13m ANTENNA SYSTEM FOR KOMPSAT-2 MISSION

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1. Introduction

KOMPSAT2, a high resolution EOS (Earth Observation Satellite), has been developed since 2000 to be launched in 2004. KARI (Korea Aerospace Research Institute) takes a main responsibility for system engineering, design, integration, test, and mission operations. To meet mission operations, mission operation center and image processing center under the development for KOMPSAT2 shall have an interface with antenna system for bi-directional communication and data acquisition via S-Band and X-Band. First this paper shows ground antenna key requirements defined in system engineering and capability of 13m antenna system, a primary antenna system in KOMPSAT2 mission operation, and finally provides the link margin analysis results.

2. KOMPSAT2 System

KOMPSAT2, a successor of KOMPSAT1, will have only one payload, MSC (Multi-Spectral Camera), providing both 1m resolution panchromatic image and 4m resolution color image. The main features of KOMPSAT2 and KOMPSAT1 are summarized in Table1.

Table 1. KOMPSAT2 vs KOMPSAT1

		KOMPSAT-2	KOMPSAT-1
System Engineering		KARI Leading	TRW/KARI Co-Development
Orbit		685km, sun-synchronous	685km, sun-synchronous
Mass		800kg	510kg
Mission life		3 yrs	3yrs, launched in 1999
Payload		MSC(Multi-Spectral Camera) - Panchromatic: 1m - Color: 4m	EOC(panchromatic: 6.6m) OSMI(color: 1km SPS(HEPD+IMS)
BUS	Structure/Thermal	Hexagonal, heat-pipe, heater	Hexagonal, heat-pipe, heater
	AOCS	3-axis, 0.035deg (pointing accuracy)	3-axis, 0.1deg (pointing accuracy)
	EPS	GaAs Solar panel	GaAs Solar panel
	Propulsion	Hydrogen Thruster	Hydrogen Thruster
	TC&R	S-Band, OBC(80386) SSPA 3W RHCP Conical spiral antenna	S-Band, OBC(80186) SSPA 5W RHCP Conical spiral antenna
On-Board Memory Size		108Gbits	8Gbits
X-Band Image Data Rate		320Mbps	45Mbps

X-Band antenna	Microstrip rectangular patch array antenna, 2-axis gimbal system	Spiral Antenna

In order to guarantee mission operation, ground antenna system shall meet the key requirements defined in system engineering. Table 2 shows key requirements to be met by spacecraft and ground antenna systems [1][2].

Table 2. System Requirements defined in System Interface Document

	S-Band Uplink	S-Band Downlink	X-Band Downlink
G/S EIRP	53.5dBW(min)		
Frequency (TBD)	2025 ~ 2110MHz	2200~2290MHz	8050~8400MHz
Data Rate	2000bps	2048bps, 1.5Mbps	320Mbps
Modulation & modulation index	PM/BPSK/NRZ-M, 1.0 radian	PM/BPSK/NRZ-L, 1.0 radian PM/NRZ-L, 1.57 radian	OQPSK, NRZ-M
Polarization	RHCP	RHCP	RHCP
G/S G/T (min)		19.5dB/deg-K	32 dB/deg-K
S/C EIRP (min)		-2.73dBW	18.5dBW
S/C G/T	-38.75dB/K		
S/C Polarization	RHCP	RHCP	RHCP
BER	1x10-6	1x10-5	1x10-6
RS Encoding		(255,223)	(255,223)

3. KARI 13m Antenna System

Figure 1 shows diagram of 13m antenna system located in KARI. Like typical other antenna system, it consists of main reflector, sub-reflector, feed assembly, servo system, ACU (Antenna Control Unit), tracking receiver, M&C (Monitoring and Control), HPA, frequency converters, MODEM, data processor, data storage system, timing system, and network system.

