INTRODUCTION OF COMS SYSTEM

Myung-Jin Baek and Cho-Young Han

Korea Aerospace Research Institute, mjbaek@kari.re.kr

ABSTRACT: In this paper, Korea's first geostationary Communication, Ocean and Meteorological Satellte(COMS) program is introduced. COMS program is one of the Korea National Space Programs to develop and operate a pure civilian satellite of practical-use for the compound missions of meteorological observation and ocean monitoring, and space test of experimentally developed communication payload on the geostationary orbit. The target launch of COMS is scheduled at the end of 2008. COMS program is international cooperation program between KARI and ASTRIUM SAS and funded by Korean Government. COMS satellite is a hybrid satellite in the geostationary orbit, which accommodates multiple payloads of MI(Meteorological Imager), GOCI(Geostationary Ocean Color Imager), and the Ka band Satellite Communication Payload into a single spacecraft platform. The MI mission is to continuously extract meteorological products with high resolution and multi-spectral imager, to detect special weather such as storm, flood, yellow sand, and to extract data on long-term change of sea surface temperature and cloud. The GOCI mission aims at monitoring of marine environments around Korean peninsula, production of fishery information (Chlorophyll, etc.), and monitoring of long-term/short-term change of marine ecosystem. The goals of the Ka band satellite communication mission are to in-orbit verify the performances of advanced communication technologies and to experiment wide-band multi-media communication service mandatory.

KEY WORDS: COMS, Payload, spacecraft platform, Meteorology, Ocean, Communication

1. GENERAL MISSION REQUIREMENT

The operational life of the COMS shall be no less than 7 years from the end of the IOT(In-Orbit-Test) period. The COMS shall be able to be stored for over 2 years in the container specially manufactured for the long-term storage. The design life of the COMS shall be no less than 10 years. The COMS shall be 3-axis stabilization type spacecraft to be capable of monitoring any regions within full disc area whenever the observation is required. In the event of attitude disorientation, the spacecraft shall be capable of reacquiring the normal operational attitude within minimal recovery time.

The attitude control system of the spacecraft shall have the stability performance enough to maintain the quality of meteorological and ocean monitoring image during the observation period. The spacecraft shall be designed to be compatible with at least the following launch vehicles and be compliant with all the constraints (configuration, weight, etc.) imposed by the launch vehicle agencies.

The COMS shall be designed to survive all launch environments imposed by the launch vehicle, such as Ariane launch vehicle families, Delta launch vehicle families, Atlas launch vehicle families, Proton launch vehicle, H-IIA launch vehicle and Sea-Launch vehicle.

The mission orbit for COMS will be selected in the range from 116° East to 138° East. The mission orbit will be finalized after the approval from ITU. The stationkeeping accuracy of the COMS shall be ±0.05° in longitude and latitude of the nominal orbital location throughout the operational lifetime. The COMS will use the L-band, S-band frequencies for the meteorological and ocean data transmission. The S-band frequency, also, will be used for the transfer orbit operation to move the spacecraft into the mission geostationary orbit and for the normal operation in the mission orbit:

a) Downlink Frequencies of Raw Image Data and Processed Data: To be determined within 1670 ~ 1710 MHz

b) Downlink Frequencies of Telemetry Data: To be determined within 2200 ~ 2290 MHz

c) Uplink Frequencies of Command and Processed Data: To be determined within 2025 ~ 2110 MHz.

The COMS Contract to develop the COMS satellite and to provide support for system activities has been awarded by KARI to ASTRIUM France. The COMS joint project group is composed of KARI and ASTRIUM engineers.

1.1 Meteorological Imager (MI) Requirements

The operational life of the MI shall be no less than 7 years from the end of IOT. The MI shall be designed to be compatible with the COMS satellite storage requirement. The duty cycle of the MI normal operation mode except for standby mode shall be no less than 95%. The table 1 shows MI the spectral channels.

