Youth project Space-π using small spacecraft for research of near-Earth space and remote sensing of the earth

S.B. Makarov *[1], S.V. Zavjalov[1], S.V. Volvenko[1], A.K. Aharonyan[2], and V.H. Avetisyan[2]

[1]Peter the Great St. Petersburg Polytechnic University, St. Petersburg, Russia
[2]Russian-Armenian University, Erevan, Armenia

Abstract

This work is devoted to the implementation of the scientific and educational project "Space-π" for the development and production of small spacecraft on the domestic digital platform in order to implement schoolchildren's projects. A very important part of this work is that a lot of school groups take part in it, not only from St. Petersburg, but from all over Russia in general, and in the future from other countries. They have the opportunity to participate via the Internet both in the processing of information and in the process of how the satellite is manufactured.

Keywords: *small spacecraft, nanosatellite, receiving-transmitting station, GLONASS*

1. Introduction

The project "SPACE-π began in Peter the Great St. Petersburg Polytechnic University (SPbPU) in 2021 and its goal was to involve schoolchildren, students and graduate students in scientific and technical activities and popularize space research, missions, technologies through team solving competitive and applied tasks. Students and schoolchildren participate in the process of development, testing of scientific and educational spacecraft into near-Earth orbit. They are engaged in processing the results obtained in the process of space missions, research and experiments.

The main scientific interests, taking into account the technological features of the project, are in the following areas:

- Earth remote sensing and space monitoring, including optical, quasi-optical, infrared and electromagnetic frequency ranges;
- Investigation of various types of radiation from the earth's atmosphere and deep space, in particular gamma radiation, electromagnetic radiation, radiation of re-reflections of the sun's rays, spacecraft;
- Studies of the state of magnetic and electric fields of the ionosphere, including fields caused by lightning discharges and non-stationary fluctuations of the atmosphere;
- Technological studies of materials and biological preparations on the effects of cosmic radiation;
- The use of cubesat technologies for organizing communication systems with ground objects, between spacecraft and the use of artificial intelligence systems to control the operation of a swarm of cubesats;
- The use of cubesats to collect large amounts of data on the organization and control of the movement of sea and river vessels, ground transport aircraft, including unmanned ones.

*makarov@cee.spbstu.ru, Corresponding author

doi:https://doi.org/10.52526/25792776-22.69.2-295

2. What is it a nanosatellite?

A nanosatellite is a smaller version of a spacecraft with all control and monitoring systems typical of large satellites. External configuration (see Fig. 1) consists of: temperature sensor, infrared sensor, MEMS triaxial accelerometer, MEMS three-axis gyroscope, MEMS triaxial magnetometer, radiation sensor, radiation recorder. Navigation equipment is based on GLONASS/GPS/BeiDou sensors. Solar panels based on GaInP/GaAs/Ge has efficiency approximate 32%.

The modular principle of building a nanosatellite makes it possible to form a scalable architecture based on a stack of printed circuit boards and modules. This approach provides fast, simple and reliable assembly of all subsystems of the nanosatellite and convenient and easy access to devices and systems installed inside the vehicle. Internal configuration of the nanosatellite is presented in Fig. 2.

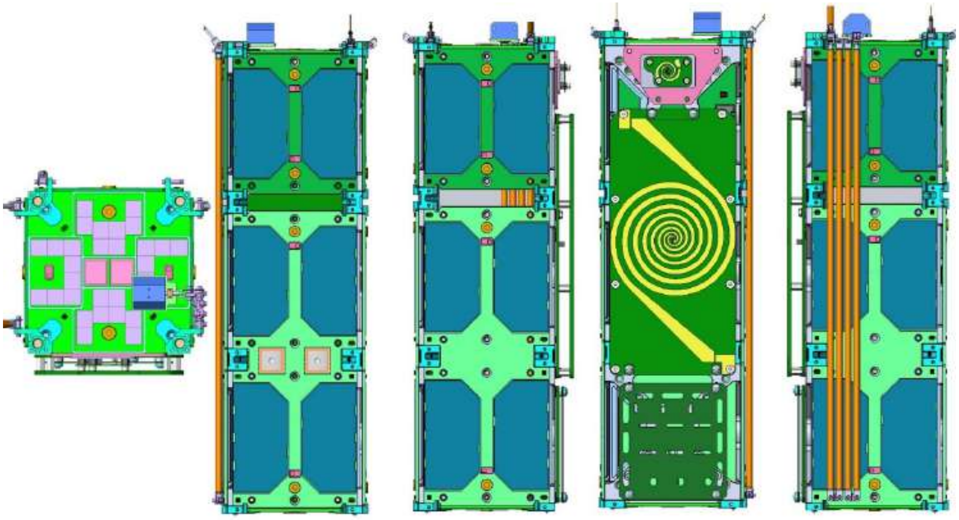

Figure 1. Appearance and content of the nanosatellite. The structure of the satellite in the sweep.

