NEW RUSSIAN AIRCRAFT-LABORATORY YAK-42D «ATMOSPHERE» FOR ENVIRONMENTAL RESEARCH AND CLOUD MODIFICATION

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1. INTRODUCTION

Investigations and control of environment are indispensible to provide with the human life and vital activity of humanity. Resent events, such as convolution of nature of volcano Eyjafjallajokudl in Iceland on 2010, catastrophe in the atomic station Fukushima in Japan on 2011, or earlier Chernobil atomic crush on 1986 demonstrated necessity of efficient reacting with the goal of defining possible dangers and with active actions on atmospheric processes for minimizing consequences. A special instrumented aircraft-laboratory could be very effective mean for atmospheric observations and weather and clouds modifications (Hiyama et. al., 2003).

Aircraft-laboratory (or special instrumented airborne platform) has a set of advantages making it effective instrument for environmental research, which give possibility:

- To fulfill simultaneous measurements of different parameters of atmosphere and underlying surface;
- To get meridian, latitudinal and altitude distributions of atmospheric parameters in given region with high spatial and temporal resolvability;
- To integrate ground-based and remote control data in common informational picture;
- To make clouds modification and control it in any given area;
- To provide observation over difficult of access regions.

2. THE MAIN GOALS OF NEW AIRCRAFT LABORATORY

The aircraft-laboratory Yak-42D "Atmosphere" created in Central aerological observatory of Russian Federal Service for Hydrometeorology and Environmental Monitoring is intended for measuring the following parameters of atmosphere and underlying surface:

- Thermodynamic parameters of atmosphere (air temperature, pressure, density and humidity, wind speed, turbulence and turbulent fluxes);
- Gas and aerosol structure of atmosphere;
- Radiation in atmosphere and from surface, radiation balance in atmosphere;
- Radioactive pollution of atmosphere and underlying surface;
- Microstructure of atmospheric clouds and participation;
- Atmospheric electricity.

The aircraft-laboratory Yak-42D "Atmosphere" is also equipped with instruments for clouds modification.

The main objectives of the aircraft-laboratory Yak-42D "Atmosphere" are the following:

- Investigations and monitoring atmospheric pollutants;
- Remote control of underlying land surface and ocean;
- Control of the climate factors in free atmosphere;
- Fulfilling scientific and applied investigations in physics and dynamics of clouds, atmospheric fronts and cyclones, planetary boundary;
- Validation of satellite observations of atmosphere and underlying surface;
- Fulfilling research and special works on clouds modification for regulation of atmospheric participations.

3. BASE CIVIL AIRCRAFT YAK-42D FOR CREATING MULTIPURPOSE AIRCRAFT-LABORATORY

Russian civil aircraft Yak-42D is used for the base of new aircraft-laboratory. The common view of bought aircraft Yak-42D # 42440 and its interior is presented in ***Fig. 1.***

The main technical parameters of Yak-42D are as follows:

- Sky crew – 2 (3) members.
- Maximum flight level – 9600 m;
- Maximum commercial load - 12000 kg;
- Flight distance with the load of 5000 kg – 4100 km;
- Air speed rang – from 350 up to 700 kmh^{-1};
- Maximum take-off weight – 57 500 kg.

The decision # РЭ-69/5.9-23 of Ministry of aviation sets for airplanes Yak-42D the following restored life:

Fig. 1. Base Yak-42D Russian civil aircraft

- Up to 40000 flight hours, up to 18000 flights and period of life up to 35 years.

Residual life of Yak-42D # 42440 aircraft is:

- 38500 flight hours, 17500 flights, 25 years.

Aircraft Yak-42D is fully equipped for flying using international lines. Aboard Yak-42D the following facilities are installed:

- Global navigation system GPS KLN-90 BRNAV;
- Token collision aircraft system TCAS-II Honeywell with the special system of signals S(EHS);
- System of earlier warning of collision with the land SRPB3;
- Oxygen equipment KSP-42;
- Automatic radio beacon ARM-406;
- Electronic altimeter VBE-1.

Aircraft Yak-42D # 42440 is permitted for the flights with precise echelonment RVSM.

4. MEASURING SYSTEM OF AIRCRAFT-LABORATORY YAK-42D "ATMOSPHERE"

The measuring system of aircraft-laboratory Yak-42D "Atmosphere" includes three levels.

<u>The first level</u> consist of different kind of sensors and measuring systems of instruments complexes (temperature and pressure sensors, navigation systems, spectrometers, radars, radiometers, particles counters and others).

<u>The second level</u> is the set of hardware-software complexes which unite sensor and measuring systems through special computer programs. These complexes produce measurements of navigation parameters, thermodynamic characteristics of atmosphere, different gases and aerosol concentrations and common content of the gases, solar radiation and radiation balance in atmosphere, radioactive pollutants, and

microphysical characteristics of clouds, electric characteristics, and radars.

The third level is the integration of hardware-software complexes to common aboard measuring system of the aircraft-laboratory Yak-42D “Atmosphere”. This system contains Data Acquisition System (DAS), facilities for cloud modification, satellite channel for fast transmission data from the aircraft to ground-based centers and means for providing control of local experiment from the special ground center. At this level processing, recording and reservation of all data, data exchange between complexes, control of experiment and transmission of data to ground-based centers are provided.

Each complex included to integrated information aircraft system can operate independently thus has the own DAS. Refusal of one of complexes (except of the thermodynamic and onboard DAS) does not lead to refusal of all measuring system of aircraft-laboratory Yak-42D " Atmosphere ".

The common structure of aircraft measuring system of Yak-42D “Atmosphere” is presented in ***Fig. 2*** and ***Fig. 3*** demonstrates scheme of the aircraft Data Acquisition System.

