Korea Ocean Satellite Center

KOREA INSTITUTE OF OCEAN SCIENCE & TECHNOLOGY

Korean geostationary OC missions: GOCI and GOCI-II

on behalf of Dr. Youngje Park,

Seongick CHO

Director of Korea Ocean Satellite Center (KOSC)

Korea Institute of Ocean Science & Technology (KIOST)

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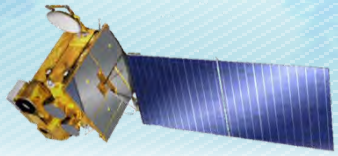


KIOST

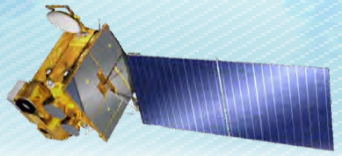
GOCI & GOCI-II R&D Projects PI
: Dr. Youngje Park
(Vice-president of KIOST)

KOSC

Director : Seongick CHO

- Research & CAL/VAL Division (Dr. Wonkook Kim)
- Ground Segment Development Team (Mr. Heejoeng Han)
- Satellite Operation Team (Mr. Sangsoo BAE)
- Satellite Development Planning Team (Seongick CHO)

Korean Ocean Satellites Development Plan



EO Program	Instruemt/Satellite	Launch year	Life (yrs)	Year 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Airbourne Instrument																
	GOCI-II Airbourne Simulator	2020 (TBD)	-				**Operation**									
Cubesat Program																
	Cubesat for Technology Verification (LWIR, Multi Angle Polarimeter)	2023 (TBD)	2						**Operation**							
		2024 (TBD)	2							**Operation**						
500kg class LEO Satellite Program (CAS500)																
	CAS500-5 (TBD) (10m GSD_VIS/NIR)	2024 (TBD)	4								**Co-application**					
	CAS500-7 (TBD) (C-Band SAR)	2025 (TBD)	4									**Co-application**				
	CAS500-8 (TBD) (100m GSD_LWIR, Multi Angle Polarimeter)	2029 (TBD)	4												**Operation**	
GEO Satellite Program GEO-KOMPSAT																
	GOCI (500m GSD_VIS/NIR)	2010	7	**Extended Operation (TBD)**												
	GOCI-II (250m GSD_VIS/NIR)	2019	10		**Operation**											
	GOCI-III (50m GSD_VIS/NIR/SWIR/LWIR)	2027 (TBD)	10										**Operation**			

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Operation and Application Status of GOCI

