



**L-39 Airplane
Crew Complex Simulator**

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Destination of simulator

L-39 airplane crew complex simulator (TL-39) is intended for teaching and training on land of cadets and pilots of L-39 airplanes to acts in total volume of their piloting duties, navigation, operation of airborne equipment, in communicative activity, to acts in the presence of various failures of airborne systems and in special situations, according to the Flight Operation Management of L-39 airplane (FOM).

Simulator provide the problem-solving of formation, perfection and maintenance the stable skills of cadets and pilots in airplane and armament control in various conditions (including counteraction of the land and air enemy).

Simulator can be used during combat training of air units and divisions, and also in educational process of military educational institutions in the time of in-depth study the subjects, connected with piloting and battle application of L-39 airplanes.

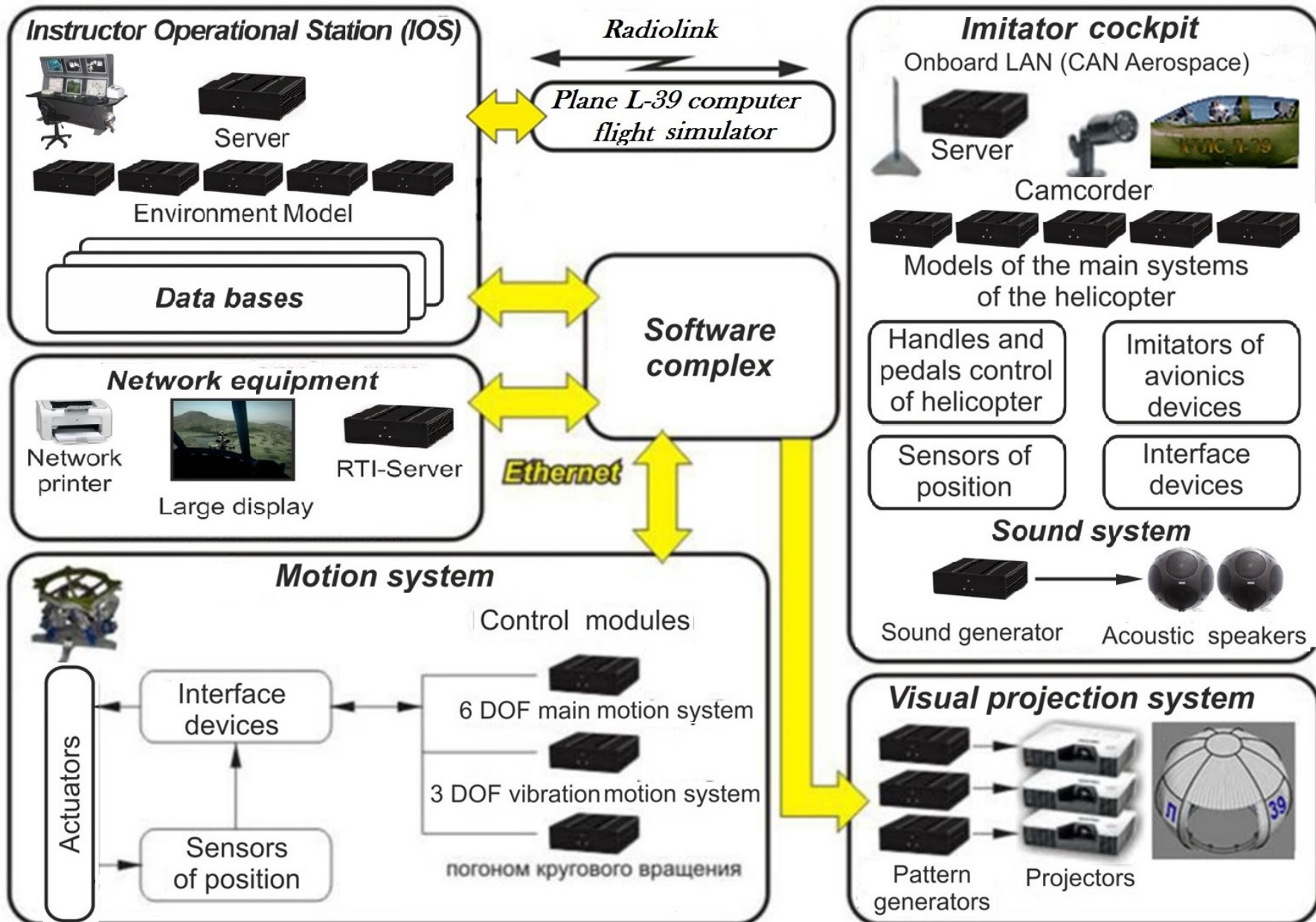
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Configuration of simulator

- ➡ front and rear cockpits simulators;
- ➡ motion system;
- ➡ visual system of outside space of cockpit;
- ➡ computer flight simulator;
- ➡ instructor's automatic working place;
- ➡ simulator's software complex;
- ➡ local computer network;
- ➡ equipment for briefing and analysis of simulated flights (After Action Review);
- ➡ power supply system;
- ➡ accessories and spare parts (set);
- ➡ technical and maintenance documentation.

