THERMAL CONTROL DESIGN FOR COMS(COMS 특별세션)

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COMS (Communication, Ocean and Meteorological Satellite) is a geostationary satellite and has been developing by KARI for communication, ocean observation and meteorological observation. Conventional thermal control design, using MLI (Multi Layer Insulation), OSR (Optical Solar Reflector), heater and heat pipe, is utilized. Ka-band components are installed on South wall, while other equipment for sensors are installed on the opposite side, North wall. High dissipating communication units are located on external (surface) heat pipe and are covered by internal insulation blankets to decouple them from the rest of the satellite. External satellite walls are covered by MLI or OSR for insulation from space and for rejection internal heat to space. The ocean and meteorological sensors are installed on optical benches on the top floor to decouple thermally from the satellite. Single solar array wing is adopted in order to secure clear field of view of radiant cooler of IR meteorological sensor. This paper presents principles of thermal control design for the COMS.

KEY WORDS: GEO satellite, communication, thermal design, Ocean sensor, Meteorological sensor

1. INTRODUCTION

The mission of the COMS is composed of three main payloads such as communication, ocean observation and meteorological observation with 7-year required lifetime. The design life is 10 years and the orbit altitude is 36000 km with maximum sun eclipse duration of 72 min.

Figure 1 shows the overview of the COMS. The ocean and meteorological sensors are installed on optical benches on the top floor (+Z direction: Earth direction) in order to decouple thermally from the satellite. Most of the communication payload units are installed on the inside of South wall (+Y wall), which is used one of the main radiators with North wall (-Y wall). Single solar array wing is installed on South wall opposite to ocean and meteorological sensors and sensor electronic units. The power subsystem units are located in South wall to maintain the closest distance with the solar array. Senor electronics units and other platform units, such as FMWs (Flight Momentum Wheel), WDEs (Wheel Drive Electronics), SCUs (Satellite Control Unit) and S-band transponders, are installed on inside of North panel. ADCS (Attitude Determination and Control Subsystem) sensors, TT&C (Telemetry, Telecommand and control) antennas and reaction thrusters are distributed all around the satellite and Li-ion battery modules are installed in South wall.

2. THERMAL CONTROL PRINCIPLES

The thermal control design of the COMS is mainly based on passive design using well established techniques and space proven hardware and supplemented by active design using heaters to compensate environmental and unit dissipation variations.

The satellite thermal control is in charge of maintaining all satellite equipment within their allowed temperature ranges during all mission phases. These phases cover pre-launch, launch, transfer orbit, in-orbit environment, including operating/non-operating and contingency modes. The satellite is as far as possible isolated form the external environment in flight configuration in order to limit the heater power consumption.

