THE KOMPSAT- I PAYLOADS OVERVIEW

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ABSTRACT

Korea Aerospace Research Institute (KARI) is developing a Korea Multi-Purpose Satellite I (KOMPSAT-I) which accommodates Electro-Optical Camera (EOC), Ocean Scanning Multi-spectral Imager (OSMI), and Space Physics Sensor (SPS). The satellite has the weight of about 500kg and will be operated on the 10:50 AM sun-synchronized orbit with the altitude of 685 km. The satellite will be launched in 1999 and its lifetime is expected to be over 3 years.

The main mission of EOC is the cartography to provide the images from a remote earth view for the production of 1/25000-scale maps of KOREA. EOC collects 510 ~ 730 nm panchromatic imagery with the ground sample distance(GSD) of 6.6 m and the swath width of 17 km by push broom scanning. EOC also can scan ±45 degree across the ground track using body pointing method.

The primary mission of OSMI is worldwide ocean color monitoring for the study of biological oceanography. It will generate 6 band ocean color images with 800 km swath width and 1km GSD by whiskbroom scanning. OSMI is designed to provide on-orbit spectral band selectability in the spectral range from 400 nm to 900 nm through ground command. This flexibility in band selection can be used for various applications and will provide research opportunities to support the next generation sensor design.

SPS consists of High Energy Particle Detector (HEPD) and Ionosphere Measurement Sensor (IMS). HEPD has missions to characterize the low altitude high-energy particle environment and to study the effects of radiation environment on microelectronics. IMS measures densities and temperature of electrons in the ionosphere and monitors the ionospheric irregularities at the KOMPSAT orbit.

INTRODUCTION

There are currently three kinds of satellite development in Korea. One is the Koreasat series for satellite communications and direct broadcast services [1]. The second is the KITSAT series for micro-satellite scientific experiment [2]. The last is Korea Multi-Purpose Satellite (KOMPSAT) series for practical application on the Earth observation [3-4].

Korea Aerospace Research Institute (KARI) is developing KOMPSAT-I per Korea National Space Program under Korea Government support. KOMPSAT-I is a small satellite with the mass of 500 kg to be operated at the sunsynchronous orbit which has 98 minutes orbit period, 28 days repeating ground track, 10:50 AM ascending orbit crossing time, and 98.13 degrees inclination at the altitude of 685km. KOMPSAT-I is scheduled to be launched at the third quarter in 1999 and earth observation data acquisition from KOMPSAT-I can be available from the end of 1999 during its lifetime of at least 3 years.

KOMPSAT-I accommodates three instruments i.e. Electro-Optical Camera (EOC), Ocean Scanning Multispectral Imager (OSMI), and Space Physics Sensor (SPS) for the mission of cartography, worldwide ocean observation, and space environment monitoring respectively.

The shape and the configuration of the instruments (EOC, OSMI, SPS) are shown in Figure 1. The operational concept of KOMPSAT-I is illustrated in Figure 2 for the mission of cartography, ocean color monitoring, and space environment monitoring.

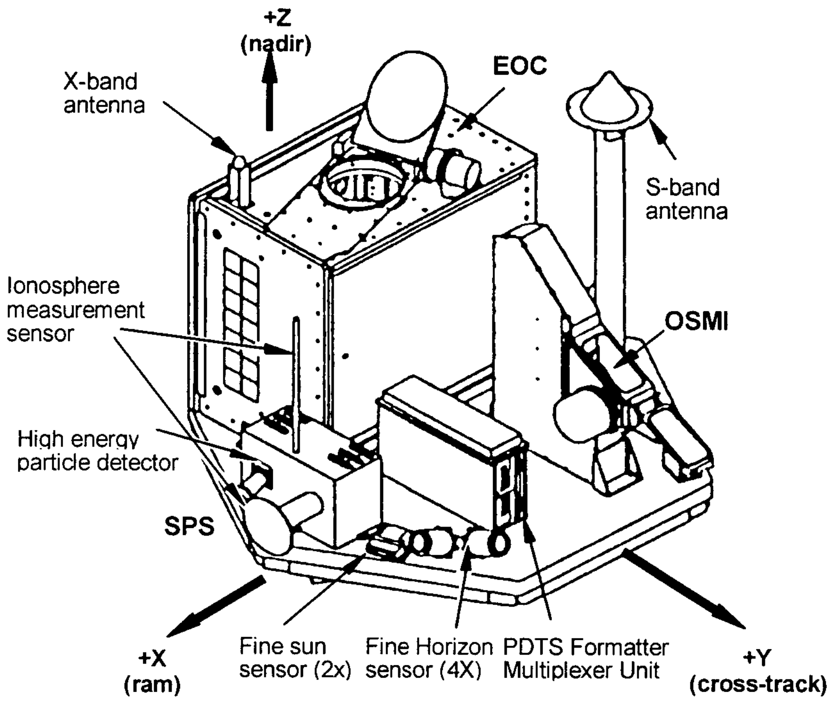


Fig. 1. KOMPSAT-I payload shape and configuration.