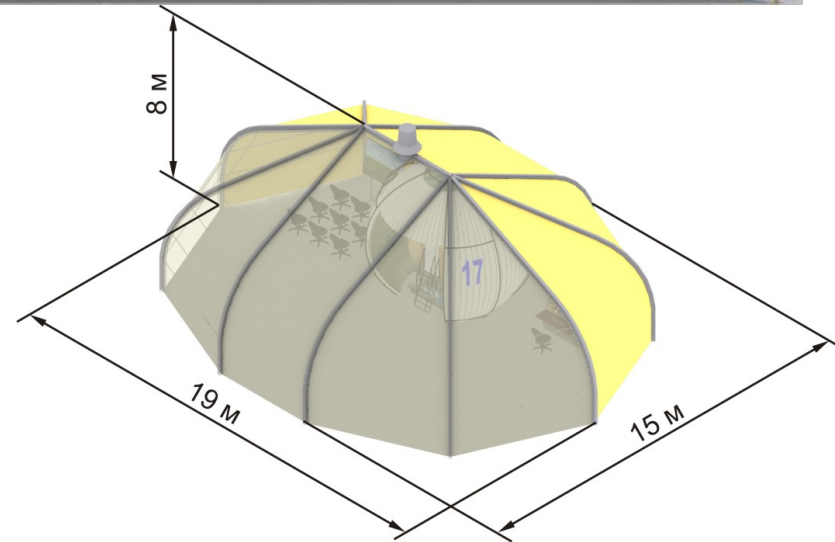
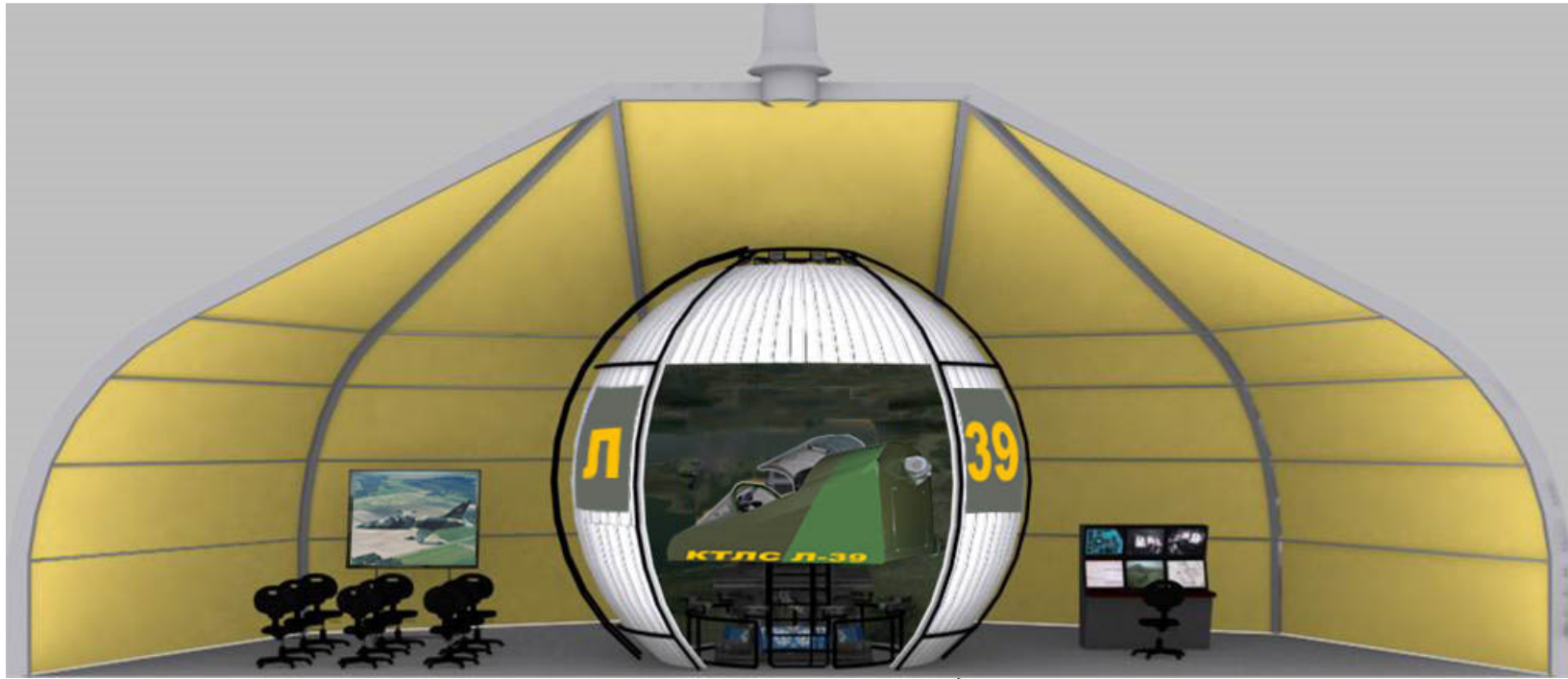
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Structure and interacting of the simulator elements



