천리안위성 영상 수신 및 처리에 대한 백업 지상국 운영

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Backup Site Operation Of COMS Image Data Acquisition And Control System

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요 약

통신, 해양, 기상의 세 분야 복합 임무를 수행하는 천리안위성(Communication Ocean Meteorological Satellite: COMS)의 기상 및 해양 영상 자료 수신 및 처리에 대한 백업 지상국 운영의 특성 및 결과를 논하였다. 먼저, 기상 및 해양 영상 자료 수신 및 처리 백업을 위한 지상국 형상, 영상 자료 처리, 백업 운영 업무의 특성을 기술하였다. 그리고 성공적인 백업 운영 확인을 위해, 정규 운영 시작 이후 처음 3년 동안의 정규 운영 결과도 제시하여 하였다. 2011년 4월부터 2014년 3월까지 영상 자료 수신, 전처리, 위성 방송 배포에 대해 달성된 운영 성능 결과를 통계 분석 자료로 제시하였다.

Key Words : Communication Ocean Meteorological Satellite, COMS, MI, GOCI, IDACS, meteorological image, ocean image, image data reception and processing, satellite image broadcast

ABSTRACT

The backup site operation of the Image Data Acquisition and Control System (IDACS) for Communication Ocean Meteorological Satellite (COMS) is discussed in terms of the ground station configuration, image data processing, and the characteristics of backup activities for both the meteorological image data and the ocean image data. The well-performed backup operation of the COMS IDACS is also confirmed with the first three years normal operation results from April, 2011 to March, 2014. The operation results are analyzed through statistical approach to provide the achieved operational performance of the image data reception, preprocessing, and broadcast.

I. Introduction

The COMS for the hybrid mission of meteorological observation, ocean monitoring, and telecommunication service was launched onto Geostationary Earth Orbit on June 27, 2010. The COMS is currently under normal operation service on 128.2° East of the geostationary orbit since April 2011. In order to perform the three missions, the COMS has 3 separate payloads, the meteorological imager (MI) [1], the Geostationary Ocean Color Imager (GOCI) [2], and the Ka-band communication payload [3]. The MI and GOCI perform the Earth observation mission of meteorological observation and ocean monitoring, respectively [4]. According to the user requirements, the meteorological mission is operated to continue 24 hours a day and 365 days a year, and the ocean mission is operated to be performed 8 times a day and 365 days a year.

The normal operation of the COMS Earth observation mission is performed by the cooperation of the three COMS ground stations which are the National Meteorological Satellite Center (NMSC) of Korea Meteorological Administration (KMA), the Korea Ocean Satellite Center (KOSC) of Korea Institute of Ocean Science & Technology (KIOST), and the Satellite Operation Center (SOC) of the Korea Aerospace Research Institute (KARI) as shown in the Figure 1. In the normal operation, the NMSC provides the meteorological mission request and takes the primary role for the reception, preprocessing, postprocessing, archive, distribution

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(satellite broadcast and ground network), and application of the meteorological image data. The KOSC provides the ocean mission request and takes the primary role for the reception, preprocessing, postprocessing, archive, distribution, and application of the ocean image data. The KARI SOC takes the responsibility for the satellite control including mission planning of Earth observation [5, 6] and provides the backup of the reception, preprocessing, archive, and satellite broadcast distribution of both the meteorological image data and the ocean image data of the COMS.

In this paper the backup site operation of the IDACS for the COMS is discussed for the preprocessing and broadcast of both the meteorological and the ocean image data with analysis of the first three years normal operation results.

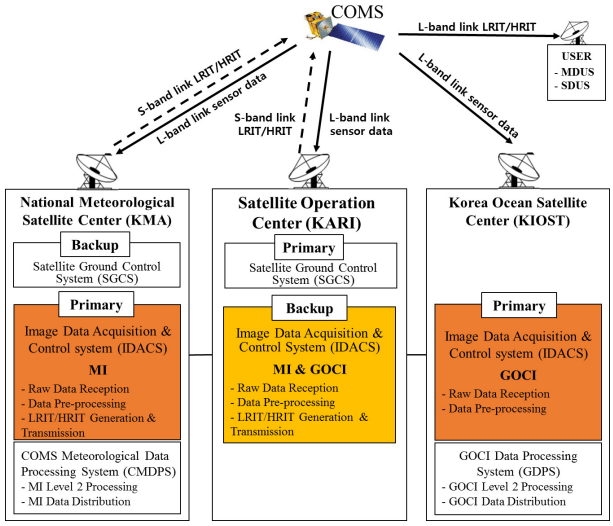


Figure 1. The ground station configuration for the COMS meteorological and ocean image data flow

