Spacecraft Control Center Of Lapan-Tubsat Micro Satellite

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Abstract

Spacecraft Control Center (SCC) of LAPAN-TUBSAT is prepared for supporting the mission operation of the satellite in orbit. This SCC is prepared in Rumpin, near Jakarta, and has link connection support with other ground station such as Spitzbergen, TU Berlin and later Biak-Indonesia. This paper describe preparation of Rumpin SCC and its interconnection to assure successful mission operation handling of LAPAN-TUBSAT

1. Introduction

LAPAN-TUBSAT micro satellite is a first Indonesian satellite which jointly developed by LAPAN and Technische University Berlin engineers. LAPAN-TUBSAT micro satellite has unique mission strategy. The agility of the micro satellite made it possible for surveillance of object in which the location is not pre-defined because its attitude and camera pointing can be manipulated off-nadir and controlled interactively (fig.1). Based on experience with DLR-TUBSAT, in which an interactive video surveillance has been proven, LAPAN-TUBSAT designed chose to fly CCD color video camera as main payload. Beside surveillance mission, this satellite also has short message store and forward as second mission.

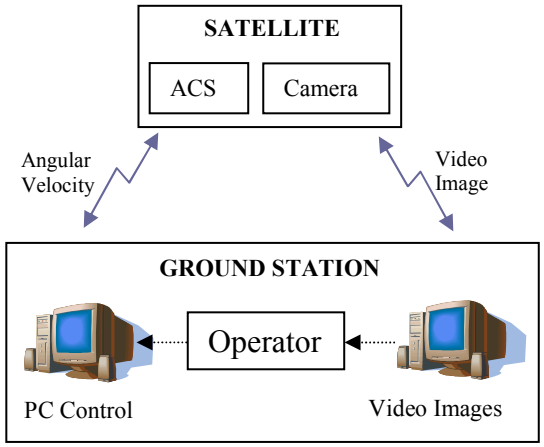

Fig. 1. Interactive Earth Observation

The uniqueness of LAPAN-TUBSAT lays in its ability to manipulate and control its attitude and camera pointing off-nadir interactively. Therefore, LAPAN-TUBSAT could monitor events such as forest fire, flood, landslide, volcano eruption, and ship or aircraft accidents.

LAPAN-TUBSAT micro satellite was launched by Indian PSVL-C7 as piggy back on 10th of January 2007 after several delays since October 2005. The rockets main payload will be the Indian cartographic satellite. As a secondary payload the launching cost will be reduced significantly.

With this launcher LAPAN-TUBSAT reach an altitude of 630 km with a 97.9 inclination degree and a period of 99.039 minutes. For monitoring the health of the satellite during its operation, LAPAN has developed one SCC and ground station which is called Rumpin Spacecraft Control Center (SCC), near Jakarta and Rancabungur Ground Station. There is a planning also to develop one more ground station in Biak Island (eastern side) in which ISRO (Indian Space Research Organization) also locating their ground station. As a satellite mission control, SCC Rumpin are connected to Spitzbergen (North Pole) and also with TU-Berlin ground station. With connection with spitzbergen station, SCC Rumpin has ability to see all satellite passes.

2. Lapan-Tubsat Communication Characteristic

LAPAN-TUBSAT satellite has two communication sub systems which are telemetry communication sub system and payload transmission sub system.

Two identical telemetry-and-telecommands (TTC) are used for communication. The TTC are operating at frequency of 437,325 MHz with FFSK modulation and has 1200 bps communication data rate and max 3,5 W hardware RF output. To avoid more power consumption, communication mode is made in half duplex mode. The omni directional UHF antennas are used for both TTC components.

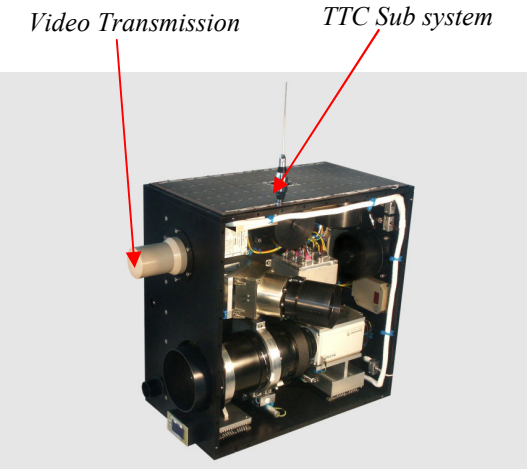

Figure 2. Lower Shelf of LAPAN-TUBSAT

For transmission of the video images, this satellite uses an S-band data transmission system. The system use an FM video modulation and work at 2220 MHz frequency. The RF power output is 3 Watt which spread using 8 dBi gain helix antenna in RHCP polarization. Since LAPAN-TUBSAT has two cameras on board, the video images of object on earth could be taken in low resolution (about 200 meters resolution) and in high resolution (about 6 meters resolution).

