System Design of Sunshield on the MSC

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ABSTRACT

MSC as a payload of KOMPSAT-2 is an optical telescope for earth imaging on a sun- synchronous orbit. The MSC is a Ritchey-Chrétien type telescope composed of hyperbolic primary and secondary mirrors with focal correcting lenses. Their relative positions should be kept aligned during imaging operation. However, the MSC is exposed to adverse thermal environment on orbit which can have some impacts on optical performance as well as structural endurance. Solar incidence can cause non-uniform temperature rise on the tube which entails unfavorable thermal distortion. Three options were proposed, which were internal shield, external mechanical shield and spacecraft maneuvering. After the trade-off studies, internal sun shield was selected as a realistic and optimal solution to minimize the effect of the solar radiation. In this paper, pros and cons are explained for the three possible choices and a design of the internal shield is discussed.

I. Introduction

A Multi-Spectral Camera (MSC) has been developed as the payload of KOMPSAT-2 (KOrea Multi-Purpose SATellite-2) since January 2000, according to the Mid and Long-term National Space Development Plan (MOST 2000) as depicted in Table 1. The MSC was selected as the only payload for the satellite, and it contains both panchromatic (PAN) and multi-spectral (MS) channels for imaging the earth. In the MS channels, there are four broad bands in the frequency ranges from blue to near-IR regions (Yong *et al.* 2001).

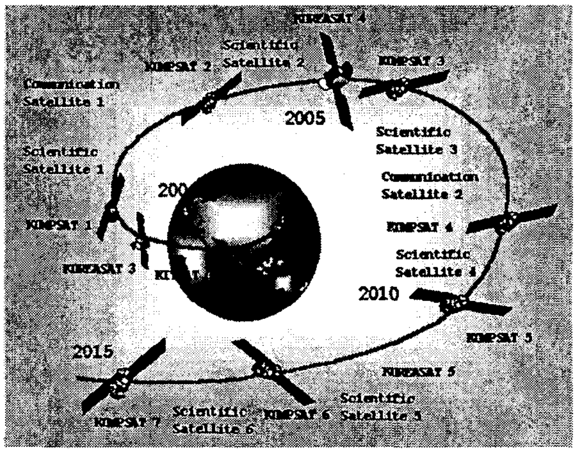

Figure 1. Mid and Long-term National Space Development Plan.

Table 1. Mid and Long-term National Space Development Plan.

Classification		Implementation Plan																			
		1st Stage						2nd Stage					3rd Stage					4th Stage			
		96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
5 GEOSs[1]	KOREASAT				3rd						4th										5th
	CBMS[2]													1st						2nd	
8 KOMPSATs	Electro-Optical Satellite				1st					2nd				3rd				6th			
	SAR Satellite															5th				7th	
	Hyperspectral Satellite														4th						8th
7 SSs[3]	KITSAT				3rd																
	Science Satellite							1st			2nd			3rd			4th		5th		6th

1 Geostationary Orbit Satellites; 2 Communication, Broadcasting & Meteorological Satellites;
3 Science Satellite.

There are many items to be considered in the system design and development. Sunshield was one of them which should have been considered at all the aspects of the system (Kim 2001). In this paper, considerations of the sunshield in the aspect of its allocation and type on the MSC are described, and trade-offs of the possible solutions are discussed.

II. Sunshield Design

KOMPSAT-2 will be in a sun-synchronous orbit with inclination of 98 degrees from the equator clockwise and always look down the Earth on the orbit (KARI 2000). However, it allows the sun to radiate directly into the telescope structure at some sections of the orbit, as shown in Figure 2 (Kim *et al.* 2000). As the nominal height of KOMPSAT-2 is 685km and one orbit lasts about 98.6minutes, the duration of the direct sun is about 14 minutes per orbit and the maximum solar incidence angle would be 25.4 degrees from the normal to the optical axis when nadir pointing.