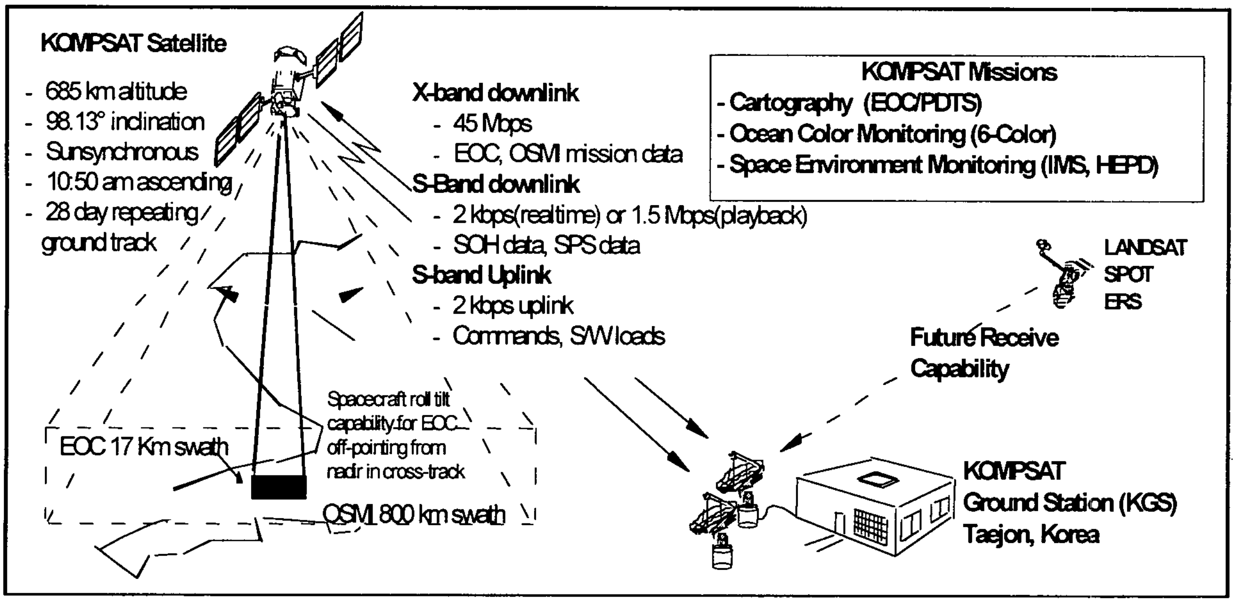


Fig. 2. The operational concept of KOMPSAT-I.

ELECTRO-OPTICAL CAMERA (EOC)

EOC has cartography mission to provide images for the production of scale maps, including digital elevation models, of the Korea peninsula from a remote earth view in the KOMPSAT orbit.

EOC collects panchromatic imagery with the ground sample distance(GSD) of 6.6m and the swath width of 17km at nadir through the visible panchromatic band of 510 ~ 730 nm. EOC scans the ground track of 800km per orbit by push-broom and body pointing method. EOC was developed to meet the following system specifications.

MTF : ≥ 10% at Nyquist frequency

SNR : ≥ 50 over entire FOV

Digitization : 8bits

EOC has the total weight of 35 kg, the maximum power consumption of 52 Watt and the image data transmission rate of ≤ 25 Mbps. EOC has the function of programmable gain and offset to take the various conditions of ground reflected radiation into account.

For EOC mission, S-band communication link is used to transmit command from the ground station and to receive the State Of Health (SOH) data of EOC. The On-Board Computer (OBC) controls S-band data with the MIL-STD-1553B interface. EOC transmits the image data to ground station via X-band channel.

