplicated field of view of the 9SH127 sighting device
- as per the position and condition of a 9A35 combat vehicle from the viewpoint of an external controlled camera
- as per the exercise protocol
- as per the reports of trainees via communication means

Assessment capability:

- automated evaluation of trainee's actions in the course of a standard or developed by an instructor exercise following the Gunnery Course's evaluation criteria
- subjective assessment of trainees' actions in a complex air and jamming environment based on the results of analysis by all means of supervision

PERFORMANCES

Simulator is designed for use in the units, is simple in exploitation and maintenance

№ seq.	Parameter name	Measurement unit	Parameter value
1	Minimal required area for setting	m^2	15
2	Premises type	---	Classroom
3	Warm-up time upon actuation	min	up to 5
4	Duration of continuous work,	hours	at least 12
5	Electric power supply voltage	V	220±10%
	Frequency	Hz	50±1
6	Maximum consumed power	kW	3.5
7	Increased operating and limiting temperature	°C	Up to +35.
	reduced operating temperature		Up to +5
8	Relative humidity at the temperature of +25°C.	%	Up to 80
9	Diagnostic system	---	In-build semiautomatic
10	Error-free running time	hours	at least 1000
11	ON/OFF Control	---	From instructor's workstation
12	SPTA	---	Individual and group (per each 4 simulators)
13	Maintenance	---	Checkup, daily maintenance, maintenance -1 (once per 6 months), maintenance - 2 (once per year)
14	Operating liquids	---	Synthetic oil in dynamic platform motor-reducers
15	Trainees and operating personnel electric safety	---	Dangerous voltage is excluded (DC +24 V is used only) Short-circuit relay protection
16	Simulator's operating records		Motor-hour meter
17	Assembled weight	kg	850
18	Operating documentation (could be performed in the Customer's language)	---	Logbook; Operating manual; On-site Assembly and Adjustment Manual, SPTA List

Comparative evaluation of the standard 9F624 simulator and TO-9A35 simulator

Serial №	Capabilities	9F624 authorized simulator	TO-9A35 simulator
1	Transfer of the 9A35 combat vehicle to a combat position	Does not support	+
2	Selection of conditions for firing	Does not support	+
3	Generating of air and jamming environment of varying complexity	Does not support	+
4	Visual target search, target detection and identification	Partially	+
5	Search for a target by external target designation	Does not support	+
6	The selection of the method and mode of firing, a homing head operation channel	Does not support	+
7	Capture the target with the missile homing head	+	+
8	Determination of the launch moment, the launch of a missile, observation of the missile flight path	Does not support	+
9	Evaluation of firing results and recurrent fire	Does not support	+
10	Monitoring compliance with standards	Partially	+

Conclusion: the standard 9F624 simulator is inappropriate for usage in the process of combat training of the 9A35 (9A34) combat vehicles gunners due to its inferior educational and methodological capabilities

The effectiveness of the use of the simulator in the Air Defense units training process

The introduction of simulators in combat training allows:

1. Implementation of the basic principles of combat training

- make the technical, reconnaissance, special training of the "Strela-10" air defense system combat crews a real basis for the activities of air defense units, ensure controllability of a training process
- exclude simplifications during lessons and exercises
- creation of training conditions close to combat
- provide intensive training for all gunners of an air defense unit
- provision of organizational and methodical connection of training with the use of simulators with the field training, including with live firing
- providing an unbiased evaluation of the training level of gunners
- to implement the principle of learning "from simple to complex", an individual approach to learning, to ensure the continuity of a training process

2. Achievement of training objectives

- ensure a real opportunity to shape and maintain the required level of skills of the “Strela-10” air defense system gunners
- to teach operators effectively use combat capabilities of the "Strela-10" air defense system in difficult air and jamming conditions, day and night
- effectively prepare the "Strela-10" air defense system gunners for live firing, and to participate in tactical exercises
- ensure the required level of the "Strela-10" air defense system gunners' mastery for the entire training period
- prepare air defense units to conduct effective actions in a modern combat

3. Reduce expenses for combat training by 70-80% under the condition of achievement of the required gunners training proficiency