CGMS-52-KMA-WP-04
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Prepared by: KMA
Agenda Item 3
Discussed at Plenary

Subject	**KMA updates since CGMS-51 and report on the medium to long-term future plans on Earth observation**
In response to CGMS action/recommendation	
HLPP reference	
Executive Summary	KMA operates GEO-KOMPSAT-2A (GK2A) equipped with meteorological payload, Advanced Meteorological Imager (AMI) and space weather payload, Korea Space wEather Monitor (KSEM). The GEO-KOMPSAT-2B (GK2B) for the oceanic and environmental mission and equipped with Geostationary Ocean Colour Imager-II (GOCI-II) and Geostationary Environment Monitoring Spectrometer (GEMS) is also operational, and data have been released since 2021. KMA is also working to strengthen the usability of satellite data not only in weather forecast but also in climate monitoring with new approach. The new retrieval with GK2A data such as AI-based Convective Initiation (CI) detection, AI-based Proxy Radar, Satellite-based Insolation and Ultra Violet (UV) Index, Flash Drought, and so on. KMA expanded GK2A Marine Weather Broadcast Service (MWBS) to provide various digital marine weather information with emergency message of urgent weather to ships on the ocean. KMA has received approval from the government R&D evaluation for the GK2A follow-on satellite GK5 development project and are preparing to begin the project.
Action/Recommendation proposed	

1 INTRODUCTION

The Korea Meteorological Administration (KMA) has been officially operating the Korean second geostationary meteorological satellite, GEO-KOMPSAT-2A (GK2A), since 25th July 2019. And this role is handled by the National Meteorological Satellite Center (NMSC). The first Korean geostationary multi-purpose satellite, Communication, Ocean, and Meteorological Satellite (COMS also known as GK1) has ended its meteorological mission on 31st March 2020. However, the communication mission will be maintained for the next few years.

In fact, the Korean government has developed and is operating two GEO-KOMPSAT-2 (GK2) satellites. It consists of a pair of satellites for multi-purpose. One (GK2A) is for meteorological dedicated satellite with the space weather as a piggyback mission. The other (GEO-KOMPSAT-2B, hereafter GK2B) is for ocean and environmental missions. Ocean mission is to monitor the ocean colour using an advanced Geostationary Ocean Colour Imager (GOCI-II) continuously. The environmental mission using Geostationary Environmental Monitoring Spectrometer (GEMS) is to monitor atmospheric environments globally with the first payload carried on the geostationary satellite. The GK2 program had been started under the cooperation with Ministry of Science, ICT, and Future Planning (MSIP, now the name has changed to Ministry of Science and ICT, MSIT), Ministry of Oceans and Fisheries (MOF), and Ministry of Environment (ME) of Korean government, and kicked off in the middle of 2012. The GK2A and GK2B satellites were launched successfully in 4 December 2018, and 18 February 2020, respectively.

2 CURRENT SATELLITE SYSTEMS

The current satellite systems for the meteorological mission and meteorological application in the South Korea are presented in Table 2.1.

Table 2.1 The South Korean current satellite systems for the meteorological application

Sector	**Satellite in Orbit** P=pre-operational Op=operational B=back-up L=limited availability	**Operator**	**Location**	**Launch date**	**Details on near real time access to L0/L1 data (Link)**	**Environmental payload and status**
East Asia and West Pacific	**COMS** (L)	ETRI	128.2°E	26/06/2010	-	Only communication payload is being operated under the limited conditions

	GK2A (Op)	KMA	128.2°E	04/12/2018	HRIT specification LRIT specification UHRIT specification	16-channel Advanced Meteorological Imager (AMI), Korean Space wEather Monitor (KSEM), Direct Broadcast via HRIT/LRIT and UHRIT
	GK2B (Op)	MOF (Ministry of Oceans and Fisheries), ME (Ministry of Environment)	128.2°E	18/02/2020	-	Advanced Geostationary Ocean Colour Imager (GOCI-II) Geostationary Environmental Monitoring Spectrometer (GEMS)

3 STATUS OF CURRENT GEO SATELLITE SYSTEMS

The GK2A for the meteorological mission using Advanced Meteorological Imager (AMI) and for the space weather mission using Korean Space wEather Monitor (KSEM) was launched 4th December 2018. The KMA has been operating officially since 25th July 2019.

The GK2B for the ocean observation mission using Advanced Geostationary Ocean Colour Imager (GOCI-II) and for the environmental mission using Geostationary Environmental Monitoring Spectrometer (GEMS) was launched 18th February 2020. And their observation images have been open to public since March 2021 and derived ocean and environmental products have released since the 2nd half of 2021.