The EOC collects image for 2 minutes per 98 minutes orbit cycle, which covers about 800 km along ground track. The EOC image can be transmitted to Korean Ground Station in real time during Korean peninsular observation or be stored in the Solid State Recorder (SSR) of PDTS out of the Korean Ground Station reception area. The stored image data can be transmitted when the data reception connection is available later. It is possible to observe earth globally using the image storage scheme. For on-orbit instrument calibration, reference ground area can be used with the built-in dark calibration capability. Uniformly bright area such as desert or snow can be observed for radiometric calibration and Ground Control Point (GCP) is used for geometrical calibration.

Figure 3 illustrates the EOC operation concept of image collection. The EOC collects stereo images of target area from opposite sides on different passes by roll-tilting of spacecraft, then ground station can make DTEM with stereo image. It is possible to collect image data 39 times in the daytime per 28 days revisit cycle by roll-tilting of up to ±45degree. For cartography, up to 30degree roll-tilting is used. Korean Ground Station can obtain EOC images 20 times out of 39 times in this case.

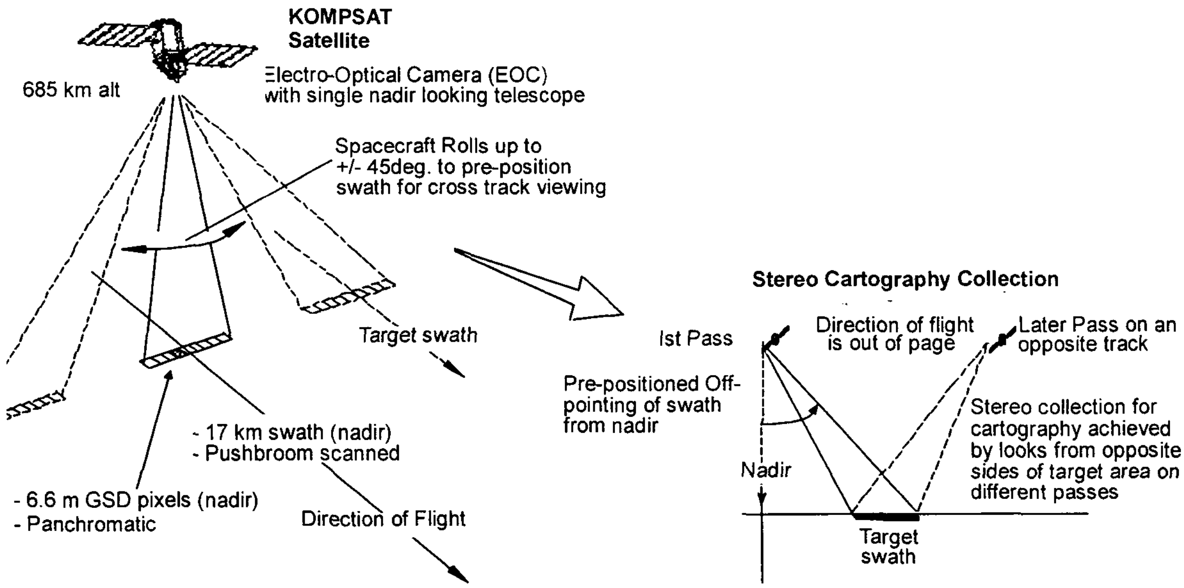


Fig. 3. EOC Operational Concept.

OCEAN SCANNING MUTISPECTRAL IMAGER (OSMI)

OSMI mission is worldwide ocean color monitoring for the study of biological oceanography. OSMI image data can be used for ocean ecological observation, ocean resource management, and ocean-atmosphere environment analyses.

OSMI is a multi-spectral imager generating 6 color ocean images with 800 km cross-track ground swath and less than 1km GSD by whisk-broom scanning method at the altitude of 685km. OSMI is designed to provide on-orbit spectral band selection ability for flexible ocean observation. The band centers and bandwidths of 6 bands are selected in the spectral range from 400nm to 900nm via ground station command after launch.

The instrument performance is measured on the ground for 8 basic spectral bands within the 400 nm to 900 nm spectral range. These bands will be used as the main spectral bands for the OSMI basic mission, among which 6 spectral bands will be selected at a time to collect image data after launch. Some major OSMI performance test results for the 8 bands are summarized in Table 1. The OSMI signal channels has 10-bit digitization.

