SSAU PROJECT OF THE NANOSATELLITE SAMSAT QB50 FOR MONITORING THE EARTH'S THERMOSPHERE PARAMETERS

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Geophysics field monitoring is actual science problem. Specially for Earth thermosphere, which are very sensitive to the natural and technogenic processes. In order to construct three-dimensional non-stationary model of the Earth's thermosphere is necessary to carry out simultaneous measurement of parameters at different points in space for a long time period. To this purpose, the von Karman Institute of Hydrodynamics (Belgium) proposed international project QB50 [1], in which planned the simultaneous launch of 40 scientific and 10 technological demonstration nanosatellites (NS) CubeSat standard. From the Russia in the QB50 project is participating only Space Research Department of Samara State Aerospace University (SSAU). At every scientific NS will be installed one of standard payload: FIPEX, mNLP, INMS [2]. All science data will be transferred to the NS developer’s Mission Control Center (MCC) during downlink sessions and then transferred to QB50 project’s data center by Internet. After data processing will be create three-dimensional non-stationary model of the Earth's thermosphere. All collected data will be available to all project participants.

Each CubeSat team’s NS has unique design, but all of them have to perform the general specifications for the QB50 System Requirements and Recommendations [3].

The current stage of the design of SSAU’s CubeSat SamSat-QB50 is the Critical Design Review (CDR). The external view of SamSat-QB50 is shown in Figure 1. SamSat-QB50 on design parameters correspond to the CubeSat 2U standard. SamSat-QB50’s onboard systems divided into *providing*, *scientific* and *experimental*. SamSat-QB50’s layout scheme is shown in Figure 2.

Providing systems perform nanosatellite control functions, energy provide and connection with the MCC: on-board computer (OBC), electrical power supply (EPS), transceiver (TT&C) and structure (STR). Providing systems have to correspond to Technology Readiness Levels (TRL) of at least 7 to ensure the required mission reliability. Therefore, as the providing systems use components that have already been flight verification: OBC - NanoMind A712D, EPS - NanoPower P31U + NanoPower P110, Transceiver - TRXVU. SSAU developed an original STR, which correspond to standard requirements and have the ability to change its geometry on the orbit.

Scientific systems are designed to perform scientific tasks, namely, thermosphere parameters monitoring. It uses a universal payload FIPEX, but its design and some specifications does not allow to connect it directly to our OBC. Therefore special board FIB (FIPEX integration board) was developed, satisfying all the requirements and specifications. Collected data is stored on the FIB and if necessary, is directed to OBC to transfer it to the MCC.