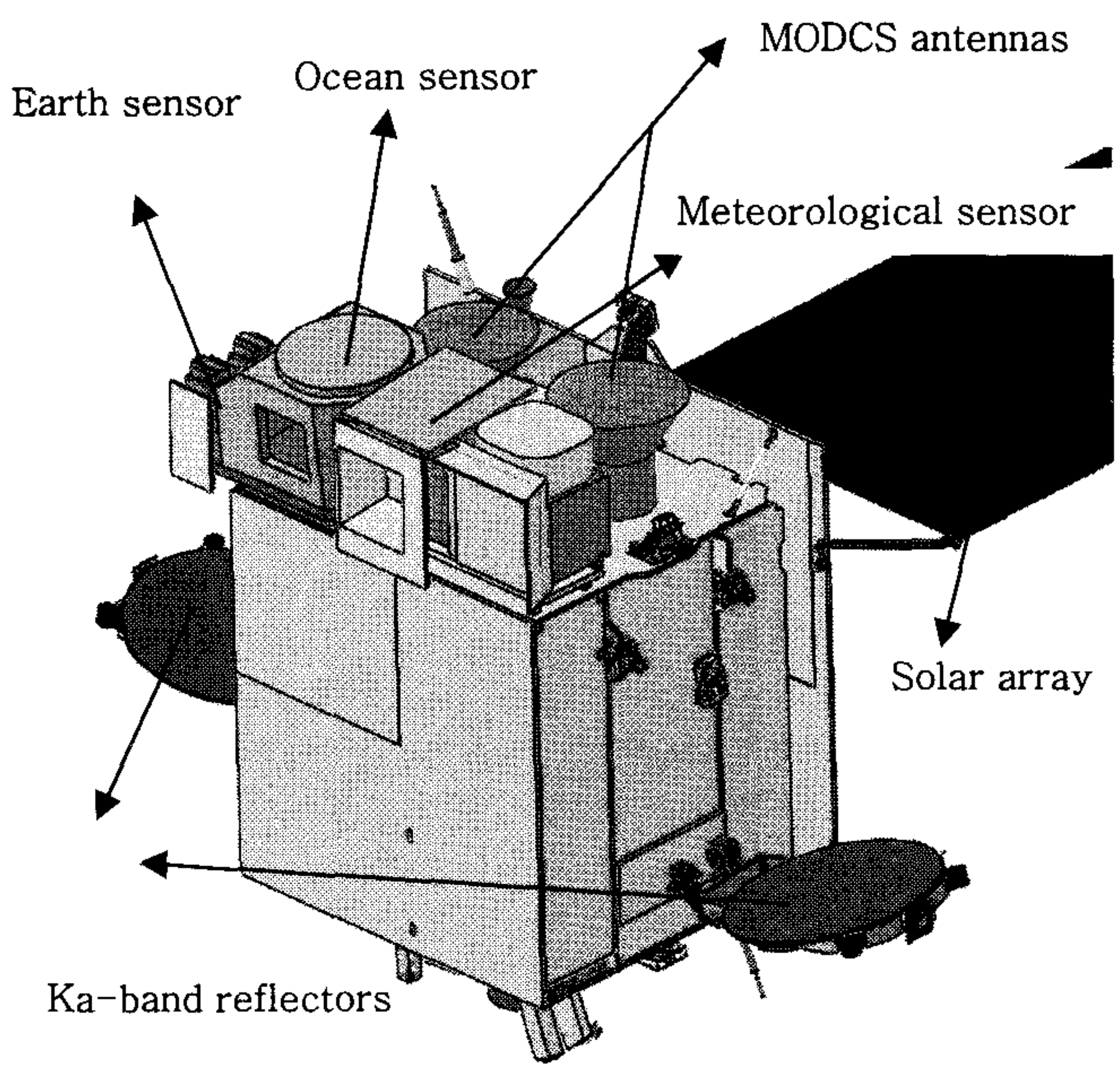

Figure 1. COMS configuration.

For each component of the satellite, thermal control subsystem is designed to provide at least 10°C margin between the evaluated worst case in flight design temperature and the temperature to which the related equipment has been / will be qualified. In the evaluation of the worst case design temperature, a margin of at least 5°C will be considered. The worst case selection will generally consider BOL (Begin Of Life) properties for the cold cases, and EOL (End Of Life) properties for the hot cases, including radiator degradation (10 years Design life) and heat pipe failure, electronics ageing, as well as LAE (Liquid Apogee Engine)/thrusters soak back and free molecular heating in the applicable phases.

Most of the satellite units are collectively controlled inside defined thermal enclosures in which the temperature variations are limited by proper sizing of heat rejecting radiators and appropriate heating power implementation limiting the temperature gradients to acceptable levels. In this case, the internal units have a black finish to maximize heat transfer inside the thermal enclosures.

Ocean and meteorological sensors are controlled independently from the rest of the satellite and have their own thermal control. Special precautions such as optical benches and MLI are considered in order to isolate them conductively and radiatively. Single solar array wing installed on only the South side of the satellite is adopted in order to secure clear field of view of the sensors to the deep space.

The internally mounted propulsion equipment are in general isolated with MLI, and provided with their thermal control heaters. The main engine and the thrusters have thermal couplings with the satellite to meet their thermal requirements while preserving the satellite thermal behaviour.