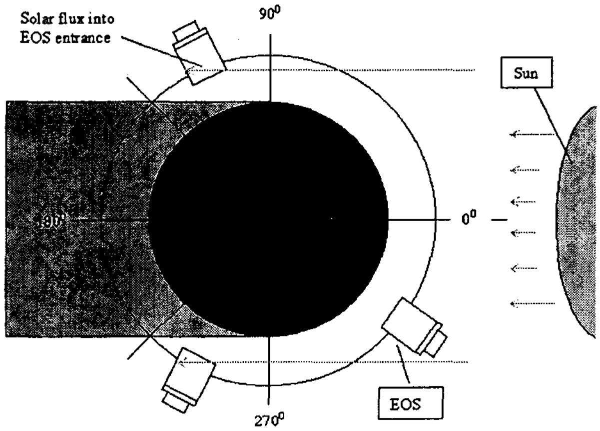

Figure 2. Incidence of solar radiation on KOMPSAT-2.

If the solar radiation is not protected, it will heat up telescope structure causing several problems. Thermal cycling with higher temperature than allowed may cause structural degradation due to delamination in telescope structures which are mainly made of composite materials. Moreover, temporal and spatial temperature variation results in elastic deformation according to thermal expansion coefficient of the structure. It may be subject to optical performance degradation because the telescope is very sensitive to relative displacement between optical elements.

Three ways of protecting the solar radiation has been studied. They are attaching an external shield, maneuvering the spacecraft, and attaching an internal shield (EL-OP 2001).

Installing an external shield is a usual and preferable solution considering effectiveness of solar incident protection when direct solar radiation into the telescope has to be prohibited. It can protect completely solar incident into telescope. As the sunshield can be attached to the platform of the spacecraft, the extra mass of the shield would not be loaded to the part of the secondary mirror which is most sensitive to optical performance.

However, the external shield raised problems according to the KOMPSAT-2 design. There are one s-band and two x-band antennae beside the telescope aperture. The s-band antenna will be used for uplink of commands and downlink of telemetry data, while the x-band antennae will downlink image data to Ground stations. If the external shield is attached to the mouth of the telescope like Figure 3, it can block the radio transmission from the x-band antennae to Ground stations because of the long extended tube. Though one of the two antennae is used at a time for a data transmission, both should be capable at any situation regardless of any situation such as the attitude of the satellite, relative position of a Ground station from the satellite, and mode of operation. Even in case one of the antennae is malfunctioned or one transmission system fails, the other one should be able to contact the Ground station. Even though a material is found successfully comprising the radio transparent requirements, it may, and normally does, generate complicate processes in production and tests.

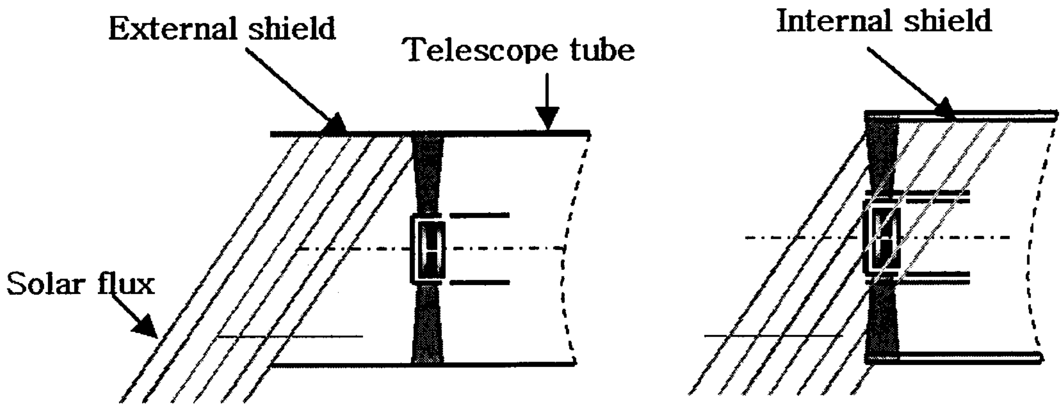

Figure 3. Schematic diagram of external and internal sunshields.

