Dynamic crew simulator of 2C6 «Tunguska» self-propelled anti-aircraft mounting

Characteristics

- Driving compartment and turret constructive adequacy
- Functional adequacy of systems and equipment
- Air and jamming situation editor
- High quality of visualisation
- Detailed 3D terrain models
- The wide range of exercise conditions
- 6DOF dynamic platform of driving compartment
- 3DOF dynamic platform of turret with circular rotation function
- Automatic evaluation of trainee's actions (specialists and crews)
- Driving and firing exercises results record keeping
- Integration capabilities into air defence units simulators' systems

Purpose, simulator's structure and learning and teaching capabilities

Dynamic crew simulator of 2C6 «Tunguska» self-propelled anti-aircraft mounting (further in the text Simulator) is designed for collective education and training of self-propelled anti-air defence crews, including crew commander, operator, and gunner, in class room. The goal is to shape and maintain steady skills in preparation for firing, conduct reconnaissance of aerial and ground targets, gun and missile firing, as well as to accomplish firing and tactical crew tasks free of motor capacity and ammunition expenses, and equipment of 2K22 air-defence gun and missile complex.

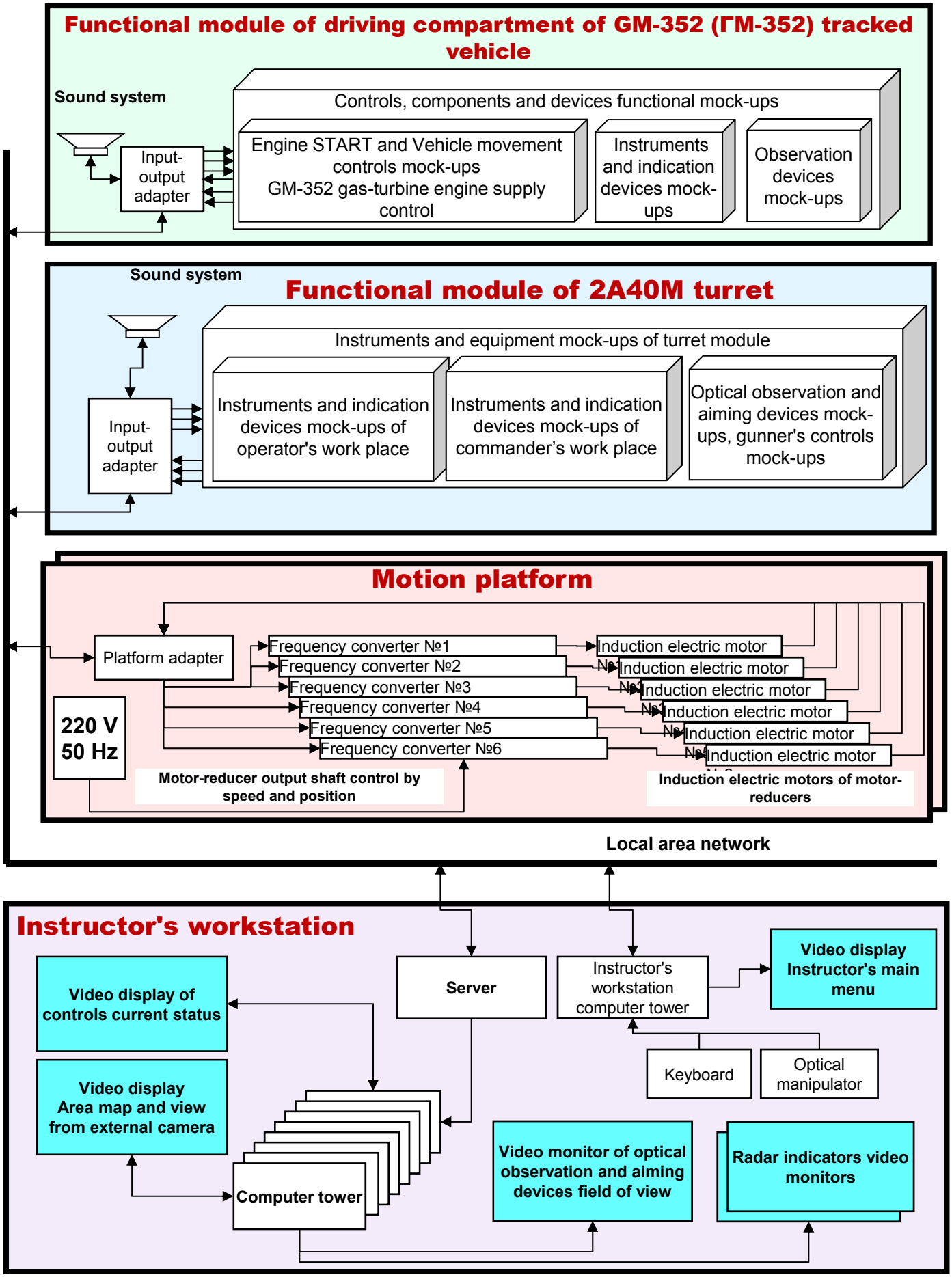
Crew training capabilities

The form of training	Trainee's categories
Individual training	GM-352 tracked vehicle drivers
	ZSU 2C6 gunners
	ZSU 2C6 commanders
	ZSU 2C6 operators
Collective training	ZSU 2C6 crew collective educating and training