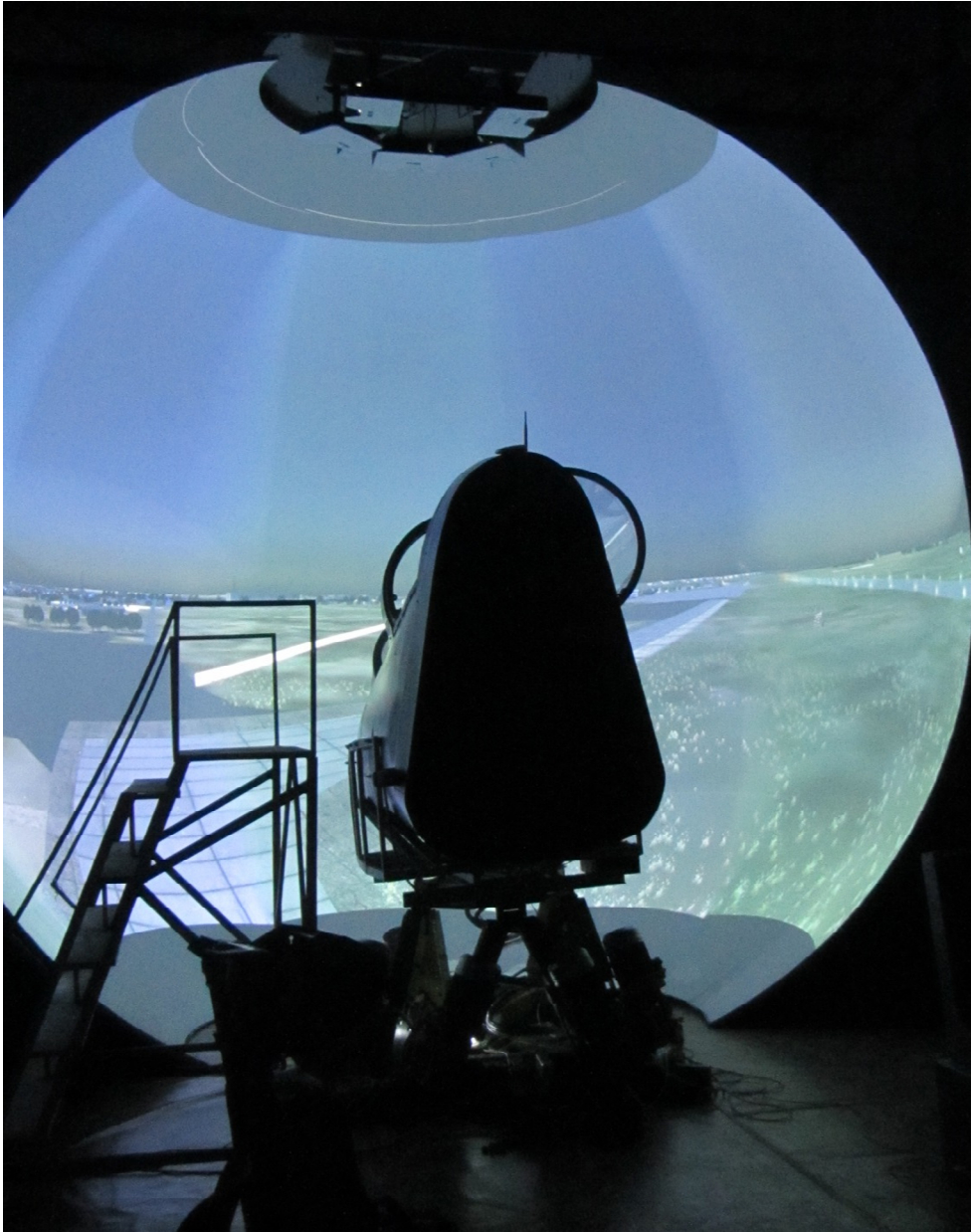
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Variant of disposing of the simulator in sweepingly erected building



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Variant of indoors disposing of the simulator



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Simulator of cockpit compartments

Cockpits simulators (front - for trained pilot/cadet, rear - for pilot-instructor) represent exact copies of corresponding compartment (between bulkheads 7 and 21a) of fuselage forward unit of L-39 airplane in scale 1:1 in internal geometrical sizes, structure and equipment accommodation.



- Flight controls completely correspond to controls of the real plane on exterior and strokes.
- Imitation system of loading of flight controls allows to reproduce non-linear control-stick forces and efforts on pedals depending on the aerodynamic forces acting on flaps, rudders and altitude on all flight phases of the plane
- Simulators of devices ensure display of their current condition. It is determined depending of controls position and of flight phase by mathematical operation models of corresponding onboard systems and engine.

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Equipment of cockpit compartments' simulators

They ensure:

- the visual information about attitude position of the plane relatively a horizon and radio beacons;
- the visual information and the information about intracabin space, including indications of devices and signaling system, about positions of controls and their changes in activity;
- acoustic information about aerodynamic noise, noise of power plant, aggregates and devices, sound effects of application of onboard aircraft armament, and also aircraft motion noise on the ground.



Front cockpit simulator



Rear cockpit simulator

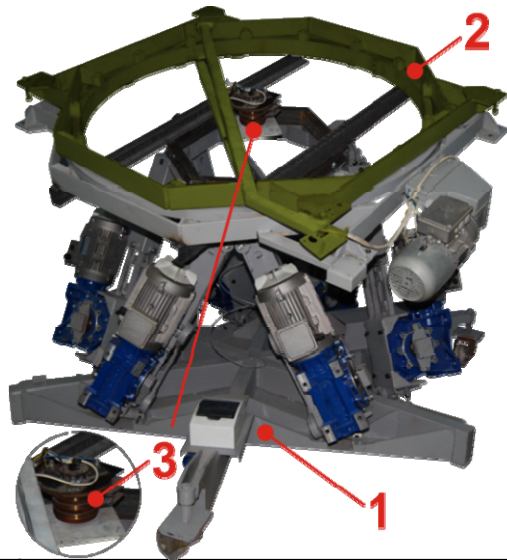
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Motion system

The motion system is intended for imitation the acceleration effects which influence to pilots in the real plane during taking - off and landing, and also in various flight conditions.

