Operation concept of overseas ground stations for KOMPSAT series

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The KOMPSAT-2 has been being operated over 5 years since it was launched at July, 2006, and KOMPSAT-3 & 5 will be launched sooner or later. A mission orbit of KOMPSAT-2 & 3 is 685km sun-synchronous with a 28-day ground repeat cycle. The KOMPSAT-5 is the first synthetic aperture radar satellite of South Korea, and its mission orbit is 550km sun-synchronous dawn-dusk orbit with a 28-day ground repeat cycle. The mission of KOMPSAT series collects earth images like ocean and land management, and disaster and environment monitoring. The MSC (Multi Spectral Camera) of KOMPSAT-2 collects 1m of panchromatic and 4m of multi-spectral images, the AEISS (Advanced Earth Image Sensor System) of KOMPSAT-3 collects 0.7m of panchromatic and 2.8m of multi-spectral images, and the SAR (Synthetic Aperture Radar] of KOMPSAT-5 has three operation modes including high-resolution, standard, and wide-swath, and its image resolutions in dedicated swaths are 1 m, 3 m, and 20 m, respectively. The overseas ground stations will be used in order to increase contact time between the KOMPSAT series and the KGS (KARI Ground Systems). A role of overseas ground stations is to track a signal, receive telemetry in real time and to send bent-piped commands, also to be used in case of the satellite contingency during the normal operations and LEOP. Now that the KGS has to ready for manage overseas ground stations for KOMPSAT series in the concept of multi-satellite operations simultaneously, MTGI (Multi TMTC Gateway Interface) tool is developed. Functions of MTGI are routing, telemetry receiving, command transmitting, and file format converting. Consequently, we are able to ready for the multi satellite operation through MTGI. This paper will show interface concept of oversea ground stations and its function, and interface concept of KGS will be revised during operations of KOMPSAT-3 & KOMPSAT-5.

I. Introduction

Most of the Earth observation satellites are remote sensing satellites in low Earth sun-synchronous orbit and send data obtained from various sensors and cameras mounted on the craft to utilize them in a wide range of applications such as monitoring natural disasters and geological and environmental research. In particular, KOMPSAT satellite can monitor large-scale natural disasters and identify the utilisation of natural resources and high-resolution Earth observation images that can be utilized in geographic information systems can also be provided. In order to fulfil this mission, it is essential that satellites be interfaced with the internal and external antenna system for the transmission of the commands and reception and processing of the satellite status data. For this purpose, TMTC Gateway Interface tool was initially developed and used for 1:1 data interface. However MTGI (Multi TMTC Gateway Interface tool) that is TCP/IP-based and designed to interface with internal and external antenna systems to set up N: N connection was developed to transmit commands and receive and process multi

satellite status data. After the completion of the data interface tool development, tests were performed in the non-real time operating environment by the development of the antenna system and ground operation system simulators. And then the performance test was carried out using the IF Loop Back function of the antenna to prove the reception, process and save of the satellite status data.

In this paper, I would like to describe the data interface method and the general interface concept for the multi-satellite operations.

II. KOMPSAT satellite's data format

A. KOMPSAT satellite's command format

All KOMPSAT satellite's command generates start·tail sequence that informs the beginning and the ends of the transmission based on CCSDS (Consultative Committee for Space Data System) format and send its command frame in the form of 8-bytes code block. 8-bytes block of code comprises 1 byte ECC (Error Correction Code) that is for 7-bytes command frame data and transmission error checking and error check code is assigned a relevant value according to the first code block, consecutive blocks of code, code block that includes hardware special command and error occurred code block. Each transmission frame that is transmitted from the ground station includes more than one command frame and the frame size is restricted so that it can be transmitted within two seconds to the satellite.