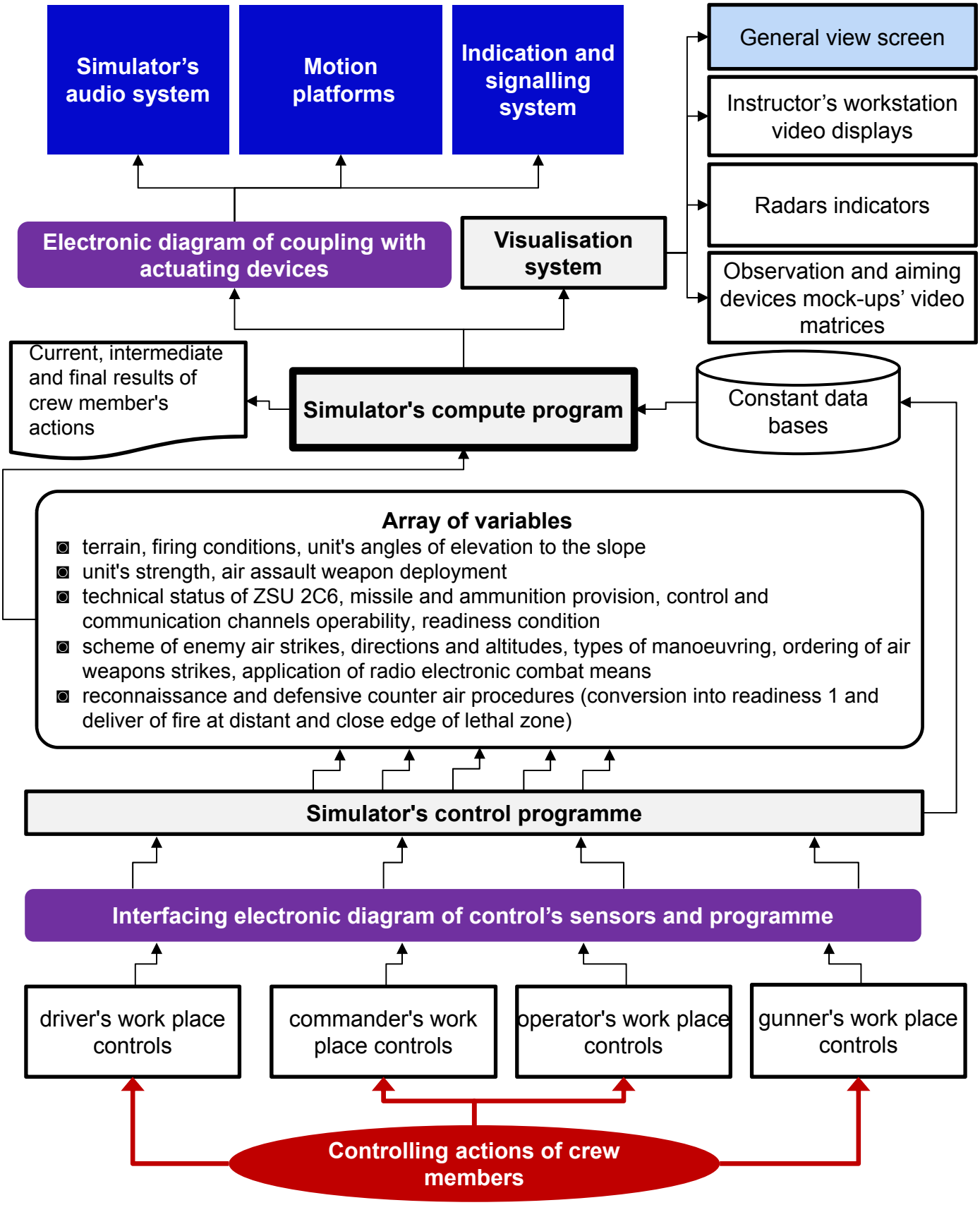
Simulator composition

№	The titles of components	Quantity, pcs.
1	Instructor's workstation	1
2	Functional module of driver's compartment of GM-352 tracked vehicle mounted on 6DOF dynamic platform	1
3	Functional module of 2A40M turret mounted on 4DOF dynamic platform	1
4	Operating documents, suite	1
5	SPTA, set	1
6	Transportation pack, set	1