Ⅱ. Configuration of Image Data Acquisition And Control System (IDACS)

The COMS IDACS has been developed for the dedicated purpose of the reception, preprocessing, archive, and satellite broadcast distribution of the COMS image data [7]. The three copies of the IDACS have been installed individually in the three COMS ground stations of the NMSC, the KOSC, and the SOC with the modifications suited to their role and responsibility. The IDACS performs the image data acquisition from the satellite, the data decomposition, the image preprocessing of the radiometric/geometric calibration, the Low Rate Information Transmission (LRIT) / High Rate Information Transmission (HRIT) data generation, the LRIT/HRIT data transmission to the satellite, the monitoring & control of data acquisition & transmission, and the external data exchange between ground stations. It is noted that the KARI IDACS provides the simultaneous process of the both the meteorological data and the ocean data to support the backup of both IDACSs of the NMSC and the KOSC, while the NMSC IDACS is dedicated to the meteorological mission and the KOSC IDACS is dedicated to the ocean mission, respectively.

The IDACS is composed of 'Data Acquisition and Transmission Subsystem (DATS)', Image Preprocessing Subsystem (IMPS), LRIT/HRIT Generation Subsystem (LHGS), and 'DATS Control & Monitor (C&M)'. The normal operation configuration of the IDACS at the KARI SOC is shown in the Figure 2 with both the internal and the external interfaces of the IDACS.

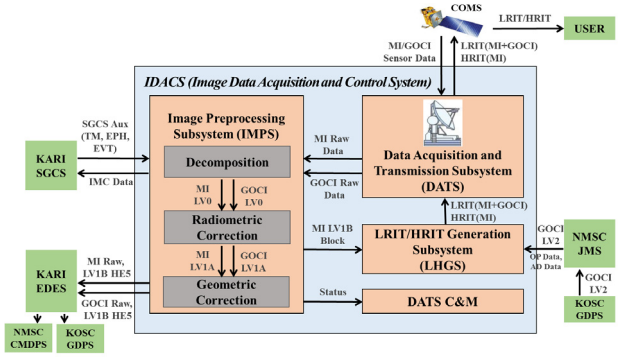


Figure 2. The configuration of the IDACS at the KARI SOC

After the MI and the GOCI take their image data for the Earth observation independently, the satellite combines the image data of the MI and GOCI to form the Radio Frequency (RF) signal which is transmitted to the Ground Stations. The combined raw image data of the MI and GOCI are called the sensor data in short. The DATS of the IDACS receives the RF signal of the sensor data from the satellite through the antenna and the associated RF parts. And then the modem part of the DATS transforms the sensor data into the raw image data of the MI and the GOCI through the demodulation, the inverse transformation of space data formatting, and the necessary decoding. The separation of the MI and the GOCI data is done at the end of the DATS processing.

The IMPS gets the raw image data as inputs for image correction processing. At first, the IMPS decomposes the

raw data to generate the level 0 product for the MI and the GOCI data, respectively. Next, the IMPS performs the radiometric correction to generate the level 1A product of each image of the MI and the GOCI. Finally, the IMPS carries out the geometric correction to make the level 1B products of the MI and the GOCI data. All the products of MI and GOCI data are stored in the data server of the IMPS. The raw image data and the level 1B products are delivered in real time to the NMSC CMDPS and the KOSC GDPS through the KARI External Data Exchange Server (EDES) for the backup of the missing data at each primary site. As ancillary inputs for the image processing, the IMPS receives the auxiliary data used for the satellite control, such as the telemetry (TM) of the satellite, the ephemeris (EPH) of flight dynamics, and the event files (EVT) of mission planning, from the KARI Satellite Ground Control System (SGCS). The IMPS generates the Image Motion Compensation (IMC) data and sends to the KARI SGCS for the feedback of the geometric correction results to the satellite operation.

The IMPS also generates the level 1B block data of the MI data, which is sent to the LHGS. The LHGS combines the MI level 1B block data and the GOCI level 2 data of the KOSC GDPS together to generate the HRIT data for the MI only and the LRIT data for the MI and the GOCI. These LRIT/HRIT data are fed into the DATS. The DATS converts the LRIT/HRIT data to the RF signal and sends them to the COMS for the real time broadcasting through the satellite to the worldwide users.

The main purpose of the DATS C&M is the status monitoring and the remote control of the IDACS subsystems. The DATS C&M provides the status monitoring and the remote control of the DATS. The DATS C&M also is used for the monitoring of the IMPS and the LHGS status as well as the IDACS-related information of the 'Telemetry, Tracking, and Command (TTC)' of the SGCS at the KARI SOC. The DATS C&M has the remote function to monitor the status of the other between primary and backup IDACS.