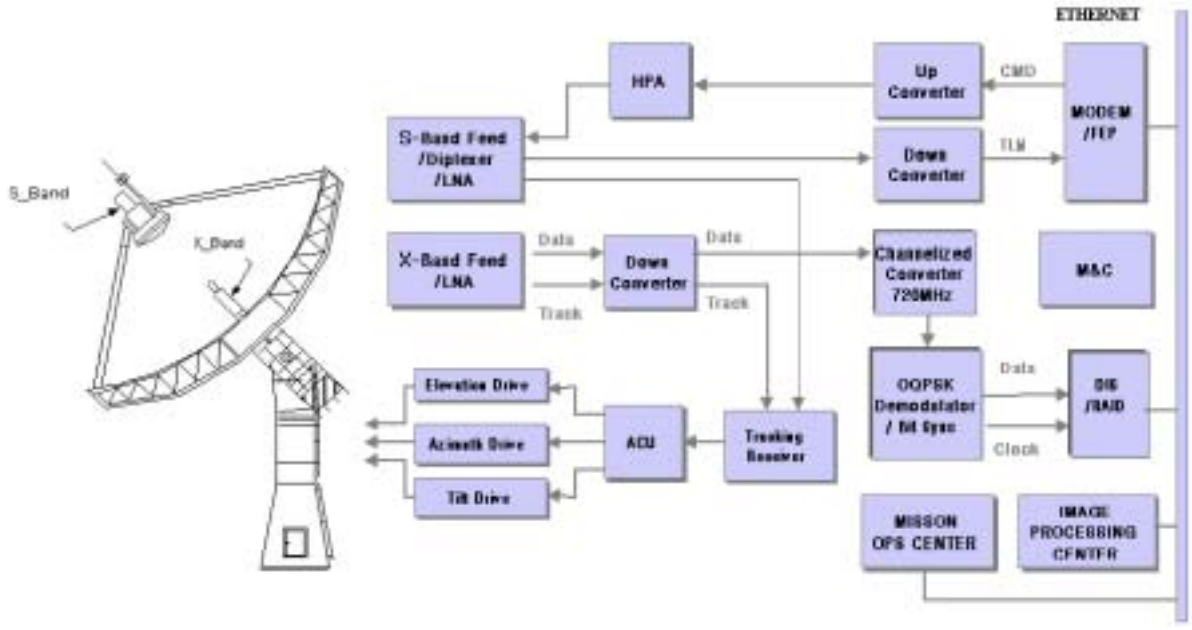

Figure 1. 13M Antenna System Diagram

Giga-ethernet system will be used for image processing center to reduce traffic expected in mass storage data. 13m antenna system can provide simultaneous TT&C (Telemetry, Tracking and Command) and image data acquisition with distinct S-Band and X-Band feed assembly system with the help of dichroic sub-reflector. Each S-Band and X-band feed assembly provides tracking error signal for auto-track system. One of two error signal source can be selected for auto-track mode. To maintain tracking mode in zenith pass, 3rd axis named tilt axis is used.

4. Link Budget Analysis

It is necessary to perform a link budget analysis to verify if reliable communication link can be guaranteed between spacecraft and ground antenna system. In general, a link budget calculation can be expressed as equation (1) [3].

$$\text{Link margin} = \text{EIRP} - \text{G/T} - (\text{Eb/No})_{\text{required}} - \text{R} - \text{K} - \text{Ls} - \text{Lo} + \text{Gc} \quad (1)$$

Where, EIRP: Effective Isotropic Radiation Power
G/T: Antenna Gain/System temperature
Eb/No: Energy per bit over noise
R: data rate
K: Boltzmann's Constant, -228.6 dBW/Hz-K
Ls: Space loss
Lo: Other losses like rain, atmospheric, polarization, implementation
Gc: Coding gain, if used

To calculate link budget accurately between KOMPSAT2 and 13m antenna system, the parameter values in Table 2 for KOMPSAT2 is used while real verified ground parameter value is used. Table 3 shows real measured value for EIRP and G/T for S-band and X-Band with solar flux density [4].