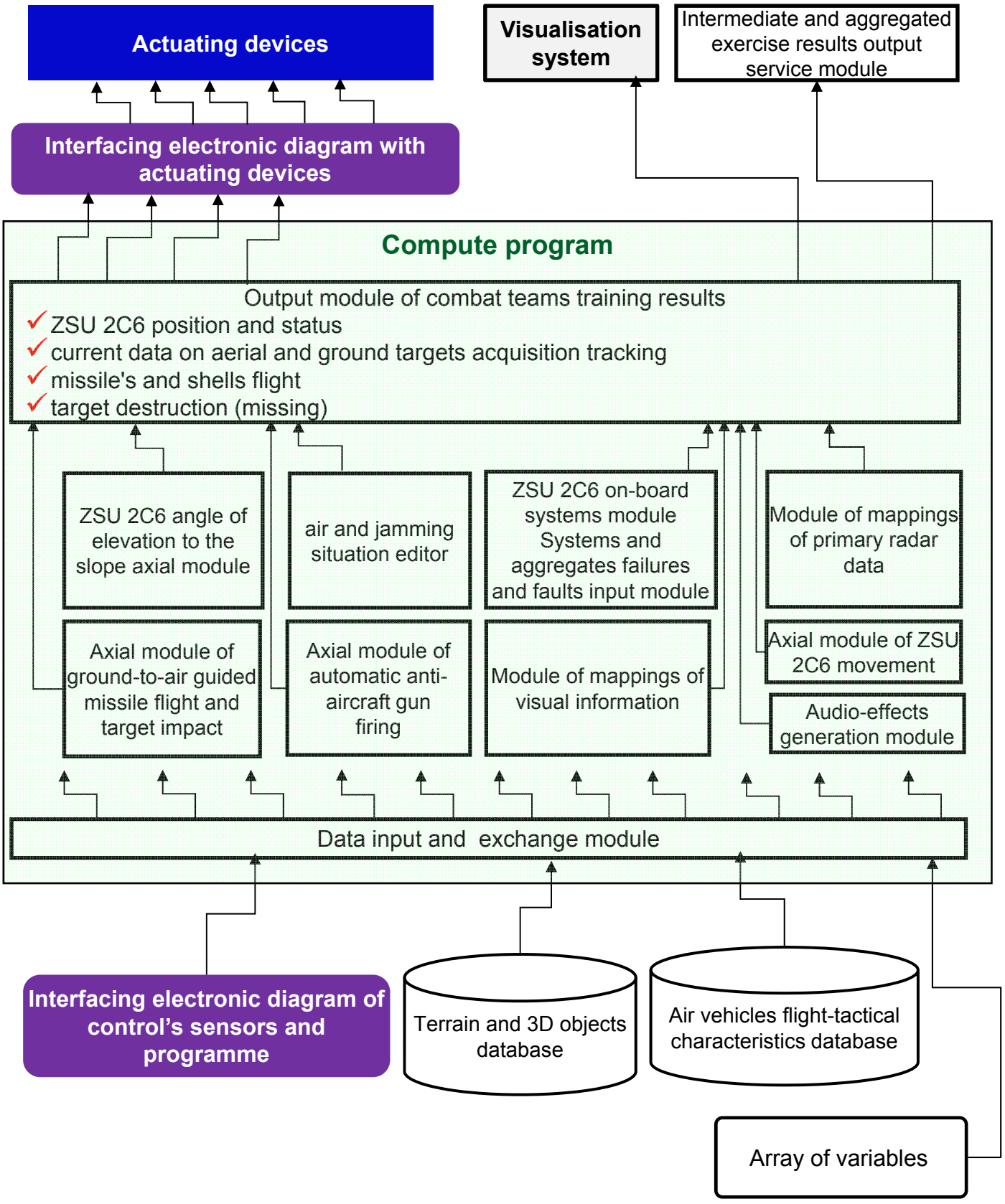
Simulator's structural diagram



Simulator's special programme structural diagram



Simulator's compute program



Functional module of driving compartment (DC) of GM-352 (ГМ-352) tracked vehicle

The module is designed both for individual tracked vehicle driver's education and training, and driver's training as crewmember and provides execution of the following procedures:

- travelling engine starting and parameters checkout
- movement along the route of the tank driving range, obstacles crossing, performance of driving exercise in accordance with Driving Course requirements
- movement over the tactical fields, supporting of required conditions for ZSU radar watch and visual reconnaissance operations
- power-supply unit starting (gas-turbine engine and power-take-off generator)
- selection of place and halt for missile firing

General view of driving compartment Module

View of controls and instruments module

Module configuration

Functional mock-ups

- lookout hatch
- steering column with change-gear lever
- fuel supply pedal
- brake pedal
- frontal instruments panel
- right instruments panel
- parking break lever
- TNPO-168 driver's observation devices
- TVNE-4B night vision device
- louvres drive control lever
- compressed air cylinder
- azimuth pointer

Equipment

- Motion platform
- audio system
- intercom head-set
- inter communication box BV-1
- fan
- driver's seat