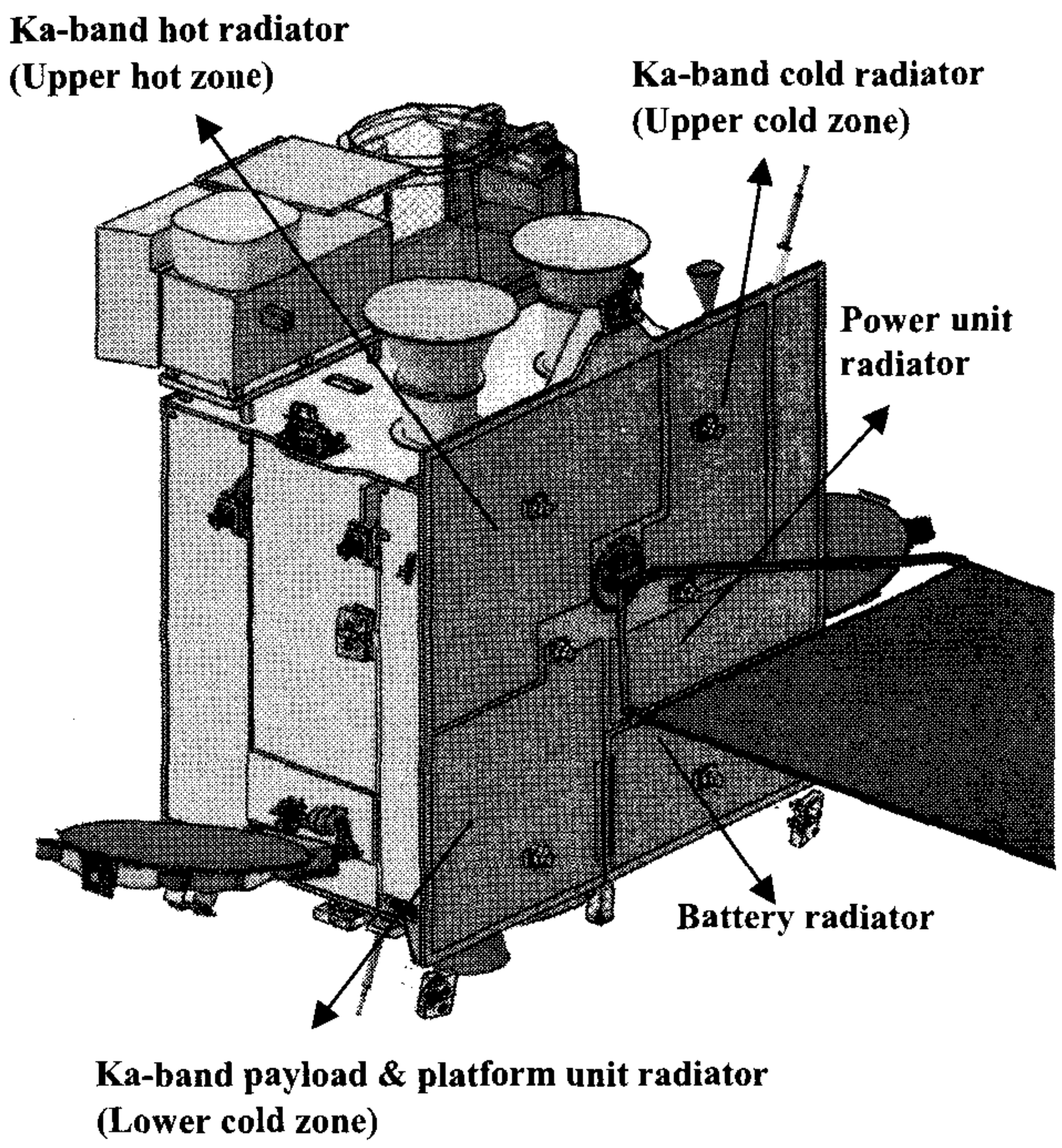

Figure 1. +Y wall (South wall) External Thermal Design.

Externally, passive radiators reject heat to space, and Multi-Layer Insulation (MLI) is used to minimize heat flow from non-radiating areas. Most of the satellite is covered by MLI except radiator areas of South and North walls as shown in Figure 2 and Figure 3. Platform high dissipative units are mounted on the panels directly behind the radiators to provide a good conductive path from unit to panel. The inside of the satellite has a high emissivity/high absorptivity finish to maximize radiative heat transfer to the radiators. The thermal isolation of the units can be achieved by low conductance thermal stand-offs and washers, and single or multi layer blankets.

