Interface and Configuration of the Hardware and Software for TT&C Station

Jai-Houng Leu,
Core Course-Applied Technology Division
General Education Committee

Chih-Yao Lo, and Cheng-I Hou

Department of Information Management
Yu Da College of Business, Miaoli County, Taiwan 361, R.O.C

Summary

The second satellite of National Space Program Office, the Republic of China, ROCSAT-2, has been announced as a LEO satellite to be launched in 2002, and defined to carry out the mission of earth remote sensing. The scientific data will be collected and downlink to the ground station at X band frequency, then routed to the proper destination via ground communication network. In the proceeding ROCSAT-1 project, NSPO has established two TT&C stations operated in S band. One of them is sited in the ASTRC. Based on the considerations of cost, schedule, and project risk, a thought under investigation is to modify one of the S band TT&C stations to S/X dual band to serve for both TT&C and remote sensing data downlink for ROCSAT-2. This project is concerned with the interface and configuration of the hardware and software. The mostly important things were trying to avoid possible schedule conflict in tracking these two LEO satellites. The results obtained are presented in this paper.

Key words:
Satellite communication .Remote sensing, band frequency

1. Introduction

In October 1991, the National Space Program Office (NSPO) was formally established as the implementing agency of the country's Fifteen-Year Space Program. The Space Project includes the necessary research work and the actual development and launching of three satellites with different missions and orbits, and the ground segment to complete this program. The ROCSAT Ground Segment (RGS) has two major goals: one was to build the basic infrastructure of the ground segment and the other was to assure the mission's success. It covers the establishment of remote sensing satellite receiving stations needed for receiving and processing data from domestic and foreign resource satellites, as well as ground stations capable of tracking, telemetry, and command (TT&C).

The first satellite of NSPO is ROCSAT-1, which was scheduled to be lunched in Dec. 1998 as a low-earth orbit science experimental satellite. The satellite will orbit the Earth at an altitude of 600 kilometers with an inclination of 35 degrees. ROCSAT-1 was designed to carry out several scientific research missions, and downlink housekeeping data to TT&C site in S band.

The S band TT&C stations were built in Chung-Li and Tainan in 1997; Figure 1 shows the general arrangement of TT&C antenna [2], and Figure 2 gives an pictorial view of the Tainan station. Both stations can track the same satellite simultaneously or track different satellite individually, and forms the dual redundant communication networks.

The second satellite of NSPO would be ROCSAT-2, and has been announced to be a LEO earth remote sensing satellite. The scientific data would be collected and downlink to the ground station at X band frequency, then routed to proper destination via ground communication network. Based on the considerations of cost, schedule, and project risk, a thought emerged naturally was concerning the feasibility of modifying one of the S band TT&C stations to S/X dual band to serve for both TT&C and remote sensing data downlink for ROCSAT-2.

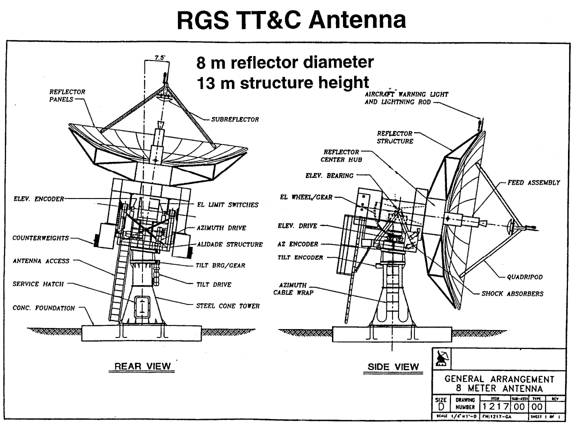

Figure 1： General Arrangement Of The Tt&C Antenna

Manuscript received November 5, 2007
Manuscript revised November 20, 2007

Figure 2： The Tainan Station

2. System Architecture

The RGS system consists of the TT&C stations (TT&C), the Ground Communication Network (GCN), the Mission Operation Center (MOC), the Mission Control Center (MCC), the Science Control Center (SCC), and the Flight Dynamic Facility (FDF).

According the mission operation plan, Chung-Li was defined to be the primary station and Tainan site plays the hot standby role. Thus in the future operation after ROCSAT-1 launched, telemetry data would be download to both TT&C sites, and then routed to NSPO via the front end data processing, whereas the command for spacecraft would be sent via the Chung-Li site mainly. See Figure 3 for system block diagram of RGS.

The modification for RGS would involve the SCC for science data processing, the MOC for performance, trend analysis and mission operation, establishing the ROCSAT-2 earth observation data processing center, and the TT&C site upgrade to receive and process X band remote sensing data. This paper is focused specifically on the modifications on the TT&C station. The specification of the current RGS TT&C is given in Table 1. Further, the configurations of the current TT&C hardware and software configuration employed are shown in Figure 4 and Figure 5[1], respectively.

