Anti-aircraft gunner’s training simulator of a portable air defense system “Igla” (“Igla-1”)
Possibilities of existing educational-training means on education and training of anti-aircraft gunners

<table>
<thead>
<tr>
<th>Structure of existing educational-training means</th>
<th>Possibilities of existing educational-training means</th>
</tr>
</thead>
<tbody>
<tr>
<td>• electrified stand 2У438</td>
<td>• studying of the device, order of functioning and application of PADS</td>
</tr>
<tr>
<td>• field training simulator of anti-aircraft gunners 9Φ635</td>
<td>• education and training of anti-aircraft gunners (including with imitation of AAGM launch with use of ejection engine) on district on simulators of air targets</td>
</tr>
<tr>
<td>• launch control set 9Φ636</td>
<td></td>
</tr>
<tr>
<td>• educational-training set 9Φ663</td>
<td></td>
</tr>
<tr>
<td>• simulator НРЗ 9Φ631</td>
<td></td>
</tr>
</tbody>
</table>

Lacks of existing educational-training means

- high degree of conditionality of imitation of air targets
- absence of imitation of thermal, smoke and aerosol jamming, imitations of various meteoconditions, overcast
- impossibility of trainings on fighting work on the targets, coming from the side (towards) the sun
- absence of a stage of imitation of AAGM flight, approaching with an air target and AAGM blasting, a miss and self-liquidation of AAGM

Results of education and training of anti-aircraft gunners on the basis of existing educational-training means

- Operations of fighting work which will be the basic in fighting conditions (detection and identification of air targets in difficult conditions, visual estimation of range of targets, estimation of possibility of firing in the conditions of jamming, on the maneuvering targets, definition of the moment of inclusion of a land power unit (LPU), definition of the moment of AAGM launch, assessment of results of firing) are not fulfilled.
- The factor of coverage of combat operations does not exceed 0.6.
The comparative characteristic of projective and helmet virtual reality systems

In the structure of training simulator the projective systems and helmet virtual reality systems are applied for visualization of surrounding space and background target conditions (on the basis of virtual reality glasses). These essentially different systems have advantages and disadvantages.

<table>
<thead>
<tr>
<th>Projective systems</th>
<th>Helmet systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td></td>
</tr>
<tr>
<td>✧ high degree of presentation for the anti-aircraft gunners of division, observing the training</td>
<td>✧ lower cost in comparison with projective systems</td>
</tr>
<tr>
<td></td>
<td>✧ mobility of a training complex</td>
</tr>
<tr>
<td></td>
<td>✧ small required area</td>
</tr>
<tr>
<td></td>
<td>✧ high resolution of images</td>
</tr>
<tr>
<td></td>
<td>✧ absence of restrictions on conducting fighting operations by trained anti-aircraft gunners (firing in pursuit, fighting operations at the big angles of a place of the fired targets)</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td></td>
</tr>
<tr>
<td>☹ high cost</td>
<td>☹ necessity of solution of technical tasks, connected with coordination of spatial position of a launching tube and the anti-aircraft gunner’s head</td>
</tr>
<tr>
<td>☹ complexity of operation</td>
<td></td>
</tr>
<tr>
<td>☹ stationary execution and considerable required area for training simulator placing</td>
<td></td>
</tr>
<tr>
<td>☹ restrictions on conducting fighting operations at shooting on pursuit courses and at big angles of place of targets</td>
<td></td>
</tr>
</tbody>
</table>

In a training simulator design the helmet virtual reality system is applied
Training simulator structure

Anti-aircraft gunner’s workplace includes:

- Protective helmet with helmet virtual reality system and gauges of spatial position of targets
- The simulator (dimensional-weight model) of launching tube (types of simulators of a launching tube, the starting mechanism, a land power unit are defined by the type of simulated PADS) with sensors of angular position of a line of aiming and the module of registration of anthropometrical characteristics of the anti-aircraft gunner
- The simulator of launching mechanism
- The simulator of a land power unit (4)

Training simulator workplaces are connected by the local computer network.

Devices of interface, audioinformation delivery, system of automated adjustment are built in a helmet of virtual reality, simulators of a launching tube and launching mechanism.
The instructor workplace includes:
- System block (2 pieces)
- Control panel of a training simulator
- Communication facility of the head with trainees
- Audio system.

