17th International Conference on Space Operations, Dubai, United Arab Emirates, 6 - 10 March 2023.

SpaceOps-2023, ID # 369

Operational Status of COMS: Mission Extension and Termination

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Abstract

Communication, Ocean, and Meteorological Satellite (COMS), which has been successfully launched at Guiana Space Center in 2010, is one of geostationary satellites in operations by Korea Aerospace Research Institute (KARI). COMS has different three payloads, Meteorological Imager (MI), Geostationary Ocean Color Imager (GOCI), and Ka-band payload for a communication mission. Although COMS has already fulfilled the original 7-year mission lifetime on 31st March 2018, the satellite maintained an appropriate health status to be operated more than the mission lifetime. As a result, after the impact assessment for entire subsystems in terms of both satellite and ground station, the 2-year mission extension was determined for all missions. Even though some of anomalies irregularly happened due to the degradation of satellite aging or severe space environment, the satellite health status was sufficiently satisfied enough to extend operational mission lifetime more.

Since Geo-Kompsat-2A/2B (GK-2A/2B), which are the subsequent satellite for the Meteorological and Ocean mission, were successfully launched and normally settled in the geostationary orbit, these missions for COMS were eventually terminated in March 2020 and 2021, respectively, with the outstanding results as the first geostationary satellite in Korea. Consequently, Ka-band payload is the currently operating payload for COMS. Also, satellite bus operation was influenced by these changes in payload operations such as thermal effect. Moreover, in order to conserve the remaining propellant, the orbital characteristic of COMS has been changed to the inclined orbit without the North-South station keeping (NSSK) maneuvering from April 2021. Because the succeeding communication satellite has to smoothly take over from COMS communication mission, the operational lifetime of satellite should be extended as much as possible. In this study, the operational status of COMS is described in detail with regard to the multi-mission geostationary satellite operations. Through the mission extension and termination, we figured out that operational constraints and procedures for COMS should be changed as well to adapt the new environment. Furthermore, the remaining task for COMS such as inclined-orbit operation and de-orbit operation will be mentioned.

Keywords: COMS, MI, GOCI, Geostationary Satellite, Mission Termination

Acronyms/Abbreviations

AMI	Advanced Meteorological Imager
COMS	Communication, Ocean, and Meteorological Satellite
ETRI	Electronics and Telecommunications Research Institute
EWSK	East-West Station Keeping
GK-2A/2B	Geostationary Korea multi-purpose satellite-2A/2B
GOCI	Geostationary Ocean Color Imager
KARI	Korea Aerospace Research Institute

KIOST	Korea Institute of Ocean Science and Technology
KMA	Korea Meteorological Administration
MI	Meteorological Imager
MPS	Mission Planning Subsystem
NSSK	North-South Station Keeping
SGCS	Satellite Ground Control System

1. Introduction

Korea Aerospace Research Institute (KARI) is normally operating both geostationary and low earth orbit (LEO) satellites. Among the geostationary satellites in operation, Communication, Ocean, and Meteorological Satellite (COMS), which is the oldest one, was successfully launched by an Ariane 5 launch vehicle in 2010 and is currently operating in normal. COMS is equipped with a total of three payloads: MI for meteorological observation, GOCI for observing marine phenomena around the Korean Peninsula, and Ka-band payload for communication mission. The development project for COMS was a multi-ministerial project in which various government agencies and research institutes are participating. KARI takes charge of satellite operation and control, the satellite images for GOCI/MI can be received and processed by Korea Institute of Ocean Science & Technology (KIOST)/Korea Meteorological Administration (KMA), respectively, and Electronics and Telecommunications Research Institute (ETRI) has a central base station for the Ka-band communications (see Fig. 1).