B. KOMPSAT satellite's state data format

Satellite state data is transmitted to the ground station in the unit of 256 bytes of CADU (Channel Access Data Unit) frame that consists of 4 bytes of Sync Word and 32 bytes of RS Code. Ground TT&C (Telemetry Tracking and Command) Modem BB receives 256 bytes of CADU (Channel Access Data Unit) data and de-randomise and RS-decode the data to recover the original signal. Then it provides the ground station with the 288 bytes of satellite state data including the 64 bytes header of Modem BB and 4 bytes of trailer after the 4 bytes of Sync Word and the 32 bytes of RS code are removed.

III. Overseas ground stations

A. KOMSAT operations using overseas ground stations

KOMPSAT satellite transmitted commands and received satellite state data using overseas ground station during the initial operating period to overcome the temporal and spatial constraints. 64 kbps leased line and a backup of ISDN (Integrated Services Digital Network) were constructed to maintain 24 hour network to overseas ground stations for the support of early stage operation and commercialisation. Wailhaim of GSOC was selected as a main overseas ground station on the network for KOMSAT-1 in conjunction with other ground stations such as Svalbard, Poker Flat and McMurdo. ISDN, ADSL (Asymmetric Digital Subscriber Line) were constructed to Svalbard, Norway for the early stage operation of KOMSAT-2 in conjunction with Malindi and Maspalomas and the early operations of KOMSAT-3 and 5 will be performed on the network of Svalbard, Norway and Troll.

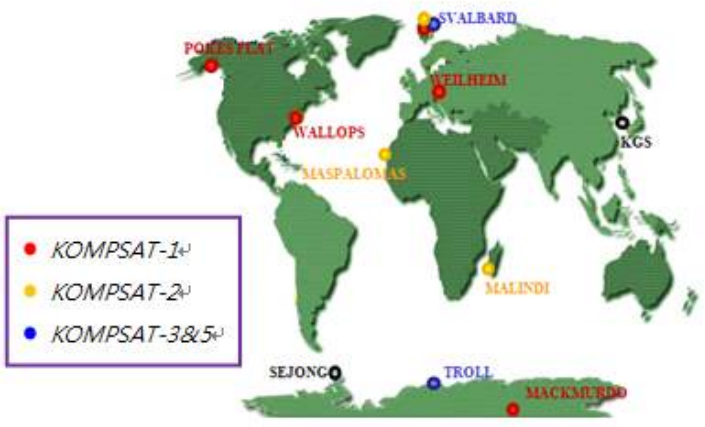

Figure 1. Overseas ground stations used for KOMSAT series

B. Data interface using overseas ground stations

Special command that is 11 bytes and normal command that is 15 + N + Fill bytes are sent in CLTU(Command Link Transmission Unit), Transfer Frame Level format to Modem BB of the overseas ground station where they are bypassed or converted to CLTU (Command Link Transmission Unit) to be sent to the satellite. During the early operation period of KOMSAT-1 and 2, satellite state data of 288 bytes were received from the overseas ground station. In case of KOMSAT-3 and 5, however, ESA (European Space Agency) standard format of 324 bytes will be used for satellite state data and hence ground station must be compatible with both of the data transmission formats.

IV. Data interface tool

A. TMTC Gateway Interface tool

The Korean peninsula's geopolitical position makes us use overseas ground station to secure the communication opportunity with KOMPSAT and the ground station must be data interfaced with the internal and external antenna systems to send the commands, receive and save satellite state data. TCP/IP-based TGI tools was developed and used to establish access route for the 1:1 interface with internal and external antenna systems, data process and save, Error reporting, receipt and bypass of the Transfer Frame Level command, transformation to CLTU format to send the data to the Modem B/B of the overseas ground station.

B. Multi TMTC Gateway Interface tool (MTGI)

TCP/IP-based MTGI was developed because there arose the need for the N:N data interface with the multi satellites during the preparation period of the KOMSAT-3 and 5 regardless of the 1:1 data interface with the internal and external antenna systems using TCP/IP based TMTC Gateway Interface tool. MTGI was designed to be connected with a maximum of four overseas ground stations using each panel. At the same time the transmission and save of the commands to the panel and the process and save of the telemetry is also possible. For this reason, it was designed to avoid conflicts of data using IP address, the port information and VCID (Virtual Channel ID) of each satellite and to process and save the data during the set-up period of the antenna and satellite operation system.