Functional module of 2A40M turret

The module is designed for discrete and collective crew training and provides execution of the following procedures:

- switching on of fighting compartment instrumentation and equipment set
- combat performance in all working modes ("**All data from radar**", "**Range from radar, angular coordinates from optical sight**", "**Inertial tracking**", "**Predetermined target speed rate, visually determined by selected target for engagement**", "**Distant scale firing**")
- search, detection, identification of air targets in all working modes, determination of jamming methods, tuning-out form jamming
- target designation (**targeting**) releasing and receiving (from external source and from commander)
- air target tracking with radar channel
- air target tracking with optical channel under different conditions
- simulated air targets engagement with use of automatic anti-aircraft gun on move and from the short halt
- simulated air targets engagement with ground-to-air guided missiles
- firing results evaluation

General view of FC Module

View of controls, instruments and equipment module

Module configuration

Imitators

- PK commander's console
- PUI control and indication panel
- OK1 control block
- all-round scanning display unit OI1
- manipulator OS2
- indicating system block CI1
- indicating system block CI2
- control system block CU5
- unit of aiming equipment POO-2
- gunner's console with joy-stick command transmitter mechanism of commands
- launching panel
- TKN-3 commander's observation device

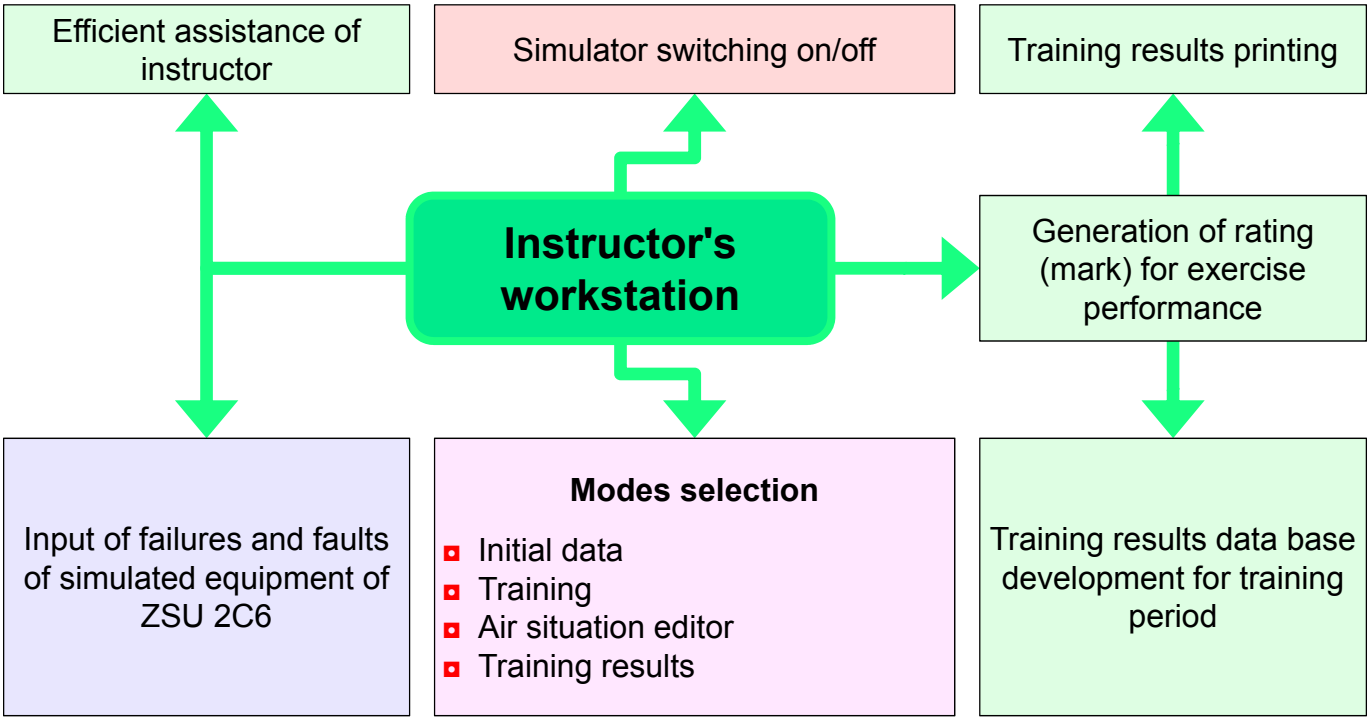
Equipment

- dynamic platform
- audio system
- communications helmet (3 set)
- inter communication box BV-2
- fan (3 pcs)
- commander's seat
- operator's seat
- gunner's seat
- navigating equipment coordinator (full-scale mock-up)