5. HARDWARE-SOFTWARE COMPLEXES OF AIRCRAFT-LABORATORY YAK-42D “ATMOSPHERE”

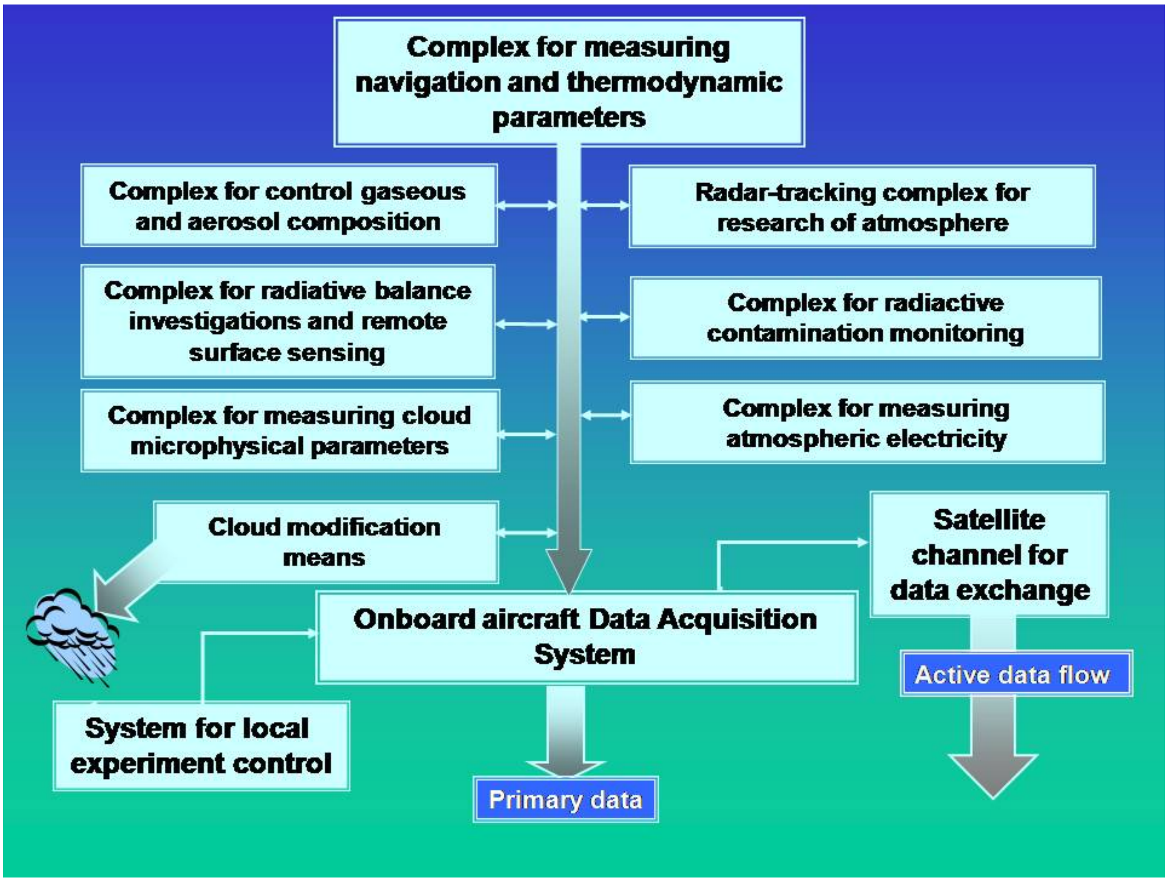

Fig. 2. Common structure of aircraft-laboratory Yak-42D measuring system

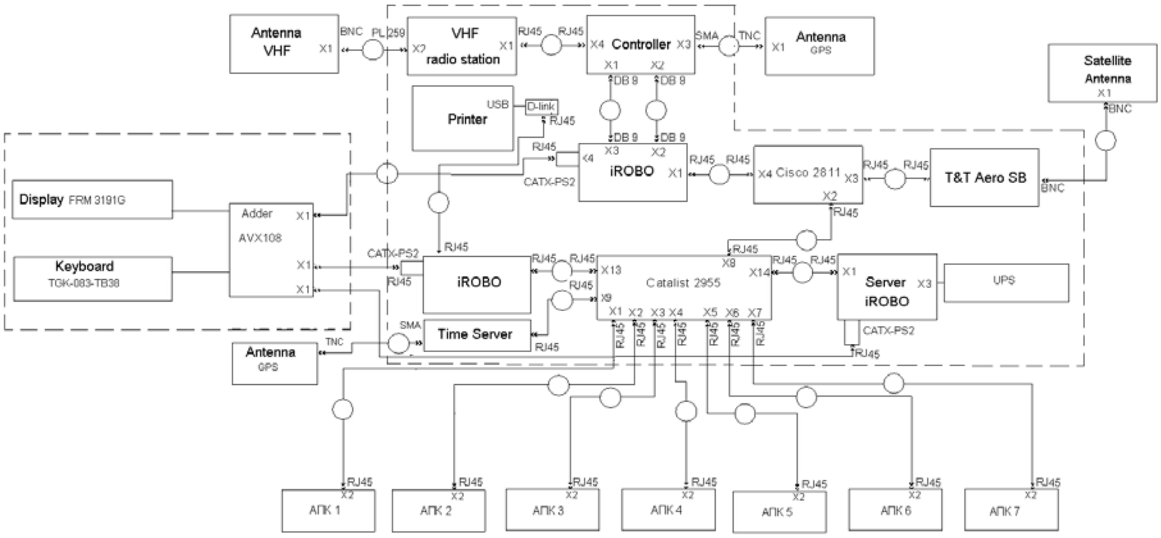

Fig. 3. Scheme of the aircraft Data Acquisition System

5.1. HARDWARE-SOFTWARE COMPLEX FOR MEASURING NAVIGATION PARAMETERS AND THERMODYNAMIC PARAMETERS OF ATMOSPHERE

This complex provides measurements of parameters, characterized precise aircraft attitude and thermodynamic structure of the atmosphere (Strunin, 2010). Data of this complex are the base for building up meteorological fields or spatial-temporal distributions of thermodynamic parameters. Navigation parameters (coordinates, heights, speed of aircraft, attitude angles) and wind speed, air temperature and humidity, atmospheric turbulence data are also necessary for presentation and analyzing data of others measuring complexes.

