Mi-17 helicopter
full flight and full mission simulator
Purpose of simulator

Simulator is intended for teaching and training on land of Mi-17 helicopters crews to acts in full range of their duties on piloting, navigation, maintenance of airborne systems and helicopter equipment, to communicative activity and to effective interacting. Crews consist of the commander (the left pilot), the navigation officer (the right pilot), flight engineer (flight mechanic). Trainings are carrying out for the purpose of build up and maintenance of crews’ resistant skills of control by helicopter and its armament in various conditions with including the failures of various airborne systems and in special cases according to the Management of flight operation of Mi-17V-5 helicopter.

Simulator general characteristics meet to the demands to complex flight simulators (FFS) of qualifying level «B» (according to standard CS-FSTD (H) «Demands to certification of flight simulators of helicopters). Simulator characteristics ensures training not only flight and navigating tasks according to a Management on Flight Operation, but also realization of trainings on fulfilment of combat missions (according to the Heading of Combat Training and the Management on Battle Application of air means of defeat).

Simulator architecture ensures capability of its drive updating while in service (according to demands of the customer), and also capability of its integration with other simulators (in common virtual battle space and time according to standard IEEE 1516.3).

The simulator can be used during combat training of helicopter’s units and divisions, and also in educational process of military educational institutions.
Components and Structure of Simulator
Configuration of simulator

Simulator consists from:
1. Flight compartment simulator
2. Mobility system (6-DOF dynamic platform and the shake table)
3. 10-channel projection system with the spherical shield
4. Instructor work station (including a hardware-software complex)
5. Computer flight simulator
6. Equipment for AAR (after action review)
Variant of simulator disposing in sweepingly erected building
Simulator of the helicopter flight compartment

Simulator of the helicopter flight compartment completely matches to the flight compartment of the real Mi-17V-5 helicopter (the series and modification indicated by the customer) on the in-house sizes, composition and disposing of work stations of crewmen, regular controls, simulators of instruments and equipment. Simulator also has the additional equipment.

The additional equipment: button of emergency power switching-off of the simulator and turning on of emergency illumination in helicopter cabin and indoors the simulator; dome lights of emergency illumination; video cameras for observation over crew acts in cabin; dynamic loudspeakers in cabin acoustical stereosystem; position sensors of helicopter regular controls; onboard local computer network; antenna for a wireless communication of onboard computer network with simulator local computer network; door; ladder for crew landing.
Mobility system of the flight compartment is intended for imitation acceleration effects which affect to crew in real helicopter during moving on the ground and in air.

### The motion system consist of:

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6DOF electromechanical dynamic platform&lt;br&gt;Actuating mechanisms type - electromechanical&lt;br&gt;Control system type - frequency on rate and position</td>
<td>±0,94 m&lt;br&gt;±0,60 m/s&lt;br&gt;±6,0 m/s²</td>
</tr>
<tr>
<td>2</td>
<td>3DOF vibration platform&lt;br&gt;Vibration frequency 3…50 Hz&lt;br&gt;Vibration amplitude 0…0,5 mm</td>
<td>±0,98 m&lt;br&gt;±0,60 m/s&lt;br&gt;±6,0 m/s²</td>
</tr>
<tr>
<td>3</td>
<td>Flashing signal about activity of motion system</td>
<td></td>
</tr>
</tbody>
</table>