Functionality of a workplace of the head:
- Selection of conditions of training performance
- Selection of exercise from library
- Formation of new exercise
- Control of actions of trainees during training (lesson)
- Diagnostics of technical condition of a training simulator
- Operative help to the head
- Training simulator turning-on/-off
- Printing of results of training
- Formation of assessment for exercise performance
- Modes «Initial data», «Training», «Editor of air conditions (AC)», «Editor of land conditions», «Results of training»
- Formation of a base of results of trainings for the period
- Input of malfunctions and failures of the equipment of a training simulator
- View of the editor of land conditions with the chosen launching site and land reference points

The main menu of the head with the panel of selection of operating modes of a training simulator
Structure of a hardware-software complex of a training simulator

Special software

The operating computer of the head

- Network exchange module
- AAGM flight model
- Module of input from standard devices
- Module of formation of user’s interface
- Module of the editor of AO and models of flight of air objects
- Module of setting of conditions of firing and position selection
- Model of visualization of a course of exercise and assessment of result

The working computer of anti-aircraft gunner

- Network exchange module
- Adapter exchange module
- Adjustment module
- PADS operating module
- Module of recalculation of coordinates, solution of tasks of adaptive data filtration
- Module of formation of three-dimensional model of visualization of district, air and land objects

The model of PADS operation corresponds to the type of a simulated complex
Structure of methodical maintenance of a training simulator

METHODICAL MAINTENANCE

Methodical maintenance of the automated system of training

Automated diagnostics of skill level

Management of parameters of the educational-informational environment according to recommendations by results of trainings

Library of tasks of training firings of beginner level

Library of tasks of training firings of high difficulty

Scenarios of actions of the air opponent

Variants of placing of hindrances

Fire control variants

Variants of actions of the aircraft
Technical characteristics

8.1. Adequacy

- Conformity of mass-dimensional characteristics of simulators of a launching tube, starting mechanism and the land power unit to characteristics of PADS
- The maximum similarity of simulators of a launching tube, starting mechanism and the land power unit to real
- The full list of reproduced functions of means of control and indication of PADS
- Conformity of ranges of moving, efforts and reaction of controls in a training simulator to characteristics of real PADS (conformity of ergonomic characteristics and a sensory-motor field of trainee’s workplace in a training simulator to anti-aircraft gunner’s workplace)
- Conformity of algorithms of functioning of the equipment of a training simulator in all modes and reaction of means of control and indication training simulator on operating actions of trainees to real PADS
- Projection of range of visibility of land objects and air targets taking into account supervision conditions
- Consideration in the model of a control loop of AAGM of all basic characteristics (realized method of aiming, characteristics of a seeker, launching and cruise engine etc.)
- Conformity of sound effects of work of a complex in a training simulator to real
- Visualization of land and air environment, flight of an anti-aircraft missile, hit (miss), self-liquidation AAGM, falling of an air target, collision of AAGM with land
- Consideration of background conditions

The training simulator provides performance of not less than 90 % of actions of the anti-aircraft gunner
Quality of visualization of background target environment

The training simulator provides imitation of conducting visual supervision taking into account optical visibility, range and type of objects, meteoconditions, time of day.

High quality of visualization of background target conditions is achieved by:

- Application of glasses of a virtual reality with high resolution
- Detailed elaboration and imaging of district structure
- Conformity of color scale of district structures and objects to real colors and contrast
- Conformity of the angular sizes, forms, local subjects, vegetation, land and air targets to real objects at visual supervision.

1. Anti-aircraft gunner’s FOV at observation of air environment
2. Initial stage of aiming
3. Visual support of target by anti-aircraft gunner (trigger is not pressed).
Field of vision of the anti-aircraft gunner at capture of target by a seeker.