3.1 Mission objectives, payload/instruments, products

3.1.1 GK2A Mission

The GK2A meteorological mission is performed by AMI with 4 visible, 2 near-infrared and 10 infrared channels (Table 3.1).

The AMI observation data are disseminated to the users using satellite broadcasting system with Large/Medium/Small Scale Data Utilization Stations (LDUS/MDUS/SDUS) in Ultra High Rate Information Transmission (UHRIT) and High/Low Rate Information Transmission (H/LRIT) formats within 3 minutes after the end of earth observation scanning as well as landline data services. Also, KMA provide GK2A AMI level 1B (L1B) data through the real-time FTP for National Meteorological and Hydrological Services (NMHSs) and both L1B data and L2+ products through the National meteorological Satellite Center (NMSC) website as below for any users.

- Website URL: http://nmsc.kma.go.kr/enhome/html/main/main.do

Mission objectives

The GK2A is a 2nd geostationary satellite for the South Korea with multi-purpose developed to meet KMA's space-based observation missions. One is meteorological mission to observe real-time atmospheric phenomena in order to detect severe weathers and their hazardous impact scope and risk. The other is space weather mission to monitor and measure the physical quantities of the near-Earth space environment. Thus, GK2A has meteorological payload, AMI for the meteorological mission and KSEM for the space weather mission.

Payload/instruments

The AMI, payload for meteorological mission of GK2A, is comparable to those of the Advanced Baseline Imager (ABI) and Advanced Himawari Imager (AHI) on board GOES-16/17/18 and Himawari-8/9, respectively. The detailed specification of AMI is as follows;

- Multi-channel capacity: 16 channels (4 visible, 2 near-infrared and 10 infrared channels)
- High spatial resolution: 0.5~1.0 km for visible and 2 km for infrared channels
- Fast imaging: within 10 minutes for Full Disk observation
- Flexibility for the regional area selection and scheduling

The channel characterizations of the AMI are summarized in Table 3.1.

Table 3.1 Channel characterizations of the AMI for the GK2A satellite

Bands		Center Wavelength (measured, um)	Band Width (Measured, um)	Spatial Resolution (km)	SNR	NEdT(K) (240/300K)	Radiometric Accuracy
VNIR	VIS0.4	0.470	0.0408	1	250	-	5%
	VIS0.5	0.5086	0.0291	1	250	-	5%
	VIS0.6	0.6394	0.0808	0.5	120	-	5%
	VIS0.8	0.8630	0.0344	1	210	-	5%
	NIR1.3	1.3740	0.0155	2	300	-	5%
	NIR1.6	1.6092	0.0410	2	300	-	5%
MWIR	IR3.8	3.8316	0.1912	2	-	3/0.2	1K
	IR6.3	6.2104	0.8397	2	-	0.4/0.1	1K
	IR6.9	6.9413	0.4004	2	-	0.37/0.1	1K
	IR7.3	7.3266	0.1823	2	-	0.35/0.12	1K
	IR8.7	8.5881	0.3552	2	-	0.27/0.1	1K
LWIR	IR9.6	9.6210	0.3789	2	-	0.35/0.15	1K
	IR10.5	10.3539	0.4683	2	-	0.4/0.2	1K
	IR11.2	11.2285	0.6636	2	-	0.19/0.1	1K
	IR12.3	12.336	1.1072	2	-	0.35/0.2	1.1K
	IR13.3	13.291	0.5566	2	-	0.48/0.3	1.1K

※ SNR@100% albedo, NEdT@240/300K, calibration accuracy@100% albedo/300K

The KSEM, the payload for space weather mission of GK2A, consists of particle detector (PD), a set of dual magnetometers (MG), and a spacecraft charging monitor (CM). The energetic particle detectors simultaneously measure the population of charged particles in the energy range of at least 100 keV to 2 MeV for electrons and 100 keV ~ 20 MeV for protons over the six viewing angles. The dual magnetometer samples variations of low frequency magnetic fields at two different locations on a deployable boom to measure the Earth's magnetic fields accurately by separating the spacecraft contribution. The spacecraft charging monitor measures integrated fluxes of electrons above 1 MeV that is crucial for the satellite operation.

The configuration diagrams of the GK2A satellite equipped with AMI and KSEM are shown in Figure 3.1, and the specifications of the KSEM sensors are shown in Table 3.2.