Ⅲ. Characteristics of Backup Activities

The IDACS provides the real time operation 24 hours a day 365 days a year for the image data acquisition, preprocessing, and broadcasting from the satellite in space to the users on the ground. For both the continuous real time operation and the maximization of image data availability, the primary IDACS at the user site requires the support by the backup site IDACS with independent full-coverage backup. For the COMS, 24 hours a day 365 days a year, hot backup operation is provided by the KARI SOC which is located to the site separated from the both user sites.

1. Backup for Image Data Acquisition and Processing

The backup site operation of COMS IDACS is conducted by the KARI SOC. The backup site operation by the KARI SOC provides fully independent backup with independent equipment, separated facilities, and different human resources for the full processes from the image data reception to the preprocessing of the level 1B for both the MI and GOCI data.

The backup site operation also provides the real time operation of the image data acquisition and preprocessing 24 hours a day 365 days a year for the MI and 8 times a day 365 days a year for the GOCI, respectively. The current baseline of the backup for the missing data of each primary site IDACS is the real time image data transfer through the KARI EDES which has on-line connection to each primary site. Upon user request, off-line support can be used for the backup of image data loss at the primary site IDACS, too.

Since the KARI SOC also performs the satellite operation of the COMS, KARI SOC provides the simultaneous operation of the primary operation of satellite control and the backup operation for image data acquisition and preprocessing. This simultaneous operation has some benefits to take prompt and effective actions for the resolution of ground station problems linked to the satellite operation, because the image data reception and preprocessing depends on the satellite operation plan and status.

2. Backup for Image Data Broadcasting

The backup site operation of COMS IDACS provides fully independent backup with independent equipment, separated facilities, and different human resources for the full processes from the image data reception to the broadcasting of the LRIT/HRIT data for both the MI and GOCI.

The backup site operation provides the real time operation of the broadcasting of the LRIT/HRIT data based on the NMSC request.

The KARI SOC has no way to acquire the LRIT/HRIT data via the COMS. The KARI SOC monitors the output status of the LHGS for the uplink of the LRIT/HRIT data to the satellite. The NMSC has the sole responsibility to monitor the reception status of the LRIT/HRIT data.

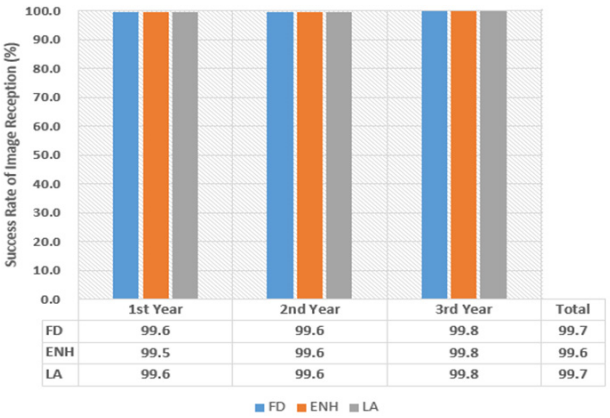
Ⅳ. Backup Operation of the KARI IDACS

Since April 2011, the real time backup site operation of the COMS IDACS has been conducted by the KARI SOC in order to support the COMS normal operation service for the users. This paper provides the results of the backup operation by the KARI IDACS during the three years normal operation from April, 2011 to March, 2014. The operation results are analyzed through statistical approach to provide the achieved operational performance of the image data reception, preprocessing and broadcast.

In order to assess the operational performance of the image data reception, image reception success rate is defined as the ratio of the number of the successfully received images with respect to the number of the images observed by the satellite, that is the ratio of the number of the raw images with respect to the number of the images of the mission plan uploaded to the satellite. The fail of the image data reception in the backup site is mainly due to the maintenance activities for the DATS including the antenna, which are carried out regularly for the system checkup and repair. During the maintenance the DATS including the antenna can miss the data from the COMS satellite depending on the antenna direction and the DATS configuration under the checkup or the repair.

