

*Session 4. Projects and missions of small spacecraft***FEATURES OF WAY CARGO SMALL SATELLITE LAUNCH
WITH "FOTON-M" OR "BION-M" TYPE SATELLITE**S. M. Shatokhin, V. A. Pospelov, N. B. Gubin,
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Currently, all over the world, a large amount of small satellites weighing up to 50 kg, intended for solution of scientific-technological and experimental problems, are being created. Due to small weight of such satellites, incommensurate with a mass of permissible useful load of the majority of carrier rockets, the most appropriate is their withdrawal as the associated burden, together with a large spacecraft (SC). This launch is linked with work on finalizing the basic KA providing conditions for the orbit insertion and conditions of the branch.

The paper considers peculiarities of way cargo small spacecraft (SSC) launch on the example of running the SSC of Cubesat type and SSC "Aist", established as a secondary payload on the spacecraft "Bion-M" №1.

On spacecraft "Bion-M" №1 as passing the output of additional payload was installed 3 department systems, providing launch of 5 SSC of Cubesat type. Data about SSC is given in table 1.

Table 1 – SSC of Cubesat type running with "Bion-M" №1 spacecraft

Name ICA	Department system	Cubesat format
G.O.D. Sat (South Korea, «Future Electronics Technology Mixer»)	FlyMate (NOVANANO, France)	1U
Dove-2 (USA, Cosmogia)	3U ISIPOD (ISIS, the Netherlands)	3U
«BEESAT-2» (Germany, Berlin technical University)	ECM-SPL Assembly (ECM-Office, Germany)	1U
«BEESAT-3» (Germany, Berlin technical University)		1U
«SOMP» (Germany, Dresden University of technology)		1U

3U ISIPOD and ECM SPL Assembly systems of separation are a container with a lid and restraint mechanism, operated by the solenoid. When triggered, the solenoid is opening the lid of the container and push the SSC by spring force. The system of separation FlyMate is equipped with an electronic control unit, own power source and stepper motor that provides output SSC from the body of the unit of the department system.

"Bion-M" №1 spacecraft is a scientific satellite designed to conduct research in the field of biology and medicine. Structurally, the spacecraft consists of sealed descent vehicle, the instrument bay and unpressurized instrument compartment. General view of the "Bion-M" №1 spacecraft is shown in figure 1.

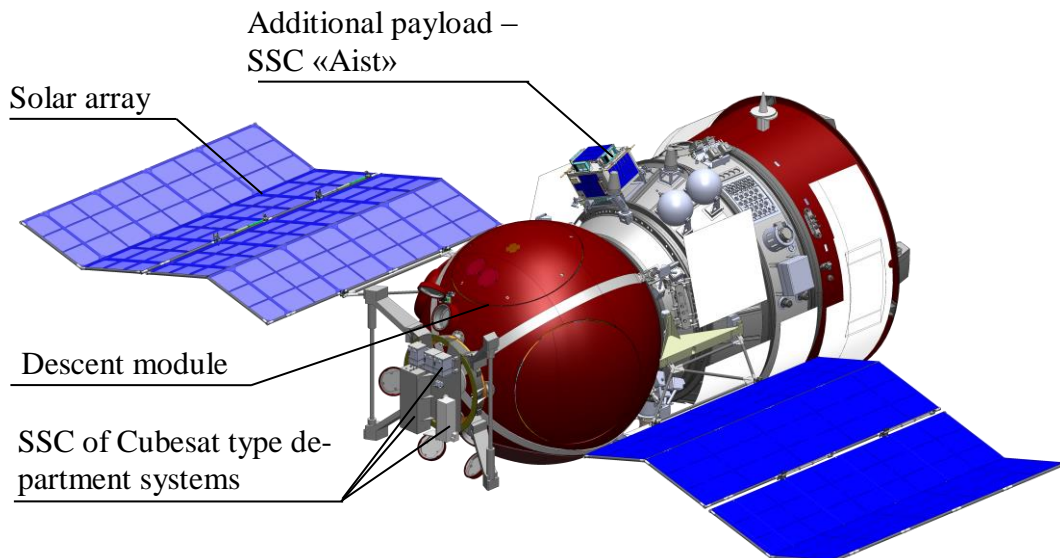


Fig. 1 - General view of the "Bion-M" №1 spacecraft

"Bion-M" №1 spacecraft is equipped propulsion system, allowing to carry out maneuvers to change the orbit and provide landing of the descent module in the specified range.

Launch of "Bion-M" №1 spacecraft took place 19.04.13. The spacecraft was launched into an elliptical orbit height 260x575 km and inclination of 64,9 degrees. Department of SSC G.O.D. Sat by FlyMate separation system held on 5 turn of the orbital flight, which corresponds to approximately 7.5 hours from the moment of the launch vehicle. On 29 orbit orbital flight of "Bion-M" №1 spacecraft held a transfer maneuver on circle working orbit with an altitude of 575 km On 32 circuit held department of SSC by 3U ISIPOD and ECM Assembly department systems. SSC "AIST" undocked from "Bion - M" last №1.

In the provision of associated launch of SSC of Cubesat type and SSC "AIST" on the "Bion-M" №1 spacecraft a number of technical questions was worked out:

- ensuring security of the relative motion of spacecraft and detachable SSC;
- ensuring the temperature in the place of installation of the department systems;
- ensuring the required parameters of activation signal systems division and the order of removal of the telemetry information confirming the SSC department;
- department systems and the SSC testing at the factory and technical complex of the cosmodrome.

Given that at the time of adoption of the decision about SSC launching, department systems and the SSC were in a state of the finished product, they had to find a solution on these issues with a minimum amount of rework.

Department of SSC of Cubesat type was held with the presence of "Bion-M" №1 spacecraft in oriented to the Sun position corresponding to the regular work of the SC. Calculation showed that the safety of the relative motion after separation can be guaranteed with SSC department at the time when SC is passing over the terminator of the Earth. However, considering specificity of work of the SC "Bion-M" №1 telemetry systems, from the point of view of guaranteed information about the SSC department, a decision was made on the issue of the activation signal of department systems within range of SC ground control in the course of the session. In this case control of the telemetry information is carried out with a higher sampling frequency.

A fairly wide range of the required design temperature at the installation of the department systems (from minus 30 to plus 50 degrees C) and short duration of the joint flight (up to 48 hours) allowed for the temperature regime of the SSC by passive means. At the time of the fire FlyMate department temperature of SC construction amounted to 14.1 °C, 3U ISIPOD - plus of 13.6 °C, ECM SPL Assembly - plus 21 degrees °C.

Electric signals with characteristics which cannot provide a guaranteed operation solenoids of 3U ISIPOD and ECM SPL Assembly department systems are used for management of

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SC "Bion-M" №1 systems. To ensure the required parameters of activation signal, supply voltage was organized from AIT of other SC systems, as well as special software has been developed, allowing to provide the required duration of the activation signal by the issuing of a sequence of commands to the device of commutation.

Electrical test of department systems and they interaction with the SC was held at the factory and technical complex of the cosmodrome with SSC models. The final test of department systems and downloading the SSC held for 10 days before the launch of SC "Bion-M" №1.