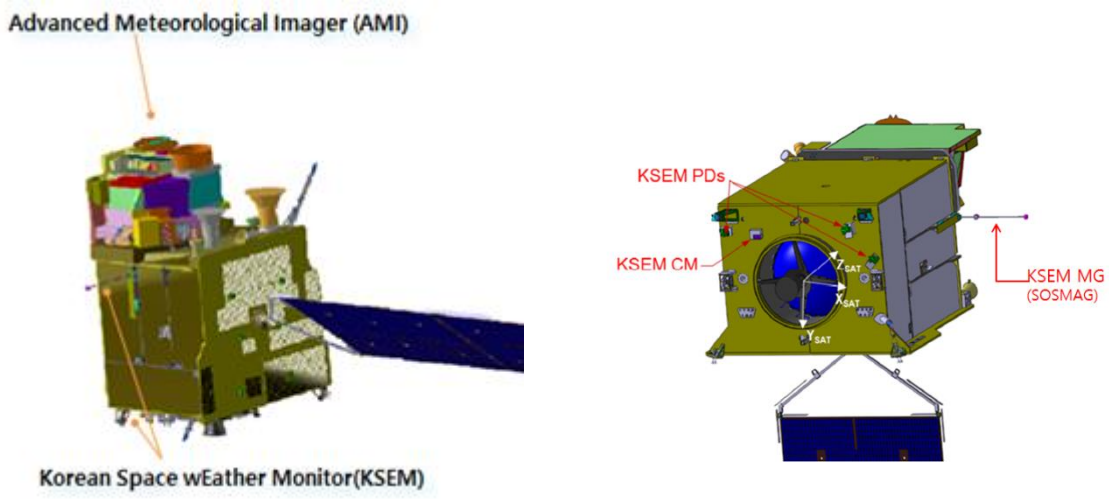

Fig. 3.1 Shape of GK2A satellite equipped with AMI and KSEM

Table 3.2 The Specification of the KSEM Sensors

Sensor	Requirements	Application Field
Particle Detector	- Electron energy range: ~100keV ~ 2 MeV - Angular Resolution (pitch angle): 60° at least	Global Electron Distribution Particles distribution on geostationary
Magnetometer	- Measurement range: ± 64,000nT (in 3 axes) - Field resolution: 1nT at least (on orbit)	Prediction for Dst and Kp Index
Satellite Charging Monitor	- Current range: ± 3pA/cm^2 - Measurement resolution: 0.001pA/cm^2	Satellite Charging Index

Products and applications

The GK2A AMI has produced high spatiotemporal measurements with 0.5~2 km resolutions every 2 minutes around Korean Peninsula and 10 minutes for full disk area. KMA has led to develop retrieval algorithms of the value-added products in cooperation with universities in Korea as well as the support from the internationally distinguished experts of satellite meteorology to maximize the application of these rapid observational data for weather and climate monitoring. Also, we focused the applications as well as the accuracy in the algorithm development to help satellite data interpreters, weather forecasters, typhoon forecasters and the users of satellite data in many other areas. The application areas include nowcasting, typhoon and ocean, surface, hydrology, fire, climate and atmospheric environment, and numerical weather prediction. Analysis skills and their guidance, some challenging products are included, which are not in 52 baseline products. KMA has optimized the retrieval algorithms and validated the accuracies of the products by using the operational AMI L1B data from July 2019.

KMA has been producing new retrieval with GK2A observation data for new approach to support weather forecast. KMA is also working to strengthen the usability of satellite data not only in weather forecasts but also in climate monitoring.

The mainly implementations for new application are as follows;

1. Monitoring and warning of extreme weather
   - Product model-simulated satellite images
   - Development of AI-based Convective Initiation (CI) detection algorithm based on GK2A
2. Fill the observation gap and replacement of ground observation data using AI technology
   - AI-based Proxy Radar using GK2A AMI data in East Asia
   - Satellite-based Insolation and UV Index
3. Increasing scope from weather to climate mission support
   - Monitoring greenhouse gas using satellite data
   - Monitoring drought
4. Satellite data assimilation
   - Impact test of GEO hyperspectral infrared sounder on NWP

3.1.2 GK2B Mission

GOCI-II onboard GK2B

Korea Hydrographic and Oceanographic Agency (KHOA) has been responsible for the definition of mission and user requirements, and for the operation of GOCI-II on GK2B.