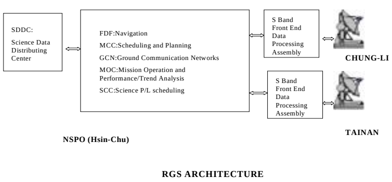

Figure 3： Rgs System Architecture

Table 1： summary of tt&c specification

Antenna	● 8 M diameter and 13M structure height ● Solid antenna reflector with 0.75 mm surface tolerance (RMS)
Frequency	● Uplink:2 GHz, EIRP 54 dBW, RHCP or LHCP ● Downlink: 2.2 GHz, G/T 21 dB, RHCP and LHCP combined
Tracking	● Tracking LEO satellite down to 300 Km ● Auto track, program track, ranging, Doppler measurement
Commanding	● PM/FM carrier modulation ● BPSK/QPSK subcarrier modulation ● Data format: PCM/NRZ-L/M/S ● 5 Mbps data rate ● CCSDS telemetry format
Telemetry Receiving	● PM/BPSK subcarrier demodulation ● Convolutional/Reed-Solomon decoding ● PCM/NRZ-L/M/S data coding ● 2 Mbps data rate ● CCSDS telemetry format

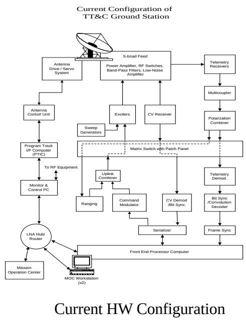

Figure 4： Current Tt&C Hardware Configuration

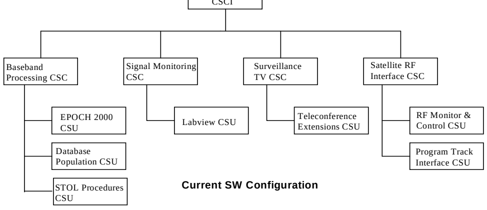

Figure 5： Current Tt&C Software Configuration

3. Requirement

ROCSAT-2 was featured with the capability of earth observation in 5-meter resolution with +/- 30-Km swath width on the 560-Km altitude orbit. Using 8 bits per pixel would result the data rate to be 150 MBbps.

The tracking requirements for the satellite at 560-Km altitude and in 97 degree inclination orbit, with 15 revolutions per day, could be satisfied by the existing TT&C stations. But the simultaneous contact of ROCSAT-1 and ROCSAT-2 was a potential problem to maintain system redundancy. Simulation shows there are 3532 seconds schedule conflict in a 90 days period. [3] The results are given in Figure 6.In order to confirm the validity of the proposed method, it has been first applied to the simulation experiment.

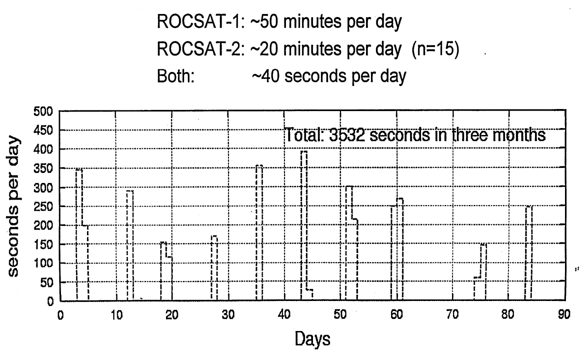

Figure 6： Simulation Results Of Simultaneous Contact

4. Modification

Based upon the consideration given above, it is logical to propose that the ground station can be modified to receive the scientific data at the rate of 150 Mbps using X band frequency, and at the same time to conduct the TT&C functions in S band frequencies. To achieve the objective, the TT&C station should be modified in such a way that the X band receiving capability is added on to the stations. The modification and upgrade include the antenna, RF/IF equipment, and baseband equipment.

Upgrading the current antenna is proposed as follow [4]:

(i) One 2" X band feed horn is added to the existing TT&C dish, and is placed at the focal point of the main reflector.

(ii) A dichroic sub-dish replaces the existing metal sub-reflector on the TT&C antenna, which is reflective at S band and transparent at X band.

Both the capability of receiving the S band and X band signals can be achieved with the modifications because the main reflector reflects both TT&C S band signal and remote sensing X band signal. The dichroic sub-dish reflects S band signal to S band feed, and allows X band signal passing through to the X band feed behind it. A proposed design is shown in Figure 7 and the estimated cost would be US$800,000 approximately.

Besides the X band horn and feed included in antenna upgrade, in RF/IF part the modification can be planned as follows [1]:

(i) X band converter for converting RF signal down to IF and vice versa for testing.

(ii) IF converter for converting IF signal to the operational band of demodulator.

(iii) Frequency synthesizer for supplying the IF converter with variable frequency signal.

In the baseband, software and hardware modifications are also needed, such as Bit Sync processor, and system integration job to merging the new capability into the current facility. A proposed modified ground system architecture and hardware are shown in Figure 8 and Figure 9, respectively.

Modifying the current TT&C station, instead of building a new X band facility, has the advantages in lower setup cost, shorter project schedule, and lower operation cost in the future.