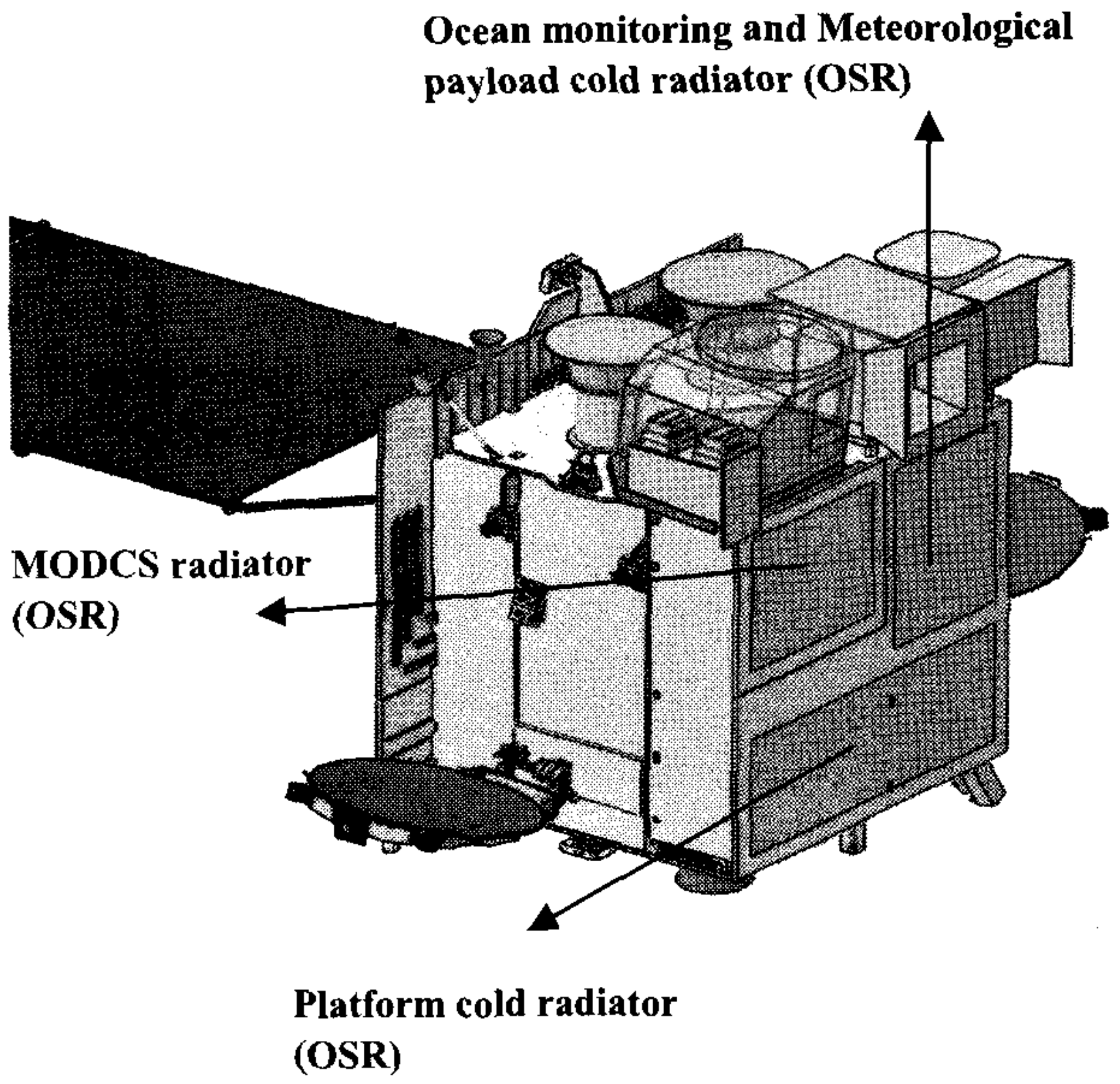

Figure 3. -Y wall (North wall) External Thermal Design.

Heater power is necessary to meet temperature requirements for particular units in some conditions. Both routine mode software controlled heaters and safe mode hardware controlled heaters are implemented. Appropriate redundancy is included for all heaters, thermistors and thermostats to prevent single point failure in the thermal control function.

3. KA-BAND PAYLOAD THERMAL DESIGN

The Ka-band communication payload installed on South wall is thermally isolated so as not to affect the performance of ocean and meteorological sensors. The Ka-band payload section of South wall is divided into thermally independent three isothermal regions in order to optimize the use of available radiator area by taking maximum advantage of the different temperature ranges of the equipments. This kind of concept can maximize heat rejection capability of radiator. The three thermal zones, such as lower cold zone, upper hot zone and upper cold zone, are shown in Figure 2 and Figure 4.