Table 1. MI Spectral Channel

No.	Channel	Band Center (μm)	Band FWHM* (μm)
1	VIS	0.675	0.55-0.80
2	SWIR	3.75	3.50-4.00
3	WV	6.75	6.50-7.00
4	WIN1	10.8	10.3-11.3
5	WIN2	12.0	11.5-12.5

Geometric Instantaneous Field of View (GIFOV) shall be 28μrads or smaller for the visible band. GIFOV shall be 112μrads or smaller for all IR bands.

1.2 Geostationary Ocean Color Imager (GOCI) Requirements

The spectral channels and their primary uses of GOCI are summarized in Table 2 and the major requirements of GOCI are specified in Table 3.

Table 2. Spectral characteristics and applications of GOCI wavebands

No	Band Center	Spectrum	Primary use
1	412 nm	visible	Yellow substance and turbidity
2	443 nm	visible	Chlorophyll absorption maximum
3	490 nm	visible	Chlorophyll and other pigments
4	555 nm	visible	Turbidity, suspended sediment
5	660 nm	visible	Baseline of luorescence signal, Chlorophyll, suspended sediment
6	680 nm	visible	Atmospheric correction and fluorescence signal
7	745 nm	near IR	Atmospheric correction and base line of fluorescence signal.
8	865 nm	near IR	Aerosol optical thickness, vegetation, water vapor reference over the ocean

Table 3. Major Requirements of GOCI

No of Channel	8 channels (6-Visible and 2-NIR)
Spatial resolution (IFOV)	500m × 500m (-20/+40%)± 20
Coverage (FOV)	≥ 2500Km × 2500Km
Spectral coverage	400 – 900nm (for 8 bands)
Digitization	≥ 11 bits
Data integration, readout, and download rate	< 30 minutes

The GOCI shall be operated on a fixed target area covering the Korean Seas and surrounding oceans. The duty cycle of GOCI requires 8 images during daytime and 2 images during night-time.

1.3 Ka band Communication Payload Requirements

The Ka-band communication service will be capable of covering Korea via individual satellite beams to provide the intended communication services. The service lifetime will be guaranteed as the period of at least seven(7) years of maneuvering the satellite life after completion of the IOT. The design lifetime against space radiation environment for the all equipment and subsystem will be guaranteed as the period of at least twelve(12) years. The Ka-Band Payload will provide multibeam functions for Korea. The Ka-Band Payload will provide the beam switching function for high speed multimedia services including the internet via satellite in the public communication network for all coverage. The Ka-Band Payload will provide a bent-pipe type function for communication services of natural disaster in government communication network of South Korea. The Ka-band payload system consists of one transponder subsystem and one antenna subsystem.

1.4 COMS Satellite Platform Requirements

COMS satellite platform consists of several subsystems to support mission payloads. The Meteorological & Ocean Data Communication Subsystem (MODCS) shall comprise all signal paths used for transmitting the meteorological and ocean data to MODAC and relaying the processed meteorological data to end users: raw Imager and Ocean Sensor Data (SD) including the MI/GOCI telemetry data and the attitude data for Image Navigation and Registration (INR); Processed Data Relay (PDR). The TC&R subsystem shall provide the capability to communicate between ground station and spacecraft, to control and monitor the spacecraft so that it meets all performance requirements and is suitable for controlling the spacecraft at all expected attitude and attitude rate.

The Electrical Power Subsystem (EPS) shall generate, store, control and distribute electrical power as required by the various loads of satellite over all mission phases and the expected modes of operation. The Attitude and Orbit Control Subsystem (AOCS) shall determine and control the attitude of spacecraft during the spacecraft design life including the orbit control. Also, the performance of the Propulsion Subsystem(PS) shall be compatible with the attitude and orbit control requirements for the COMS satellite operation. The Thermal Control Subsystem(TCS) shall be designed to maintain all equipments and structures within the design temperature ranges under all the expected worst case conditions. The Structure and Mechanism Subsystem (SMS) shall provide the support, alignment and protection for the payloads and all spacecraft subsystem components. Finally, the FSW subsystem shall provide the capability to manage and control the overall spacecraft and payloads.