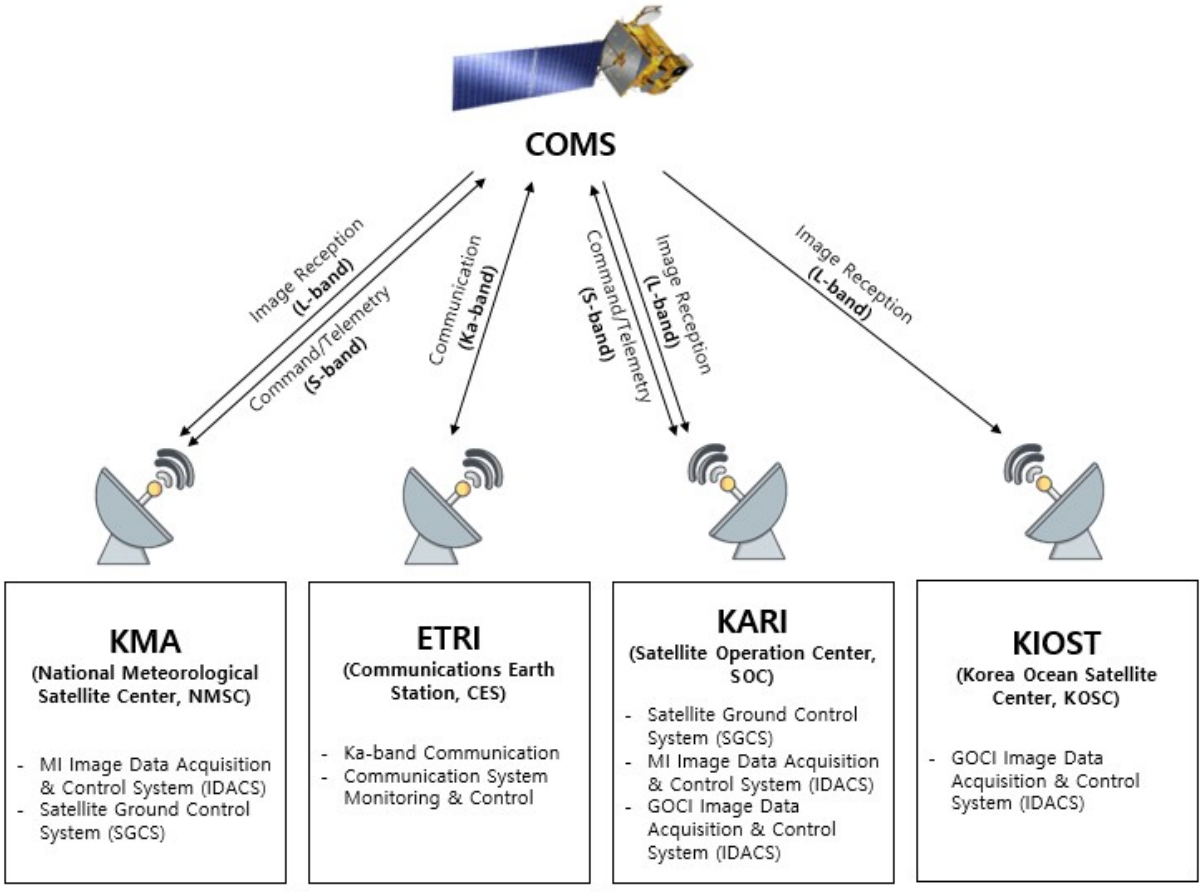


Fig. 1 COMS ground segment architecture (original)

Originally, the mission lifetime for COMS is 7.7 years after the launch date, in other words, COMS mission lifetime was satisfied in Mar. 2018. The health status of satellite at the end of original mission lifetime was excellent to be operated more in space environment. In addition, three application organizations (ETRI, KIOST, KMA) was also actively using COMS and willing to continuously utilize the payload, so all of them agreed to extend the satellite mission operation period. The extension of the satellite mission could be decided according to the opinion of each organization for the mission extension on whether to utilize the payload, and if the satellite mission was no longer desired, the mission termination procedure was performed instead of the mission extension. Actually, each application organization was in development the subsequent satellites, Geostationary KOrea Multi-Purpose SATellite-2A/2B (Geo-KOMPSAT-2A/2B, GK-2A/2B), when deciding to extend the COMS operational period at first. In other words, satellite mission extension could be affected by various conditions including not only the satellite health status, but the development status of a subsequent satellite. From the next chapter, the mission characteristics of COMS, which has been in operation for about 13 years will be explained in detail, and explain what changes have occurred in terms of satellite operations when mission extension or mission termination occurs.

2. Mission extension and termination for COMS

COMS, which is the multi-mission satellite and has been operating stably during the normal operation period, reached its mission lifetime in March 2018. As a result, COMS has performed a total of four operational mission extensions from the end of mission lifetime to the present, and in the process, a total of two missions were terminated depending on the opinion of the application organization or operational situation. As shown in Table 1, all three missions were decided to be extended for 2 years at the first. Each application organization has expected to utilize the payload data as much as possible before the following satellite launched. Also, because of right after the end of mission lifetime, both satellite health status and the remaining fuel were good enough to extend all missions for 2 years.

