Structural Design Development of GOCI

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Abstract: COMS(Communication, Ocean, and Meteorological Satellite) is the geostationary satellite for the mission of satellite communication, ocean monitoring, and meteorological service. It is scheduled to be launched at the end of 2008. Ocean payload of COMS named as GOCI(Geostationary Ocean Color Imager) observes ocean color and derives the chlorophyll concentration, the concentration of dissolved organic material and so on. In operational oceanography, satellite derived data products are used to provide forecasting and now casting of the ocean and coastal water state. In this work, conceptual design of structural part of GOCI is carried out and two baseline concepts are proposed. The one is dioptric module that uses lens system and the other is TMA(Three Mirror Anastigmat) module that uses mirror system. Trade-off studies between two concepts are investigated by considering optical and mechanical performances. Finally, on-going tasks and future development plan are briefly discussed.

Keywords: Ocean Color Sensor, COMS, GOCI, Structure, Optics.

1. Introduction

The Communication, Ocean, and Meteorological Satellite(COMS), to be launched in 2008, is the geostationary satellite which has three missions of satellite communication, ocean monitoring and meteorological service. The basic mission of this geostationary satellite is to improve the accuracy of domestic weather forecast, so as to allow in particular a rapid and efficient reaction in case of natural disasters, to preserve the sea environment and manage sea resources and to validate new communication technologies in order to face the foreseen increase of the demand for communication services. The overall configuration of COMS is shown in Figure 1.
The system is organized around the space segment, which consists in a satellite placed on a geostationary orbit, and the various components of the ground segment. These elements are organized into a classical and sound architecture, which is able to meet the objectives of this mission.
The meteorological mission has the following goals: continuous monitoring of imagery and extracting of meteorological products with high resolution and multi-spectral imager; early detection of special weather such as storm, flood, yellow sand, etc; extraction of data on long-term change of sea surface temperature and cloud.
The objectives of the satellite communication mission are as follows: in-orbit verification of the performances of advanced communication technologies; experiment of wide-band multi-media communication service.
The ocean monitoring mission will be mentioned in the next chapter in detail.
The three missions of COMS are schematically described in Figure 2.

2. Overview of GOCI

GOCI(Geostationary Ocean Color Imager) is the core instrument of the COMS system for ocean monitoring. It acquires data in 8 visible wavebands with a spatial resolution of about 500m over the Korean sees. The ocean data products that can be derived the measurements are mainly the chlorophyll concentration, the optical diffuse attenuation coefficient, the concentration of dissolved organic material or yellow substance, and the concentration of suspended particulates in the near-surface zone of the sea. In operational oceanography, satellite derived data products are used in conjunction with numerical models and in situ measurements to provide forecasting and now casting of the ocean state. Such information is of genuine interest for many categories of users.
The operating principle consists in imaging a portion of the specified image frame, termed slot. A Pointing Mirror provides a bi-dimensional circular scanning on the Earth. By successively pointing 16 pre-defined directions, the array is moved in the field of view to cover the complete image area as illustrated in Figure 3. Each slot is imaged over the 8 spectral channels. The image is acquired for two gain levels corresponding to sea and cloud radiance levels, respectively. The image data are sent in real-time to the satellite.
The Calibration/Shutter mechanism holds the calibration devices. When the GOCI is not operating, the shutter closes the instrument cavity, providing a stable thermal environment. The Shutter is moved either to the open position for nominal Earth imaging, or to one of the calibration positions when the sun is available in the calibration field of view.
The filter wheel, with the 8 optical filters, moves to get each spectral channel image for a slot. It contains mechanism part.