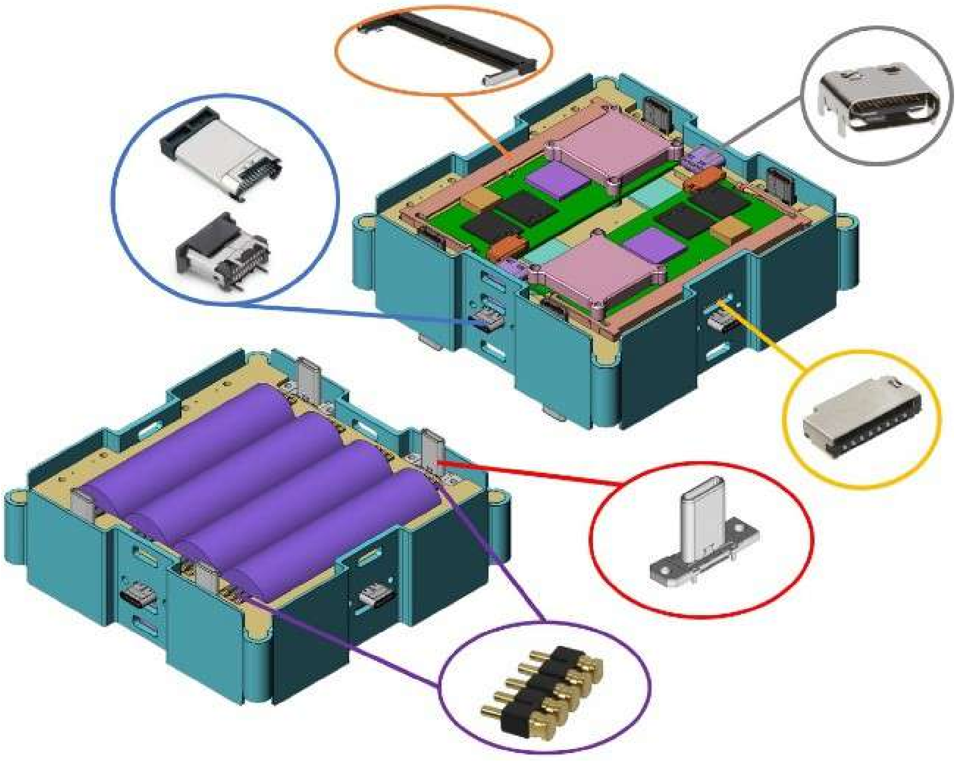

Figure 2. Internal configuration of the nanosatellite.

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The supporting frame provides reliable mechanical fixation of all subsystems of the satellite platform and the payload unit of the spacecraft, and also ensures reliable separation of the satellite from the launch container at the moment of launching into a given orbit. In addition, the frame is part of the nanosatellite's thermal regime control system.

The main part of the spacecraft is the microprocessor unit, which is the main control and management body of the satellite. The software is original and allows you to use telemetry channels to select certain satellite operation modes. The memory capacity of the microprocessor unit up to 128 GB allows you to store a large amount of data obtained in one turn of the device.

An important element of the satellite is the antenna-feeder devices. These devices provide reception of electromagnetic oscillations in a wide range of frequencies and allow this range to be divided into four parts. This provides a selective frequency response from several megahertz to units of gigahertz.

3. Control and signal reception

Reception and processing of various signals from various sources: analysis of the level of attenuation of known signals depending on the time of day, the state of the magnetic field, the ionosphere. When the spacecraft is put into orbit with the help of the Fregat upper stage, after the containment is dropped, the nanosatellite is taken out of the container. Each container contains four nanosatellites.

The main information reception center is located at the Peter the Great St. Petersburg Polytechnic University (see Fig. 3). The main channel for transmitting information is the telemetry channel. For this, a tracking antenna system is used.

Average span parameters of antenna: the average total visibility duration per day is 26.4 minutes. At the same time, this duration varies from 0.16 to 7.35 minutes, depending on the trajectory of the vehicle.

Figure 3. Control and signal reception center.

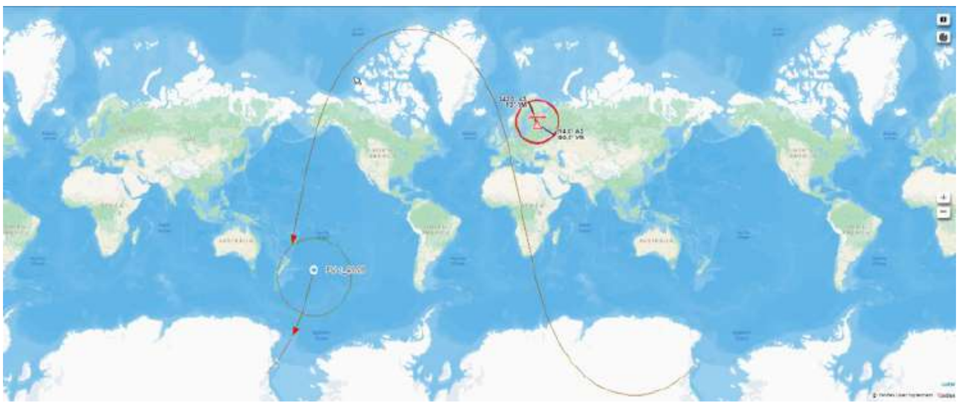

Figure 4. Data of trajectory measurements of the nanosatellite Polytech Universe 1.

It is important to note that access to the data server will be open to everyone for review and analysis of readings taken

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During the flight of vehicles along the trajectory (see Fig. 4) above the earth's surface, the values of the radiation power at a specific frequency are measured at certain time intervals. These results of measurements in time (points of reading information by a cubesat) are linked via the GLONASS/GPS system to a map of the earth. A set of points with geographic coordinates and radiation level data associated with them makes it possible to create a map of the distribution of electromagnetic radiation power on the earth's surface.

4. Summary

Peter the Great St. Petersburg Polytechnic University is one of the participants in the Russian educational project Space π. This is a project of the Planet Duty Program of the Innovation Assistance Fund, in which the winners of the Open Space competition of the Russian schoolchildren movement participate. The project is aimed at attracting schoolchildren to the field of science-intensive technologies related to space research. As part of the project, schoolchildren offer their own ideas for payloads for satellites, participate in their development, use data from satellites to implement their own projects. It is planned that within the framework of the project, by 2025, 100 domestic cubesats will rotate in the Earth's orbit.

Acknowledgements

This work was supported Ministry of Science and Higher Education of the Russian Federation (state assignment).

doi:https://doi.org/10.52526/25792776-22.69.2-295