3. Rumpin Spacecraft Control Center

Rumpin SCC is prepared as main ground station and also center operation office for LAPAN-TUBSAT satellite and future LAPAN's satellite. Rumpin SCC is located near Jakarta. Rumpin SCC consists of 3 antenna systems. One parabolic antenna with 4.5 meter diameter consist of dual feed systems in X and S-band reception. The other one is steerable UHF antenna which uses a high gain Yagi antenna (fig.3). Rumpin SCC is also equipped with autonomous Doppler compensation.

The S-band antenna reception is directly connected with special S-band video receiver to receive the video signal from the satellite. UHF steerable antenna in ground station has function for uplink and downlink telemetry transmission for controlling LAPAN-TUBSAT satellite and also store & forward mission.

UHF antenna is connected to special LAPAN-TUBSAT's modem called ground station adapter. This station adapter is one of the devices of LAPAN-TUBSAT system. The functions of the device are as modem and buffer, which together with the RF systems in the ground station, communicate to LAPAN-TUBSAT. In the system configuration, the ground station adapter (ID=1) stand between the PC (ID=0) on the ground station and TTC (ID 2 and A) on satellite side.

The ground station adapter are consists of FFSK Modem, Analog Packet Data Interface and 16 Bit H8/536 Microprocessor, including data and program memory. The modem are configured at 1200 bps and half duplex setting. The Microprocessor control the modem and analog data interface. The ground station adapter also uses reset generator and voltage generator to control the power supply in its system. The adapter use RS232 interface with baud rate 38400 bps, 8 bit, 1 stop bit and none parity. The DB9 connector only uses 3 pins for Rx, Tx and Ground. For the Analog Data Interface to the UHF transceiver, a DB9 connector is used, with 3 pins as Packet Data, Push-to-Talk (PTT) and Receive 1200 bps.

Ground station adapter receives input command from a PC via serial communication interface. The command is then handled by H8/536 microprocessor, which its software base on four byte protocol. After the data and command packed with byte synchronizer, code word and CRC code, then data will be sent through synchronous communication to FFSK Modem. The modem will then modulate the packet and in parallel the microprocessor control the Analog Packet Data Interface to enable the PTT to transmit the data through Transceiver radio. The reverse working flow is done for downlink telemetry data from the satellite.

A video screen to see which object is looked by satellite also prepared. With this screen, satellite operator could interactively see the object and send command to satellite for attitude maneuver for special object on the earth which may few degrees off nadir.