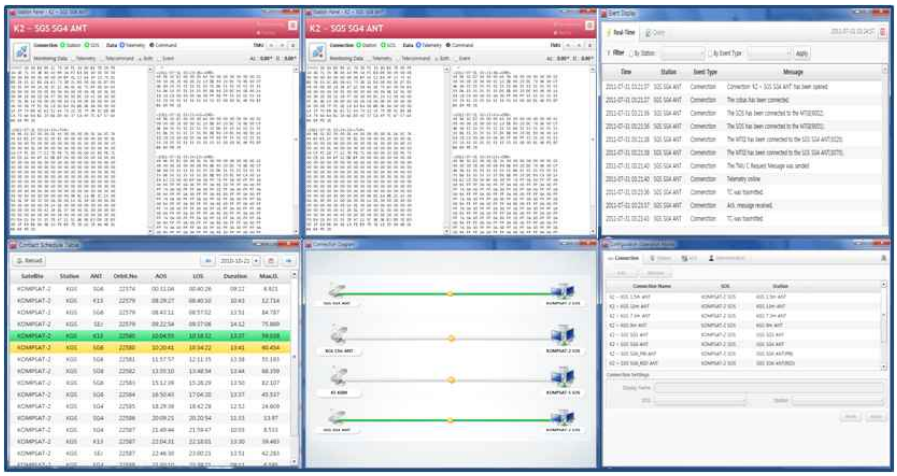

Figure 2. MTGI GUI

The command transmitted and telemetry that is input through MTGI GUI (Graphical User Interface) was designed for the real time monitoring to find the problems that occur during the input and output procedure. And the azimuth and elevation of the antenna system were described using the AER (Azimuth & Elevation Report) file that is provided in STK (Satellite Tool Kit) during the communications with the internal and external antenna systems. The efficiency of the operation can be increased by predicting the avail time slot for the command transmission if we know the Mask Angle of the overseas ground station. Satellite contact information like satellites, ground stations, antennas, orbit number, AOS·LOS, and Maximum Elevation is described using Contact Schedule Table and the connection and network status between the antenna systems and the satellite operation systems are real time monitored through Connection Diagram. The operator must be aware of the communication information with the satellites for the successful operation using overseas ground stations. The satellite contact time is notified by MTGI

to operators ten minutes before the contact with the voice message of “10 minutes before AOS” referring to the Contact Schedule Table to avoid the mistakes of operators. Also, TGI terminates the connection prior to the change of the channel in case of the mode change of satellite and TMU channel can be changed by MTGI just by pressing a single button in a way of minimizing the loss of data. The event logs produced during the multi satellite operation can be filtered by station or type or by both for the efficient identification and also the events that occur during the day can be viewed by search function by date and time.

V. The Test of data interface using MTGI

A. Test using simulation program

Tests were performed in the non-real time operating environment by the development of the antenna system and ground operation system simulators after the completion of the data interface tool development. Ground Control System Simulator has programs to perform Telemetry Request message transmission, Telemetry receiving, command transmission and receiving acknowledge messages for the transmission of the commands. Sufficient amount of verification time was reserved to prevent such errors that can occur in the real environment by the test in the non real time environment using the simulation tool.

Figure 3. The satellite operation simulator for test using simulation program

B. Test using IF Loop Back

The performance test is carried out using the IF Loop Back function of the antenna to prove the reception, process and save of the satellite status data. IF Loopback test can inspect the Downlink interface of the ground system by using the telemetry for the Loopback and setting up the same antenna system as used to receive the actual telemetry. Antenna system plays a role to send the 256 bytes CADU input data to the ground station by converting it into 288 bytes data and providing it as data interface tool. Also, it receives and bypasses the Transfer Frame Level that is transmitted from the round station or converts it into CLTU format and transmits it to Modem B/B.

