New results on spin determination of BLITS from High Repetition Rate SLR data

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Abstract

The nanosatellite BLITS demonstrates a successful design of the new spherical lens type satellite for Satellite Laser Ranging (SLR). The spin parameters of the satellite were calculated from more than 1000 days of SLR data collected from 6 High Repetition Rate (HRR) systems: Beijing, Changchun, Graz, Herstmonceux, Potsdam, Shanghai.
Analysis of the 892 passes (September 26, 2009 - June 18, 2012) shows precession of the spin axis around orientation of the along track vector calculated at the launch epoch of the satellite RA=$9^h16^m39^s$, Dec=43.1º. The spin period of BLITS remains stable with the mean value T_{mean}=5.613 s, RMS=11 ms.

Spin determination

The specific construction of BLITS makes range measurements possible only when the laser is pointing to the transparent hemisphere of the body; in this investigation we assume that the reflections are possible up to 90º incident angle between the laser beam and the optical axis of the hemisphere. As the satellite is spinning, the laser beam of the SLR system is alternately pointing to the transparent or coated hemisphere, thus series of measurements / no measurements intervals during a pass are visible.
The high repetition rate of the laser allows measuring the duration of the intervals with sub-ms resolution, thus giving accurate information about the spin of the satellite.
The spin parameters of BLITS and its optical response were previously determined (Kucharski et al., 2011a, 2011b) with measurements from Graz SLR station only (until 433 days since launch). For this investigation we use range data provided by all SLR stations which operate with kHz lasers (of short pulse width): Beijing, Changchun, Graz, Herstmonceux, Potsdam, Shanghai. The 962 analyzed passes have been measured between September 26, 2009 and June 18, 2012 (1005 days since launch).

Results

Fig. 1 presents the orientation of the spin axis: 87 values, each calculated from a common analysis of 5-12 passes. The spin axis oscillates around the orientation of the along track vector at the launch epoch (RA=$9^h16^m39^s$, Dec=43.1º, calculated from the satellite's position predictions), which is assumed to be the initial orientation of the spacecraft. The RMS of the values around the polynomial trend functions (Fig. 4) is: $RMS_{RA}=4^m31^s$ and RMS_{Dec}=0.72º. The precession of the spin axis can be caused by Earth's gravity field as it acts on the offset between the center-of-pressure (geometry) and the center-of-mass of the satellite. The offset is caused by the difference in the mass between the two hemispheres of the body - the external surface of one hemisphere is aluminum coated and covered by a varnish layer.

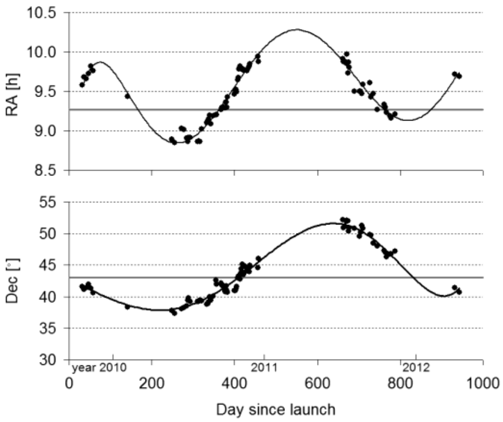

Fig. 1. Spin axis orientation

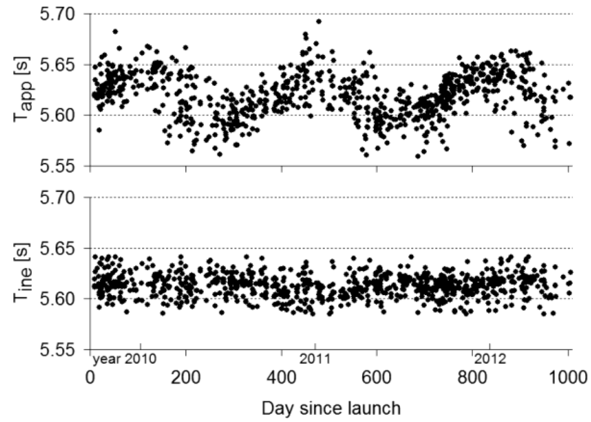

Fig. 2. Spin period

The spin period of BLITS during 433 days since launch calculated by (Kucharski et al., 2011a) was stable with a mean value of T=5.613 s. During the present investigation we calculate spin period as a time between the two transition epochs (observed borders between the return / no return intervals) separated by 5.6 ± 0.5 s. The values obtained for a single pass are corrected for the apparent spin and filtered by 2.5 σ criterion; the mean value of the filtered dataset indicates an inertial spin of the satellite. The inertial spin period of the body can be calculated as $T_{ine}=T_{app}/(1+LON_{laser}/360^{o})$ [s], where T_{app} is an observed (apparent) value of the spin period.
Fig. 2 presents the apparent and inertial spin period of BLITS calculated from 892 passes measured between September 26, 2009 and June 18, 2012. The inertial spin of the satellite remains stable during the investigated period, with the mean value T_{mean}=5.613 s, RMS=11 ms. Due to the sun-synchronous orbit the apparent spin T_{app} oscillates with a 1 year period as the orientation of the satellite's spin coordinate system changes within the inertial, Earth's body centered reference frame.
The large dataset delivered by the multiple SLR stations allowed increasing the accuracy of the spin period determination in comparison to the previous work (Kucharski et al., 2011a). The long time series of T does not show - as common for the heavy, metallic satellites (e.g. LAGEOS, LARES) - an exponential slowing down caused by the magnetic field of the Earth; the glassy, non-conductive, body of BLITS prevents the magnetic field from inducing the eddy currents within the satellite structure and breaking its rotation.

References

Kucharski, D., Kirchner, G., Koidl, F. Spin parameters of nanosatellite BLITS determined from Graz 2 kHz SLR data. Adv. Space Res., 48 (2), 343-348, doi: 10.1016/j.asr.2011.03.027, 2011a

Kucharski, D., Kirchner, G., Lim, H.-C., et al. Optical response of nanosatellite BLITS measured by the Graz 2 kHz SLR system. Adv. Space Res., 48 (8), 1335-1340, doi: 10.1016/j.asr.2011.06.016, 2011b