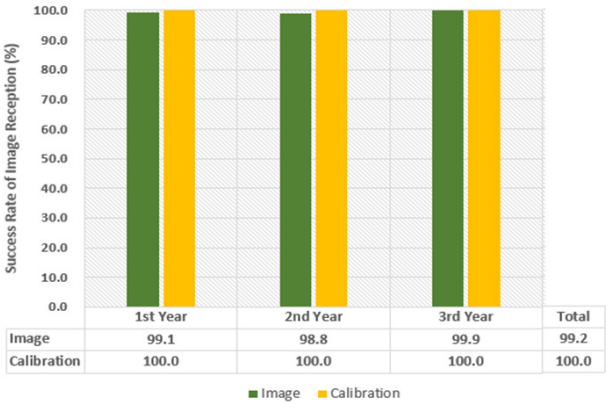
The Figure 3 and 4 show the image reception success rate of the meteorological and the ocean images achieved by the backup site IDACS at the KARI SOC during the three years normal operation. For the meteorological mission during the three years normal operation, the image reception success rates of 99.7%, 99.6%, and 99.7% are achieved for the Full Disk (FD) image, the Extended Northern Hemisphere (ENH) image, and the Local Area (LA) image, respectively. It is noted that the 3rd year (April 1, 2013 ~ March 31, 2014) operation results in better preprocessing success rate than the 1st year (April 1, 2011 ~ March 31, 2012) and the 2nd year (April 1, 2012 ~ March 31, 2013) operation for all the image types. This means that the meteorological image reception of the KARI IDACS gets to stable and well-performing status since the 3rd year operation.

For the ocean mission during the three years normal operation, the image reception success rates of 99.2%, and 100.0% are achieved for the ocean image and the calibration image, respectively. It is noted that the 3rd year operation results in better preprocessing success rate than the 1st and 2nd years operation. So that the ocean image reception of the KARI IDACS reaches stable and well-performing status since the 3rd year operation.



	1st Year	2nd Year	3rd Year	Total
FD	99.6	99.6	99.8	99.7
ENH	99.5	99.6	99.8	99.6
LA	99.6	99.6	99.8	99.7

Figure 3. The reception success rate of meteorological image



	1st Year	2nd Year	3rd Year	Total
Image	99.1	98.8	99.9	99.2
Calibration	100.0	100.0	100.0	100.0

Figure 4. The reception success rate of ocean image

As the index to assess the operational performance of the image data preprocessing, the image preprocessing success rate is defined as the ratio of the number of the successfully preprocessed images with respect to the number of the images observed by the satellite, that is the ratio of the number of the level 1B images with respect to the number of the images of the mission plan uploaded to the satellite. The main reason for the failure of the image

preprocessing after the image data reception is abnormal behavior of the IMPS in the process of the radiometric correction and the geometric correction depending on the image data status and the hardware and software operation condition. It is not easy to keep the system in stable condition during 24 hours a day and 365 days a year. These continuous operation during long period can generate various anomaly in terms of the stability of the hardware and the software.

The Figure 5 and 6 show the image preprocessing success rate of the meteorological and the ocean images achieved by the backup site IDACS at the KARI SOC during the three years normal operation. For the meteorological mission during the three years normal operation, the image preprocessing success rates of 99.1%, 99.2%, and 99.3% are achieved for the FD image, the ENH image, and the LA image, respectively. Please take notice that the 2nd year operation results in better preprocessing success rate than the 1st year operation for all the image types. And the 3rd year operation shows all most same level of the preprocessing success rate as the 2nd year operation, so that the meteorological image preprocessing of the KARI IDACS runs into stable and well-performing status since the 2nd year operation.

For the ocean mission during the three years normal operation, the image preprocessing success rates of 99.0%, and 100.0% are achieved for the ocean image and the calibration image, respectively. It is noted that the 3rd year operation results in better preprocessing success rate than the 1st and 2nd years operation. So that the ocean image preprocessing of the KARI IDACS gets to stable and well-performing status since the 3rd year operation.