Type of actuators - electromechanical.

Control system type - frequency in speed and position.



The motion system consist of:

1	6DOF electromechanical dynamic platform
2	Rotating contact device for power supplies transfer
3	3DOF vibration platform
4	Flashing signal about activity of motion system

The main dynamic characteristics of motion system

In order	Name of characteristic	Linear displacement and angles of pitch, rotations, not less	Linear and angle traverse speed, not less	Linear and angle accelerations, not less
1	Relocation along transverse axis	±0,45 m	±0,70 m/s	±6,0 m/s ²
2	Relocation along longitudinal axis	±0,45 m	±0,70 m/s	±6,0 m/s ²
3	Relocation along vertical axis	±0,35 m	±0,50 m/s	±9,0 m/s ²
4	Roll	±23,0°	±30,0°/s	±220°/s ²
5	Pitch	±22,0°	±30,0°/s	±220°/s ²
6	Yaw	±25,0°	±70,0°/s	±220°/s ²
7	Vibration frequency range, Hz	0-50		
8	Vibration amplitude, mm	Up to 0,2		

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Visual system of outside space of cockpit

Fixed projection imaging system of aft-of-cockpit space is used in the simulator. This system ensures a capability of piloting and navigation during carry out of trainings according to Rules of contact flights. It also ensures conducting of visual observation and survey the targets and imitating shooting with taking into account meteorological conditions, range and type of land and air targets, smokes, fires, etc.



Composition

1	The self-supported spherical shield (glass-fibre, fixed), piece	1
2	Wide-angle projectors on swinging arm, pieces	10
3	Metal assembly farms with a mobile ladder for attachment, service and adjustment of projectors, complete set	1

Characteristics

Resolving capability, pixels on the channel	no less than 1024 x 768
Frame frequency, frames per second	no less than 30
Displaying sector (horizontal x vertically), deg	no less than 225 x 70

Features of construction of visualization projection system

- Laser and light-emitting diode projectors possess high luminous radiation and contrast range, are not critical to insignificant oscillations of construction, do not demand individual cooling. The warranty period of service of light source exceeds a lifetime of conventional lamps in the most perfect projectors.
- Method of program alignment (calibration) of projectors and overlapping ("lacing") of images from different projectors ensures high picture quality

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Quality of visualization of the outside cockpit space

High quality of visualization is reached by the following:

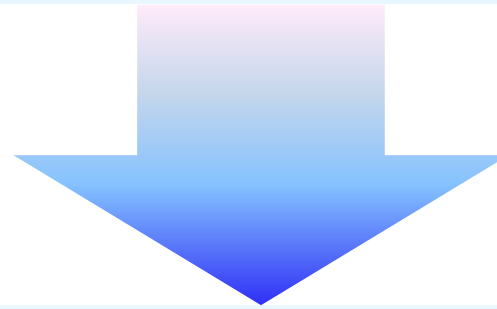
- application of high-quality multichannel projection system and implementation of high resolution (not less 1024x768 on each channel, frame rate - not less than 60 shots per second) on 6 m spherical diameter shield;
- creation of the continuous ("jointless") image with viewing angles 225 ° on horizontal and 70 ° on vertical;
- support of survey of space in airport area with an observability of runway, taxiways, the lighting equipment, buildings, locality landscape; with high extent of detailed elaboration and portrayal of airspace, aircrafts and ground objects, of locality landscape, vegetation, structures and infrastructure installations;
- 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);
- by choice the type of air defeat means with indication on instructor's working place;
- by Imitation the point of impact (explosion) of air defeat means applied by the trained pilot.

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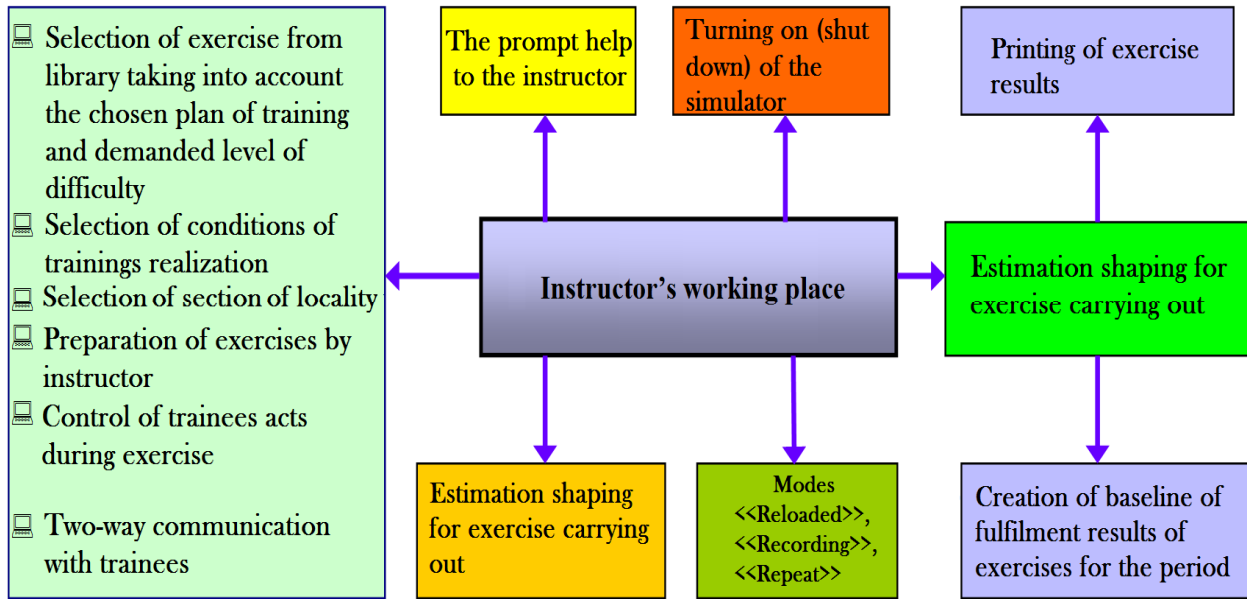
Adequacy of land and air situation is ensured:



- Creation of three-dimensional models of the geotypical and coordinate dimensioning sections of earth surface by 400 x 400 km size;
- The maximum detailed elaboration of separate regions in radius up to 5 km (regions of aerodromes and position regions of the land or above-water targets). Regions included texture-oriented earth surface, discernible landscape objects (rivers, lakes, mountains, woods, fields, etc.), flight strips, taxiways and landing fields, roads, buildings, and also installations of airfield equipment, lighting aerodrome facilities.



Instructor's automatic working place

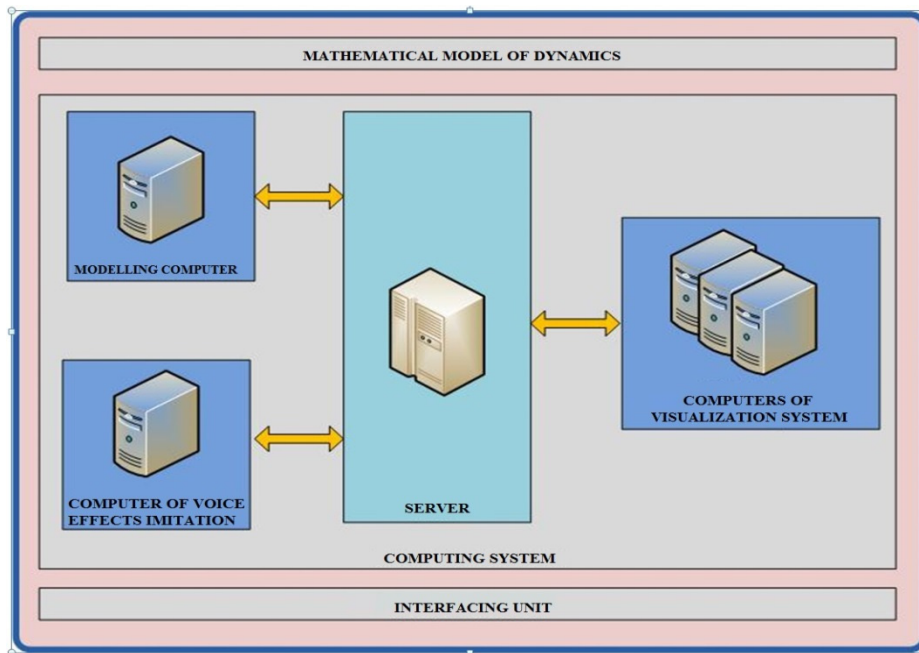


- choice the region of carrying out of the forthcoming flying mission from the available in the simulator geoinformational baseline;
- formation the initial position and condition of parties virtual subdivisions, and also the scenario of their acts (operational tasks) during training carrying out;
- formulation the flying mission, operational task; set the weather conditions of fulfilment of the flying mission;
- carrying out functions of the flight director; ;
- promptly variation of the current scenario of training;
- modelling the acts for virtual motorised-rifle, tank, rocket, artillery, anti-tank, antiaircraft and air units of the parties;
- control and representation of a current position of the airplane, and also common tactical land and air situation in the virtual battle space;
- carrying out the two-sided voice traffic with the trained pilot of the airplane;
- documenting the fulfilment by the pilot results of flying missions;
- demonstrating the pilot acts during all flight stages by reproduction recorded on the simulator the profiles of fulfilment of flying missions;
- storage of trainings results of all trainees and realization of their analysis;
- printing the training results.

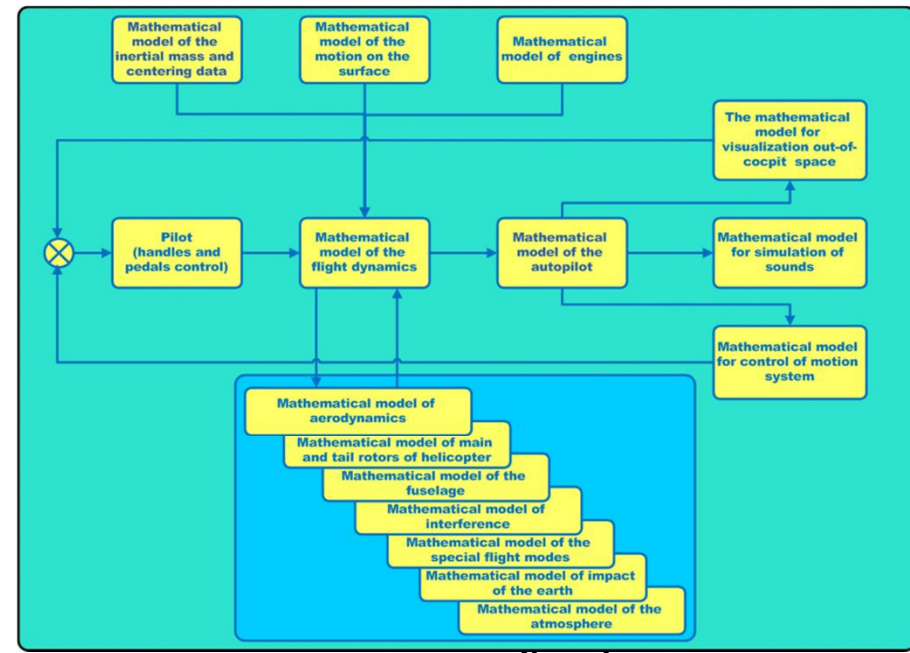
1	Unified table	1
2	Keyboard	1
3	Optic mouse	1
4	22,5" monitor	6
5	Uninterrupted power supply unit	1
6	Handset	1
7	Laser printer	1
8	System unit (not less Pentium IV 2,6 GHz) with general and specific software	6
9	Servers with general and specific software	2