The following sensors and measuring systems are installed aboard aircraft-laboratory Yak-42D “Atmosphere”:

- Global position system GPS and GLONASS BPSN-2, Russia;
- Inertial reference system IRS Honeywell Laseref VI, USA;
- Radio-altimeter of high levels A-075, Russia;
- Radio-altimeter of low levels A-053, Russia;
- Half-spherical 5-points pitot-static heads Rosemount 858AJ and 858Y, USA;
- Pressure probe PVD-30, Russia;
- Air data transducers Rosemount MADT 2016B, USA;
- Dynamic pressure sensor Rosemount 1221F2AF7B1B, USA;
- Differential pressure sensors Rosemount 1221F2VL7B1A, USA;

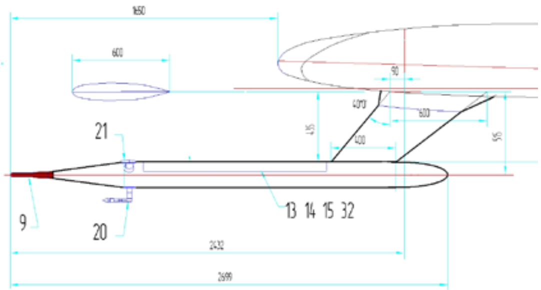

Fig. 4. Scheme of under-wing boom for thermodynamic sensors

Fig. 5. Inertial reference system Laseref VI

Fig. 6. Global position system

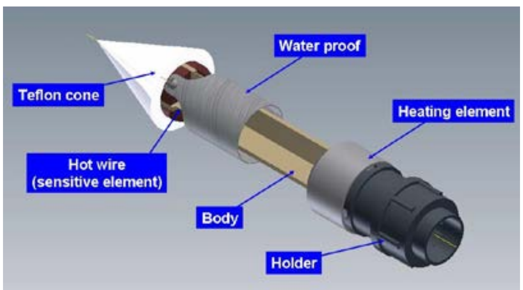

Fig. 7. High-frequency aircraft thermometer CAO

- Sensors interface units SIU, CAO, Russia;
- Temperature sensors Rosemount 102CT2D6, USA;
- Temperature sensor Rosemount 102LA2AG, USA;
- Temperature sensor Rosemount 102LA2AG, USA;
- High-frequency aircraft thermometer HFAT CAO, Russia;
- Inertial measuring unit AIST-350, Russia;
- Condensation hygrometer General Eastern 1311XR, USA;
- Aircraft condensation hygrometer ACH, CAO, Russia;
- Ultra-violet hygrometer UVH, CAO, Russia.

Some of these sensors and systems are installed in the special boom under the wing (***Fig. 4***). These sensor and systems provide measurement of so call primarily parameters, which than used for calculating all necessary thermodynamic characteristics of atmosphere. Common views of some sensors and systems from the above list are presented in ***Fig. 5 – 8.***

Listed sensors and measuring systems are united to the hardware-software complex through the special

Fig. 8. Ultra violet hygrometer CAO

computer program. The complex produces data processing for defining thermodynamic parameters of atmosphere, recoding the data, and data transmission to the aircraft Data Acquisition System:

- Latitude and longitude, geometric height of aircraft-laboratory flight;
- True height (radio-height) and barometric height of the flight level;
- Components of ground speed of the aircraft;
- Attitude angles of the aircraft (roll, pitch and heading angles);
- True air speed of aircraft and true air temperature;
- Components of wind speed in geographic coordinate system;
- Dew-point/frost point temperature and absolute air humidity;

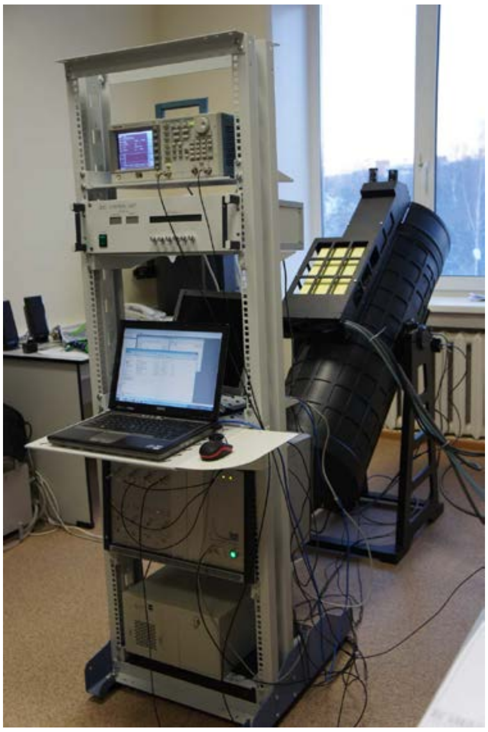

Fig. 9. Aircraft multi-wavelength aerosol lidar ML-375-A

- Turbulent fluctuations of wind speed, air temperature and absolute air humidity.

5.2. HARDWARE-SOFTWARE COMPLEX FOR THE CONTROL OF GASEOUS AND AEROSOL COMPOSITION OF THE ATMOSPHERE

This complex allows monitoring of changes in chemical composition, including the monitoring of pollutants and greenhouse gases in the atmosphere control of the stratospheric aerosol layer

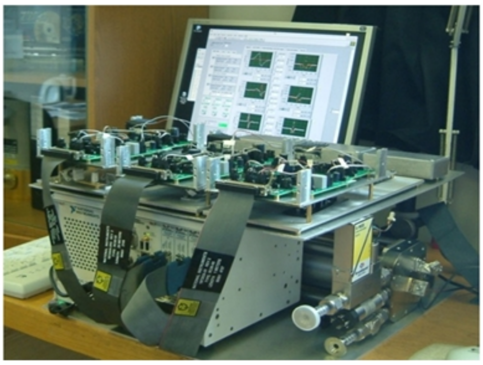

Fig. 10. Aircraft tunable diode laser spectrometer

and the ozone layer of the atmosphere. To solve these problems requires systematic airborne measurements of spatial and temporal distributions of gases and aerosols on various scales, and altitudes in the free atmosphere. Airborne sensing of gaseous and aerosol composition of the atmosphere will identify as early as possible climate factors that may lead to changes in regional and global scales, and are associated either with the natural fluctuations in climate-parameter, or by anthropogenic influences.

- Aircraft multi-wavelength aerosol lidar ML-375-A (***Fig. 9***) is designed to measure the backscattering coefficient and the aerosol extinction in the spectral range 355 nm - 1064 nm. Based on the data made assessment of the main physical characteristics of aerosols, such as size, density and complex refractive index.

- Aircraft tunable diode laser spectrometer (***Fig.10***) for measurement of the concentration of greenhouse gases (water vapor, carbon dioxide, methane) and their isotopic composition in the atmosphere, CAO, Russia. Airborne spectrometer consists of the electronics module (1), which supports the work of six diode lasers, and 3 measuring channels for H_2O (2), CH_4 (3), CO_2 (4).