Geostationary Orbit

Receiving Station

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126.5˚E, 37.2˚N

Center Coordinate

130˚E, 36˚N

128.2˚E

Height : 35,857km

Above the equator at 128.2 ˚E

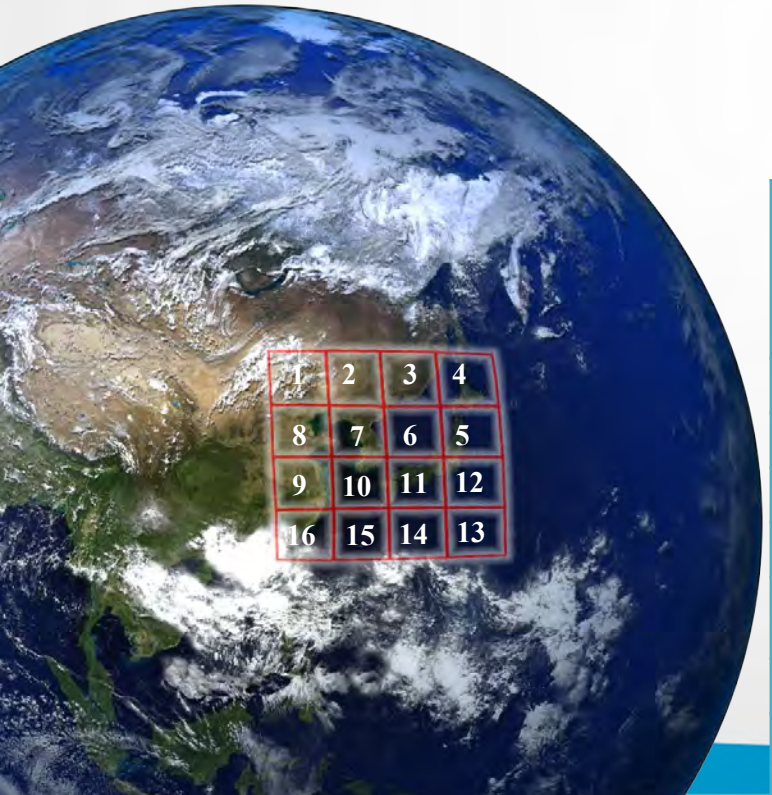
GOCI

- COMS : Communication, Ocean & Meteorological Satellite
  - Developments of COMS(H/W) and GDPS(S/W) : 2003
  - Establishment of KOSC (Ground System) : 2005
  - The first Korean Geostationary multipurpose Satellite
  - Launch date : June 27 2010
  - Lifetime : 7 years
  - Payloads (3 Missions)
    - Geostationary Ocean Color Imager (GOCI)
    - Meteorological Imager
    - Ka-band Communication

GOCI

◆ Geostationary Ocean Color Imager

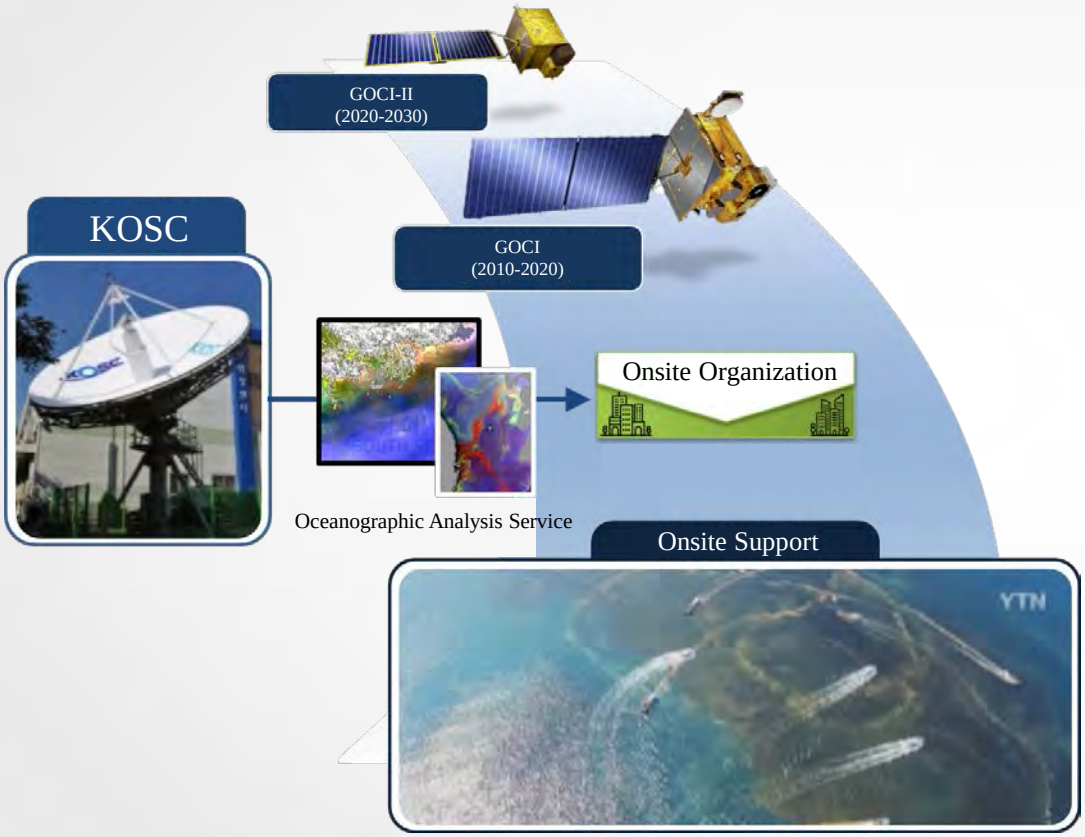
- GSD(Ground Sampling Distance) : 500m * 500m
- Target Area : 2,500km * 2,500km (Center : 130◦E 36◦N)
- Included Nations : Korea, China, Taiwan, Japan, Russia, etc.
- Temporal Resolution : 1hour (8 times / day)



