SLR Coverage Analysis for STSAT-2

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Abstract

The STSAT-2 (Science and Technology of Satellite – 2) is a low earth orbit micro satellite for the space technology research and space science. This satellite is the first Korean satellite which will be launched by the KSLV-1 (Korea Space Launch Vehicle – 1) in 2009 in Korea. It has three missions: the DREAM mission, the SLR mission and the space core technology verification mission. Among other things, the SLR mission is to measure the precise distance between the STSAT-2 and a SLR ground station and then to determine the precise orbit of it. In this paper, as one of the SLR mission analysis, the SLR coverage is analyzed during the SLR mission according to the attitude status of the operation concept. Finally, the result is provided.

Introduction

This satellite is the first Korean satellite which will be launched by the KSLV-1 (Korea Space Launch Vehicle – 1) in 2009 in Korea. Table 1 shows the summery of the STSAT-2. As showed in table 1, this orbit of the STSAT-2 is not a sun synchronous orbit. The figure 1 shows the eclipse period of the STSAT-2 for 1 year. This eclipse period changes from the minimum 0 minute to the maximum 37minutes.

The STSAT-2 has 3 major missions: Dual channel Radiometer for Earth and Atmosphere Monitoring (DREAM), Satellite Laser Ranging (SLR), Satellite Bus Technology Verification (SaTReC KAIST, 2005).

Table 1. Summary of the STSAT-2 specifications

Property	Value
Orbit	Inclination : 80^{o}, Apogee : 1500 km, Perigee : 300 km
Lifetime	2years
Instrument	DREAM : 10.66kg, 16W
	SLR : 0.82kg
Weight	100kg
Power	160W @EOL

Attitude Control	3-axis attitude stabilized control
	Pointing Accuracy : < 0.14^{o} (2σ)
	Attitude Knowledge : < 0.066^{o} (2σ)
RF link margin	S-band : 3dB @ 10deg
	X-band : 3dB @10deg
Data Rate	S-band Uplink : 1.2kbps, 9.6kbps
	S-band Downlink : 9.6kbps, 38.4kbps
	X-band Downlink : 10Mbps
Launch	July 31, 2009 by KSLV-1 (STSAT-2A) January 31, 2010 (STSAT-2B)

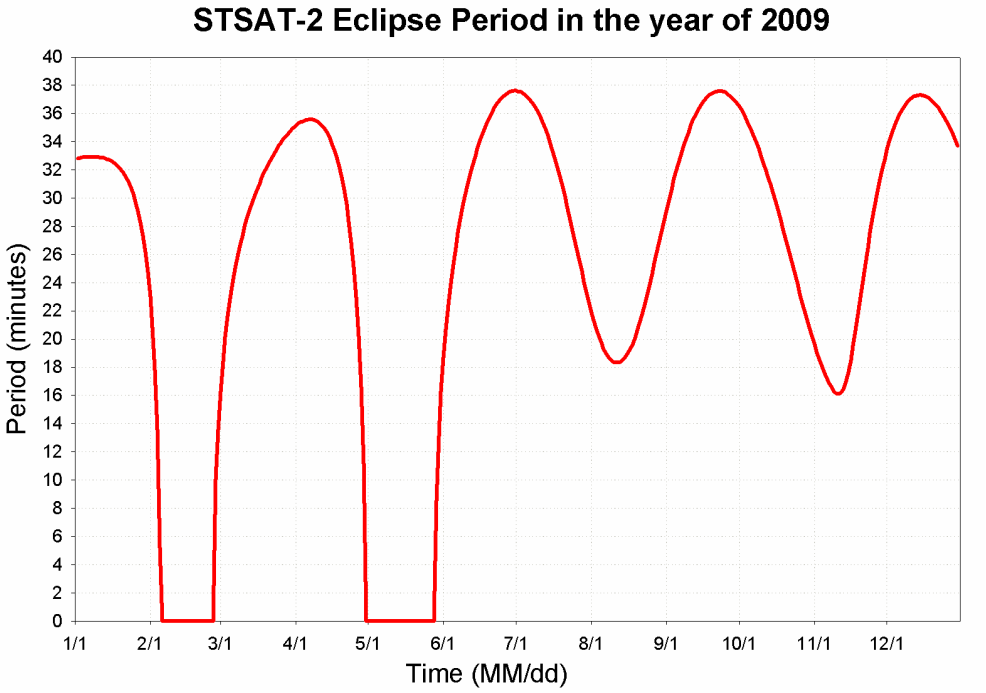

Figure 1. The eclipse period of the STSAT-2

SLR mission requirements

The SLR mission, the second mission, is to measure the distance between the STSAT-2 and SLR ground stations to determine a precise orbit. The LRA for the SLR mission is equipped with +Z axis of the STSAT-2. The operation concept of STSAT-2 has 3 attitude control modes.