Figure 4. The satellite operation simulator for test using simulation program

C. Test in the real time environment

The real time operation test for the data interface tool test was carried out in conjunction with all the ground systems after the test in non real time environment. This is due to the fact that setting up the access path and telemetry reception is variable. Multi operation function test of data interface tool was performed during the real time communication by IF Loopback using different antennas and by the reception, process and save of the four telemetries in conjunction with the simulator of KOMSAT-3 and 5.

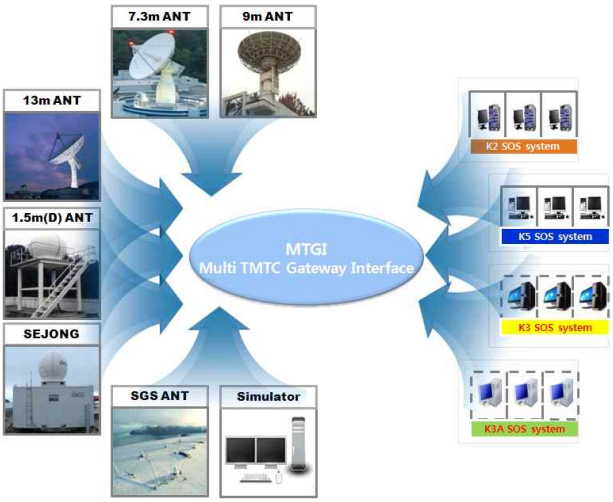

Figure 5. Data interface tool test in real time environment

VI. Operation Concept

The 1:1 data interface method with internal and external antenna system using TCP/IP based TMTC Gateway Interface tool and N:N data interface method with 4 internal and external antenna systems using MTGI have their own advantages and disadvantages. The multi data interface tool using MTGI is better in case of normal and commercial missions and the 1:1 data interface method is more efficient during the network and data interface tests. Therefore the 1:1 data interface method with internal and external antenna system using TCP/IP based TMTC Gateway Interface tool will be used during the early operation period of KOMSAT-3 and 5 and thereafter N:N data interface method with 4 internal and external antenna systems using MTGI will be used for the normal and commercial mission operations.

VII. Conclusion

KOMPSAT satellite can monitor large-scale natural disasters and identify the utilization of natural resources and high-resolution Earth observation images that can be utilized in geographic information systems can also be provided. In order to fulfil this mission, it is essential that satellites be interfaced with the internal and external antenna system for the transmission of the commands and reception and processing of the satellite status data. For this purpose, TMTC Gateway Interface tool was initially developed and used for 1:1 data interface. But TCP/IP-based MTGI was developed because there are the need for the N:N data interface with the multi satellites during the preparation period of the KOMSAT-3 and 5. The multi data interface tool using MTGI is better in case of normal and commercial missions and the 1:1 data interface method is more efficient during the network and data interface tests. Therefore the 1:1 data interface method with internal and external antenna system using TMTC Gateway Interface tool will be used during the early operation period of KOMSAT-3 and 5 and thereafter N:N data interface method with 4 internal and external antenna systems using MTGI will be used for the normal and commercial mission operations.

Appendix A
Acronym List

KGS	KARI Ground Station
KARI	Korea Aerospace Research Institute
TMTC	Telemetry, Telecommand
LEOP	Launch and Early Operation Phase
MTGI	Multi TMTC Gateway Interface
SAR	Synthetic Aperture Radar
STK	Satellite Tool Kit
AER	Azimuth & Elevation Report
VCID	Virtual Channel ID
KOMPSAT	Korea Multi-Purpose Satellite
MSC	Multi Spectral Camera
AEISS	Advanced Earth Image Sensor System
ISDN	Integrated Services Digital Network
COP	Command Operation Procedure
CLTU	Command Link Transmission Unit
GUI	Graphical User Interface
AZ	Azimuth
EL	Elevation
AOS	Acquisition of Signal
LOS	Loss of Signal
ESA	European Space Agency
TMU	Telemetry Unit
AER	Azimuth & Elevation Report

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