Instructor's workstation

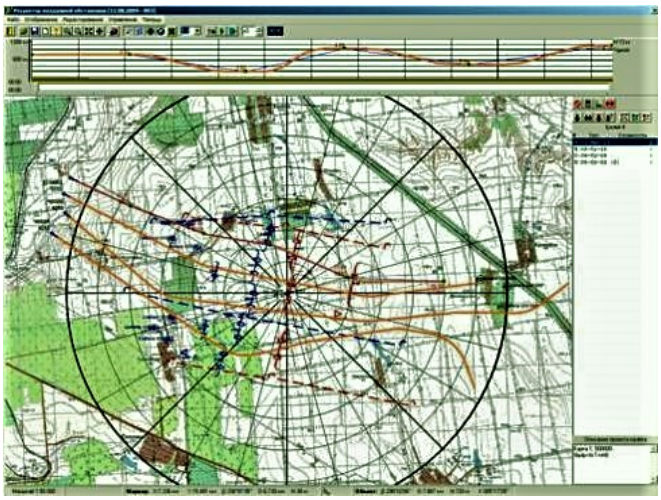
Instructor's workstation provides:

- switching on/off, and testing of simulator technical status
- two-ways communication with crew
- registration of trainees
- determination of ordering and selection of exercise conditions and method to conduct
- selection of air target engagement issues to solve and terms of missions accomplishment (type of terrain, season and time of a day, meteorological conditions)
- development of air, jamming and ground situation with use of in-built editor when preparing training events and exercises
- crew training level evaluation in compliance with Gunnery Course and Firing Regulations and Combat Performance requirements
- monitoring of trainees actions in the course of combat performance and control of training progress (amendments in the course of training session, exercise reiteration, modification of training conditions)



Instructor's main menu

Air and jamming situation editor



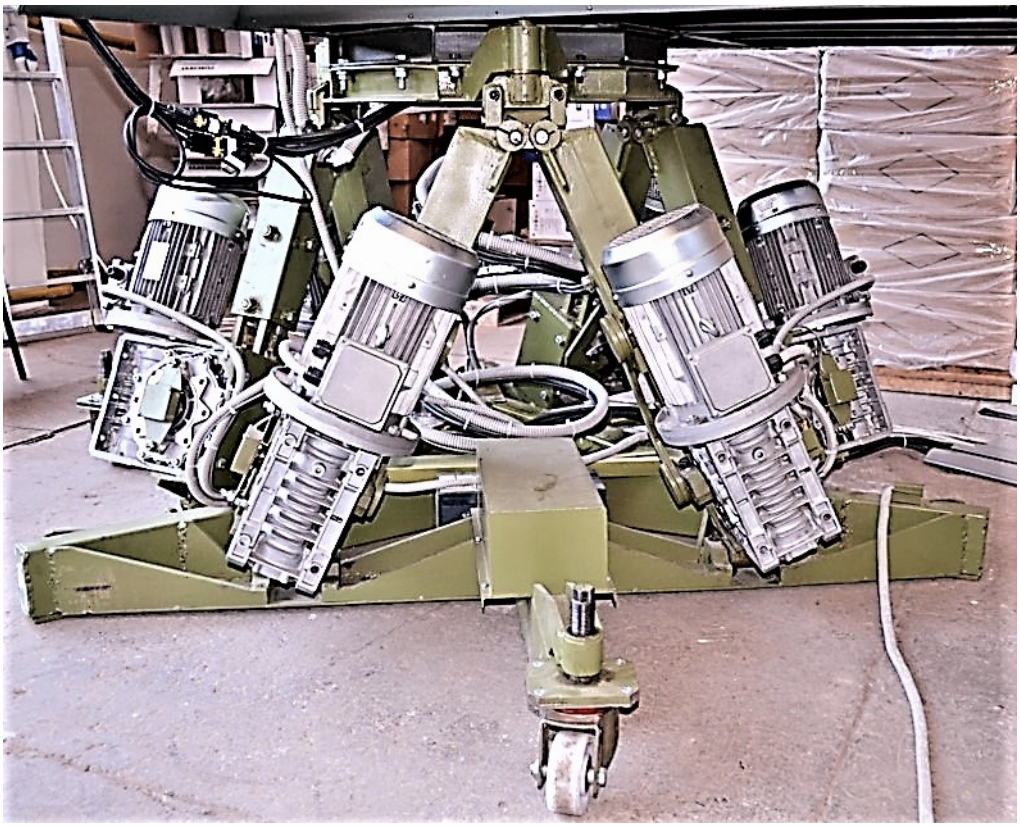
Motion platform

6DOF motion platform ensures adequacy of cabin's inclinations and accelerating forces on trainees when starting, accelerating, application of brakes, turns of GM-352 tracked vehicle in accordance with landscape relief and road conditions.