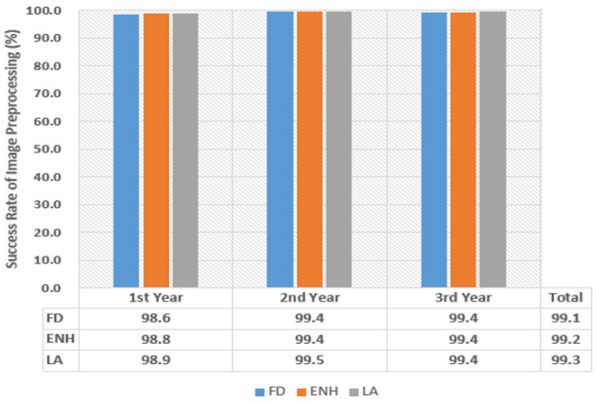


Figure 5. The preprocessing success rate of meteorological image

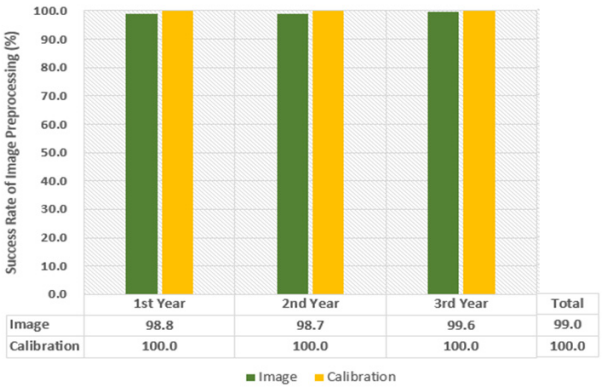


Figure 6. The preprocessing success rate of ocean image

In order to assess the operational performance of the image data broadcast, the image broadcast success rate is defined as the ratio of the number of the successfully broadcasted images with respect to the number of the images observed by the satellite, that is the ratio of the number of the transmitted LRIT/HRIT images with respect to the number of the images of the mission plan uploaded to the satellite. Please keep it in mind that the broadcast success rate is for not the received LRIT/HRIT images but the transmitted LRIT/HRIT images. By the definition of the image broadcast success rate, the failure of the image broadcast includes the fails of the reception and the preprocessing of the image data. The main failure of the image broadcast in the backup site operation has been due to the failure of the image preprocessing in the backup site operation.

The image broadcast backup operation by the KARI SOC has been conducted 24 times for the total accumulated time of 1019 hours during the three years normal operation as shown in the Table 1. The Figure 7 and 8 show the image broadcast success rate of the meteorological and the ocean images achieved by the backup site IDACS at the KARI SOC for the 24 backup operations during the three years normal operation. For the meteorological mission during the three years normal operation, the image broadcast success rates of 99.5% and 99.7% are achieved for the FD and the ENH image, respectively. The LA image is not broadcasted via the satellite. For the ocean images during the three years normal operation, the KARI IDACS operates in perfect performance with the image broadcast success rates of 100.0%.

Table 1. Broadcast backup operation results during the three years normal operation

	Backup Operation Number	Backup Operation Duration(hours)
1st year operation	7	375
2nd year operation	8	416
3rd year operation	9	228
Total	24	1019

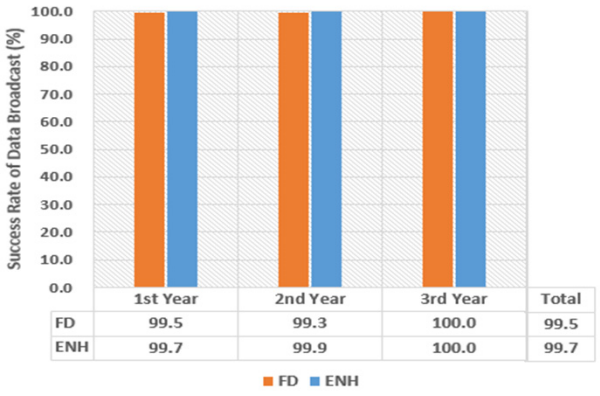


Figure 7. The broadcast success rate of meteorological image

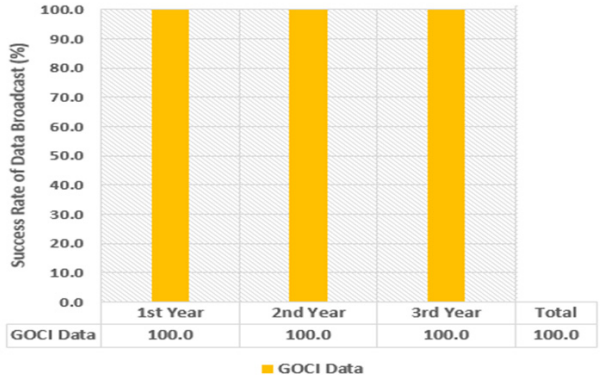


Figure 8. The broadcast success rate of ocean image

Ⅴ. Conclusions

The backup site operation of the IDACS for the COMS is discussed for the preprocessing and broadcast of both the meteorological image data and the ocean image data.

The well-performed backup operation of the COMS IDACS is also confirmed with the first three years normal operation results from April, 2011 to March, 2014. For the meteorological mission, the image preprocessing success rates of 99.1%, 99.2%, and 99.3% are achieved for the FD, the ENH, and the LA image, respectively and the image broadcast success rates of 99.5% and 99.7% are achieved for the FD and the ENH image, respectively. For the ocean mission, the image preprocessing success rates of 99.0% is achieved for the ocean image and the KARI IDACS operates in perfect performance with the image broadcast success rates of 100.0%.

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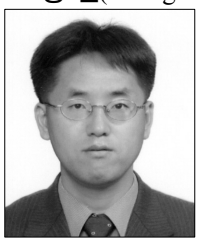

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