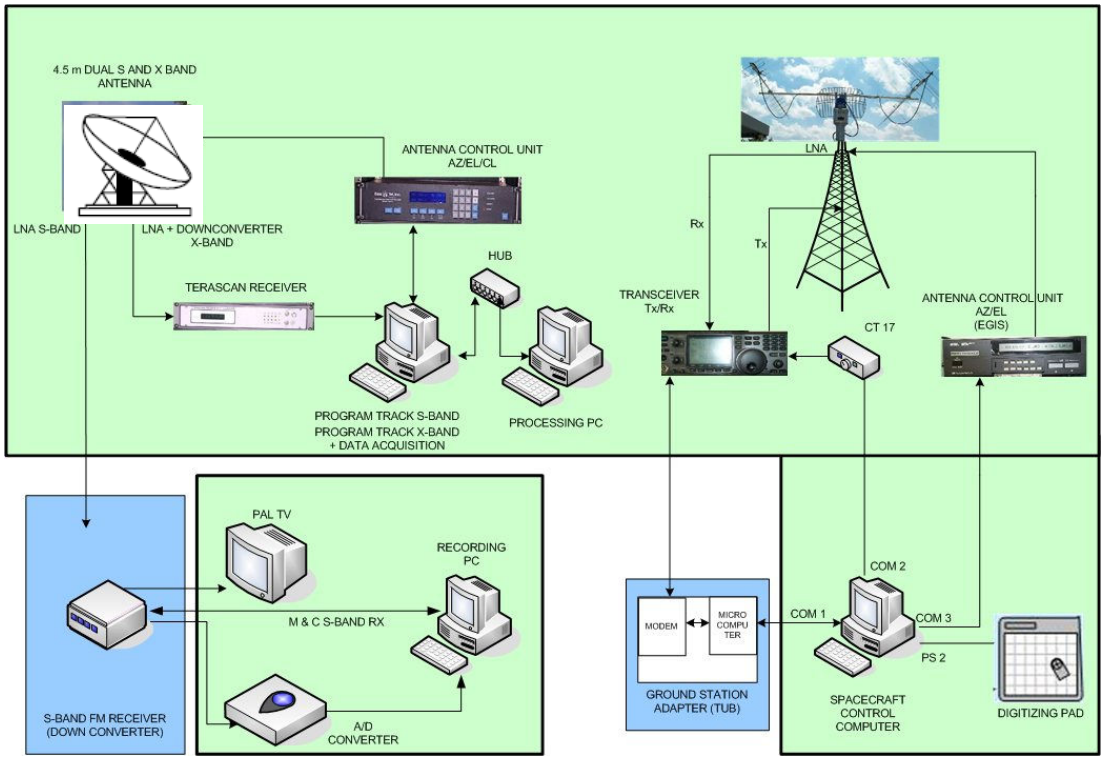

Figure 3: System Architecture of Rumpin SCC

As an SCC (fig.4), interconnection with other ground station is needed to have full support of the satellite mission. Rumpin SCC could connect to other Indonesian ground station as Rancabungur (Bogor) ground station and Biak ground station (eastern Indonesia). Rancabungur (Bogor) ground station is backup SCC in case Rumpin SCC got a problem and Biak ground station is developed for surveillance mission in eastern side of Indonesia.

As mentioned above Rumpin SCC are connected with Spitzbergen Ground Station in North Pole and TU-Berlin Ground Station. With this advantage connection, satellite operator in Rumpin SCC, could monitor all LAPAN-TUBSAT satellite pass and do necessary action if needed for the mission such as pre defined satellite attitude before reach Indonesia for surveillance mission.

All of the connections are done with internet connection which special client-server software for LAPAN-TUBSAT satellite. With this special software, satellite operator in emergency case could connect to all the ground stations and monitor satellite telemetry data even from their home.

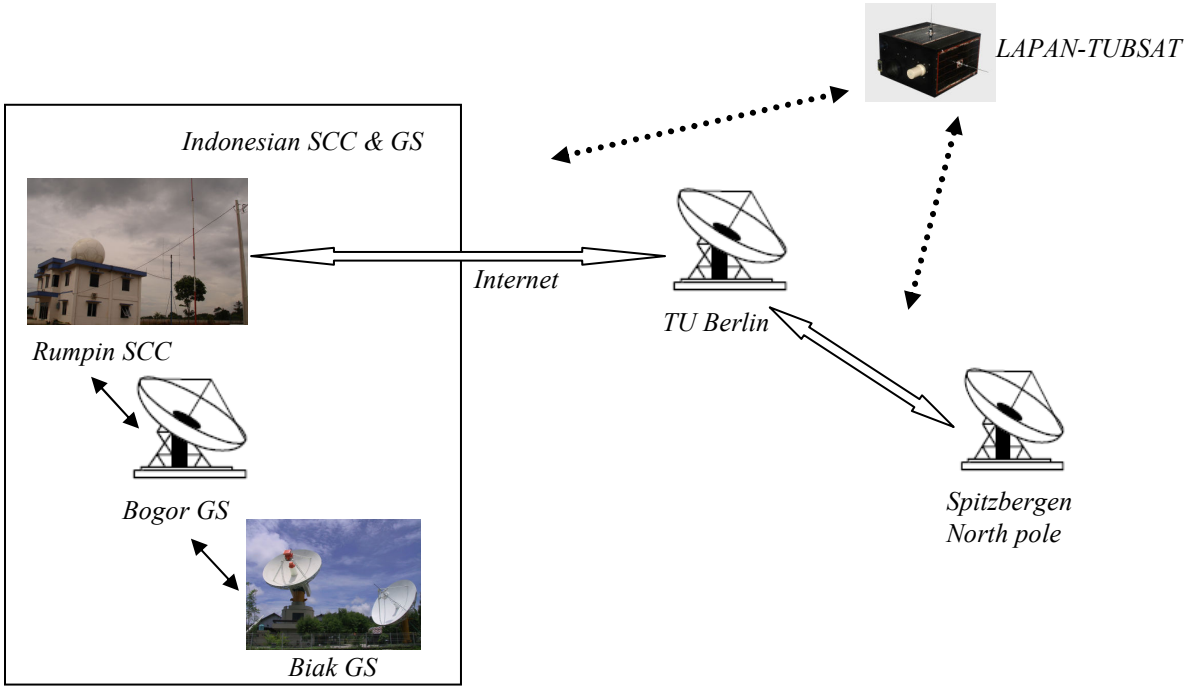

Figure 4: Rumpin SCC and interconnection with other four ground stations

Beside for LAPAN-TUBSAT satellite, Rumpin SCC is already used for receiving Modis data from Terra & Aqua satellite in X-band frequency. The Modis data is used for environment & weather monitoring application in Indonesia, especially in western side.