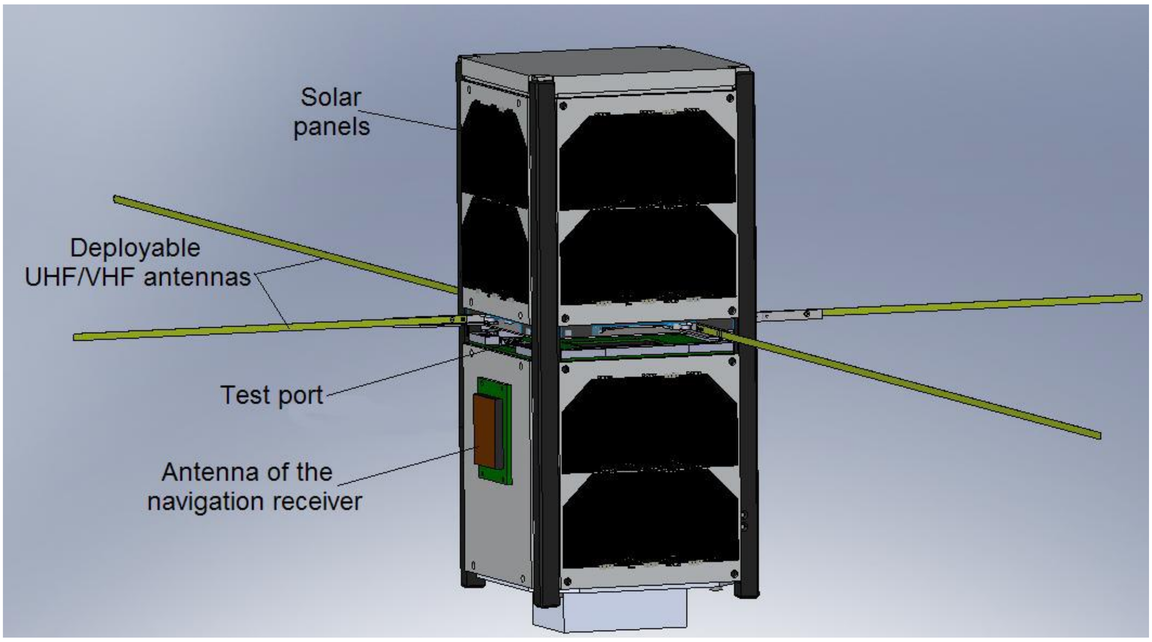
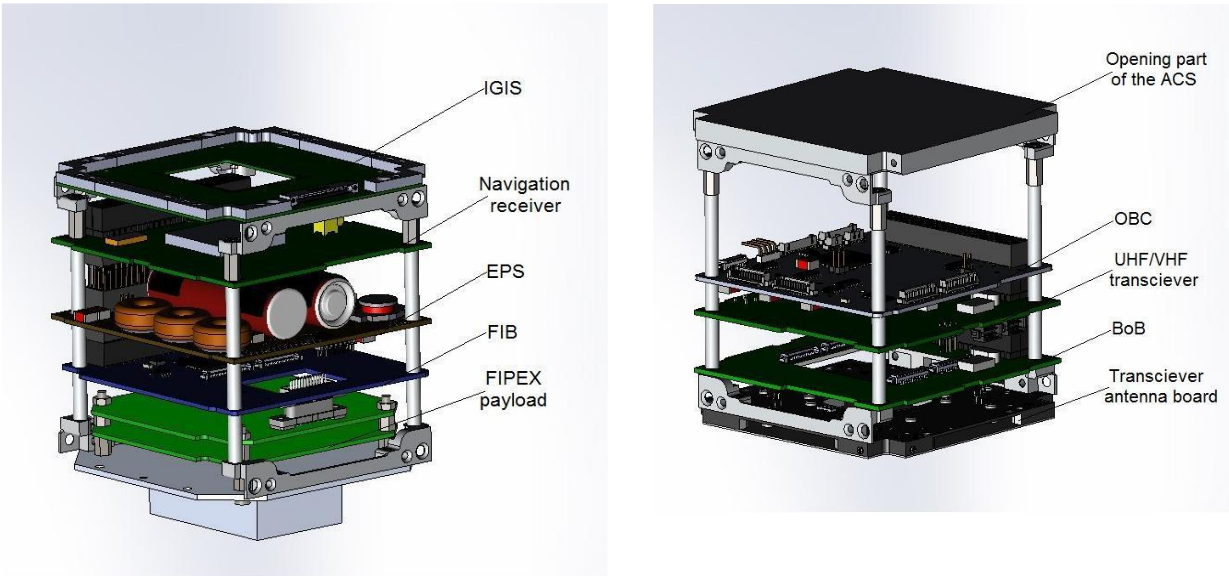


Fig. 1 – The external view of SamSat-QB50



a) b)

Fig. 2 – SamSat-QB50's layout scheme
(a – first unit; b – second unit)

The experimental systems that have not been flight verification have to have TRL value 6 and below. The use of such systems is due in some cases, specific limitations on the part, economic and time constraints, as well as SSAU team opportunities. Experimental systems in SamSat-QB50 are orientation and stabilization system, a navigation system and antenna system.

Earlier of the following payload set was chosen FIPEX, due to its low mass (less than 0.2 kg) and low requirements on the accuracy of the orientation of the longitudinal axis of the satellite (equipment FIPEX) along the vector of the incident flow (± 20 deg).