Table 3. 13m Antenna Capability

	Measured Value	Remark
13M EIRP	58.0 dBW	60W HPA
S-Band G/T	23.5 dB/K	@ 2200MHz
X-Band G/T	37.4 dB/K	@ 8050MHz

The values for required Eb/No is used in derived value for QPSK/BPSK modulation [3]. 3dB was allocated into Lo for rain, atmospheric, and implementation loss in receiver. Ls was calculated with equation (2).

$$\text{Ls} = (4\pi d/\lambda)^2 \quad (2)$$

In equation (2), d is distance between spacecraft to ground antenna and λ is wavelength. Link

budget calculation was performed for S-Band uplink, S-Band 2048bps downlink mode, S-Band 1.5Mbps downlink mode, and X-band 320Mbps using equation (1)and (2) with the values in Tables 2 and 3. Figure 2 shows analysis results obtained for 4 different communication modes.

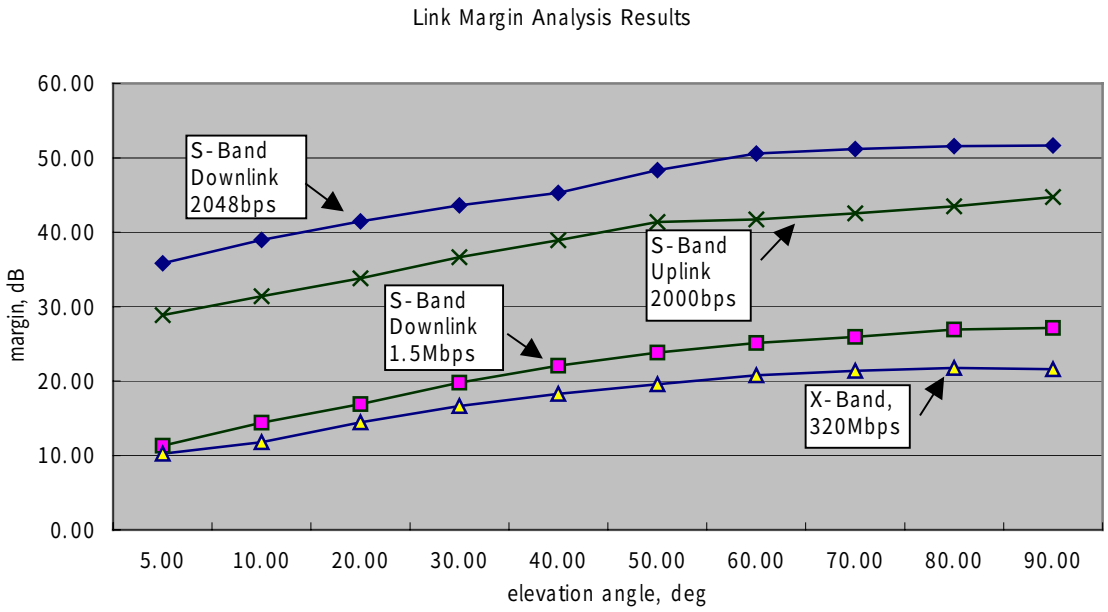

Figure 2. Link Margin Analysis Results

Figure 2 shows reliable communication mode for all cases can be provided at 5 deg of elevation angle with sufficient margins between KOMPSAT2 and 13m antenna system during mission operation. From the link margin values obtained from analysis, smaller antenna system can be used for back-up antenna system.

5. Summary

Structure and functional description were provided for KARI 13m antenna system, which will be used as a primary antenna system for KOMPSAT2 mission operations. was introduced. With both KOMPSAT2 parameter value and real verified 13m antenna system parameter value were used in link budget calculations. It was shown that 13m antenna system meets the system requirements and guarantees the reliable communication link for S-Band and X-Band with sufficient margins.

References

[1] KARI Documents, KOMPSAT2 S-Band SGICD, 2002.

[2] KARI Documents, KOMPSAT2 XICD, 2002.

[3] Bernard Sklar, *Digital Communications: Fundamentals and Applications*, Prentice-Hall, pp242-297.

[4] Datron Advanced Technologies, *Acceptance Test Procedure for KARI S-Band Upgrade*, 2001.