Table 4. COMS-1 Satellite Configuration and Heritage

	COMS Configuration	Heritage/Comment
Payload		
MI	Visible and infra-red Radiometer(ITT)	Recurring Imager
GOCI	New development for COMS(ASTRIUM)	Benefit from previous development of ASTRIUM
Ka band Comm Payload	Advanced Ka band communication techniques(ETRI)	Customer furnished item
Platform		
Structure and Thermal Control	Specific to COMS	Reuse of classical and well mastered techniques and architecture
Propulsion	Derived from Eurostar 3000	Eurostar 3000 units, accommodated in 2-tank configuration
Platform Avionics	Recurring Eurostar 3000	Full recurrence
AOCS	Eurostar 3000, customized for COMS mission	Addition of gyros, easy adaptation of software modularity
Electrical Power	Recurring Eurostar 3000	Battery and other units from Eurostar 3000 modularity

2. COMS SATELLITE DESCRIPTION

2.1 Overall Descriptions

The single-wing 2-panel solar array provides the electrical power to the satellite and allows keeping a free space for the MI radiant cooler field of view towards the North. This asymmetrical configuration results in unusually large external disturbing torques due to solar pressure. However the length of the wing is kept small.
All the required fields of view are easily provided to the instruments, AOCS sensors and antennas, whatever the orbital position is in the specified range 116 E / 138 E. Adequate canting of the GOCI and of the Ka band Communication Payload antenna and sources will be accurately defined after freezing of the reference orbital position. The specified possible drift of the satellite on the orbit will be compensated through adequate pointing bias around pitch axis, which will remain well within the maximum biasing capability. The solar array is free from any shadowing from the satellite main body on station.

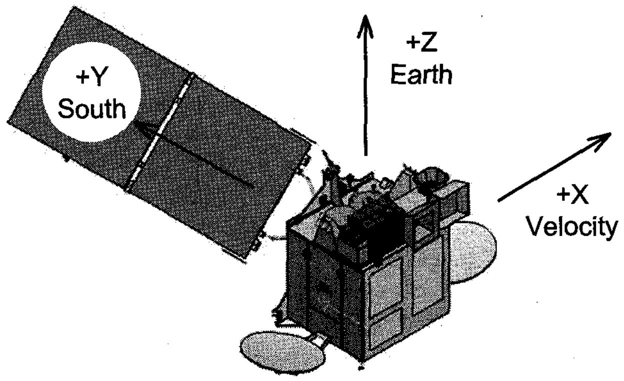

Figure 1. COMS On-Orbit Configuration

The platform electrical architecture provides an optimum performance and heritage of the Eurostar 3000 model. Centralized spacecraft computer and fully regulated power bus architectures have been employed based on ASTRIUM Eurostar in term of design robustness, Failure Detection Isolation and Recovery (FDIR) strategy, and operation ease. The Telemetry, Command and Ranging and Data Handling function has been designed to provide full compliance with a wide range of spacecraft control approaches (4 kbps telemetry, send-verify-execute sequence, shadow mode, large telemetry channels growth margin, etc). The data transmission between the central spacecraft computer and the other key units is performed via a serial 1553B digital data bus. This provides a very flexible and standard data transmission system, which can be easily adapted and tested to specific needs, with no hardware modification. The interface of the spacecraft units to the data bus is performed either via the modular payload interface unit and the actuator drive electronics, or directly to the bus for some attitude control equipment's or power subsystem regulator. Any unit connected on that bus can be switched off if it disturbs the bus itself.

A reliable and flexible Electrical Power Subsystem (EPS) provides the spacecraft units with a fully protected, double insulated 50 V power bus, fully regulated in sunlight and eclipse. Maximum spacecraft robustness is provided: the power consumptions are strictly monitored by the on-board software & hardware protections. The COMS solar array is a standard Eurostar gallium arsenide 2-panel. The batteries are based on Li-Ion technology. The battery management in orbit is fully autonomous, automatic, safe and can be either modified or reconfigured by ground after a failure.