The choice of the passive attitude control system, which is based on the use of the restoring aerodynamic torque, due to several reasons: the relative simple of implementation; reducing time for development and testing as compared with an active ACS; the need to save energy consumption. Therefore, it was proposed the original decision for increasing of restoring aerodynamic torque by means of the transformation of the NS to format CubeSat3U (actually aerodynamic stabilizer) and the creation of the reserve of static stability about 0.16 [4].

The simulation showed that, given the uncertainty of the initial conditions of separation, including the error of the deployer, is necessary to install a damping device, which as been selected hysteresis rods. Figure 3 shows graphs of density distributions of the maximum angle of attack depending on the characteristics of normal distribution of the magnitude of the initial angular velocity acquired satellite after exiting from the separation deployer without damping oscillations and the initial zero angle of attack. Analysis of the results is shown that the required value of the attack angle can be obtained only at low initial angular velocity of the satellite (less than 0, 15 deg / sec with a probability of 0.95).

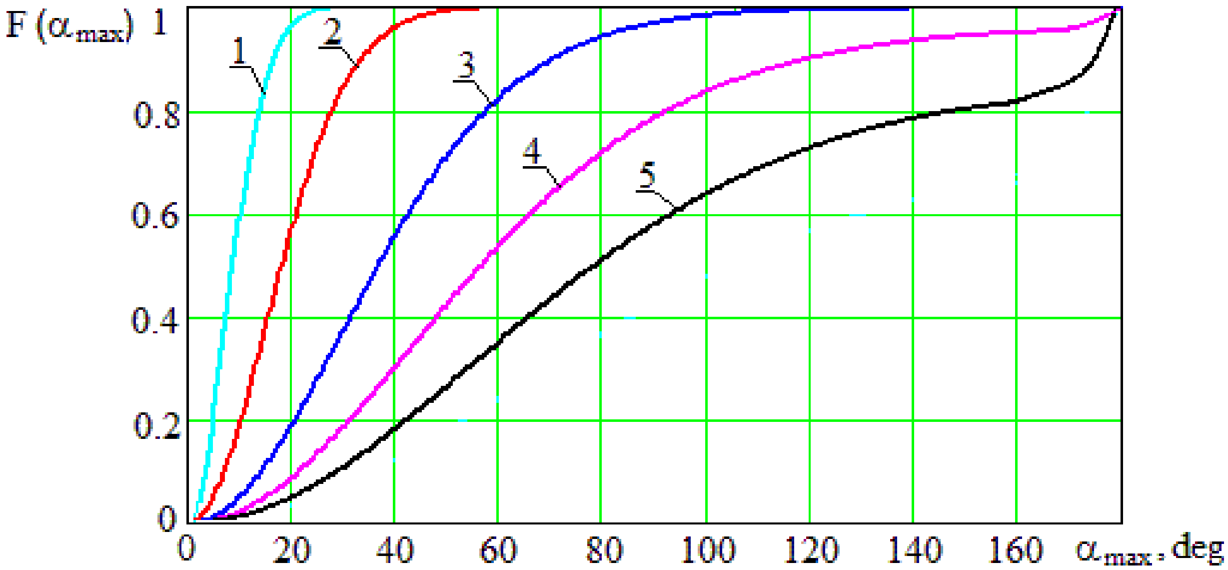


Fig.3 – Graphs of density distributions of the maximum angle of attack depending on the characteristics of normal distribution of the magnitude of the initial angular velocity acquired satellite after exiting from the separation adapter
(1 - $3\sigma_{\omega_y} = 3\sigma_{\omega_z} = 0.15$ deg/s, $3\sigma_{\omega_x} = 0.03$ deg/s; 2 - $3\sigma_{\omega_y} = 3\sigma_{\omega_z} = 0.5$ deg/s, $3\sigma_{\omega_x} = 0.1$ deg/s; 3 - $3\sigma_{\omega_y} = 3\sigma_{\omega_z} = 1.0$ deg/s, $3\sigma_{\omega_x} = 0.2$ deg/s; 4 - $3\sigma_{\omega_y} = 3\sigma_{\omega_z} = 1.5$ deg/s, $3\sigma_{\omega_x} = 0.3$ deg/s; 5 - $3\sigma_{\omega_y} = 3\sigma_{\omega_z} = 2.0$ deg/s, $3\sigma_{\omega_x} = 0.4$ deg/s.)