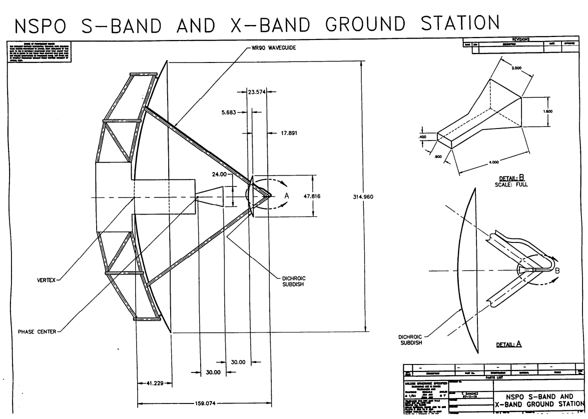

Figure 7： Design Of S/X Band Antenna

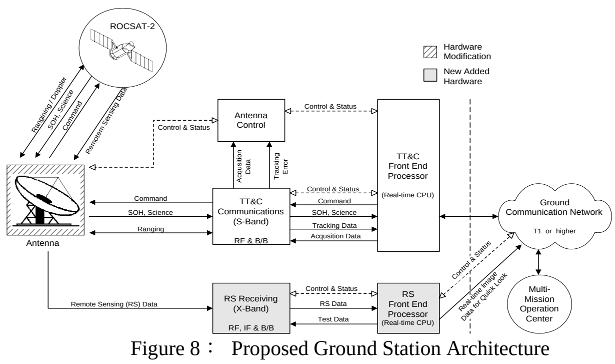

Figure 8： Proposed Ground Station Architecture

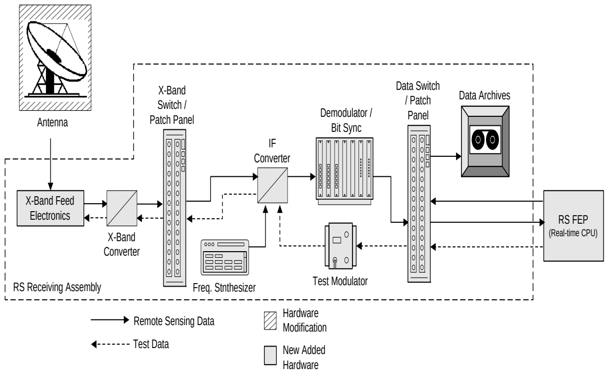

Figure 9： Modification Of Hardware

5. Concluding Remarks

Modifying current S band TT&C stations to S/X dual band to serve for both TT&C and remote sensing data downlink was discussed from the aspects of technical and financial issues. But the problem of simultaneous contact of ROCSAT-1 and ROCSAT-2 satellites in such system architecture causing the reliability concerns in communication networks should draw further attention. The other option always existed is to build a new X band ground station and define one S band station dedicated to ROCSAT-2 missions. The final decision has not been made yet.

Acknowledgment

This work was done under the technical and financial support of NSPO, National Science Council.

References

[1] Robin Kao, ROCSAT-2 Ground Station Preliminary Study Report. NSPO, Jan. 5 1998.
[2] Joe Valvano, Monica DeShone, Eric Chen, Presentation: Tracking, Telemetry & Command Subsystem Detailed Design, ATSC, May 7 1996.
[3] Presentation: ROCSAT-2 Mission Defination Mid-term Evalution (ROCSAT-2.PO.86.018), NSPO, Jan. 15 1998.
[4] George G. Cheng, Summary Of Some Antenna Issues On ROCSAT-1 & ROCSAT-2 Ground Stations, ANTCOM, Nov. 10 1997.
[5] Meeting Minutes Of ROCSAT-2 Ground Stations (ROCSAT-1.GS87.54), NSPO, APR. 23 1998.
[6] R. Holdaway, Ground System, “Spacecraft systems engineering,” 2nd edn, p.443 John Wiley & Sons, England, 1995.

Jai-Houng Leu received the B.S. degree in Aeronautics and Astronautics from National Cheng-Kung University, Taiwan in 1987, and his Ph.D. degrees also in Aeronautics and Astronautics by direct accessment from National Cheng-Kung University, Taiwan in 1993. He works for R&D project execution and management in Industrial Technology and Research Institute, MOEA, Taiwan from 1987 to 2002. Currently, he is the Assistant professor of the Department of Information Management, also dean of R&D Department, Yu-Da College of Business,Taiwan. He got some international licences of business(LICCEB) and proget management(IPMA). His research interests include random data analysis, remote sensing, statistical analysis, data transformation security and project management and analysis by system dynamics and puzzy theory.

Chih-Yao Lo received the MSc degree in Information Technology Department from UMIST in 1991. Currently, he is the Assistant professor of the Department of Information Management, Yu-Da College of Business. His research interests include Multi-agent, Game Theory, Hort Technology and Artificial Intellience.

Cheng-I Hou received the B.S. degree in Computer Science from Slippery Rock University in 1986, M.S. degree in Computer Science from Nova University in 1987 and his Ph.D. degrees in Computer Information Systems from Nova Southeastern University in 1993. Currently, he is the Assistant professor of the Department of Information Management, Yu-Da College of Business. His research interests include Wireless Networks, Office Automation, Artificial Intellience, Embedded Systems, Distance Learning and Horticulture Technology.