### The main dynamic characteristics of motion system

<table>
<thead>
<tr>
<th>In order</th>
<th>Name of characteristic</th>
<th>Linear displacement and angles of pitch, rotations</th>
<th>Linear and angle traverse speed</th>
<th>Linear and angle accelerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Displacement along longitudinal axis</td>
<td>±0,94 m</td>
<td>±0,60 m/s</td>
<td>±6,0 m/s²</td>
</tr>
<tr>
<td>2</td>
<td>Displacement along transverse axis</td>
<td>±0,98 m</td>
<td>±0,60 m/s</td>
<td>±6,0 m/s²</td>
</tr>
<tr>
<td>3</td>
<td>Displacement along vertical axis</td>
<td>±0,70 m</td>
<td>±0,40 m/s</td>
<td>±9,0 m/s²</td>
</tr>
<tr>
<td>4</td>
<td>Roll</td>
<td>±24,0º</td>
<td>±34 º/s</td>
<td>±220º/s²</td>
</tr>
<tr>
<td>5</td>
<td>Pitch</td>
<td>±23,0º</td>
<td>±35 º/s</td>
<td>±220º/s²</td>
</tr>
<tr>
<td>6</td>
<td>Yaw</td>
<td>±34,0º</td>
<td>±35 º/s</td>
<td>±220º/s²</td>
</tr>
</tbody>
</table>
The mobility system possesses load-carrying capacity of 2 500 kg and ensures various architecture of the simulator:
1. Flight compartment on the platform and with the fixed spherical shield in radius of 6 or 9 m.
2. Cabin together with the shield on common platform.
The fixed two-levelled visual projection system of aft-of-cockpit space is used in the simulator. This system ensures a capability of piloting and navigation according to Rules of contact flights during carrying out the trainings, and also conducting the visual observation and survey of the targets, imitating shooting with taking into account meteorological conditions, range and type land and air targets, smokes, fires, etc.

Hybrid laser and light-emitting diodes projectors possess high luminous radiation and contrast range. They are noncritical to insignificant oscillations of construction, do not demand individual cooling. The service warranty period of light source in 4 times exceeds a lifetime of conventional lamps.

The method of program adjustment of projection systems visualization ensures high picture quality, exact "sewing together" of images from different projectors, build-down of demands to computing power of server, build-down of demands to stability of critical bucklings of visual system. It reduces time and money spending for set-up of the simulator due to giving to its user the capability to make independently adjustment the visual system.
Instructor’s working place

- Selection of exercise from library taking into account the chosen plan of training and demanded level of difficulty
- Selection of conditions of trainings realization
- Selection of section of locality
- Preparation of exercises by instructor
- Control of trainees acts during exercise
- Two-way communication with trainees

Instructor’s capabilities of preparation and during carrying out trainings

- Choice the region of carrying out of the forthcoming flying mission from the available in the simulator geoinformational baseline;
- Formulation the flying mission: Combat mission; Battle load of the helicopter; Itinerary and flight profile; Solo flight or in pair or link composition (as leader or wingman);
- Formulation the weather conditions of the flying mission fulfilment;
- Implementation the flight director functions;
- Operative variation of the current training scenario (the task of unnominal situations, introducing the failures etc.);
- Representation of a current position of the helicopter in the virtual battle space and on an electronic topographical map;
- To carry on conversation with trained crewmen in a two-way communication regime;
- The operative control of training with a capability of its stop, the post-flight analysis of acts of each crewman;
- Documenting the results of fulfilment of flying missions by crew;
- Storage of trainings results of all trainees and realisation of their analysis;
- The hardcopy of training results.

<table>
<thead>
<tr>
<th>Number</th>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unified table</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Keyboard</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Optic mouse</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>22,5&quot; monitor</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Uninterrupted power supply unit</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Handset</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Laser printer</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>System unit with general and specific software</td>
<td>6</td>
</tr>
</tbody>
</table>
Modelling of helicopter motion dynamics (on the ground and in air) realized in real time taking into account flapping motion of blades of bearing and tail rotors, both in operational altitude band and flying speeds, and on flight particular treatments (a vortical ring of bearing or of tail rotors, "grab", "wing heaviness", tail rotor failure, failure of engines). Helicopter aerodynamics in proximity of the ground (screen effect) taking into account features of a relief of a particular site of an earth surface (flat, deserted, crossed, mountain, a water table) is calculated. The external suspension is modelled (on pylons) in the conditions of reaction of the helicopter to a way of separation of freight and reaction to change of weight of the helicopter (smooth - at fuel utilization, step - at application of an ammunition). External wind disturbances and atmosphere condition are set and correctly considered according to the adopted standard. Imitating modelling of operation of all systems of the helicopter implements with a control capability of technical failures of separate

The block diagram of program complex of Simulator
High quality of visualization of the outside cockpit space

High quality of visualization is reached by the following:
- application of high-quality multichannel projection system and implementation of high resolution (not less 1024x768 on each channel, frame rate - not less than 60 shots per second) on 6 m spherical diameter shield;
- creation of the continuous ("jointless") image with viewing angles 240° on horizontal and 80° on vertical);
- conformity of texture colour gamma of locality and installations to real colours and contrast range;
- conformity of angular sizes, forms, local subjects, vegetation, land and air targets to real objects;
- provision the variation of visibility conditions and intensities of illumination accordingly to geographic latitude, day time and meteorological conditions;
- provision of local variation of visibility because of the atmospheric phenomena (a smoke, a fog, cloud cover and so forth).