In case of the 2nd mission extension, there was the first official mission termination among three operational missions of COMS. The subsequent satellite for meteorological observation was successfully launched in December 2018, and GK-2A was in normal operation status with Advanced Meteorological Imager (AMI) payload, which has higher resolution and better performance than COMS MI, after the In-Orbit Test (IOT) period. Therefore, it was decided that the meteorological mission would end naturally, and GK-2A satellite took over and continues to perform the mission. In the 3rd mission extension, it can be confirmed that the ocean mission has ended in Table 1, and like the meteorological mission, the following satellite GK-2B, which will take over the ocean mission of COMS, was successfully launched and was in normal operation, so there was no major problem with the end of the ocean mission. Therefore, from the 3rd mission extension, the Earth observation missions no longer exists in COMS satellite operation.

Table 1. Characteristics of mission extensions for COMS

	Period	Extended Mission	Terminated Mission
1st Mission Extension	'18.4.1-'20.3.31 (2yrs)	Communication Ocean Meteorology	-
2nd Mission Extension	'20.4.1-'21.3.31 (1yr)	Communication Ocean	Meteorology
3rd Mission Extension	'21.4.1-'22.3.31 (1yr)	Communication	Ocean
4th Mission Extension	'22.4.1-'23.3.31 (1yr)	Communication	-

As the meteorological and ocean missions were terminated in a row, only the extension of the communication mission is being decided and operated for the current 4th mission extension. Unfortunately, since a successor satellite to take over the communications mission is currently under development, COMS should be operational for several more years. Due to the characteristics of geostationary satellites, because of the limitations of continuously extending missions with limited fuel, COMS operating characteristics had to be changed. The next chapter will show what changes have occurred in the satellite operation situation following the extension of the mission.

3. Operational Status of COMS

COMS is located over the equator at 128.15° east longitude, approximately 36,000 km from the earth, and its original mission was to be a multi-mission satellite that simultaneously performs communications, ocean, and meteorological missions. Therefore, in order to increase the accuracy of the earth observation, the north-south and east-west directions were maintained by continuously using propellant to be located within the station keeping box. However, as all earth observation missions ended, it was no longer necessary to perform north-south station keeping maneuvers. Due to these changes for the operational circumstance, there have been major changes not only to satellite but also to Satellite Ground Control System (SGCS).

3.1 MI/GOCI imaging stop

MI can observe meteorological phenomena on the Korean Peninsula, Northern Hemisphere, and global regions through 1 visible channel with 1 km spatial resolution and 4 infrared channels with 4 km spatial resolution, and GOCI can observe the marine environment around the Korean Peninsula through 6 visible bands and 2 Near Infra-Red (NIR) bands with a higher spatial resolution (500 m) (see Fig. 2). Especially, GOCI is the first geostationary ocean color observation in the world, and it can observe the ocean phenomena surrounded by Korean peninsula 8 times in a day.

As explained in the previous chapter, the meteorological and ocean missions were terminated in April 2020 and April 2021, respectively, and imaging mission was simultaneously stopped at the mission terminating date. Since imaging missions were terminated, mission planning for imaging through Mission Planning Subsystem (MPS) is not necessary anymore. Although mission constraints were applied according to the original satellite operation concept designed to simultaneously operate two Earth observation payloads, operating concept for mission planning was also changed since there are no more imaging missions at all. As a result, different mission constraints should be applied when COMS mission schedule are planned comparing with prior to mission termination (see Fig. 3).