Fig.11. NO-analyzer ECOPHYSICS

- Spectrometer, ultraviolet and visible range Shamrock SR-303i Andor Technology for measurements of the total content of O_3, NO_2, BrO, OClO in the atmosphere.
- Ozone Analyzer Model 205 (2B Tech, Inc., USA) and chemiluminescent ozonometer, CAO, Russia for measuring the concentration of ozone and its fluctuations in the range from 1.0 to 1000 ppb.
- Chemiluminescent instruments for nitrogen oxides, ECOPHYSICS, Switzerland for measuring concentrations of NO (***Fig.11***), NOx, NOy in the range from 0.3 to 500 ppb.
- High-frequency pulsation measuring chemiluminescent nitrogen dioxide, CAO, Russia for measuring Ripple-NO2 concentrations in the range from 0.1 to 100 ppb.
- Greenhouse Gas Analyzer G2301-mc (Picarro, Inc., USA).
- Non-dispersive infrared analyzer SO2/N2O air LI-7500ADP, USA;
- Gas chromatograph Agilent-7820A with a device for sampling air Hermes, Germany. Whole air samples (NMHC, alkyl nitrates, long lived tracers like halocarbons), CO2, N2O, CO, CH4.
- High-precision fluorescence aircraft hygrometer, CAO, Russia. Fluorescent aircraft hygrometer

designed to measure spatial and temporal distributions of the relative volume concentration of H_2O in the range from 1 to 2000 ppm (m^{-1}).

5.3. HARDWARE-SOFTWARE COMPLEX FOR THE RADIATIVE BALANCE INVESTIGATIONS AND REMOTE SENSING OF CLOUDINESS AND UNDERLYING SURFACE

This complex measures the upward and downward integral fluxes of solar and thermal radiation for the radiative transfer and radiative heat exchange investigations. The net shortwave fluxes, being measured at the aircraft and at the underlying surface, gives a possibility to define absorption of solar radiation by the atmospheric layers below and above the aircraft, respectively. Along with the similar measurements of the thermal radiation it gives a possibility to evaluate influence of the natural and anthropogenic aerosols and greenhouse gases on the radiative balance. The high-resolution measurements of the shortwave spectral reflectance by a hyper-spectral viewer allows investigating the influence of the natural and anthropogenic factors on the surface. Maps of the surface brightness temperatures obtained using the 4-channel IR radiometer also may be useful for investigations of the surface. For example they give a possibility to evaluate the soil moisture as well as to found sources of carbon dioxide and methane.

Fig.12. Pyranometers CMP22, Pyrgeometers CGR4 and UV-radiometer UV-S-B-T/C

Additionally such maps of cloudiness contain information about cloud structure and radiative properties. The McW radiometer, which the water vapor channel centered at 6.2 μ, is applied to get information on in-cloud temperature. Radiometer will work in horizontal direction in this case. This information is free from typical errors of immersion type thermometers due to their (or their shield) wetting or icing in clouds

Thus on board of the aircraft there are the following instruments:

- Pyranometers CMP22, Kipp&Zonnen, Germany;

- Shortwave integral (0.2 -3.6 μm) hemispherical fluxes.

- Pyrgeometers CGR4 Kipp&Zonnen, Germany;

-Longwave integral (4.5 – 42.0 μm) hemispherical fluxes.

- UV-radiometer UV-S-B-T/C Kipp&Zonnen, Germany;

- UV hemispherical fluxes in (0.28 – 0.315 μm) and (0.315 – 0.400 μm) spectral range.

Common view of these sensors is presented in ***Fig. 12***.

- Shortwave hyper-spectral viewer (NIR and VIS spectral regions), NPO «LEPTON», Russia (***Fig. 13***);

- Pictures of the underlying surface in 150 channels from 0.420 to 0.900 μm.

- Longwave 4-channel viewer 4КСР(Т) , Main Geophysical Observatory, Russia;

- Pictures of the underlying surface in 4 channels from (1.8 – 12.5 мкм).

- McW two-channel radiometer,

Fig. 13. Shortwave hyper-spectral viewer

MGO, Russia;

- Two channels (22 and 37 GHz) for retrieval of the water vapor content in the atmosphere and liquid water in clouds.

5.4. HARDWARE-SOFTWARE COMPLEX FOR RADIOACTIVE CONTAMINATION MONITORING

This system enables assessing a degree of radioactive pollution of the air (air volumetric activity) and underlying surface based on gamma radiation dose rate and isotopic composition. Measurements of volumetric activity of radon decay products, given detection of various man-made impurities in the air, permit identifying a possible source of pollution and direction of impurities with respect to the source. By measuring space

Fig. 14. Gamma spectrometer with scintillation and high purity germanium detector GEM 40-86 «ORTEC»

Fig. 15. Space neutron counter

neutrons a source of such particles can be identified (on request from Institute of Applied Geophysics). Data obtained about volumetric activity of short-lived decay products of radon-222 at different heights can be used as a tracer of air masses. The system includes:

- Radiometer-dosimeter DMG-01 for detecting radioactive clouds in the atmosphere and radioactive footprints on the ground - SI RPA "Typhoon". The range of gamma radiation dose rate measurements: 10 nGy hr^{-1}-10 Gy hr^{-1} (1 μR hr^{-1}-1000 R hr^{-1}).
- Gamma spectrometer (***Fig. 14***) with scintillation and high purity germanium detector GEM 40-86 «ORTEC», USA, pulse analyzer DSPEC Pro «ORTEC», USA, and collimator screen - SI RPA "Typhoon". Gamma radiation from the underlying surface,

  -range of detected gamma quanta energy: 0.1-3.0 MeV;

  -range of measuring ^{137}Cs contamination density of the area, with a flight at 50 m height: 2 104 –2 107 Bqm^{-2}
- Setup "Vega-1M" for measuring radon-222 concentration in the troposphere (aerosol sampler "Vega-1M" radiometric system "RUS-2B") - SI RPA "Typhoon". Atmospheric concentration of radon-222 is the air mass tracer.
- Space neutron counter (***Fig. 15***) (neutron detector LB-6411 and datalogger unit UMo LB 123) "Berthold Technologies", USA)

Range of measuring neutron energy: up to 20 MeV

Range of measured doses: 30 nSv hr^{-1} - 100 mSv hr^{-1}.

5.5. HARDWARE-SOFTWARE COMPLEX FOR MEASURING CLOUD MICROPHYSICAL PARAMETERS AND COMPLEX OF CLOUD MODIFICATION MEANS

This complex provides measurements of atmospheric aerosols of different origin in a wide range of sizes at the level of the flight of aircraft-laboratory. Monitoring of atmosphere transparency, concentrations and size spectra of atmospheric aerosol will give opportunity to evaluate the degree of natural and anthropogenic disturbances due to emissions of particles from different sources.