Simulator's software complex (SSC)

Program complex structure



Structure of mathematical model of flight dynamics of the airplane



Modelling of the airplane motion dynamics (on ground and in air) realized in real time, both in operation altitude range and flying speeds, and on flight particular treatments. Aerodynamics of the plane settles up in proximity of the ground taking into account features of a relief of a concrete site of an earth surface. The external pod (on pylons) is modelled from condition of airplane response on a way of drop of freight. Response to variation of weight of the airplane is modelled (smooth - at fuel utilisation, stepwise - at application of an ammunition).

External wind disturbances and atmosphere state are set and correctly considered according to the adopted standard.

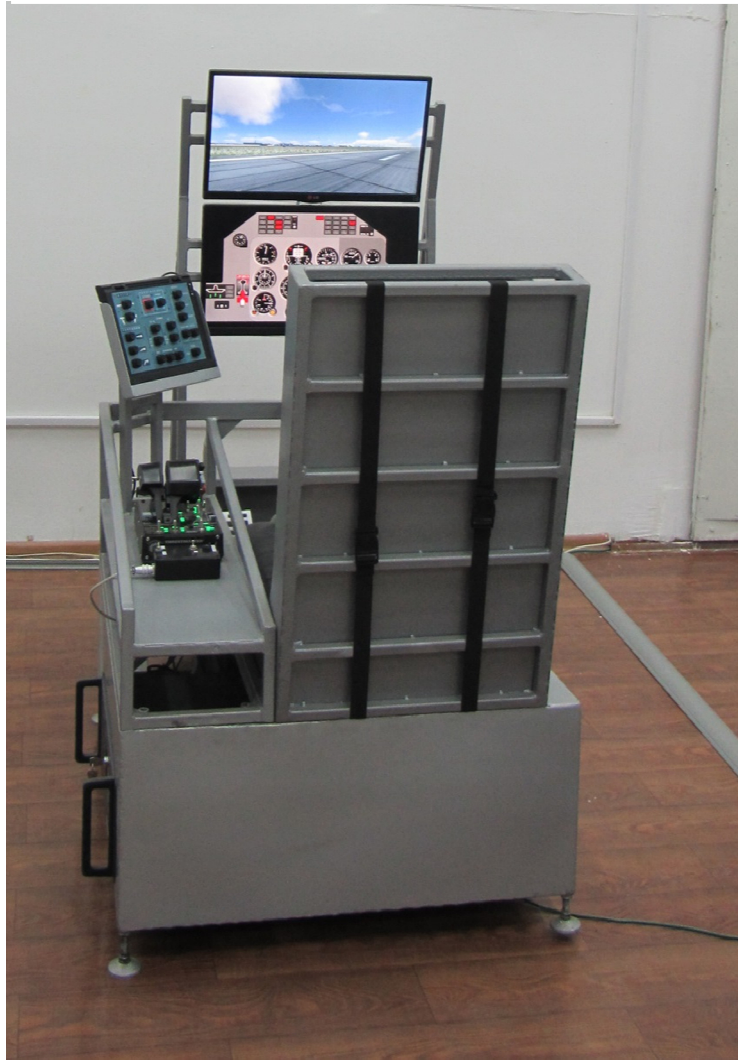
Simulation modelling of operation of airplane main systems implements with possibility of control the technical failures of separate aggregates, instruments and systems.

- Adequate modelling of acts of the airplane in real time, both in regular regimes, and on flight particular treatments (an engine failure, a propeller surge, a landing gear absenteeism, failure of the main generator etc.).
- The external pod (on pylons) is modelled from condition of airplane response on a way of drop of freight. Response to variation of weight of the airplane is modelled (smooth - at fuel utilisation, stepwise - at application of an ammunition).
- Correct taking into account of external wind perturbations and an aerosphere condition according to the accepted standard.
- Simulation modelling of operation of airplane main systems implements with possibility of control the technical failures of separate aggregates, instruments and systems.