The EPCs (Electronic Power Conditioning), CAMPs (Channel Amplifier), up converters assembly and RF channel filter are located in the lower cold zone (Ka-band payload & platform unit radiator) as shown in Figure 3.

The TWTs (Travelling Wave Tube), O/P switches, OMUX (Output Multiplexer) are located in the upper hot zone (Ka-band hot radiator) which is maintained at higher temperatures for the TWT and OMUX design limits. Horizontal surface heat pipes are used to spread the concentrated heat loads generated by equipments such as TWT collectors and OMUX. Internal MLI covers TWT/OMUX hot area to decouple it from the rest of the satellite.

The payload beacon equipment, down converters assemblies, I/F switch network, IF channels filters, MSM (Microwave Switching Matrix) & DCU are located in dedicated upper cold one (Ka-band cold radiator).

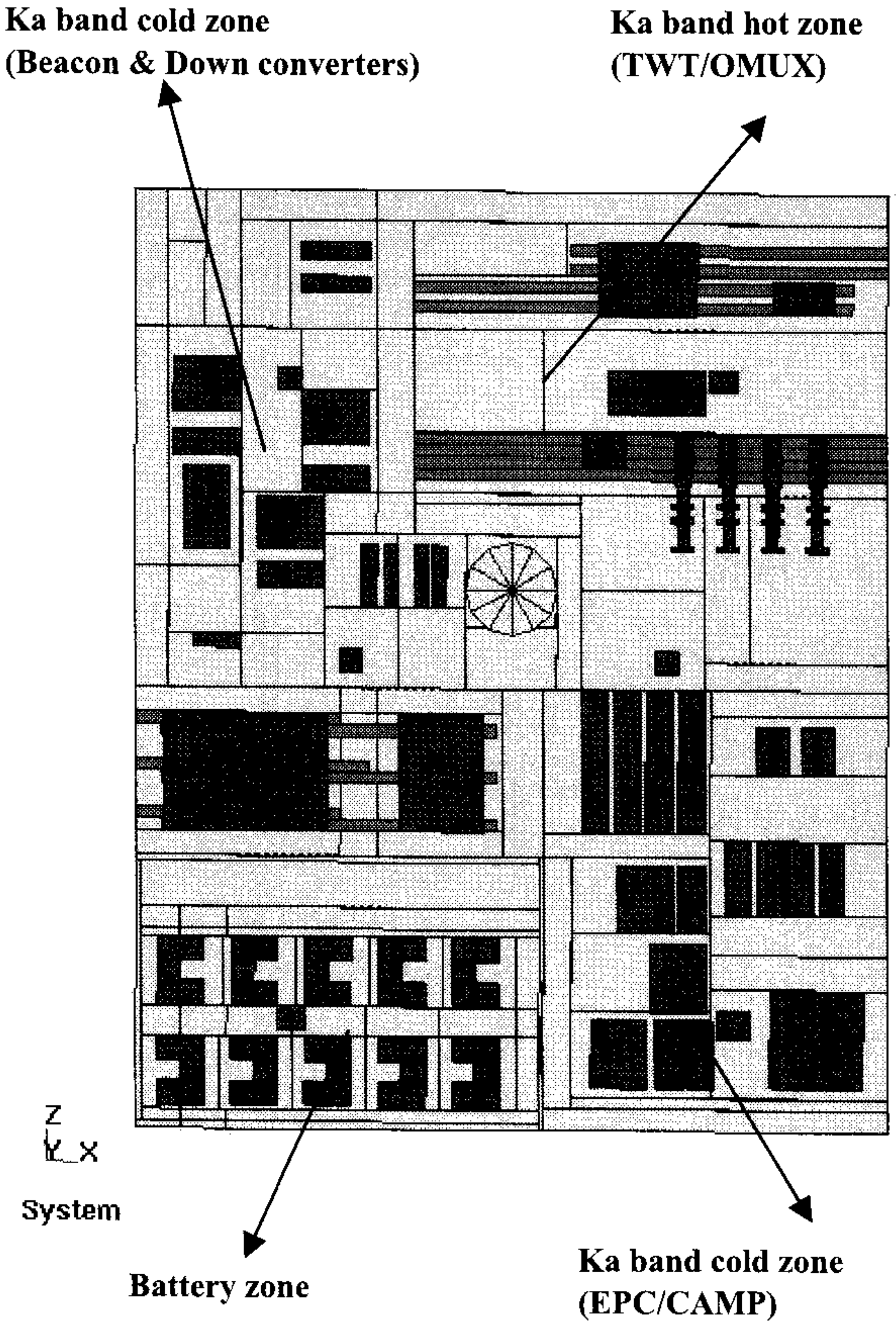

Figure 4. +Y Wall Internal thermal design.