Basic characteristics of dynamic platform

index	value
Type of driving motors	Non-synchronous with short-circuited rotor
Type of reducer	worm
Driving engine control	Frequency-response by speed and position of rotor output shaft
Pitch angle	+/- 20 degrees
Roll angle	+/- 20 degrees
Heave	+/- 100 mm from middle position
Yaw angle	+/- 30 degrees from «Zero» position
Surge	+/- 300 mm from middle position
Sway	+/- 300 mm from middle position
Angular velocity of displacement along the axis	0-20 degrees/c
Accuracy of processing of control signals	<0,2 degrees angularly
	<10 mm positionally
Consumed power (average)	4,5 kW

6DOF platform view



Technical characteristics

Constructive and functional adequacy

Aggregated simulator's adequacy coefficient ≥0,8

Coverage of crew combat work procedures ≥ 0,9

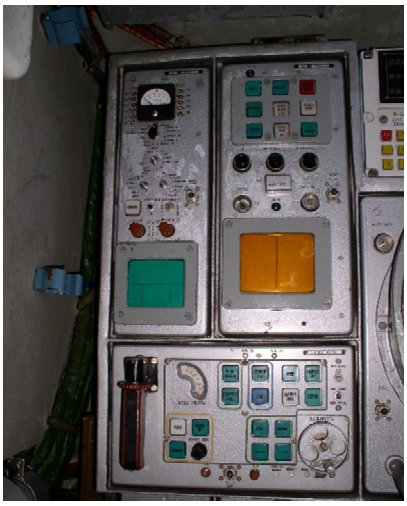
Constructive adequacy of simulator: correspondence of simulator's design to real ZSU 2C6

- correspondence of internal geometric dimensions of driving compartment and fighting compartment mock-ups to real
- correspondence of equipment mock-ups locations to real ZSU 2C6
- correspondence of controls (steering wheel, levers, pedals, and hand wheels) travel ranges, and forces in simulator to characteristics of real ZSU 2C6

Sample: ZSU 2C6 operator's work place structure

In the simulator

In the ZSU 2C6



Functional adequacy: correspondence of simulator's characteristics to real ZSU 2C6

- full list of reproducible functions of systems and equipment to real controls and indicators of ZSU 2C6
- correspondence of functional algorithms of simulator's instruments and equipment, in all working modes and reactions of controls and indicators on controlling actions of trainees
- portraying of radar information on screens of target locator and target tracker (СОЦ and ССЦ) mock-ups
- visualisation of ambient environment within field of views of optical observation and aiming devices mock-ups
- air targets detection ranging in accordance with characteristics of target locator (СОЦ) and target tracker (ССЦ), landscape relief, air targets characteristics, jamming situation
- missile flight path computation in compliance with characteristics of control loop, realised in 2K22 "Tunguska" complex
- shells trajectory computation based on ballistic characteristics of 30-mm guns and ammunition used
- consideration of all GM-352 tracked vehicle characteristics in motion model of simulator
- correspondence of sound effects of travelling motor working, gas-turbine engine, turret and automatic anti-aircraft gun drives, missile launching, automatic anti-aircraft gun firing to real ones
- reproduction of inclination angels of ZSU hull during movement and acceleration effects when speeding up, deceleration and turns

Technical characteristics

High quality visualisation of target environment enables full-functional air targets radar and visual reconnaissance training, as well as missile firing and automatic anti-aircraft gun firing with respect to radar and optical visibility, ranges and types of target , and meteorological conditions

High quality visualisation of target environment is achieved by:

- usage of liquid crystal displays and high-resolution matrices in cathode-ray indicator and optical observation and aiming device's mock-ups
- exact correspondence of portrayed radar information on cathode-ray indicator mock-up screens to real - redial circular and rectilinear scanning, target designation markers, authentication signal benchmarks, target benchmarks, and terrain features, spoiler irradiation
- detailing of terrain textures
- correspondence of structure and colour scale of terrain and objects textures to real colours and contrast
- compliance of angular dimensions, the shape of local objects, vegetation, and ground targets to real objects within the field of vision of optical observation and aiming devices.
- imitation of visual effects of the missile launch and air-defense gun firing by smoke generation and flare light within the field of view of optical observation devices of the gunner, commander and driver (when the direction of firing matching driver's and commander's observation devices' axes);
- imitation of visual effects of missile flying and shells traces, as well as hitting (destruction) of air and ground targets

Indicator types in simulator

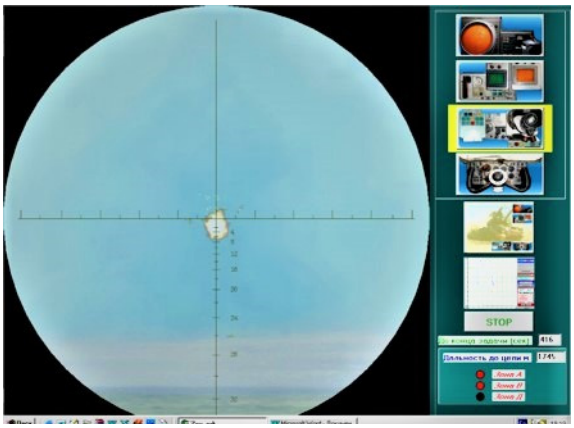
all-round scanning display unit OI1

range and azimuth-range indicator

Gunner's optical observation device field of view visualisation

when tracking the helicopter

when helicopter is destroyed by missile



Technical characteristics

Reliability

Simulator ensures reliable work of simulator during the whole operating period (warranty and post-warranty operating time)