High quality of visualization of land and air environment is ensured:

- Creation of three-dimensional typical models and connected to region the sites of earth surface in the size 400’400 km;
- The maximum detailed elaboration of single areas in radius up to 5 km (areas of aerodromes and areas of arrangement of the land or surface targets); Including texturized earth surface, discernible landscape objects (rivers, lakes, mountains, woods, fields, etc.), runways, taxiways and landing fields, roads, buildings, and also objects of ground equipment, lighting aerodrome facilities.
**Adequacy of Simulator**

Simulator ensures demanded adequacy due to implementation the high constructive and functional adequacy of its separate elements and all hardware product as a whole at the time of simulator’s development and manufacture.

Constructive adequacy is attained due to:

- full conformity of simulator geometrical sizes of helicopter front cockpit cabin and space disposing of simulators of controls, units and equipment;
- maximum likeness the fast-head panels of simulators of controls to the real equipment;
- conformity of illumination of equipment, instruments scales, headers and inscription to the simulated airplane illumination.

Functional adequacy is attained due to:

- conformity of operation algorithms of simulators of onboard systems, devices and units to control actions of crew, and accordingly, correct reaction of controls and indication;
- reproduction of the full list of procedures of control which are necessary at fulfilment by crew of all basic functions during preparation to flight and in its course;
- conformity of moving ranges, force and reaction of handles, levers, pedals, switches in helicopter cabin to real;
- calculation and visualization of flight trajectory of the helicopter and other flight vehicles according to the detailed mathematical model of flight of Mi-17V-5 helicopter and aircraft performance characteristics of other flight vehicles, and also to the meteorological conditions;
- calculation and visualization of flight trajectories of aviation weapon according to their characteristics;
- realistic imitation of sound effects of helicopter activity of units and aggregates, and also the atmospheric phenomena and combat sounds.
Adequacy of the mathematical model of mission of helicopter Mi-17V-5 in a wind tunnel

During working out was conducted research of aerodynamic characteristics of scale model of helicopter Mi-17V-5 in a wind tunnel for the purpose of increase of adequacy of the mathematical mission model. Circular aerodynamic characteristics of the helicopter body were received. Testing flights by the helicopter-prototype for the purpose of definition of characteristics of stability and controllability in operational altitude band and speeds of flight have been simultaneously conducted. Own package of initial data for verification of the developed mathematical mission model has been received as a result.
Reliability of Simulator

Simulator’s reliability is based on following principles:
- Application in manufacture of the reliable accessories checked up by in-service experience, incoming control conducting,
- Working out of the program solutions expelling conflicts of the special software with general software, and also with hardware,
- Repeated check of the developed design solutions,
- Application of the design solutions ensured a long-period operation of mechanical units,
- By operations and a stage-by-stage quality control of mechanical and electrical assemblage of simulators,
- Application in designs of simulator units only contactless sensors of turn angles and displacement (based on Hall microcircuits sensors),
- Application of protection equipment for printed-circuit boards of electronic devices and contacts of connectors from environment effect,
- Use of computers in the industrial (protected) modification,
- Application of uninterrupted power supply units for computers,
- Provision of necessary thermal operational modes of simulator equipment
- Provision of reserves on power of power sources.

The warranty and service life
- The warranty period of simulator service life makes 3 years in case of compliance to service regulations and conducting the maintenance according to the operational documentation.
- Simulator service life makes not less than 8 years in case of compliance to service regulations and conducting the maintenance and repair according to the operational documentation.