Figure 4 shows the geometrical dimensions of the SamSat-QB50 after transformation of the structure.

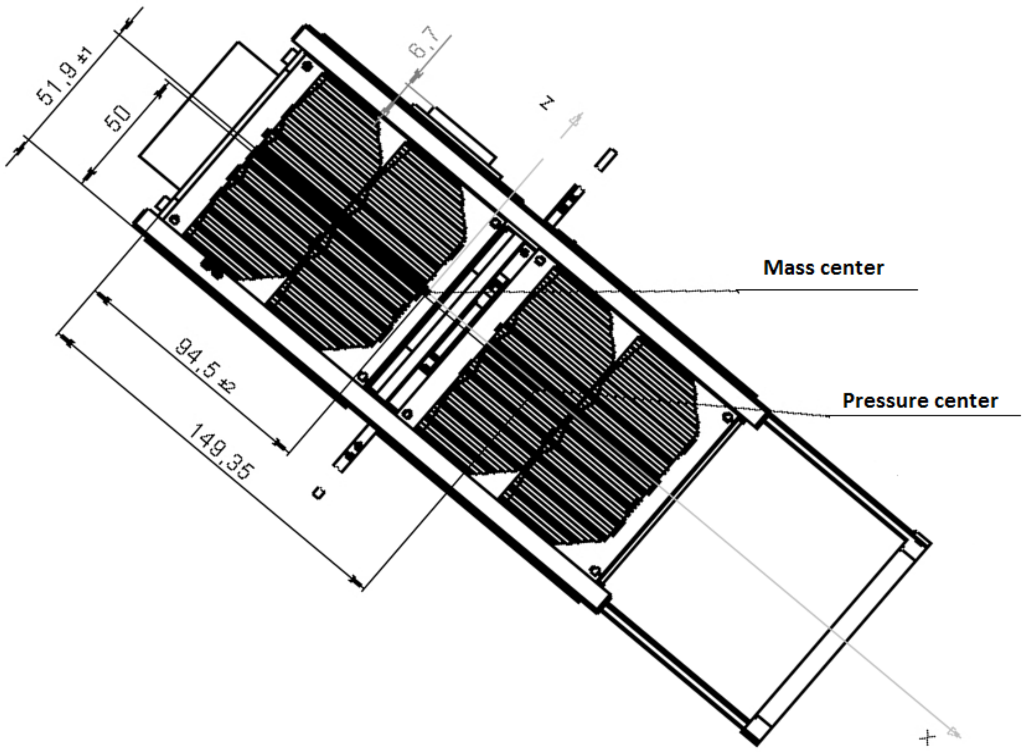


Fig. 4 –SamSat-QB50 after transformations

The proposed approach to the design of low-orbital satellites which use a transformable design for aerodynamic stabilization can be used for orbits with altitudes up to 350 km.

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References:

1. *https://www.qb50.eu/*
2. *https://www.qb50.eu/index.php/tech-docs/category/3-sensor-units*
3. *QB50 System Requirements and Recommendations, Issue 6, 9 July 2014*
4. *Selection of design parameters of aerodynamically stabilized nanosatellite for thermo-sphere research within the QB50 project / 5th European CubeSat Symposium, Book of Abstracts, 3-5 June 2013, Ecole Royale Militaire, VKI, Brussels./ I.Belokonov, L.Gluhova, D. Ivanov, A. Kramlikh,M. Ovchinnikov, I. Timbay, E. Ustiugov*