Field of vision of the anti-aircraft gunner after missile firing and operation of ejection engine

Work of the cruise engine, flight of AAGM to the target

Visual assessment of results of firing
The training simulator is developed for operation in armies, is simple in operation and service.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Parameter name</th>
<th>Unit of measurement</th>
<th>Parameter value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minimum required area for placing</td>
<td>m²</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Premise type</td>
<td></td>
<td>Educational class</td>
</tr>
<tr>
<td>3</td>
<td>Readiness for employment after inclusion</td>
<td>min</td>
<td>Not more than 5</td>
</tr>
<tr>
<td>4</td>
<td>Duration of continuous work</td>
<td>hour</td>
<td>Not less than 12</td>
</tr>
<tr>
<td>5</td>
<td>Power supply: voltage</td>
<td>V</td>
<td>220±10%</td>
</tr>
<tr>
<td></td>
<td>frequency</td>
<td>Hz</td>
<td>50±1</td>
</tr>
<tr>
<td>6</td>
<td>Power consumption</td>
<td>kW</td>
<td>1,5</td>
</tr>
<tr>
<td>7</td>
<td>Raised working and limiting temperature</td>
<td>°C</td>
<td>up to +35</td>
</tr>
<tr>
<td></td>
<td>Reduced working temperature</td>
<td></td>
<td>up to +5</td>
</tr>
<tr>
<td>8</td>
<td>Relative humidity at temperature +25°C</td>
<td>%</td>
<td>up to 80</td>
</tr>
<tr>
<td>9</td>
<td>Diagnostics system</td>
<td></td>
<td>Built-in semi-automatic</td>
</tr>
<tr>
<td>10</td>
<td>Time before failure</td>
<td>hour</td>
<td>Not less than 300</td>
</tr>
<tr>
<td>11</td>
<td>Management of turning-on and turning-off</td>
<td></td>
<td>Remote, from the head’s workplace</td>
</tr>
<tr>
<td>12</td>
<td>Spare parts</td>
<td></td>
<td>Individual and group (four 4 training simulators)</td>
</tr>
<tr>
<td>13</td>
<td>Servicing</td>
<td></td>
<td>Control survey, daily TO, TO-1 (once in 6 months), TO-2 (once a year)</td>
</tr>
<tr>
<td>14</td>
<td>Electrical safety of trainees and attendants</td>
<td></td>
<td>Exclusion of dangerous voltage on the trainee’s workplace. Protection against short circuit on head’s workplace</td>
</tr>
<tr>
<td>15</td>
<td>Registering operating time of a training simulator</td>
<td></td>
<td>Program counter of motor-hours</td>
</tr>
<tr>
<td>16</td>
<td>Weight of assembled training simulator</td>
<td>kg</td>
<td>130</td>
</tr>
<tr>
<td>17</td>
<td>Operational documentation</td>
<td></td>
<td>Data card, operation manual, manual on installation and adjustment, manual on repair, spare parts sheet</td>
</tr>
</tbody>
</table>
9. Educational-methodical possibilities

- Conducting visual investigation in various conditions of visibility
- Performance of firing exercises in various conditions (normal, mountain, and deserted district, in day and night conditions, in winter and in summer, in various meteoconditions)
- Performance of firing exercises with use of various operating modes of a complex, on the opposite and pursuit courses, on maneuvering and non-maneuvering targets
- Maintenance of a principle of training “from simple to difficult”, individual approach to formation of skills of fighting operation at anti-aircraft gunners
- Organizational and methodical interrelation of lessons and trainings on the training simulators with drills in the field and combat firing
- Objectivity of assessment of level of skills of each anti-aircraft gunner of division, definition of dynamics of acquisition of skills of fighting operation in the whole spectrum of conditions of air and jamming environment
- Controllability of process of education and training, high intensity of preparation
- Decrease in conditionality of education and trainings, approach of conditions of training of anti-aircraft gunners to conditions of real fight.

Training simulator possibilities on formation of conditions of training:

- Selection of a position of the anti-aircraft gunner on district
- Display of land and air environment on maps M:50 000
- Formation of a route and profile of flight of air targets (quantity of simultaneously displayed targets – up to 16)
- Formation (setting) of background conditions and hindrances (thermal, smoke and aerosol hindrances, sun, clouds, optical-electronic hindrances)
- Selection of type of air target (helicopters AN-64, Mi-8, Ka-26, attack planes A-10, Su-25, pilotless FO, cruise missile ALCM, tactical destroyer MiG-29, Su-27, F-15, transport aircraft AN-24, “Hercules”)
- District types – normal, mountain, deserted (by request of the Customer the three-dimensional model of any real site of district can be created)
- Time of day – day, twilight, night
- Meteoconditions – sunny weather, overcast, wind of various speed and direction
- Season – summer, winter (under requirements of the Customer according to conditions of geographical area of lessons and trainings)