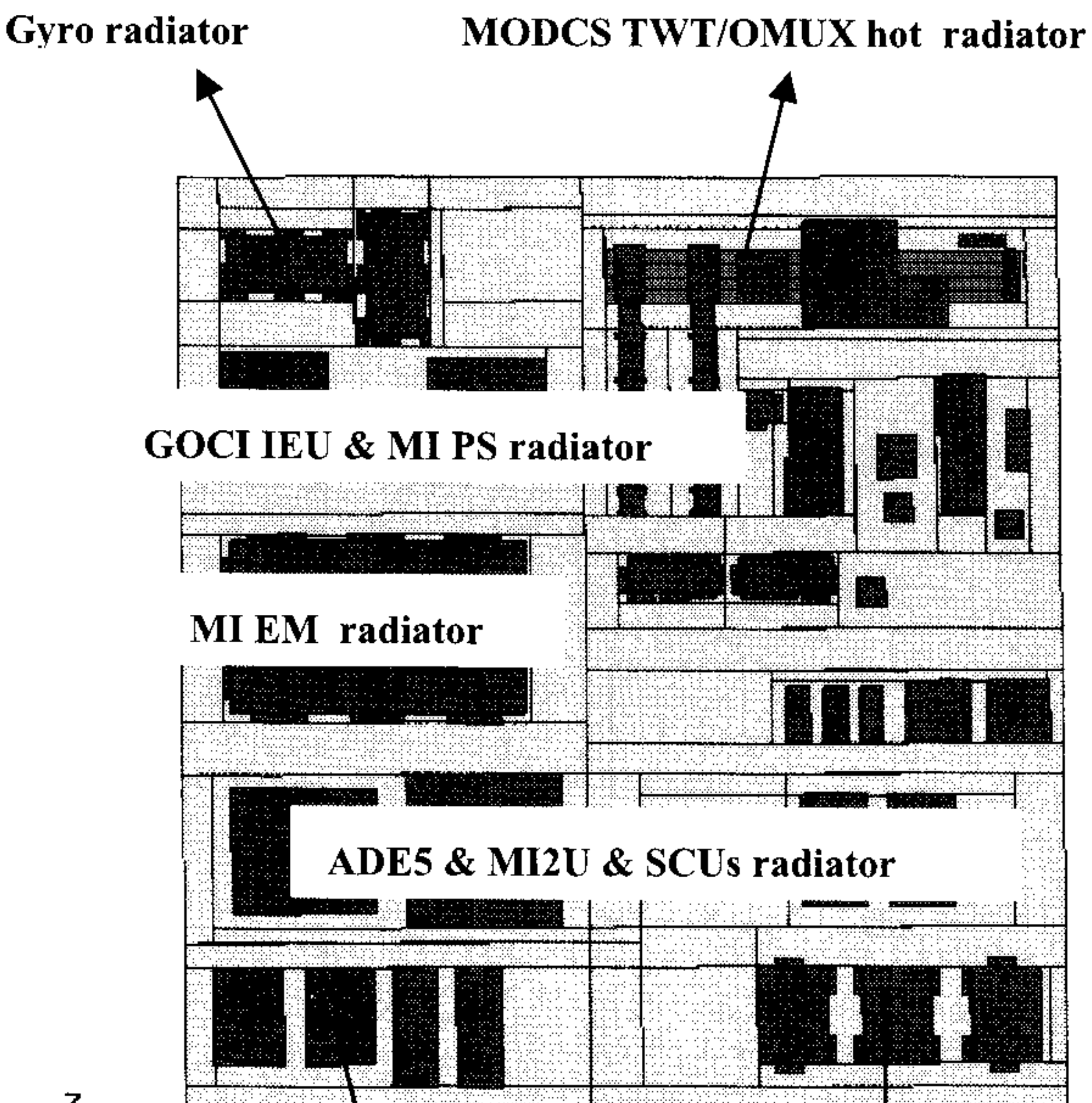

Figure 5. -Y Wall Internal thermal design.