The GOCI-II is a next generation of the GOCI, one of the major payloads in COMS, which was the first ocean colour imager in the world operating on the geostationary orbit. The GOCI had been developed to provide a monitoring of ocean colour around the Korean Peninsula to detect, monitor, quantify, and predict short term changes of coastal ocean environment for marine science research and application purpose. Now GOCI operation has ended, and GOCI-II has taken over the mission. The GOCI-II has capacities of highly enhanced radiometric/geometric performance in comparison with those of GOCI.

Table 3.3 shows the spectral bands and radiance performance of GOCI-II including the new spectral bands. It is expected that additional spectral bands bring more specific coastal monitoring and application researches as well as more accurate atmospheric correction.

Table 3.3 Spectral Bands and Radiance Performance of the GOCI-II

Band	Band Center	Band-width	Nominal Radiance	Maximum Ocean Radiance	Threshold Radiance	Maximum Cloud Radiance	SNR @ nominal radiance
1	380 nm	20 nm	93	139.5	143.1	634.4	998
2	412 nm	20 nm	100	150.0	152.0	601.6	1,050
3	443 nm	20 nm	92.5	145.8	148.0	679.1	1,145
4	490 nm	20 nm	72.2	115.5	116.0	682.1	1,228
5	510 nm	20 nm	64.9	108.5	122.0	665.3	1,180
6	555 nm	20 nm	55.3	85.2	87.0	649.7	1,124
7	620 nm	20 nm	53.3	64.1	65.5	629.5	1,102
8	660 nm	20 nm	32.0	58.3	61.0	589.0	1,060
9	680 nm	10 nm	27.1	46.2	47.0	549.3	914
10	709 nm	10 nm	27.7	50.6	51.5	450.0	914
11	745 nm	20 nm	17.7	33.0	33.0	429.8	903
12	865 nm	40 nm	12.0	23.4	24.0	343.8	788
13	Wideband		-	-	-	-	-

※ Spectral radiances values are in $Wm^{-2}\mu m^{-1}sr^{-1}$

GEMS onboard GK2B

National Institute of Environmental Research (NIER) of Ministry of Environment has been responsible for the mission and operation of GEMS on GK2B.

The GEMS on GK2B contributes to the understanding of pollution events globalization, source/sink identification, and long-range transport of pollutants and Short-Lived Climate Forcers (SLCFs), as a part of the activities of Atmospheric Composition Constellation under the Committee on Earth Observation Satellites (CEOS). This

Constellation coordination activity is focused on collaboration to improve and extend data utilization from environmental missions including Korea's GEMS, Europe's Sentinel-4, and the US's Tropospheric Emissions: Monitoring of Pollution (TEMPO), which will be able to provide the "baseline" constellation data products.

The GEMS is expected to contribute monitoring air quality and SLCFs including ozone and aerosols over Asia in high temporal and spatial resolution. Using a scanning UV-Visible spectrometer, its observations can contribute to provide a set of tropospheric column products over the Asia-Pacific region at spatial resolution of 8 km and temporal resolution of 1 hour. Other products include NO_2, HCHO, SO_2, and aerosol optical depth.

Table 3.4 shows the requirements of the GEMS for the mission success.

Table 3.4 Payload Requirement of the GEMS

Item	Requirement
Lifetime	> 10 years after IOT
Reliability	> 0.85 @ 7 years
Field of regard	> 5,000 km(N/S) × 5,000 km(E/W) N/S: 45°N ~ 5°S, E/W: Selectable between 75°E ~ 145°E
Duty cycle/Imaging time	8 images during daytime (30 min imaging + 30 min rest) × 8 times/day
Ground sampling distance	< 7 km(N/S) at Seoul GSD area < 56km^2 at Seoul (Aspect ratio shall be less than 1:3)
Spectral range	300 nm to 500 nm
Spectral resolution	< 0.6 nm
Spectral sampling	< 0.2 nm
Signal-to-noise ratio	> 720 @ 320 nm > 1500 @ 430 nm
Data quantization	≥ 12 bits
MTF (Instrument level)	> 0.3 in N/S direction @ Nyquist frequency > 0.3 in E/W direction @ Nyquist frequency
Radiometric calibration accuracy	< 4%
Spectral calibration accuracy	< 0.02 nm
Polarization factor	< 2% (310-500 nm) No inflection point within 20nm for all wavelength range

3.2 Status of spacecraft

GK2A

The GK2A was launched on December 4, 2018. It has been located at 128.2°E. GK2A has two payloads, AMI and KSEM for meteorological and space weather missions each. They are currently healthy and working well and will be working continuously until 2031.