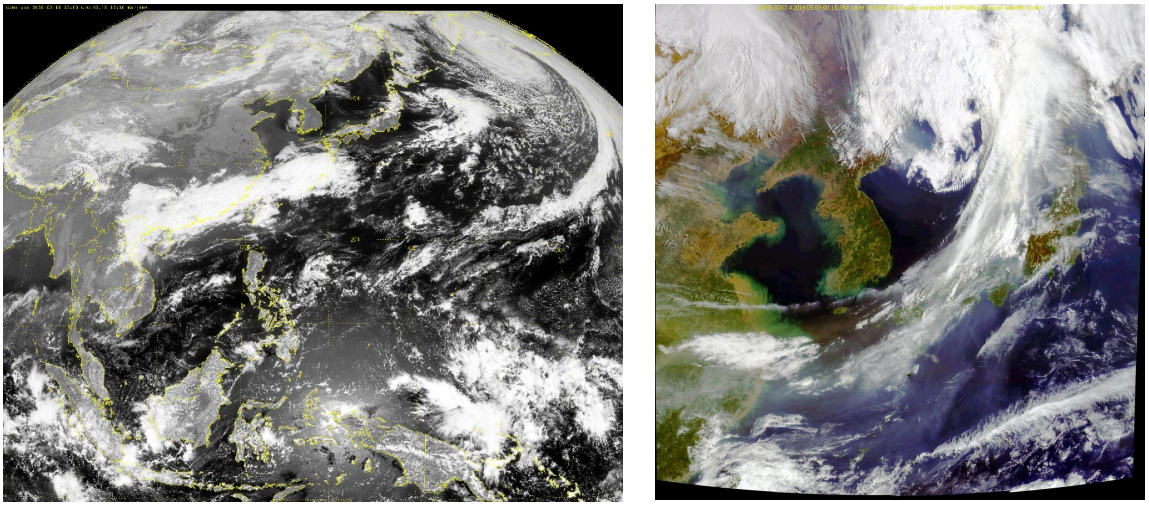
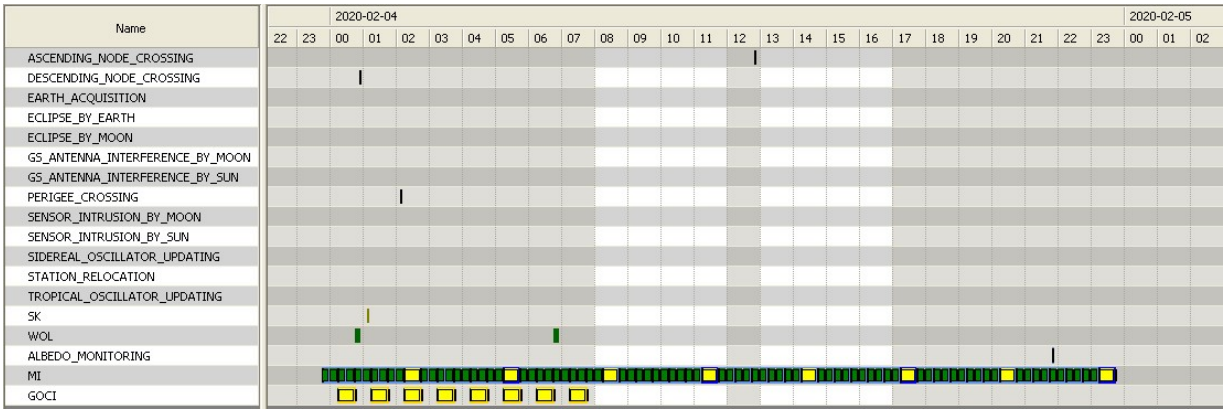


Fig. 2 Image example for MI (left) and GOCI (right)

(a)



(b)

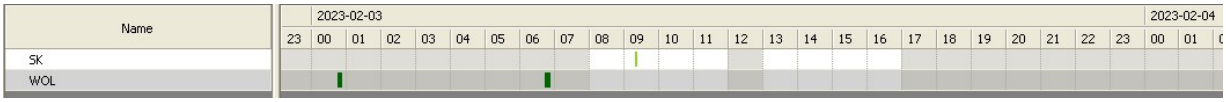


Fig. 3 COMS mission planning example (a) before and (b) after the mission terminations

Moreover, according to the mission termination, operation mode of payload also changed. In order to operate satellite stably in terms of thermal, MI has permanently switched to stand-by mode from operational mode in July 2020 after the investigation. Meanwhile, GOCI has no other operation modes, the status of GOCI is identical as normal operations when no imaging, which means the closed shutter.

3.2 Inclined-orbit operations

Since COMS was originally designed to operate in geostationary orbit, the station keeping maneuvering in north-south and east-west directions is essential to maintain the satellite inside the station keeping box of 0.1 degrees horizontally and vertically. After both meteorological and ocean missions were terminated, however, the concept of satellite operation has been changed to the inclined-orbit operation without performing north-south station keeping (NSSK) to prolong the mission lifetime. As a result, the orbital inclination, is continuously increasing (see Fig. 4), the rate of increase in orbital inclination is about 0.9 degrees per year. In fig. 4, (a) is the starting date of the inclined-orbit operations, and (b) indicates the period performed NSSK maneuvering temporarily because of the operational constraint, which could be settled by updated the current orbital inclination periodically.