Another negative factor is that the length of the satellite including the external sunshield becomes longer than that of the existing thermal vacuum chamber in KARI (Korea Aerospace Research Institute). Therefore, the sunshield should be detached during the environmental test of the whole satellite and re-assembled after the environmental test, which adds more complications to test processes. In addition, as the sunshield would be attached to the platform of the spacecraft, there will be increase of the interface works between venders of the bus and the MSC.

The solar radiation into the telescope tube can also be avoided by maneuvering the spacecraft appropriately. As depicted in Figure 2, the direct sun entered into the telescope during the changes between day and night, i.e. just before entering into the Earth's shade and just after coming out of the shade. In order to avoid the direct sun, pitch maneuvering of the satellite toward the shade would be needed. During ingress to the shade, pitch maneuvering in moving direction of the satellite is needed, and backward pitch maneuvering is needed during egress. By the maneuvering, no direct radiation would come into the telescope. This method has an advantage that it does not require any additional weight because it is not mechanical shield. However, modifications of existing control algorithm and software are required, which may not be easy tasks for the Attitude and Orbit Control Subsystem of KOMPSAT-2. The control algorithm and software of KOMPSAT-2 came from those of KOMPSAT-1 as a heritage. Implementing the maneuver algorithm into the ready-existing software can introduce bugs and unexpected malfunctions. Correcting software codes made by other programmers is sometimes more difficult than making new codes. Though the concept of maneuvering the spacecraft for avoiding direct sunlight is simple and clear, in practice corrections can lead to unexpectedly wrong maneuvering of the spacecraft, which can lead to damage or even loss of the valuable spacecraft.

The third choice is an internal sunshield with better conductive material of the tube. The internal sunshield is placed inside of the mouth of the telescope (Figure 4), which can not completely keep solar radiance from reaching some part of the telescope. Thus, telescope should be designed accordingly to minimize the temperature rise through heat re-distribution (Lee & Kaufman 2001). Addition of weight on the secondary mirror side of tube also increases risks under the dynamic launch environment. Even though it has several disadvantages comparing to the other two fore-mentioned cases, the internal shield has an important advantage that it does not hinder the x-band radio transmission.

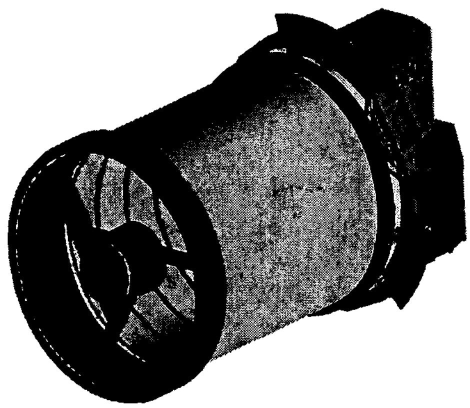

Figure 4. Internal sunshield.