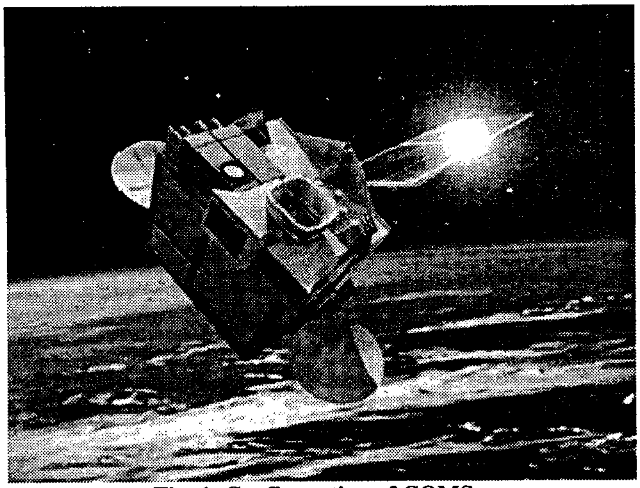

Fig. 1. Configuration of COMS

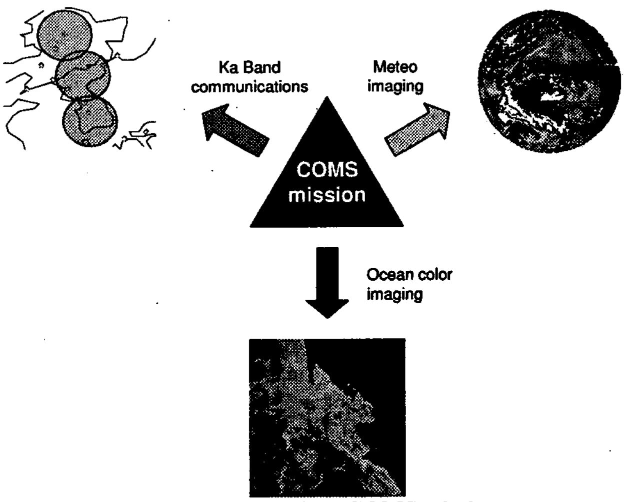

Fig. 2. The three-fold COMS mission

The Detection Module, comprising the detector array and Front End Electronics. The array is a custom CMOS Image sensor featuring rectangular pixel size to compensate for the Earth oblique projection over Korea, and electro-optical characteristics matched to the specified instrument operations.
The Instrument Electronics Unit, including image data processing, mechanism control, interface telemetry and housekeeping functions.
The Primary Structure is mounted on the Interface frame through bipods ensuring a high stability of the structure.
The Secondary structure is also fixed to the Interface frame and surrounds the Primary structure. It holds the Shutter wheel and is covered with MLI to guarantee the thermal stability of the Main Unit cavity
The Main Unit mounting is adjusted to provide the desired pointing direction, optimised with respect to the spacecraft orbital location.
The instrument electronics are gathered in a single unit (IEU), located inside the platform, close to the instrument main unit. The Front End Electronics provides a first amplification and impedance adaptation to allow a safe transport of the signal to the processing electronics within the IEU.

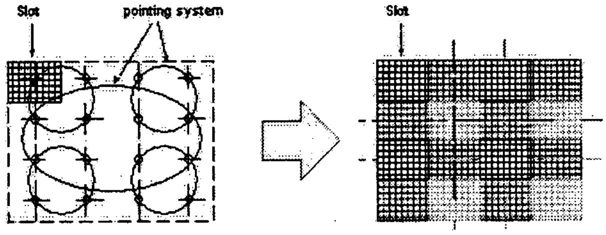

Fig. 3. Pointing princile

3. Conceptual Design of Structural Part

Two baseline designs of optical system are proposed. The one uses dioptric module that includes lens system and the other uses TMA(Three Mirror Anastigmat) module that includes mirror system.
Two optical concepts are described in Figure 4 and 5. Dioptric module consists of a series of lens and two folding mirrors. Lights reflected from the pointing mirror pass a series of lens, then folded by the two folding mirrors and then make an image at focal plane. TMA module consists of three mirror and two folding mirror. The entered lights are reflected by the pointing mirror, three mirrors and folding mirror sequentially, then finally make an image at focal plane. In this module, concave hyperbolic, convex parabolic and concave spherical mirrors are used sequentially.
The advantage of dioptric module is that it is straight through. In this module, optical quality is mainly determined by the lens system. Therefore, alignment scheme is much simpler than that of TMA module. Moreover, we can add a lot of lens element serially to obtain the required optical performance. The manufacturability of each lens is less complex than that of mirror.
However, dioptric module has intrinsic defects of chromatic aberrations due to varying refraction indexes with wavelength. Optical quality is changeable between bands. In the other hand, TMA module doesn't suffer from chromatic aberrations. Transmission properties of lens vary from BOL(Begin Of Life) to EOL(End Of Life) due to radiation effect. It degrades telescope performance nearly 50% in the hardest case.
TMA module has the advantages in the viewpoints of chromatic aberration and transmission degradation. However, it can use limited number of elements (only three mirrors), therefore aspheric surfaces are mandatory to reduce spherical aberration. Manufacturability of aspheric surface is difficult and manufacturing cost is high. Moreover, mounting and alignment scheme is more complex.
In the TMA module, mirrors can be made of the same material as supporting structure. That is, TMA module

can be manufactured of a single material. It leads to athermal property. In other words, for a uniform temperature increase or decrease, the entire system expands or contracts by an amount dependent on the thermal coefficient. Since this is a uniform scaling of all system parameters, the image will still be in focus. For multiple material systems, such as dioptric module, precise thermal control to reduce thermal gradient is necessary.

Table 1 shows the comparison of the characteristics of each module. The merits and demerits of each module are mutually complementary.

Two designs lead to structurally different concepts. Figure 6 and 7 show schematic draft proposals of each module. In both design, folding mirrors are used for compact structure. Each design provides isostatic mount with satellite. Optical bench and housing frame that surrounds optical components are proposed for both designs. In these designs, perturbations induced by mechanism part should be take into account to calculate detailed optical performance.