Fig. 16. Nevzorov LWC/TWC probe

The microphysical complex of aircraft-laboratory includes following devices:

- Nevzorov LWC/TWC probe (Russia) liquid and total water content (***Fig. 16***) 0,003 gm^{-3} - 4 gm^{-3};

- Cloud Extinction Probe (Russia) extinction factor 1 – 200 km^{-1};
- The analyzer of a phase and structure of clouds AFSO (Russia) particle size spectra 10 – 400 mkm;
- Super-large particles sizes probe (Russia) large particle size spectra 200 – 6000 mkm;
- Cloud Condensation Nuclei Counter, Dual Column, CCN-200 (DMT, USA) Condensation Nuclei concentrations. The air flow to devices UHSAS, CCN200 and SP2

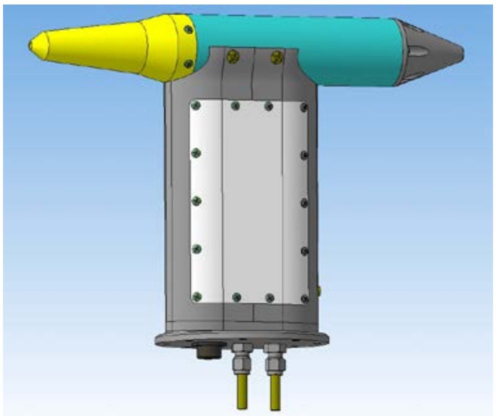

Fig. 17. The aircraft sample inlet for UHSAS, CCN200 and SP2

is brought with the help aerodynamic inlets, installed on a fuselage apart 1,2 - 2 m from devices (***Fig. 17***);

- Ultra High Sensitivity Aerosol Spectrometer – UHSAS (DMT, USA) aerosol particle spectra 0.055 – 1 μm;
- Passive Cavity Aerosol Spectrometer Probe, PCASP-100X (DMT, USA) aerosol particle spectra 0.1 – 3.0 μm;

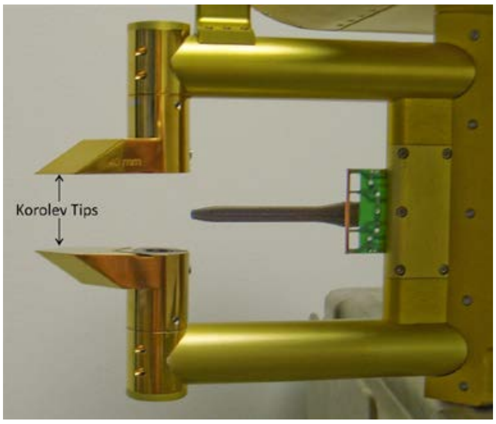

Fig. 18. Cloud Imaging Probe CIP DMT

- Single Particle Soot Photometer, SP2 (DMT, USA) black carbon mass in particles, number concentration up to 5000 particles cm^{-3};
- Cloud Droplet Probe, CDP (DMT, USA) cloud particle spectra 2 – 50 μm;
- Forward scattering spectrometer probe FSSP-100ER (DMT, USA) cloud particle spectra 2 – 50 μm;
- Cloud Imaging Probe CIP DMT (DMT, USA) 2-Dimensional Images of particles from 25-1550 μm with

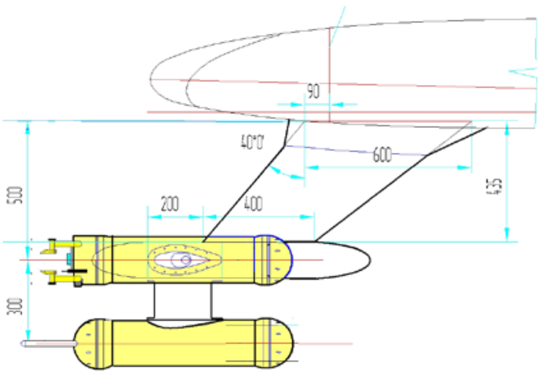

Fig. 19. PMS/DMT canisters under the wing

new type of tips (***Fig. 18***);

- PMS Optical Array Probe OAP-2DC (PMS, USA) 2-Dimensional

Images of particles from 25-1550 μm;

- Precipitation Imaging Probe PIP (DMT, USA) 2-Dimensional Images of particles from 100 -6200 μm;
- Cloud Particle Imager SPI (SPECinc., USA) -Resolution 2,3 μm, up to 1000 particles s^{-1},
- Local Data Acquisition System M300 (SEA inc., USA).

PMS/DMT canisters and SPI are installed on the pylons located underneath the wings (***Fig.19***).

Fig. 20. The set of pyrotechnic means UV-26

Fig. 21. The small ice particle generator SIPG-A

For expansion of opportunities to use aircraft-laboratories, the latter are equipped with the cloud seeding means, allowing performing weather modification activities.

To perform cloud seeding by ice-forming, hygroscopic, and cooling agents on the aircraft will be put the appropriate technical means.

In order to seed clouds with the help of ice-forming and hygroscopic agents the aircraft will be equipped with two sets of UV-26 mean to release pyrotechnic flares of type PV-26 in the amount of 1024 cartridges. ***Fig. 20*** shows a set of UV-26.

For cloud seeding by cooling agents (liquid nitrogen) the aircraft is equipped with the small ice particle generator SIPG-A (***Fig. 21***) permitting to seed clouds in the range of dosages of 0, 5 kg min^{-1} up to 10 kg min^{-1}.

All microphysical data are saved on the disk of local DAS M300.

5.6. THE HARDWARE-SOFTWARE RADAR-TRACKING COMPLEX FOR RESEARCHES OF ATMOSPHERE

This complex provides reception of cuts of clouds and precipitations with measurement of structures of their radar-tracking reflectivity and values of radial projections of speeds of movements of particles in clouds, detection of zones of turbulence, three-dimensional fields of

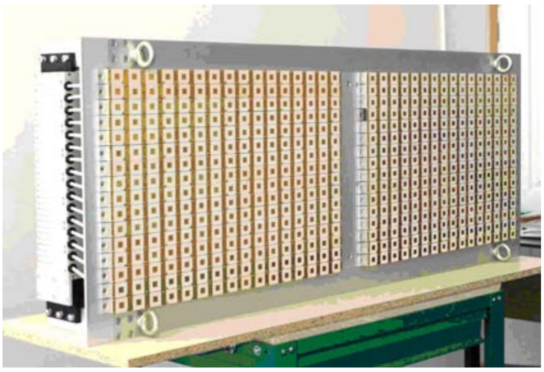

Fig. 22. View of nadir/zenith radar

radar-tracking reflectivity, a map of height of cloud tops; a map of weather phenomena; a map of precipitation intensity; a map of visibility in precipitation zones.