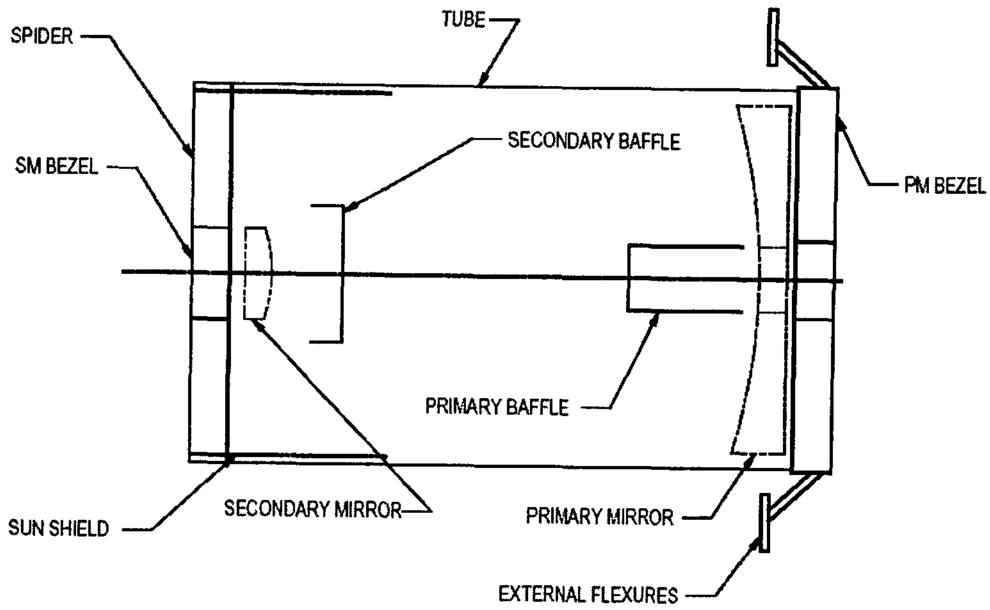

Figure 5. Schematic diagram of the telescope with internal sunshield (ELOP 2000).

In addition, as the overall height of the spacecraft is not prolonged, the whole spacecraft can be tested in the thermal vacuum chamber. Therefore, nothing is changed in the spacecraft side, that is, no extra interface is required for installing an external shield and no spacecraft maneuvering is necessary to avoid direct sunlight. Internal sunshield seems safe and best optimized choice among the three ways considering many aspects of the spacecraft.

IV. Conclusion and Discussions

KOMPSAT-2 will go round on a sun-synchronous orbit which allows direct sunlight to enter into the mouth of the telescope. If the sunlight is not blocked out, excess heat will degrade the performance of the telescope. Three possible solutions have been suggested and their effects have been assessed in the view of satellite system and MSC. They are summarized in Table 2.

Among the three solutions, it was found that internal shield is regarded as an optimal choice. Further study should be followed on the internal sunshield to identify and verify thermal effects as well as structural difficulties. Detailed design of an internal sunshield would be produced after the in depth study.

Table 2. Effects of the solutions for avoiding direct sunlight.

Solution	Method	Effects
External shield	Attached to the platform of the spacecraft	Preferred solution for shielding effectiveness No direct radiation into the telescope Require radio transparent material Require environmental testing in the thermal vacuum chamber without the shield
Spacecraft maneuver	No mechanical shield No additional weight	No direct radiation into telescope Requires modification of spacecraft control
Internal shield	Attached to inner part of the telescope	No spacecraft change No additional height Sophisticated structural and thermal design

Acknowledgments

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References

[1] Birger, L., *High Stability Telescope Structure (HSTS-60) Development Specification*, EL-OP Industries LTD., **MSC-SS-2**, r.1, p.8, 2000.

[2] EL-OP, *Preliminary Design Review of the Multi-Spectral Camera Program*, 2000.

[3] KARI (Korea Aerospace Research Institute), *KOMPSAT-2 System Design Review*, **K2-D0-300-004**, 2000.

[4] Kim, E., Yong, K-L, & Lee, S-R, Sun Incidence Angle Analysis of KOMPSAT-2 Payload During Normal Mission Operations, *J. Astron. Space Sci.,* **17**, pp.309-316, 2000.

[5] Kim, Y.-S., Oh, K-H, & Paik, H-Y, System Design of the MSC for KOMPSAT-2, *Proceedings of the 2001 KSRS Spring Meeting*, KSRS, **4**, pp.149-153, 2001.

[6] Lee, E-S, & Kaufman, A., *Thermo-elastic analysis of optical module,* EL-OP Industries LTD., **MSC-SS-4**, 2001.

[7] MOST (Ministry Of Science & Technology), *Mid and Long-term National Space Development Plan*, p.7, 2000.

[8] Yong, S-S, Kong, J-P, Heo, H-P, Kim, Y.S., & Paik, H-Y, The Analysis of MSC(Multi-Spectral Camera) Operational Parameter, *Proceedings of International Symposium on Remote Sensing*, pp.198-203, 2001.