GK2B

GK2B was launched on February 18, 2020. It has also been located at 128.2°E. GK2B has two payloads, GOCI-II and GEMS for oceanic and environmental missions each. They will be working continuously until 2031, too.

3.3 Ground segment matters

Both of GK2A and GK2B are conducted by the Korea Aerospace Research Institute (KARI) using its Satellite Ground Control System (SGCS) since launch satellite.

KMA has two antennas to receive the observation data for the GK2A at ground station in National Meteorological Satellite Center (NMSC) at Jincheon located in almost middle of the South Korea. Also, Ministry of Environment (ME) and Ministry of Oceans and Fisheries (MOF) have their antennas and ground systems to receive the GK2B GEMS data and COGI-II data each at their satellite centers, National Environmental Satellite Center and National Ocean Satellite Center, respectively.

3.4 Data transmission

GK2A AMI observation data are transmitted by broadcast to L/M/SDUS system users after being converted into UHRIT and H/LRIT formats. KMA provide the UHRIT and H/LRIT services free of charge and those data are encrypted to identify the users of UHRIT and H/LRIT. The domestic and foreign users who want to use L/M/SDUS services should proceed a formal application following the procedures outlined on the website of the NMSC of KMA below;

1. National Meteorological Satellite Center website URL
   - https://nmsc.kma.go.kr/enhome/html/main/main.do
2. Data service webpage of NMSC
   - https://datasvc.nmsc.kma.go.kr/datasvc/html/main/main.do?lang=en
3. Application for Transmission by Countries webpage of NMSC
   - https://datasvc.nmsc.kma.go.kr/datasvc/html/base/cmm/selectPage.do?page=static.reqStation

The technical documentations to understand about the application procedures for becoming a user station and the description on how to decrypt the encrypted data are posted on the website.

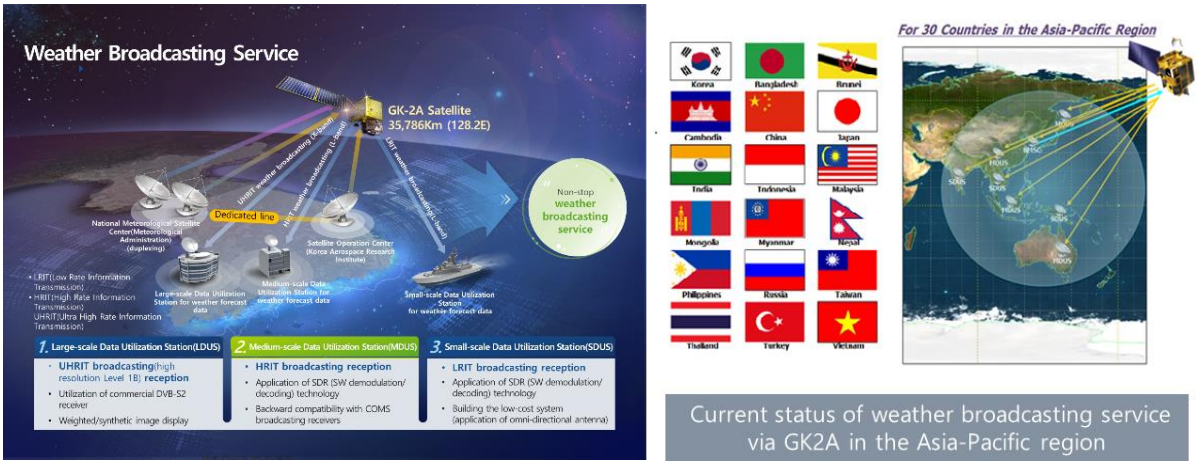

Figure 3.2 Concept of GK2A AMI UHRIT and H/LRIT direct broadcasting

Currently, the UHRIT provides Full Disk (FD) images from each of 16 channels of AMI every 10 minutes in full spectral and spatial resolution, and three kinds of L2 meteorological products images such as Rainfall Rate, Sea Surface Temperature, and Cloud Top Products. The HRIT provides FD images from 5 channels as the same spatial resolution of COMS Meteorological Imager (MI). Additionally, LRIT provides marine weather information including GK2A IR images, sea surface wind, sea surface temperature, sea ice, weather chart, typhoon information, and emergency disaster information in text format.

KMA has operated new marine information service via GK2A LRIT broadcast since 23rd July 2020 in parallel with KMA's weather-fax service. After that, KMA expanded GK2A Marine Weather Broadcast Service (MWBS) to provide various digital marine weather information to islands and ships on the ocean. The MWBS is available in GK2A FD measurement domain (RA II and RA V regions). In 2023, KMA added the international broadcast service with Emergency message of urgent weather.