Possibilities on processing and storage of results of employment and trainings:

- Documenting of results in electronic form (printing)
- Archiving results for a day or for a period
- Inclusion of a training simulator in the system of centralized account and processing of results of training

View of the editor of air conditions on head’s workplace
Didactic possibilities

Possibilities of the head on the control of actions of trainees:
- By current condition of means of controls and indication of PADS
- By the duplicated field of vision of the anti-aircraft gunner
- By the report of errors during exercise performance
- By reports of trainees

Possibilities on assessment of actions of trainees:
- Automatic assessment of actions at performance of firing exercises with consideration of complexity of exercises according to indicators and the list of critical errors (according to “Firing Rules…”)
- Automatic formation of recommendations on management of training process

Panel of control of training and actions of the trainee on the head's workplace

Indicators of assessment
1. Timeliness of turning-on of the land power unit
2. Correctness of selection of a priority of firing of the target in the opposite or pursuit course
3. Stability of capture and tracking of target
4. Correctness of selection of the moment of AAGM launch
The training simulator allows to train anti-aircraft gunners, to form and support steady skills of performance of following operations of fighting performance:

- Search and detection of air targets in air conditions of various complexity, in various conditions of meteorological visibility, season and time of day, in the conditions of the organized smoke, aerosol and thermal hindrances, on various district;
- Visual recognition (identification) of type of target;
- Visual estimation of distance to the target;
- Identification of belonging of the target by means of simulator of ground-based interrogator;
- Selection of a kind of firing (“OPPOSITE – IN PURSUIT”);
- Selection of operating mode of the launching mechanism (“MANUAL-AUTOMATIC”);
- Assessment of a launching zone, definition of the moment of launch and AAGM launch on air targets, including on the targets, operating in the conditions of hindrances, imitation of sound effects of work of a complex and surrounding background;
- Imitation of launch and flight of AAGM according to characteristics of a control loop of a missile;
- Supervision over aiming AAGM on the target;
- Assessment of results of firing.

### Results of introduction of a training simulator of the anti-aircraft gunner in combat training in a combination with existing educational-training means

- Leading of factor of coverage of operations of fighting work to 0.94. Training of anti-aircraft gunners to full and effective use of fighting possibilities of PADS in difficult conditions of fighting environment.
- Creation of conditions of lessons and trainings close to the fighting. Maintenance of methodical interrelation of lessons and trainings on a training simulator with training in the field.
- Objectivity of assessment of level of readiness of anti-aircraft gunners.
- Operated process of lessons and trainings.
- Possibility of training of divisions of anti-aircraft gunners.
Reliability

The training simulator provides reliable work during the whole period of operation (warranty and after-warranty operation periods)

The program of maintenance of reliability of a training simulator is based on following principles:
- Application in manufacture of the reliable accessories checked up by operating experience, entrance control
- Working out of the program solutions excluding conflicts of the special software with general, and also with hardware
- Repeated check of developed project solutions
- Application of the project solutions providing long work of mechanical nodes
- After-operational and stage-by-stage quality assurance of mechanical and electric assemblage of training simulators
- Application in structures of nodes of a training simulator of exclusively contactless sensors of angles of turn and moving (on the basis of magnet-sensor microcircuits)
- Application of protection frames of printed-circuit boards of electronic devices and contacts of sockets from influence external environment
- Use of computers in industrial (protected) forms
- Application of sources of uninterrupted supply for computers
- Maintenance of necessary thermal operating modes of equipment of training simulators
- Maintenance of stocks by capacity of power supply sources

Warranty and service life
- The warranty period of operation of a training simulator is 1 year at observance of operational rules and maintenance service performance according to the operational documentation.
- Training simulator service life is not less than 8 years at observance of service regulations and maintenance service and repair performance according to the operational documentation.

- The training simulator provides continuous work 12 hours a day
- Time before failure of the training simulator is not less than 300 hours