LNAs are located on the bottom of top floor. They are radiatively controlled by lower zone or upper cold zone cavity.

4. GOCI AND MI THERMAL DESIGN

The GOCI (Geostationary Ocean Color Imager) and MI (Meteorological Imager) sensors are accommodated each on dedicated CFRP I/F plates, allowing decouple them structurally (hence conductively) and radiatively from the rest of the satellite (as shown in Figure 3). This allows the implementation of a dedicated thermal control of these units (sensors), to meet their thermal performances, and the reduction of the pointing accuracy related to thermoelastic distortion.

The GOCI and MI electronics as shown in Figure 5 are entirely located on the North (-Y) radiator panel, in the +Z zone in order to maintain the required temperature for the units and to be close to their sensors.

5. MODCS THERMAL DESIGN

The MODCS (Meteorological and Ocean Data Communication Subsystem) electronics are entirely located on a dedicated panel, upper part of North (-Y) wall as shown in Figure 5, in order to be close to the MODCS antennas. TWTs and OMUX are installed on surface heat pipe to spread hot dissipation of these units to radiator and finally to the space. Also TWTs and OMUX are covered with internal MLI to decouple this hot area from the rest of the satellite.

6. PLATFROM THERMAL DESIGN

6.1 Power Subsystem Equipment

The PSR (Power System Regulator) and PRU (Pyro Release Unit) are located in a radiator area of +Y wall as shown in Figure 2 and Figure 4 in order to be close to the solar array wing. The battery module, as shown in Figure 4, uses embedded heat pipes and active heaters for its thermal control and it is covered by internal MLI to decouple from rest of the satellite. The dissipation of battery module is spread using embedded heat pipes, then a dedicated radiator and finally to the space. The SADM (Solar Array Drive Mechanism) is radiatively and conductively controlled within Ka-band upper cold zone cavity.

6.2 TC & R Equipment and Other Platform Units

The AOCS units are located on the –Y wall of the satellite as shown in Figure 5. Two gyro units for Z and X direction are installed on upper part of –Y wall with their own radiators as shown in Figure 5. One gyro unit for Y direction is located on lower part of top floor and is radiatively controlled by these radiators. The FMWs are radiatively controlled on both lower part of the +X –Y and –X –Y cavities. The wheels electronics (WDEs) are mounted on the bottom of +X-Y and –X-Y panel. Radiator (OSR) and embedded heat pipes, for the +X side with sharing the same radiator as the S band transponder, are utilized for their thermal control. These radiators are also used for FMW thermal control. The ADE5 (Actuation Drive Electronics) shares the same radiator as the MI2U (Meteo Imager Interface Init) and the SCUs, using embedded heat pipes to spread heat. This radiator is also used for FMW thermal control. The S-band transponders share the same radiator as the WDEs that are located on the bottom +X side of the – Y panel, using embedded heat pipe to spread the heat. This radiator is also used for the FMW thermal control.

6.3 Appendages

The AOCS sensors, TT&C antennas and the reaction control thrusters are distributed all around the satellite. Their thermal control will be performed by correct balancing between allowable heat leak from the satellite and installed power, determined by the suitable conductive couplings with the satellite structure and the sizing of electrical heaters against external environment effects. IRES (Infra-Red Earth Sensor) thermal control requires its own OSR radiator (-Y oriented) and bent heat pipes to spread the heat from the equipment to the radiator. The use of heat pipe will decrease thermal gradient across IRES panel and minimize the mass impact due to the specific configuration of the IRES for the COMS.

7. CONCLUSIONS

The thermal design of the COMS was carried out to satisfy the requirements of three payloads. Single solar array wing is adopted in order to secure clear field of view of radiant cooler of IR (Infra-Red) meteorological sensor. Optical benches are used for earth sensor (IRES), ocean sensor (GOCI) and meteorological sensor (MI) to isolate thermally from the satellite. Two layers of heat pipes, vertically embedded and horizontal surface (external) heat pipes, are used to spread high dissipation generated by TWTs and OMUX of Ka-band.

Thermal analysis was performed to verify the thermal design of the COMS and the results showed that temperatures of the all units and structures were within the requirements. The thermal vacuum test for the final validation of thermal design will be carried out in large thermal chamber in KARI.

ACKNOWLEDGEMENTS

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