The radar-tracking radar complex of aircraft-laboratory is equipped with coherent X-ray wavelength radar with vertical sector field of view. Radar is based on active phased array (APAA). The complex consists of two radars – one pointed towards zenith and another towards nadir - with ability to control the position of an electron pattern 5x4 degrees within 60 degrees in the plane transferring the direction of flight (***Fig. 22***). To improve the detection and to allow a study of meteorological objects with weak reflectivity in X-band (such as layered cloud forms) the radar is using complex sounding signals, which is based on nonlinear frequency modulation and phase shift keying. A radiated power of transmitting APAA is 1200 W. The ratio of radiation to the pause is equal to 10. The system has overall potential sufficient to detect hydrometeors with reflectivity up to -35 dbZ at a distance of 10 km. In radar pointed towards the nadir, there is a provision for a mode of lateral view of the earth's surface, which in implemented using the synthesis of a radiation pattern.

Radars use a design with separate transmit and receive phased arrays based on the printed micro strip radiators. The control system of an APAA allows you to create up to 64 positions of a radiation pattern.

5.7. HARDWARE-SOFWARE COMPLEX FOR MEASURING ATMOSPHERIC ELECTRICAL CHARACTERISTICS

This complex provides possibility to measure electrical characteristics of the atmosphere including clouds and other atmospheric phenomena which obtain electrical charge (Begalishvily et al. 1993).

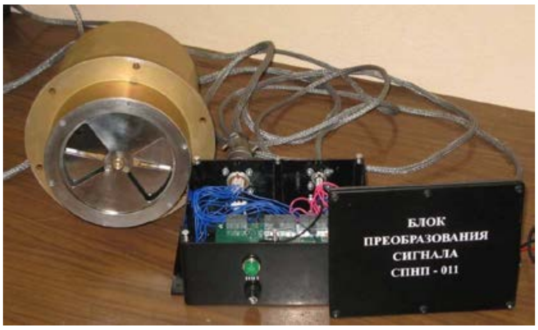

Fig. 23. Aircraft electrical field mill SPNP-011

Potential of ionosphere and its changes due to natural reasons and artificial modification can be derived from the measurements. The complex can be used also to discover electrical charges in troposphere associated with aerosol layers and clouds. Electrically charged layer clouds which are dangerous phenomena

Fig. 24. Aircraft air conductivity probe SAIV-011

for aircrafts can be studied with the mentioned instruments. Another important possibility to use the complex is a possibility to assess seeding results, as electrical cloud characteristics usually change after seeding. Our early investigations have also shown that radioactive emissions and their temporal and spatial variations can be also detected with the help of presented complex.

This complex includes the following instruments.

- Active compensator of an aircraft charge (AKZS).

An instrument is used to regulate aircraft electrical charge. The principle of such regulation is based on regulation of corona discharge from the aircraft. Special discharge rods are installed on aircraft wings.

- Aircraft electrical field mill (SPNP-011).

The instrument (***Fig. 23)*** is used to measure electrical field strength E at the position where the probe is installed. Six probes SPNP-011 are installed at different parts of the aircraft fuselage. Processing of the data provides possibility to derive electrical field vector E and aircraft charge Q.

- Aircraft air conductivity probe (SAIV-011).

The probe (***Fig. 24)*** is used to measure air conductivity of both polarities. Aspiration method is used for measurements.

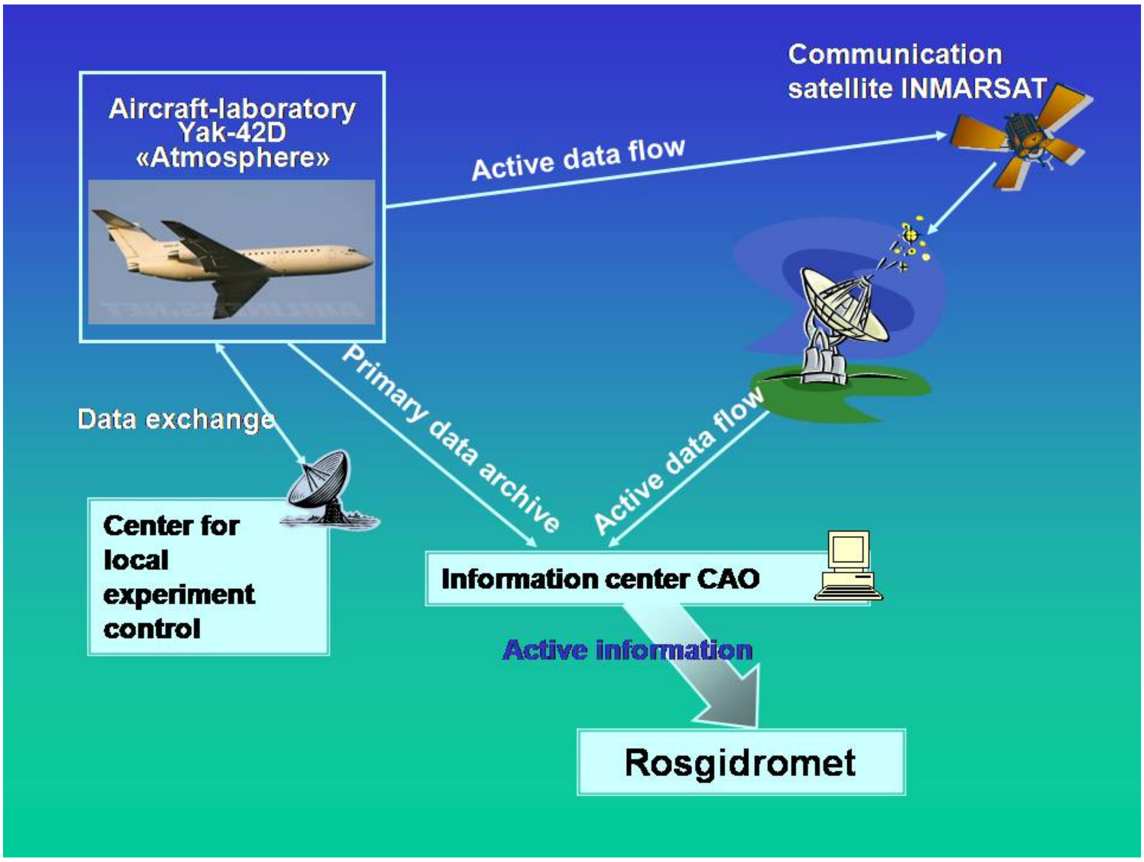

Fig. 25. The structure of information interaction between aircraft-laboratory Yak-42D “Atmosphere” and ground-based centers

5.8. ONBOARD AIRCRAFT DATA ACQUISITION SYSTEM (OA DAS)

OA DAS provides collecting and archiving of data from measuring devices and the systems which are included in all hardware-software complexes.