Reliable work program is based on the following principles:

- usage of reliable, experience-proven components and incoming inspection during manufacturing
- development of programme solutions eliminating conflicts of special programme with general software, as well as with hardware
- repeated verification of design solutions
- application of design solutions ensuring long-term operation of mechanical assemblies
- functional and staged control of quality of mechanical and electrical assembly of simulators
- exclusive use of non-contact turning angles and motion proximity sensors (based on magnetically sensitive circuits)
- application of printed board protection means of electronic devices and connector pins from the influence of environment
- use of computers in the industrial (secured) version
- use of uninterrupted power sources for computers
- providing of necessary temperature modes for simulator equipment
- provision of power supply margin

Warranty and Life Time

- Warranty period of simulator operating is 1 year, subject to strict adherence of operating rules and maintenance works held in accordance with maintenance documentation.
- Simulator life time is at least 8 years, subject to strict adherence of operating rules and maintenance and repair works held in accordance with maintenance documentation.

® Simulator running continuously constitutes 12 hours per day.

® Simulator running hours is at least 1000 hours

Operating Characteristics

Simulator is designed for uses in units, is simple in operating and maintaining

№	Parameter's title	Unit of measure	Parameter's value
1	Minimal area for placement	m^2	30
2	Premise type	---	Classroom
3	Warm-up time upon actuation	minutes	up to 5
4	Duration of continuous daily work	hours	at least 12
5	Uninterrupted power supply unit availability	---	Simulator computing facilities are equipped with uninterrupted power-supply unit
6	Electric power supply voltage	V	220±10%
	Frequency	Hz	50±1
7	Maximum power consumption	kW	12
8	Average power consumption	kW	6
9	Increased operating and limiting temperature	°C	Up to +35.
	Decreased operating and limiting temperature		Up to +5.
10	Relative humidity at the temperature of +25°C.	%	Up to 80
11	Diagnostic system	---	Built-in semi-automatic
12	Running hours	hours	at least 300
13	Switch ON/OFF control	---	From Instructor's work station
14	SPTA	---	Individual and group set (for 10 simulators)
15	Maintenance	---	Check-up, daily check, maintenance -1 (once per 6 months), maintenance -2 (once a year)
16	Operational liquids	---	Synthetic oil in motor-reducers of dynamic platform
17	Trainees and maintenance personnel electrical safety	---	Elimination of dangerous voltage in driving compartment and fighting compartment cabins (+24V direct current is used) Short-circuit relay protection
18	Simulator's running hours accounting		Operating hours programme counter
19	Simulator assembled weight	kg	2 840
20	Operating documentation	---	Logbook, Operating Manual, Assembly and Adjustment Manual on-site of untended use, SPTA List

Educational and methodological capabilities

Simulator's training capabilities

- Individual training of
  - drivers
  - commanders
  - operators
  - gunners
- Collective crew training

Exercise conditions development capabilities

№	Functional capabilities title	Quantitative and qualitative characteristics
1	3D training area model dimensions (L-W-H), km	8,80x80x5;
2	Air targets altitude, m	0-5000
3	Number of targets, simultaneously present in the air	18
4	Air targets manoeuvring methods	By altitude, course, and speed
5	Jamming types	Active sound Non-synchronous pulsing Passive Deceptive by range
6	Simulated air targets	Tactical fighters (Type F-16, Su-27) Low-flying attack aircraft (type "Alfa Jet", Su-25) Combat helicopters (type Mi-17, AH-64) Cruise missiles (type ALCM)
7	Time of a day	Daylight (sunny, foggy), night, twilight
8	Meteorological conditions	Rain, fog
9	Terrain types	Normal country, deserted, mountainous

Crews training capabilities

Combat mission reception from battery commander, direct preparation for firing, including
search, target detection with use of target locator (СОЦ), tuning-out from jamming
radar identification of target state affiliation
target designation output on target tracker (ССЦ)
secondary search, detection, target acquisition and tracking (ССЦ)
target tracking in ИНЕР mode
sector search of target tracker and tuning-out from jamming
searching and tracking of target with use of optical sight (OP mode)
target tracking in semi-automatic tracking mode (SA mode)
target tracking in semi-automatic aiming mode (SAA mode)
decision making on target engagement, assignment of firing method
Air targets engagement
selection of missile weapon (M-mode), target engagement with ground-to-air guided missile (the first), damage assessment, target engagement with ground-to-air guided missile (the second), damage assessment
evaluation of A zone, selection of automatic anti-aircraft gun (A-mode), automatic anti-aircraft gun firing (A3G), damage assessment, target tracking reset