® Simulator ensures continuous work within 12 hours a day

® Simulator mean-time-between-failures (MTBF) makes not less than 500 hours
### Service performance data of the simulator

<table>
<thead>
<tr>
<th>No</th>
<th>Parameter name</th>
<th>Unit of measure</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Placement type</td>
<td>---</td>
<td>On the ground floors of capital buildings or special easily collected structures of type «Sprung»</td>
</tr>
<tr>
<td>2</td>
<td>Minimum square of placement</td>
<td>m²</td>
<td>216 (12 x 18 m)</td>
</tr>
<tr>
<td>3</td>
<td>Minimum height of placement</td>
<td>m</td>
<td>8,4</td>
</tr>
<tr>
<td>4</td>
<td>Readiness time after turning on</td>
<td>min</td>
<td>No more than 15</td>
</tr>
<tr>
<td>5</td>
<td>Duration of continuous activity</td>
<td>hour</td>
<td>No less than 12</td>
</tr>
<tr>
<td>6</td>
<td>Electric power: voltage</td>
<td>V</td>
<td>220±10%</td>
</tr>
<tr>
<td></td>
<td>Electric power: frequency</td>
<td>Hz</td>
<td>50±1</td>
</tr>
<tr>
<td>7</td>
<td>Maximum electric energy input</td>
<td>kW</td>
<td>55</td>
</tr>
<tr>
<td>8</td>
<td>Average electric energy input</td>
<td>kW</td>
<td>24</td>
</tr>
<tr>
<td>9</td>
<td>Increased working and limiting temperature</td>
<td>°C</td>
<td>Up to +35°</td>
</tr>
<tr>
<td></td>
<td>Reduced working temperature</td>
<td>°C</td>
<td>Up to +5°</td>
</tr>
<tr>
<td>10</td>
<td>Relative humidity at temperature +25°C</td>
<td>%</td>
<td>Up to 80%</td>
</tr>
<tr>
<td>11</td>
<td>Diagnostic system</td>
<td>---</td>
<td>In-built, semiautomatic</td>
</tr>
<tr>
<td>12</td>
<td>Control of turning on and shut down</td>
<td>---</td>
<td>From instructor working place</td>
</tr>
<tr>
<td>13</td>
<td>Spare and repair parts set</td>
<td>---</td>
<td>Individual</td>
</tr>
<tr>
<td>14</td>
<td>Maintenance works</td>
<td>---</td>
<td>Check, Daily maintenance, Maintenance N1 (TO-1) (once in 6 months), Maintenance N2 (TO-2) (once a year)</td>
</tr>
<tr>
<td>15</td>
<td>Operational liquids</td>
<td>---</td>
<td>Petroleum oil in geared motors of dynamic platform</td>
</tr>
<tr>
<td>16</td>
<td>Electric safety of trainees and attendants</td>
<td>---</td>
<td>Exclusion of dangerous voltage in the cockpit simulator (direct current voltage +24V is used). Protection against short circuit</td>
</tr>
<tr>
<td>17</td>
<td>Accounting of simulator operating time</td>
<td>---</td>
<td>Program counter of hours</td>
</tr>
<tr>
<td>18</td>
<td>Common simulator mass</td>
<td>kg</td>
<td>3600</td>
</tr>
</tbody>
</table>
Training and methodical possibilities of simulator

Simulator ensures support the next crew training programs:

• initial training;
• re-education from other type of helicopter;
• carrying out of periodic training and improvement of professional skill of acting pilots;
• realization of annual checks;
• testing of a training level of new pilots;
• recovery of qualification after break in flight activity;
• training of the technical-engineer personnel in analysis of simulated faults;
• reduction of minimum of flight hours of pilots.