1) Sun pointing mode of -Z axis
2) Earth pointing mode of +Z axis
3) KAIST ground station pointing mode of +Z axis

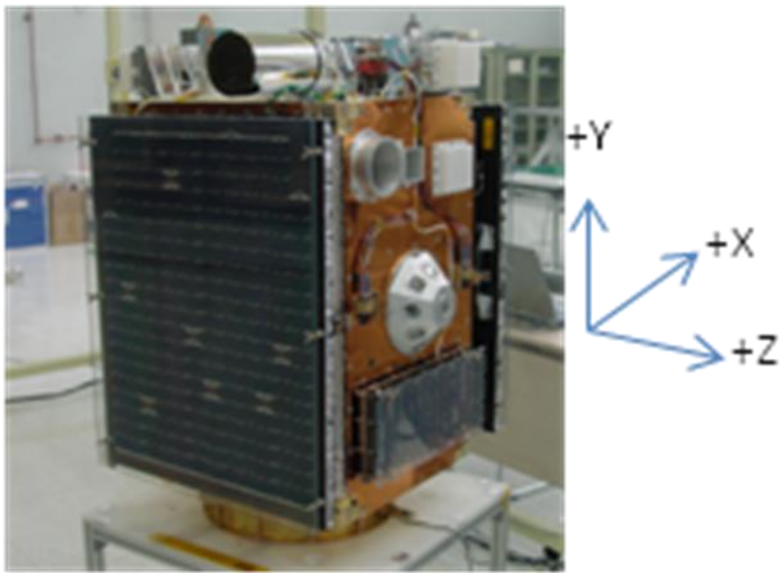

Figure 2. STSAT-2 Configuration

But there is no specified attitude control mode for the SLR mission. That means; the SLR mission should be operated in all of 3 attitude modes during the pass time at the SLR stations.

To carry out properly the SLR mission in these various attitude modes, the SLR mission needs the mission requirements. There are 4 requirements for the SLR mission.

1) The elevation angle of the SLR ground stations for the SLR mission should be more than 30 degrees.
2) The contact time during the pass time should be more than 1 minute to obtain the useful data at the SLR ground stations.
3) The observation time should be in the night time at China SLR stations.
4) The field of view of the SLR equipped with the STSAT-2 should be within ± 60° during the contact time for the measurement.

The analysis of the mission requirements

The requirements for the SLR mission should be examined whether they are possible to apply for the SLR mission. To verify the requirements analyzes the coverage of STSAT-2. The coverage means to examine which range of these requirements is able to apply for the SLR mission. At first, the contact time is analyzed for the coverage at the Shanghai station and the Herstmonceux station. The table 2 shows the position in the geocentric map of these stations (ILRS homepage).

Table 2. The position of the Shanghai station and the Herstmonceux station

No.	Station	Latitude (degree)	Longitude (degree)	Altitude (m)
1	Shanghai	31.0975	121.1917	27.832
2	Herstmonceux	50.86738	0.336122	75.404

The contact time is obtained from the orbit dynamics (Wiley *et al*., 1992). As a analysis result of the requirement 1 to 3, the Shanghai station can measure the SLR for the average 3minutes of 1 pass time per 2 days in the night time and the Herstmonceux station can measure the SLR for the average 12minutes of 2 pass time per 1 day in the day and night time (Jun Ho Lee *et al*. 2005).

Secondly, to verify the requirement 4, the field of view between the LRA of the STSAT-2 and the SLR station during the pass time about 3 attitude modes is examined using the Satellite Tool Kit 6.0. The Shanghai station can experience all of 3 attitude modes during the pass time: 1) The sun pointing mode, 2) the earth pointing mode, 3) the KAIST ground station pointing mode. As the analysis result, the contact duration within the $\pm 60^{o}$ of the field of view during the sun pointing mode is about 22% of the pass time, the contact duration within the $\pm 60^{o}$ of the field of view during the earth pointing mode is about 11% of the pass time, and the contact duration within the $\pm 60^{o}$ of the field of view during the KAIST ground station pointing mode is about 83% of the pass time in the Shanghai station. The Herstmonceux station can experience 2 attitude modes of 3 attitude modes during the pass time: 1) The sun pointing mode, 2) the earth pointing mode. As the result of the analysis, the contact duration within the $\pm 60^{o}$ of the field of view during the sun pointing mode is about 28% of the pass time, and the contact duration within the $\pm 60^{o}$ of the field of view during the earth pointing mode is about 11% of the pass time in the Herstmonceux station. The field of view is distributed between the minimum 11% and the maximum 83%. Assuming one pass time is about 14minutes, 11% of the field of view means 1.54minutes

Conclusion

In this paper, the requirements of the SLR mission, the second mission of the STSAT-2, were examined relating to the orbit property and the attitude modes. To verify the mission requirements, Two SLR stations were chosen because these stations may be possible to observe the STSAT-2: 1) the Shanghai station, 2) the Herstmonceux station. The coverage analysis firstly was performed to verify the requirement 1 to 3. The result shows to satisfy the requirement 1 to 3. The analysis of the field of view also was performed using the orbit calculation and the attitude mode control. The result shows that the field of view between the SLR of the STSAT-2 and these stations is able to be within $\pm 60^{o}$ during the pass time of these stations. As a result, four requirements for the SLR mission are valid. Thus, the precise orbit data obtained from the SLR mission will be able to use for the DREAM mission data processing and the satellite operation.

References

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