Computer flight simulator

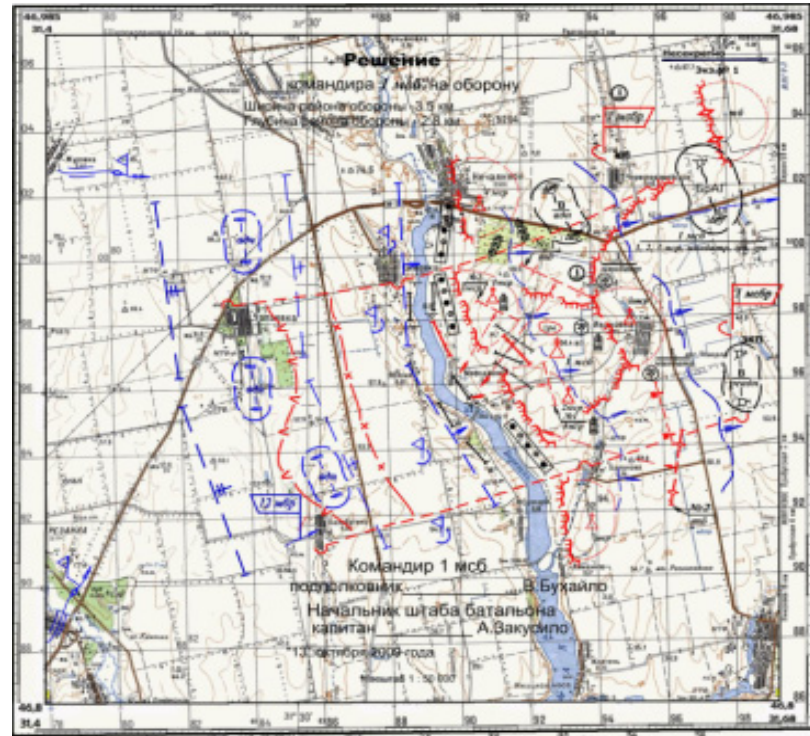
The computer flight simulator of airplane L-39 is built on the basis of the airplane mission model, intended for before training preparation of cadets. It ensures:

- Familiarization with the basic operational modes of the airplane and the basic controls,
- Taking - off, flight, landing taking into account airplane L-39 aerodynamic characteristics;
- Fulfilment of twin flights with the basic crew on the simulator.



Capabilities on simulator integration:

- Integration of the airplane simulator in unified virtual space with other complex simulators (motorised-rifle, tank, rocket, ammunition, anti-tank, anti-aircraft and air units);
- Simultaneous operation of the simulator in unified simulated tactical circumstances in real time with other air simulators;
- Representation of an arrangement of the virtual battle means to a district map;
- Application of air defeat means on the air, land and marine targets with imitation of visual effects of their application and with estimation of possible damaging.



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Adequacy of the simulator

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

Constructive adequacy is attained due to:

- full conformity of simulator geometrical sizes of airplane 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 airborne systems models, simulators of controls and handles, reaction of controls and indication on pilot actions with capability of control the technical failures of separate assemblies, instruments and systems;
- conformity of moving ranges, force and reaction of handles, levers, pedals, switches in airplane cabin to real;
- calculation and visualization of flight trajectory of the airplane and other aircrafts according to the detailed mission model of airplane L-39 and flight characteristics of other aircrafts, and also meteorological conditions;
- calculation and visualization of flight trajectories of air defeat means according to their characteristics, antiaircraft and other ammunition, and also according to principles of operation of guidance loops of air and antiaircraft guided missiles;
- realistic imitation of sound effects of activity of assemblies and airplane equipment;
- modelling of acts of the airplane in real time, both in regular regimes, and on flight particular treatments (an engine failure, a propeller surge, a landing gear absenteeism, failure of the main generator etc.), correct taking into account of external wind perturbations and atmosphere condition;
- imitating modelling of operation of airplane main systems

18 Research of aerodynamic characteristics of L-39 airplane model in the wind tunnel

Probing of aerodynamic characteristics of a scale model of airplane L-39 in the altitude tunnel is conducted at various deviation angles of controls over the range angles of attack $-60 \div +60$ deg. and slip angles ± 20 deg. for the purpose of raise of adequacy of the mathematical mission model and for the purpose of modelling of supercritical modes of flight (drop, spin).



Reliability of the simulator

Simulator reliability program is based on:

- to development of program solutions which expel conflicts of the special program and common software, and also conflicts to hardware
- application in manufacture of the reliable accessories checked up by in-service experience, and incoming control
- to repeated check of the developed design solutions
- application of the design solutions which ensure a long-lived operation of mechanical assemblies
- on quality control of each operation and stages during mechanical and electrical assemblage of simulators
- application in constructions of assemblies of simulator the contactless sensors of turn angles and movings (on the basis of magnetic sensitive microcircuits)
- application of protection means of printed-circuit boards of electronic devices and connectors contacts of from environment affecting
- 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 lifetime is not less than 8 years at observance of service regulations and realization maintenance and repair according to the operational documentation**

® **Simulator ensured a 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

No	Parameter name	Unit of measure	Value
1	Placement type	---	On the ground floors of capital buildings or special easily collected structures of type «Sprung»
2	Minimum square of placement	m ²	100
3	Minimum height of placement	m	6
4	Readiness time after turning on	min	No more than 15
5	Duration of continuous activity	hour	No less than 12
6	Electric power: voltage	V	220±10%
	frequency	Hz	50±1
7	Maximum consumed power	kW	35
8	Average consumed power	kW	11
9	Increased working and limiting temperature	°C	Up to +35°
	Reduced working temperature		Up to +5°
10	Relative humidity at temperature +25°C	%	Up to 80%
11	Diagnostic system	---	In-built, semiautomatic
12	Control of turning on and shut down	---	From instructor working place
13	Spare and repair parts set	---	Individual
14	Maintenance works	---	Check, Daily maintenance, Maintenance N1 (TO-1) (once in 6 months), Maintenance N2 (TO-2) (once a year)
15	Operational liquids	---	Petroleum oil in geared motors of dynamic platform
16	Electric safety of trainees and attendants	---	Exclusion of dangerous voltage in the cockpit simulator (direct current voltage +24V is used). Protection against short circuit
17	Accounting of simulator operating time		Program counter of hours
18	Common simulator mass	kg	3680
19	Documentation	---	Log book, Operating Manual, Assembling and Application Tuning Manual of the Simulator, Spare Parts List , Tutorial for Instructors