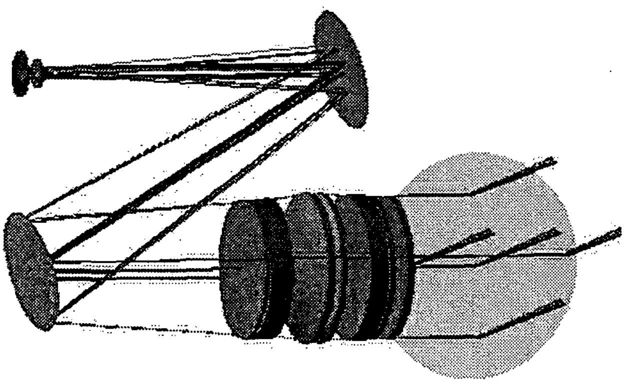

Fig. 4. Optical layout of the dioptric module

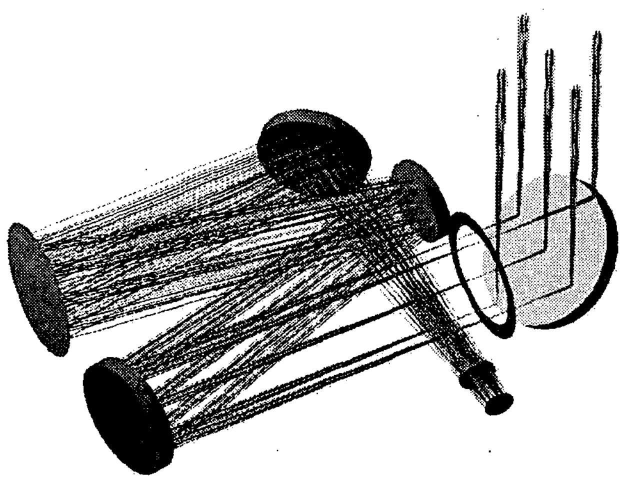

Fig. 5. Optical layout of the TMA module

Table 1. Comparisons of the dioptric and TMA module

	Dioptric	TMA
Alignment	Quite simple	More complex
Manufacturability	More simple	More complex
Chromatic aberration	Unavoidable	No chromatism
Transmission property	Degradation due to radiation	Very low radiation sensitivity
Thermal control	More complex	More simple

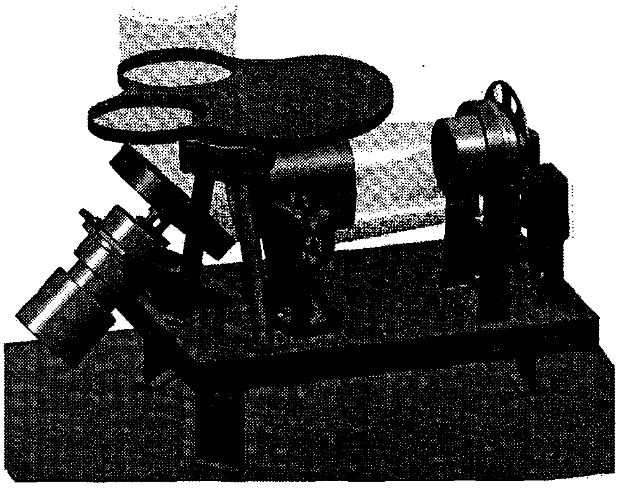

Fig. 6. Draft structural design of dioptric system

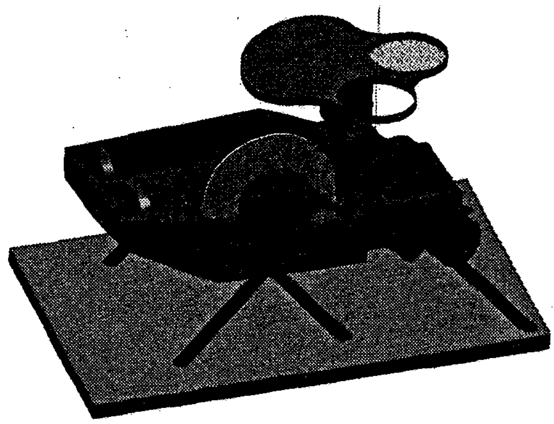

Fig. 7. Draft structural design of TMA system

4. Concluding Remarks

In the structural viewpoint, GOCI is composed of primary and secondary structure. Primary structure contains core optical components, such as lens and mirrors,

and provides critical load path. Draft conceptual designs of primary structure are carried out in this work. The secondary structure that covers the primary structure and holds the shutter is under development.
Structural parts can sustain loads generated by launcher and satellite and contain sufficient stiffness to satisfy required stability. These requirements are provided in terms of environmental specifications. More precise trade-off studies with respect to environmental spec and the developments of baseline design are in progress.

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