4. Link Budget & Test

Link budget calculation is needed to know theoretically the RF link quality between the satellite and ground station. This link calculation calculated the RF link assuming LAPAN-TUBSAT orbit is 630 km SSO and the ground station is in Rumpin. These calculations consist of UHF Up & Downlink calculation also Video downlink calculation in S-band frequency.

For UHF Uplink calculation with assumption that EIRP from ground station about 23,98 dBW then the margin to the satellite would be about 15,6 dB. Downlink calculation for UHF with EIRP satellite about 3,94 dBW, and G/T ground station about -10 dB/K then the margin at the ground station would be 17,55 dB. Both of calculations used maximum range between satellite and ground station and others loss parameters.

Concerning the S-band video downlink calculation from LAPAN-TUBSAT satellite to ground station Rumpin, calculation is carried out using 5^0, 10^0, 20, 45^0, 90^0 elevation, EIRP of satellite about 13,06 dBW and G/T of ground station about 15,32 dB/K, others parameters of the ground station and losses parameters assumption. The calculation result that available margin for the video receiver is between 4,4 to 16,87 dB for 5 to 90^0 elevations. Link calculation results theoretically mentioned that the link for all communication systems from LAPAN-TUBSAT satellite to or vice versa for operation is in enough margins.

The test to confirm the link budget calculation is conducted several times for UHF and S-band reception. This test is done using DLR-TUBSAT satellite which already in orbit and has similarity communication specification with LAPAN-TUBSAT satellite. Result of that test show good result which confirms the link calculation as Rumpin SCC could receive video picture from DLR-TUBSAT over Indonesia and also uplink command and telemetry downlink could be done properly.

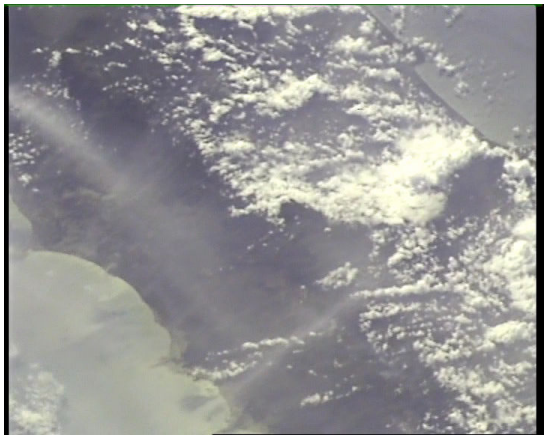

Figure 5: Video Picture of Bangka Island

Also after launch of LAPAN-TUBSAT, SCC Rumpin could immediately receive the signal from LAPAN-TUBSAT and also its video picture. Figure 5 shows the video picture over Bangka island near Sumatra which was taken with low resolution camera of LAPAN-TUBSAT.

A beautifull high resolution video picture over city of Latina, Italy was taken from LAPAN-TUBSAT could be seen in Figure 6.

Figure 6: High Resolution Video Over Latina, Italy

With assumption of nadir pointing, Figure 5 shows the communication coverage of LAPAN-TUBSAT satellite. The circle shows coverage of TTC in UHF band and the green shape show Rumpin Spacecraft Control coverage S-band video transmission during nadir pointing along satellite's ground track.

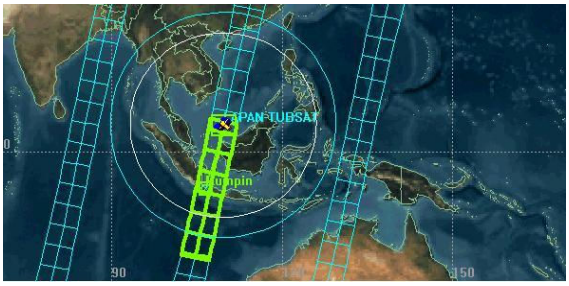

Figure 7: Communication coverage of LAPAN-TUBSAT

5. Conclusion

Rumpin Spacecraft Control Center is an important ground segment system for LAPAN-TUBSAT satellite mission operation. System infrastructure and ground station interconnection, assure that mission operation of LAPAN-TUBSAT will be done properly.

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