OA DAS carries out the following functions:

- Initial data collecting and processing on workplaces;
- Collecting and storage of processed results in Onboard archive;
- Displays of results from uniform onboard archive;
- Exchange of current data between measuring complexes;
- Data transmission on liaison channels;
- Internal monitoring of measuring system and the control of its integrity;
- Export of results of flight to ground archive of data;
- Storage of results of flight experiments in Ground archive.
- Managements of local experiment on updating clouds from ground command center.

Onboard Aircraft Data Acquisition System is constructed on the basis of industrial computers of type “iROBO”, network equipment CiscoCatalyst, Satellite communication System “T&T Aero SB Lite”, radio data transmission system “Land – Aircraft – Land” (Petrov et al., 2007).

The structure of information interaction between aircraft-laboratory

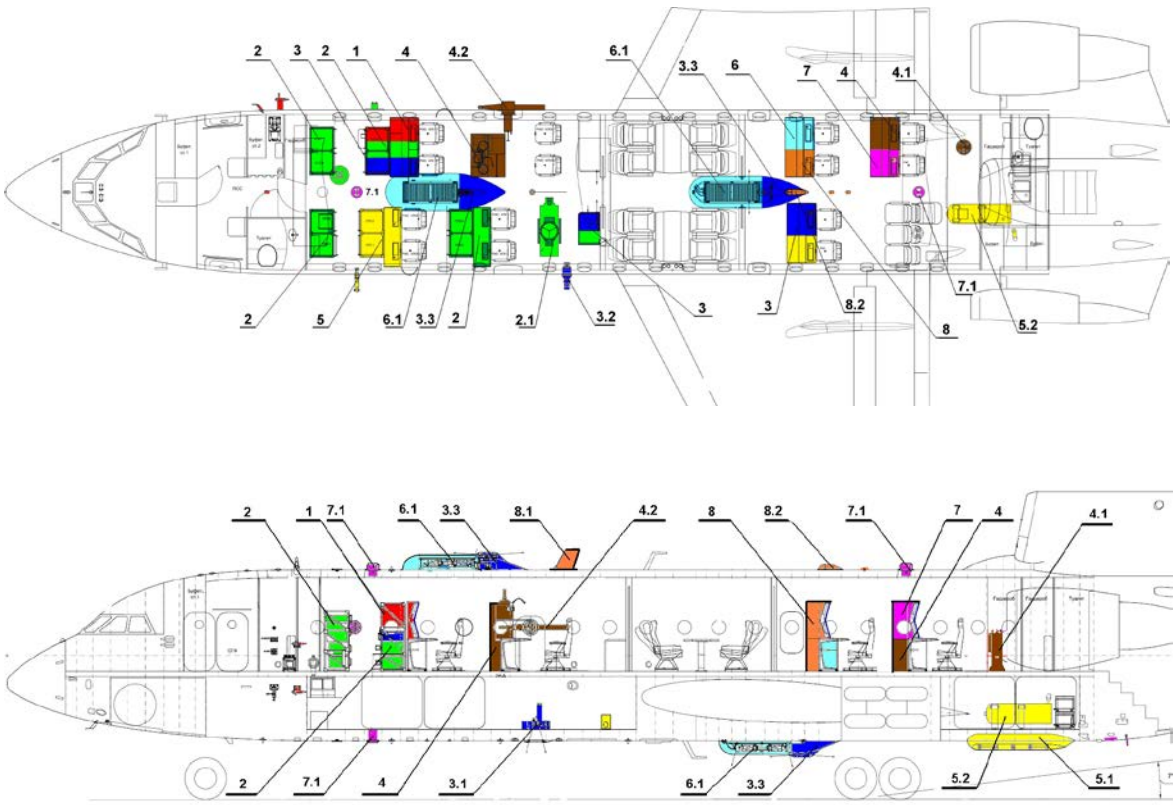

Fig. 26. The common view of aircraft-laboratory Yak-42D “Atmosphere” layout

Yak-42D “Atmosphere” and ground-based center for local experiment control and information center CAO is presented in ***Fig. 25***.

6. EQUIPMENT LAYOUT OF AIRCRAFT-LABORATORY YAK-42D “ATMOSPHERE” AND CONDITION OF ITS DEVELOPMENT

The common view of equipment layout aboard Yak-42D (vies from the side and from above) is presented in ***Fig. 26***.

We use the following denotes in the figure:

1. Complex for researches of Thermodynamic parameters of atmosphere;

2. Complex for researches of Gas and aerosol structure of atmosphere;

2.2. Aircraft multi-wavelength aerosol lidar ML-375-A;

3. Complex for researches of Radiation in atmosphere and from surface, radiation balance in atmosphere;

3.1. Hyper-spectral viewer;

3.2. Long wave 4-channel viewer 4KCP(T);

3.3. Thermal radiation sensors;

4. Complex for researches of Radioactive pollution of atmosphere and underlying surface;

4.1. Gamma spectrometer with scintillation and high purity germanium detector GEM 40-86 «ORTEC»;

4.2. Aerosol sampler “Vega-1M”;

5. Complex for researches of Microstructure of atmospheric clouds and participation;

5.1. The set of pyrotechnic means UV-26;

5.2. The small ice particle generator SIPG-A;

6. Radar-tracking complex for researches of atmosphere;

6.1. Coherent X-ray wavelength radar;

7. Complex for researches of Atmospheric electricity;

7.1. Aircraft electrical field mill SPNP-011;

8. Central server of DAS and data transmission system;

Fig. 27. A model of aircraft-laboratory Yak-42D “Atmosphere”

8.1. VHF antenna;

8.2. Satellite communication system antenna.

In the front part of the aircraft fuselage different kind of gas proves are located (pitot-static heads, air temperature and humidity sensors, air sampling probes for number of measuring systems, cloud particle probes and others). At the top and the bottom parts of fuselage there are a number of special fairings of radar antennas, pyranometers and pyrgeometers sensors. Aircraft-laboratory also has a set of special windows for upward view and downward view lidar, spectrometer, ultraviolet and visible range