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Training and methodical possibilities of simulator

Simulator ensures support the pilot training programs:

- initial training;
- re-education from other type of an aircraft;
- 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 ;
- reduction of minimum of flight hours of pilots

Training on the simulator allows:

- To increase efficiency of training process 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 is universal educational methodical means of land preparation of flight personnel and ensures:

- Familiarization with controls of the airplane and its systems;
- Training of skills on an assessment of the situation and decision making at piloting;
- Training of skills of acts in special (emergency, unnominal) cases in flight;
- Training of skills of acts by controls on separate elements of exercises (flying missions);
- The automated task setting on training;
- Independent preparation for flights;
- preparation for flying mission in group;
- comprehensive analysis of made errors in piloting technique and maintenance of the airplane systems.

Tasks which are worked through on the simulator:

- Studying of informational-operating field of front cabin, logic of interacting with airborne systems according to manuals for airplane;
- Airborne equipment check before flight;
- Preparation for start-up, start-up and engine check;
- Preparation for a taxiing-out and taxiing in day time and night conditions;
- Take-off and climb in day time and night conditions, a circular flight;
- Fulfilment of figures simple, advanced flying and aerobatics elements;
- Airplane piloting visually and on instruments in all altitude range, rates, an angle of bank and a pitch, including in a flight criticality (drop, a spin normal and turned over, a spin planar);
- Airplane piloting on back-up instruments;
- Enroute flight, including with use of equipment "ISKRA-K" for an air navigation problem solving;
- Training of acts at failures of systems of the airplane, derangements and in the special cases envisioned by manuals;
- Fulfilment before landing manoeuvre and a landing approach, landing day and night, in difficult meteorological conditions, from a straight line and with turns.

The additional tasks completed in battle complete equipment variant of the simulator

- Fulfilment of flights on battle application (flights on launch of guided missiles with a self-steering on air targets, on shooting by uncontrollable rockets on ground targets, on bombing, on photoshooting on air targets);
- Targeting and application of uncontrollable rocket and ammunition armament of the airplane to land (surface) and to air targets;
- Targeting and bombing equipment application;
- Complex application of uncontrollable rocket both ammunition armament and bombing;
- Training of acts in special cases at emergency reset of armament and an ammunition from all suspensions in flight;
- Training of methods of fulfilment of attacks to the targets from a level flight, from a dive and from pitching with application of various aircraft armament;
- Overcomings of an air defence of the opponent.

Simulator's capabilities on imitation the special situations (emergency, supernumerary) and working through the skills to way out the airplane from them:

- Self-engine cut-off in flight
- Engine failure on take-off
- Start engine in-flight
- Oscillations of engine speeds
- Spontaneous variation or engine speed hold-up
- Propeller hunting
- Flight in icing conditions
- Failure of the pumping up fuel pump
- Oil pressure drop on an entry in the engine
- Failure of the regulator of temperature
- Clogging of the fuel filter
- Engine excessive vibration
- Fire in a engine compartment
- Not landing gear retrace
- Not a undercarriage extention from the basic (emergency) system
- Emergency retrace of a landing gear

- Not an output of flaps from the basic hydrosystem
- Not retrace of ground spoilers
- Failure of a main system of a retardation of wheels
- Failure of the basic generator
- Failure of the basic and reserve generator
- Converter LUN-2457.8 failure
- Converter LUN-2456-01-8 failure
- Failure of one converter LUN-2458.8
- Wear of the warning device of emergency operations
- Failure of gyroscopic horizon AGD-1
- System PVD failure
- Failure of gyromagnetic compass ГМК-1АЭ
- Radio communication failure
- Radio compass RLK-41 failure
- Failure of radio navigating equipment "ISKRA-K"
- Emergency landing

Advantages of use of the simulator in course of flight and combat training

CAPABILITIES

Acquisition and perfection of skills of the pilot in a volume of duties according to the Management on flight maintenance of airplane L-39, and also combat training provision in a volume of the Heading of Battle Application

SAFETY

Modelling of emergency (non-staff) situations which cannot or be created or which extremely dangerously in real flight

OBJECTIVITY OF THE ESTIMATION

Simulator allows to make the presented details analysis of fulfilment of the flying mission as a whole, and separate procedures of training

REALNESS

- High extent detailed elaboration of underlying surface and aerosphere in the dome-shaped system of visualization of aft-of-cockpit space;
- Full adequacy of the complete equipment, disposing and application of controls and the cabin equipment;
- Modelling of dynamics of the airplane in the conditions of regular and special (emergency) situations;
- Modelling of effects of acceleration in behaviour of the airplane on land and in air;
- Implementation of the vibrational effects caused by activity of various airplane units;
- High-quality imitation of acoustical effects of activity of airplane systems, affecting of an environment, airborne armament application.

PROFITABILITY

Maintenance of the simulator demands much less expenses, than maintenance of the real airplane.

RELIABILITY

Simulator can be exploited till 12 hours a day irrespective of meteorological conditions