Educational and methodological capabilities

Exercise (training events) conditions development capabilities:

- instructor's main menu “friendly” interface
- wide capability of air situation editor
- rapid transferring to new exercises
- selection of terrain sector, season, time of a day, meteorological conditions directly in instructor's main menu
- selection of enemy actions methods
- reiteration of exercise (multiple if required)
- simulation of ZSU failures and faults

Trainee’s actions supervision capability by

- current state of controls and indicators of turret and driving compartment functional modules
- duplicated radar screens of cathode-ray indicators
- duplicated fields of views of optical sight OP and observation device TKN-3
- duplicated fields of views of lookout hatch and driver’s observation device
- ZSU positioning from the viewpoint of controlled video cameras
- ZSU positioning on the tank driving range, and tactical field
- protocol of performance of driving and firing exercises
- reports of trainees via communication means

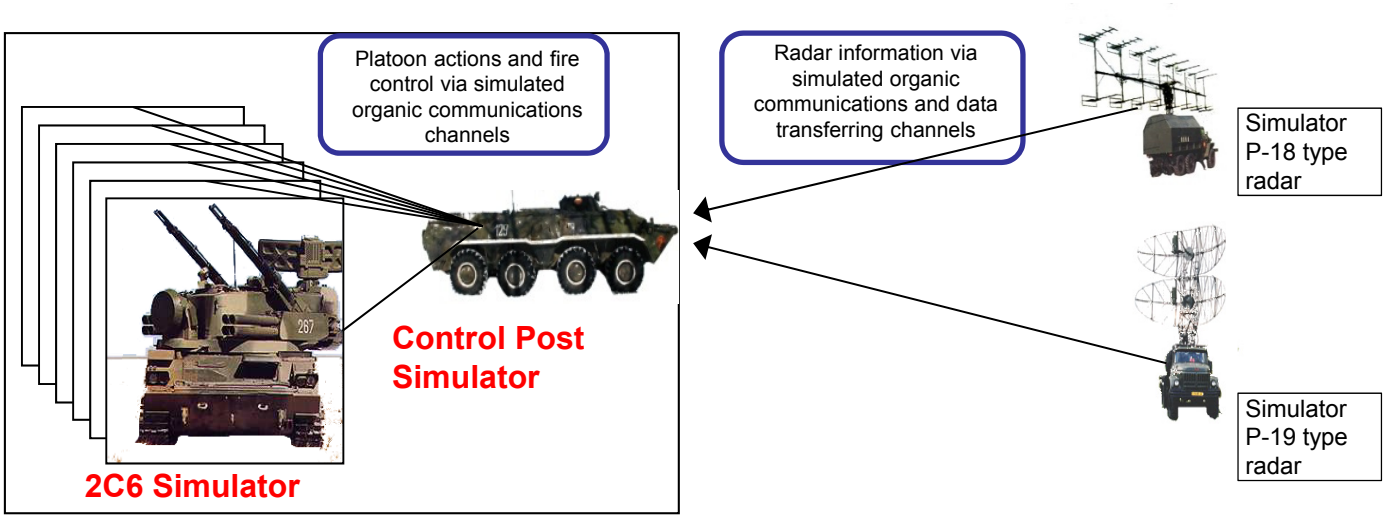
Trainee’s actions evaluation capability

- automatic evaluation of driver's actions in compliance with Driving Course requirements
- automatic evaluation of commander's, operator's and gunner's actions in compliance with Gunnery Course and Firing Regulations requirements
- Subjective trainee's actions evaluation based on analysis of results obtained from all available monitoring sources (or selected)

- Training results documenting in electronic form (results printing, if required)
- Results archiving for a day or training period

The Simulator of air-defence battery, equipped with air-defence gun and missile complex “Tunguska”

Battery simulator structural diagram



ТМК-2К22 Simulator is designed for collective training of platoons as part of a battery, as well as battery commander training during complex training events, conducted in unified simulated air, ground and jamming situation.

Simulators are the backbone of multilevel combat training system of air-defence units, equipped with 2С6 «Tunguska» self-propelled anti-aircraft weapons

Combat training phases	**Trainee’s categories**	
	Crews and combat teams	Battery and platoons commanders
Individual training (technical, reconnaissance, special)	Interactive educational programs to study structure, weapon operations and combat work	Interactive educational programs to study Gunnery Course and Firing Regulations
Collective training crews and weapon teams	Integrated crew simulators	Command post simulator PU-12M (PPRU 9C80)
Collective training of platoons and battery	Battery simulator	

Developer and manufacturer:
LCC «Research and Production Company «Energy 2000»
Povitrophlotsky, 94-A, Kiev, Ukraine
www.simulator.ua

Developer and manufacturer provides:

- manufacturing the simulator
- assembly, adjusting, commissioning and acceptance testing at the site of intended use
- training of customer's technicians
- warranty service for 3 years
- post-warranted maintenance (subject to separate contract)