Table 1. OSMI basic spectral bands and major performance
(TBR: To Be Resolved)

Spectral Bands	B0	B1	B2	B3	B4	B5	BX	B6
Band Center (nm)	412	443	490	510	555	670	765	865
Bandwidth (nm)	20	20	20	20	20	20	40	40
SNR	TBR	> 450	> 450	> 450	> 350	> 350	> 350	> 350
MTF (%)	> 20	> 20	> 20	> 20	> 18	> 18	> 15	> 15
Polarization (%)	TBR	< 5	< 5	< 5	< 5	< 5	TBR	< 5

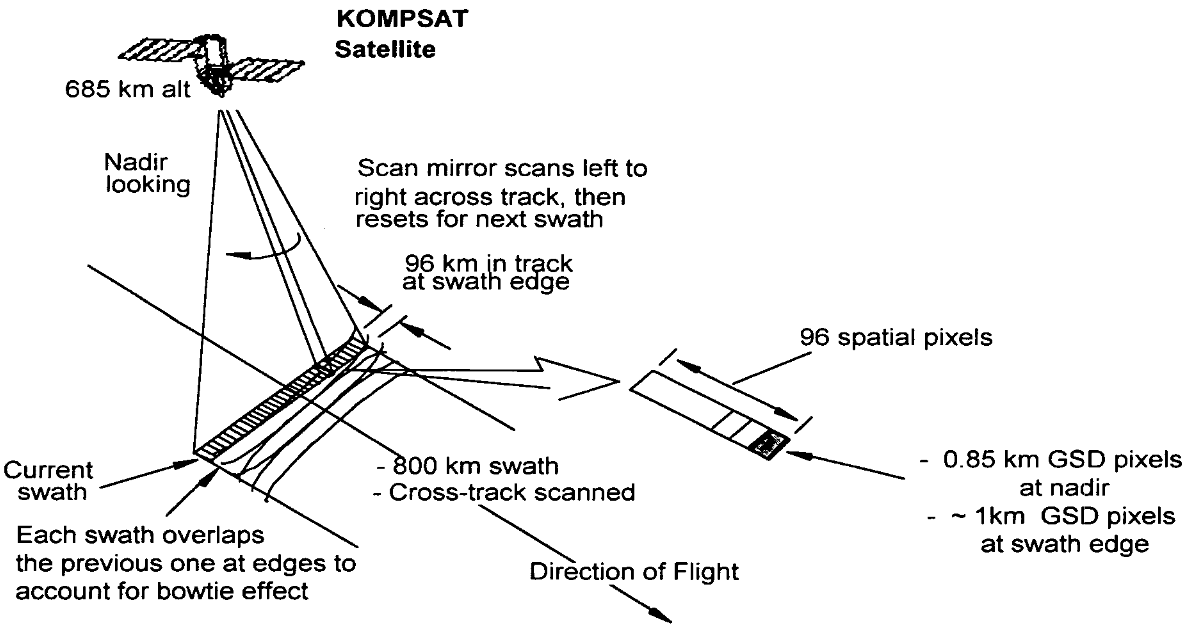
The OSMI ocean color spectral bands B0 through B4 provide ocean color data while band B5, BX and B6 provide information for atmospheric (aerosol) corrections.

For OSMI mission, S-band communication link is used to transmit command from the ground station and to receive the State Of Health (SOH) data of OSMI. The On-Board Computer (OBC) controls S-band data with the MIL-STD-1553B interface. OSMI transmits the image data to ground station via X-band channel.

The OSMI has 4 operational modes; (1) the standby mode, (2) the imaging mode, (3) the dark calibration mode, and (4) the solar calibration mode. The OSMI instrument is designed to perform imaging operation for 20% per orbit and a planned on-board solid state recorder will support worldwide imaging operation by providing data archive and downlink to the ground station at Taejon, Korea. OSMI has two built-in radiometric calibration functions. Solar calibration data are taken on North pole per orbit and dark calibration is normally performed before and after image acquisition and solar calibration.

Fig. 4. OSMI Operation Concept.

SPACE PHYSICS SENSOR (SPS)



SPS consists of High Energy Particle Detector (HEPD) and Ionosphere Measurement Sensor (IMS). HEPD has missions to characterize the low altitude high energy charged particle environment and to study the effects of radiation environment on microelectronics such as single event upset, total dose effect and RAM test. IMS measures densities and temperature of electrons in the ionosphere and monitors the ionospheric irregularities in KOMPSAT orbit. We can study the effect of spacecraft charging through IMS.