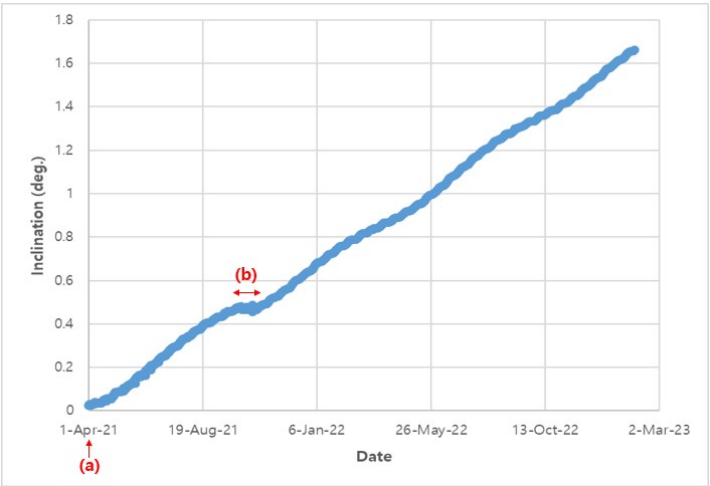


Fig. 4 Trend analysis for the inclination

As mentioned in chapter 2, the following satellite for communications mission is still in development, and mission continuity requires communications mission of COMS to continue for several more years. In order to save the propellant for operating the satellite as much as possible, the operational concept of COMS was changed to the inclined-orbit operations. The original design of COMS operations was not appropriated within the inclined orbit, an analysis for increasing inclination as of 5 degrees has been additionally performed. As a result, the actual orbital inclination, which is currently almost 1.6 degrees, is updated once a month as the inclined-orbit management.

4. Conclusions

COMS has been operating stably for about 13 years since its launch in 2010. After a successful mission lifetime of 7.7-year, there have been four mission extensions. COMS, which had three missions, is currently only performing communications mission, and the others, meteorological and ocean missions, were completed in March 2020 and March 2021, respectively. As a result, the ground architecture for COMS operations in current was totally changed as shown in Fig. 5, ETRI is the only application organization for communications mission. The health status data for the payload can be delivered through FTP server between ETRI and KARI. Currently, KARI is the only site of the satellite operations and control, while there was a backup site for the satellite control in NMSC before meteorological mission termination. Since there is equipped with backup system for SGCS along with the main system in KARI SOC, operating the satellite in stable for more years is absolutely possible in terms of the ground system.

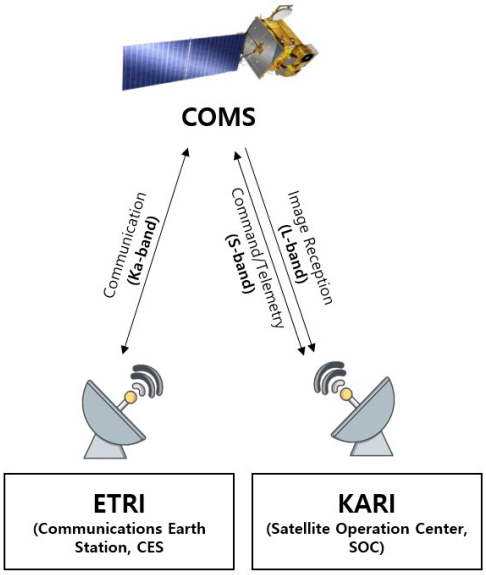


Fig. 5 COMS ground segment architecture (present)

Also, the overall characteristics of operating geostationary satellites in KARI are indicated in Table 3. GK-2A and GK-2B inherit the meteorological and ocean mission of COMS, individually, all geostationary satellites in operation are stably performing their respective missions. In the near future, when the launch of a satellite taking over the communications mission approaches, COMS has to perform a de-orbit procedure, which is already prepared by the engineers. Until the communication mission, which is the last mission of COMS, is terminated, the satellite must be continuously monitored and maintained in a stable state so that the disposal procedure can be performed normally.

Table 2. Detailed characteristics for geostationary satellites of KARI

	COMS			**GK-2A**	**GK-2B**	
Mission	Meteorology	Ocean	Communications	Meteorology	Ocean	Environment
Payload	MI	GOCI	Ka-band	AMI	GOCI-II	GEMS
Launch Date	2010.06.27			2018.12.05	2020.02.19	
Observation Time (UTC)	00:00~24:00	00:15~07:45	-	00:00~24:00	20:15~10:45	22:45~08:15
Spectral Channels	VIS 1, IR 4	VIS 6, NIR 2	-	VIS 4, IR 12	VIS 9, NIR 3	UV-VIS (0.6 nm)
Operational Status	Termination	Termination	In operation	In operation	In operation	In operation

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