The COMS Attitude and Orbit Control System (AOCS) reuses to a very large extent the Eurostar E3000 AOCS, as far a hardware and functional architecture are concerned. The Transfer and Acquisition phase is identical to Eurostar E3000 and is based on three axes stabilization. It allows simple operations of the spacecraft, without loss of safety. Station Keeping phases permit to maintain the spacecraft orbit inclination and eccentricity and are automatically managed with a high level of on board security. East/West maneuvers and pitch momentum off-loading are automatically managed by pulsed sequences in normal mode. Table 4 shows the summary table of the COMS satellite platform configuration and heritage which is a mostly dedicated adaptation of the Eurostar E3000 platform, that is the standard ASTRIUM platform developed for telecommunication satellite and adapted for COMS.

2.2 Launch Vehicle Compatibility

The compact size of COMS makes it compatible with very large margins to all ranges of currently used fairings as shown Figure 2.

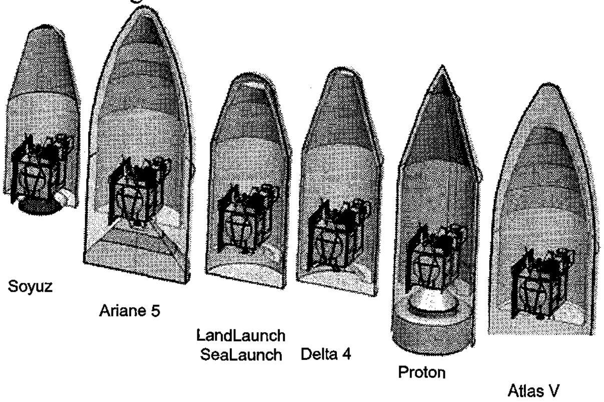

Figure 2. COMS Launch Vehicle Compatibility

2.3 Brief Description of MI and GOCI

The MI is a visible and infrared imaging radiometer that measures energy from Earth's surface and atmosphere. It can be considered as the quantitative observer in a system to supply environmental data and data products. The MI for the COMS satellite is an off-the-shelf model of ITT's Commercial Advanced Geo-Imager (CAGI). The MI collects radiometric data in 5 spectral channels ranging from the visible to the thermal infrared, and useful for cloud and pollution detection, storm identification, fire location, cloud height measurement, water vapor wind vectors, ozone measurement, and surface and cloud top temperatures. It produces 10 bit digital numbers spanning the signal range of the channel linearly proportional to the radiance at the input aperture.

The GOCI is the second core instrument of the COMS system. It acquires data in 8 visible wavebands with a spatial resolution no larger than 0.5 km over the Korean seas. 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 instrument will be designed and manufactured in ASTRIUM in house. The time required to acquire a full image, comprising the 16 slots in all 8 wavebands, is lower than 30 min, including image integration and readout time and filter wheel motion. The acquired data are directly transferred to the data communication system for immediate downlink in L Band to the ground segment.

3. CONCLUSION

In this paper, Korea's first geostationary Communication, Ocean and Meteorological Satellte (COMS) program is introduced. COMS satellite is a hybrid satellite in the geostationary orbit, which accommodates multiple payloads of MI(Meteorological Imager), GOCI(Geostationary Ocean Color Imager), and the Ka band Satellite Communication Payload into a single spacecraft platform. The MI mission is to continuously extract meteorological products with high resolution and multi-spectral imager, to detect special weather such as storm, flood, yellow sand, and to extract data on long-term change of sea surface temperature and cloud. The GOCI mission aims at monitoring of marine environments around Korean peninsula, production of fishery information (Chlorophyll, etc.), and monitoring of long-term/short-term change of marine ecosystem. The goals of the Ka band satellite communication mission are to in-orbit verify the performances of advanced communication technologies and to experiment wide-band multi-media communication service.

REFERENCE

1. KARI, Request for Proposal for the Communication, Ocean and Meteorological Satellite(COMS) of Korea, 2004
2. Feasibility Study on the Development of Communication Broadcasting and Meteorological Satellite, 2002.
3. COMS Kickoff Meeting, EADS Astrium, 2005
4. COMS System Requirement Data Packages, EADS Astrium, 2005.