Mission Design Problems for Spectrum-Roentgen-Gamma Project

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Spectrum-Roentgen-Gamma (SRG) project is intended for whole sky review in X and Gamma ray bands. Besides, some particular area of the sky and chosen sources of radiation are to be explored separately with extended times of observation. For this two telescopes are planned to be used mounted onboard spacecraft of the same name (SRG). The last is to be launched into vicinity of Solar-Terrestrial collinear libration point L2 in 2018. As launch vehicle Zenith with Fregat upper stage is planned.

The technology of sky review consists from operations aimed to scan the sky by telescope axes by rotation spacecraft around axis which roughly following Sun direction. Telemetry data are transmitted to the Earth ground stations through mean gain antenna. Its axis coincides with rotation axis what generates some constraints on mission design. Among them are allowed amplitude limits of near libration point orbit along directions orthogonal to the Sun-Earth line.

These limits determine the possibilities to transmit the data to the ground station taking into account the diagram characteristics of mean gain antenna and spacecraft radio visibilities intervals duration. In addition there is limitation on acceptable maximum angle between rotation axis and Sun direction. Well known standard approaches for solutions of these problems are complicated by technical obstacles. In the paper results of mission optimization are presented if framework of physical and technical conditions. In the list of technical constraints there is the mass of onboard propellant needed for orbital maneuvers in order to decrease amplitude of the operational trajectory. So the alternative approach is developed based on the use of upper stage delta-V possibilities in order to execute such maneuver before spacecraft separation, taking into account constraints on permissible time interval between the last two upper stage burns . It was shown that such method does work decreasing the amplitude of operational trajectory to the demanded level. Its effectiveness increases with time interval since start from initial parking orbit to the next burn of upper stage engine. In the paper the cost of such approach is presented in terms of demanded delta-V.

Important part of SRG project mission design is development of the methods of compensation some difficulties of the use the bus of spacecraft which has been developed initially for the other space projects, “Electro” for example. So mission design was to be flexible enough in order not to demand excessive modifications of the bus and ground segment of the project. Flexibility also means keeping the list of launch dates which does not include the forbidden ones. Key information to be taken into account for final decision related to launch date choose and connected with it operations scenarios are presented.

As the least risky scenarios are considered those which do not demand decreasing operational orbit amplitude by additional burn of engine mounted on the upper stage or on spacecraft itself. This version of scenario means for some intervals of mission quite visible decrease of visibility interval from ground stations and degrading of telemetry data transmission conditions. But as it was shown in the paper the possibilities still exist to transmit data from spacecraft each day to the only one available ground station without constraints on the launch date. In this case nominally the operational orbit is reached by only one delta-V impulse for start from initial low near Earth parking orbit. Such results occurred to be achievable thanks to fact that choosing only one parameter one can transfer spacecraft from initial circular orbit to the trajectory which is kept in vicinity of L2 point. Obviously the other parameters are to be inside some box. In our case described in the paper, these free parameters were used for optimization the mission at large. The variants of technically feasible scenarios broaden the area of choice with the use of numerical results given by the paper.