◆ Spectral Bands Characteristic and Requirements of GOCI

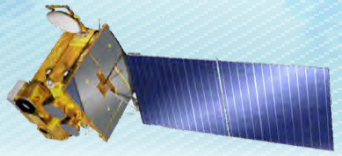
Band	Central Wave Length	Band Width	SNR	Primary Application
B1	412nm	20nm	1,070	Yellow substance and turbidity
B2	443nm	20nm	1,190	Chlorophyll absorption maximum
B3	490nm	20nm	1,170	Chlorophyll and other pigments
B4	555nm	20nm	1,070	Turbidity, suspended sediment
B5	660nm	20nm	1,010	Baseline of fluorescence signal, Chlorophyll, suspended sediment
B6	680nm	10nm	870	Atmospheric correction and fluorescence signal
B7	745nm	20nm	860	Atmospheric correction and baseline of fluorescence signal
B8	865nm	40nm	750	Aerosol optical thickness, vegetation, water vapor reference

User-Oriented Operational service

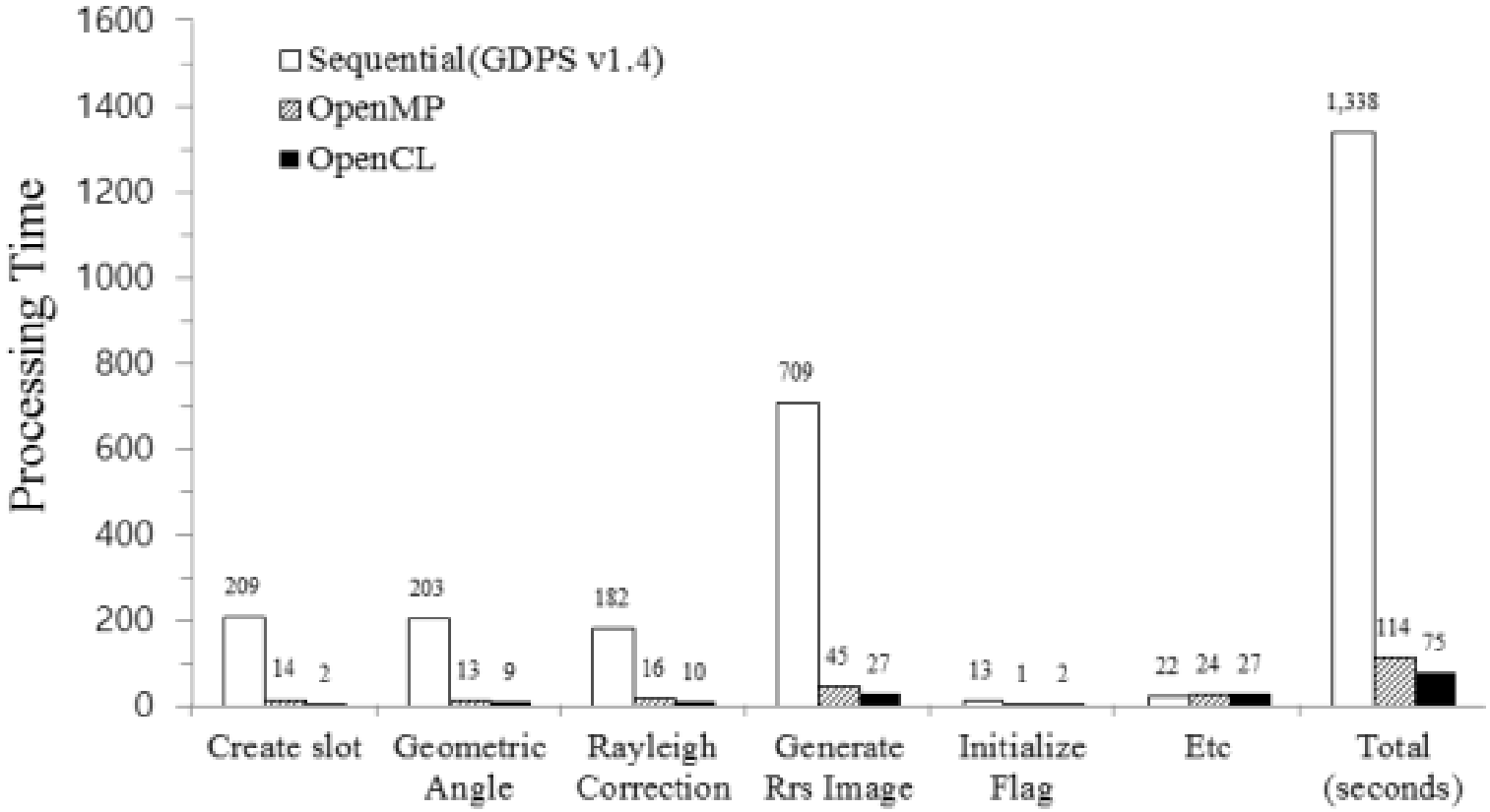


Term	PRIMARY ISSUE