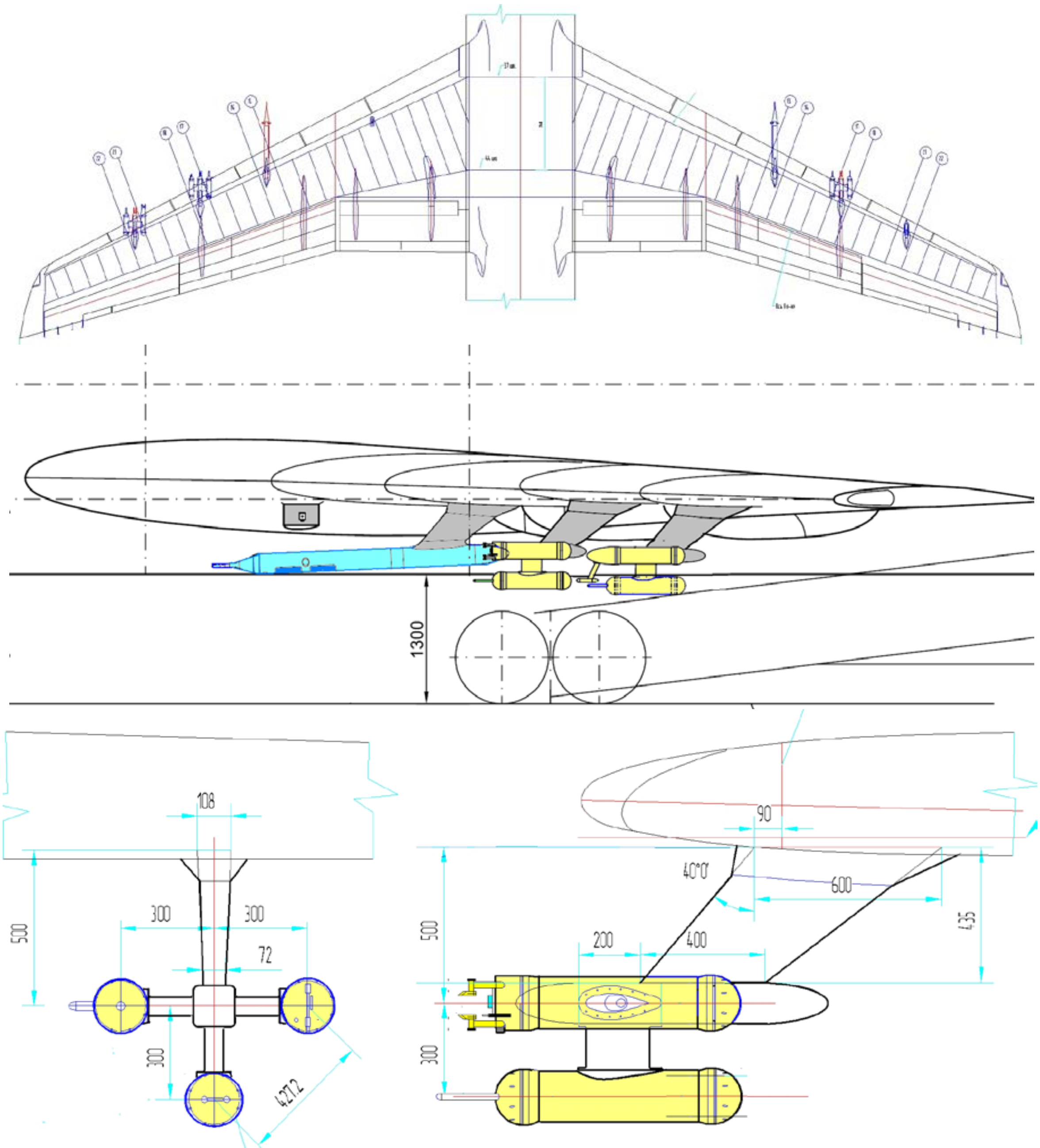

Fig. 28. Location of sensors under the wings

Shamrock, microwave radiometers, hyper-spectral viewer, long-wave 4-channel viewer, cloud extinction probe. A lock-chamber for collecting samples of radon-222 measuring is also installed at the right side of the fuselage. Six sensors for measuring electricity field of atmosphere are located along the fuselage. Several fuselage hard points and aperture plates are also installed for deployment of new instruments as needed.

The 3-D view of future aircraft-laboratory is presented in photo of aircraft model (***Fig. 27***).

Six pylons for carrying two remote bars for thermodynamic and microphysical sensors and 9 canisters of PMS/DMT type with microphysical instruments are located underneath the wing.

PMS/DMT canisters and SPI probe are installed at the pylons located underneath the wings (***Fig. 28***). There are three additional places on the pylons for further installations of canister type devices.

Aboard Yak-42D “Atmosphere” there are 8 working places for 10 operators maximum, including scientific head of the flight. It is possible to place 4 seats for additional members of experiments. The scientific instruments are located in a cabin of the aircraft using standard 19-inch racks. The model view of working place aboard aircraft-laboratory Yak-42D “Atmosphere” is presented in ***Fig. 29***.

In order to gain some insight about the current situation with creating of

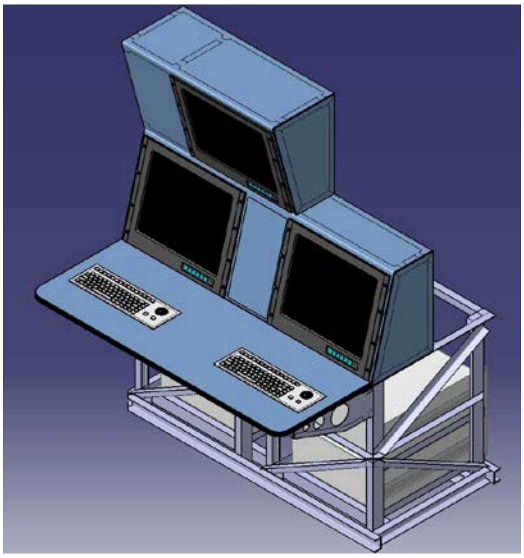

Fig 29. The model view of working place aboard the aircraft-laboratory

Fig. 30a. Current situation with the aircraft-laboratory creating

Fig. 30b. Current situation with aircraft-laboratory creating

aircraft-laboratory a few pictures of the aircraft in hangar under working are presented in ***Fig. 30a*** and ***b***. According to working plan all jobs should be completed in the first part of the 2013 and after this the aircraft-laboratory could fulfill special flight tests.

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