HEPD consists of Proton and Electron Spectrometer (PES), Linear Energy Transfer Spectrometer (LET), Total Dose Monitor (TDM) and Single Event Monitor (SEM) and these are separated physically. PES is composed of 7 channels (three channel of Proton, three channel of Electron, a channel of alpha particle) and physically consists of Telescope and Signal Processing Unit. LET Spectrometer consists of a Solid State Detector and measures the amount of energy transferred to Silicon. TDM consists of four pairs of RADiation sensitive Field Effective Transistor (RADFET) and SEM monitors single event upsets using random access memory (RAM).

IMS consists of Electron Temperature Sensor (ETS) that measures the temperature of thermal electrons in the ionosphere and Electron Density Sensor (EDS) that measures the density and temperature of electrons. IMS EDS is a modification of Langmuir Probe (LP). Dynamic measurement range of IMS is $10 \sim 10^6$ Electrons/cm^3 in electron density and $0 \sim 1$eV in electron temperature.

HEPD and IMS are installed in a SPS (HEPD+IMS) box and total weight is 7.6Kg and maximum power dissipation is 16W. Data transfer rate of HEPD is 1.5kbps and that of IMS is 5.6kbps. SPS needs time data, position and attitude of spacecraft and the intensity of earth magnetic field and SPS can obtain time data, position and attitude of spacecraft from the spacecraft. ETS and LP face ram direction directly.

SPS calibration data and SPS SOH (State Of Health) data are transmitted to the Ground Station normally through S-band after being saved to memory of OBC (On-Board Computer). The operation of SPS is controlled by ground command transferred by OBC that communicates with Ground Station through S-band. SPS has 100% duty cycle.

PAYLOAD DATA TRANSMISSION SUBSYSTEM (PDTS)

The purpose of the PDTS is to provide KOMPSAT-I with an X-band downlink capability to transmit EOC/OSMI image data and OBC data to the KOMPSAT Ground Station (KGS). The PDTS consists of an internally redundant Formatter/Multiplexer Unit (FMU), separate primary & redundant X-band transmitter units, a RF assembly, and an X-band Antenna.

The FMU is commanded to accept image data from one or both of two imaging instruments (EOC and OSMI) and playback telemetry data from the On-Board Computer (OBC) which contains state-of-health, satellite reference information (time, ephemeris, and orientation). The FMU is able to receive the image data at the maximum input data rates of Table 3 (defined for the EOC and OSMI as the rate of data obtained via the interfaces).

Table 2. PDTS input data rate

Input	Maximum Rate
EOC data 25 Mbps	
OSMI data	1 Mbps
OBC data	1.5 Mbps

To provide compatibility with the Korean Ground Station (KGS), the image data are formatted and encoded for transmission in CCSDS Grade 2 prior to being sent to the X-Band transmitter. The formatted data from FMU are passed to X-band Transmitter for real-time information transmission. The FMU contains Solid State Recorder (SSR) to store processed EOC/OSMI image data and OBC data for later playback downlink to KGS when KOMPSAT-I is within the data reception coverage of the KGS. The storage capacity of SSR is 8Gbits at the beginning of life and 2.5Gbits at the end of life.

The X-Band transmitter uses offset quarter phase-shift-keying (OQPSK) modulation and has the data transmission rate of 45Mbps. The transmitter center frequency is 8.3GHz and the transmitter output power is 3 watts. Transmitter output is visible to the ground station up to 1500 km from the satellite nadir point in the ground. The X-band link margin is more than 3dB with Bit Error Rate (BER) of 10^{-6}. The Mass of PDTS is 14.5 Kg and the peak power consumption is 63 watts.

CONCLUSION

Korea Aerospace Research Institute (KARI) is developing three instruments of Electro-Optical Camera (EOC), Ocean Scanning Multispectral Imager (OSMI) and Space Physics Sensor (SPS) to be accommodated onto Korea Multi-Purpose Satellite I (KOMPSAT-I) for the mission of cartography, ocean color monitoring, and space environment monitoring respectively.

EOC is expected to produce advanced products in the fields of cartography and Geological Information System (GIS) by providing high resolution images for the production of scale maps, including digital elevation models, of the Korea peninsula. The OSMI's on-orbit spectral band selection ability provides great flexibility in ocean color monitoring and research opportunities to support the next generation of sensor design. SPS will contribute to understand the space environment around KOMPSAT orbit.

The flight models (FM) of EOC, OSMI and SPS were manufactured. The instruments are assembled with spacecraft bus and tested as a part of the satellite system at KARI until the end of 1998. After the final check on the interfaces between the satellite, KGS, and the launch vehicle of Taurus, the satellite is to be launched in August of 1999 and it is expected to operate more than 3 years.

ACKNOWDGEMENTS

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