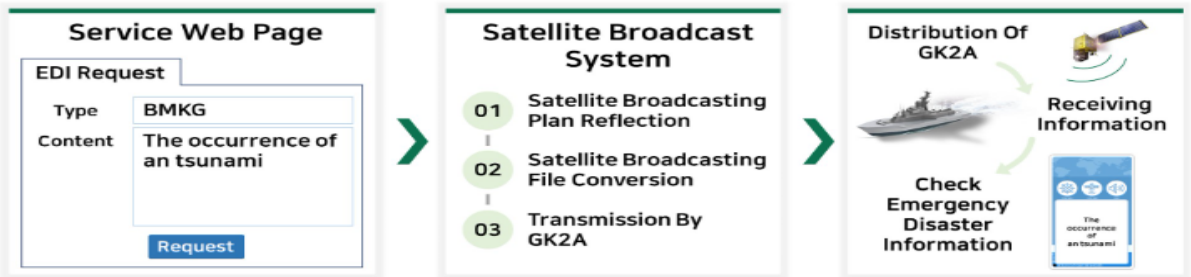

Fig. 3.3 Request procedure for users of RA II and RA V regions

Also, 16 channels data of GK2A AMI's FD in 10 minutes and Local Area (LA) in 2 minutes are available on real-time FTP via landline which is named as the GK2AAMI RFS (Real-time FTP Service).

3.5 Projects, services

Service via Satellite
Please refer to 3.4.

Service via Landline
Besides the GK2A RFS referred in 3.4, the NMSC provides GK2A L1B data of all 16 channels and L2+ products to users by posting the processed data on NMSC website (See the section 3.4).
All registered members of the website can log on, search, and download those data up to 100GB for one-time request. Here is the list of GK2A meteorological products open to users. More products are under development and they will be available after being operational.

Also, in order to promote GK2A AMI and KSEM data utilization in public and private sectors as well as the NMHSs, KMA has implemented the open API service of the GK2A data including 66 products of AMI and 8 products of KSEM in the NMSC website from November 2020.

1) OPEN API user: KMA Open API service can be available to any agency, company, academia and person that want to use the GK2A AMI and KSEM data
2) Application: If you want download data through the Open API system, you need to sign up the NMSC website membership (or sign in using Social Network Service (google, facebook) account) and apply to issue your key using application form (https://datasvc.nmsc.kma.go.kr/datasvc/html/base/cmm/selectPage.do?page=static.openApi2)

DCPC-NMSC
As a part of WIS DCPC project lead by WMO, NMSC is operating DCPC-NMSC website and providing the GK2A AMI data such as all 16 channels L1B in netCDF and PNG graphic file format and 24 of L2 products in netCDF and PNG graphic file formats.

The registered user can search, access, download the GK2A meteorological data on this user portal web address: http://dcpc.nmsc.kma.go.kr

Open MET Data Portal
KMA is also preparing the portal website for the unification service of meteorological and climate data include GK2A AMI's data.

3.6 User statistics

None available.

4 FUTURE SATELLITE SYSTEMS

KMA has received approval from the government R&D evaluation for the GK5 satellite development project and are preparing to begin the project with Ministry of Science and ICT (MSIT). GK5 satellite development project will begin in 2025 to take over the GK2A mission in 2031. GK5 will be have meteorological imager like as AMI but improvement with 18 channels and space weather payload, KSEM-II.

KMA is also preparing small size satellite such as microsat or smallsat with payloads for the Greenhous Gas (GHG) detection and for the rim sounding with Global Navigation Satellite System – Radio Occultation (GNSS-RO) techniques for the future.

5 STATUS OF FUTURE GEO SATELLITE SYSTEMS

For the GK2A follow-on satellite GK5, development project approval has been received, and the project is in the preparation stage to begin.

For the GK2B follow-on satellite is in phase of planning and feasibility study.

6 STATUS OF CURRENT LEO SATELLITE SYSTEMS

KMA's meteorological micro-satellite development plan is in phase of planning the project after policy research in 2023.

7 ACTIONS AND/OR RECOMMENDATIONS FOR CONSIDERATION BY CGMS PLENARY SESSION

KMA has no actions or recommendations for consideration by the CGMS-52 Plenary Session.

8 CONCLUSIONS

This agency report summarizes the status of KMA's current and future satellite systems for the CGMS-52 Plenary Session.