Simulator is universal educational methodical means of land preparation of flight personnel and ensures:

✓ Familiarizaition with controls of the helicopter and its systems
✓ Training of skills on assessment of the situation and decision marking at piloting of acts in special (emergency, unnominal) cases in flight and during fulfillment of tactical tasks;
✓ Training of skills of acts by controls on separate elements of exercises (flying missions);
✓ The automated task setting on training
✓ Individual preparation for flights
✓ Preparation for flying mission in group
✓ Comprehensive analysis of made errors in piloting technique and maintenance of the helicopter systems

Training on the simulator allows:

› to increase efficiency of training process and re-education of flight personnel
› to keep up the flight skills in the conditions of the restricted flight hours
› to reduce the charge of materials and resource of aeronautical engineering for educational and training flights
› to increase an air safety due to raise of readiness of pilots to unnominal situations
› to reinforce the control over discipline of flights
› Gives a wide range of research in new progressive methods and methods of flight training
Simulator allows to train:

- Initial skills of piloting of the helicopter in regular operating mode of the equipment in simple and difficult meteorological conditions at following stages of flight:
  - Preflight preparation and equipment check before start of engines;
  - Start of engines (АН-9В, ТВЗ-117В);
  - Taxiing;
  - Take-off;
  - Hovering;
  - Climb;
  - Cross-country flight;
  - Maneuvering on various modes of flight;
  - Decrease;
  - Landing approach;
  - Landing;
- Instrument flight rules operation;
- Conducting of visual orientation;
- Flights against the terrain background with various forms of a relief;
- Flights in night and day conditions;
- Flights in summer and winter conditions;
- Procedure of accomplishment of crewmen obligations in regular flight conditions;
- Crew actions on localisation of the arisen refusals of the equipment;
- Technology of crewmen interaction;
- Decision of navigation tasks and piloting on the avionics devices in real aeronavigation conditions with usage of the refreshed databases delivered with simulator;
- Skills on conducting of radio exchange with dispatchers of air traffic;
- Skills of operation with onboard systems of the helicopter;
- Training of actions in difficult and emergency situations.

Additional tasks, trained in a variant of simulator for transport-fighting helicopter:

- Reconnaissance, detection, identification and identification of the targets on the land or in air;
- Fighting maneuvering and aiming to the targets on the land or in air with imitation of application of aviation ammunitions, according to the Course of combat training;
- Adaptation of visualization of out-of-cockpit space and the cabin equipment with application of night vision glasses OBH-1 type at accomplishment of flights in night conditions;
- Management of onboard protection frames of the helicopter (automatic machines of the false thermal targets, etc.)
Simulator's capabilities on realization special (emergency, contingency) situations and development of skills on pull out the helicopter from them

- Mode of "vortex ring" on main and tail rotors
- Taking-off or landings on dusty or snowcovered airports or platforms,
- Flight at extreme small height over a crossed lay of land,
- Making a landing on an unprepared platform which selected from air,
- Making a landing on a platform of the limited sizes,
- Landings to a mode of autorotation,
- Failure of the vital systems and helicopter aggregates in flight

Monitor on instructor work station for video monitoring of crew actions in the cabin and of current position of the cabin.
Advantages of simulator use for training piloting and combat training of helicopter's crews and helicopter's sub-units

CAPABILITIES
On simulator it is easier and more safe, than in actual flight, to train actions of crewmen in full their duties according to the Management on flight operation of Mi-17 helicopter with capability of their repetition, including features of battle application.

REALISTIC
Simulator imitates flight with high degree of the realness, which reached due to the 6-DOF motion system, the spherical screen and system of visualization of out-of-cockpit space. Imitation of effects of acceleration, acoustic effects, vibration are imitated with high degree of adequacy.

SAFETY
Simulation of emergency (contingency) situations which cannot be created or extremely dangerously in actual flight.

OBJECTIVE EVALUATION
Simulator allows to carry out the all-round detailed analysis of accomplishment of the crew flying mission as a whole, and also separate skills by each crewman.

RELIABILITY
Simulator can be used till 12 o'clock a day irrespective of Meteorological conditions.

EFFICIENCY
Operation of simulator demands much less costs, than using of the real helicopter for training.
The developer and the manufacturer of the Mi-17 Helicopter Crew Complex Simulator ensures:

✓ Manufacture of Simulator and its delivery to a proper place of use
✓ Fixation to locality and building of a special hangar type premise for disposing and simulator exploitation
✓ assembly and start-up the simulator in operation
✓ training the operation personnel of user
✓ warranty service
✓ Authoring support and upgrade of the program complex during all continuance of simulator exploitation