March ~ May	• Yellow Dust • Chlorophyll Distribution • Red Tide • Cold Pool • Forest Fire • Green Tide
June ~ August	• Red Tide • Green Tide • Cold Pool • Low Salinity Water • Fog • Smog • Typhoon
September ~ November	• Red Tide • Chlorophyll Distribution • Low Salinity Water • Typhoon • Smog
December ~ February	• Smog • Ice Berg • Heavy Snow • Fog • Asian's Sargassum
Etc	• Volcano • Ocean Dumping

Development of Operational Service System



- GPU based HPC system for high speed Atmospheric Correction
- High speed Geometric Correction is under development (by June. 2017)
- User-oriented Operational Service System (by Dec. 2017)
  - **Target processing time from RAW to Lv.2 : less than 10 minutes**



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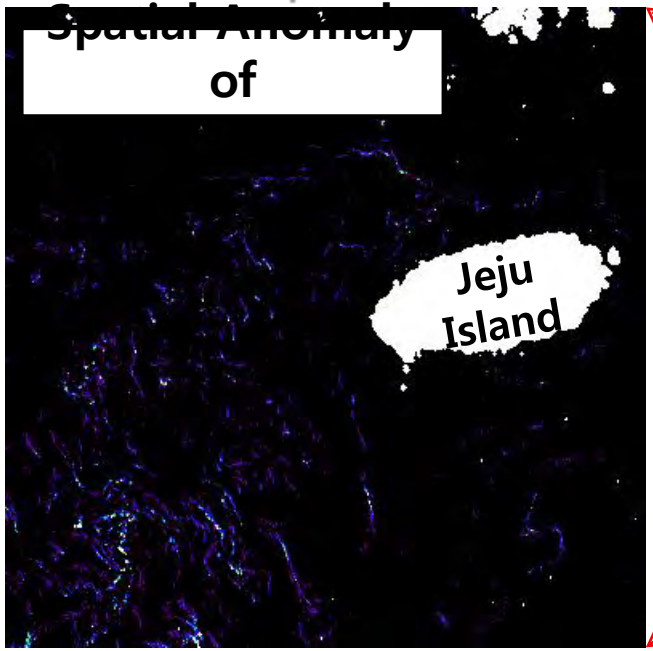
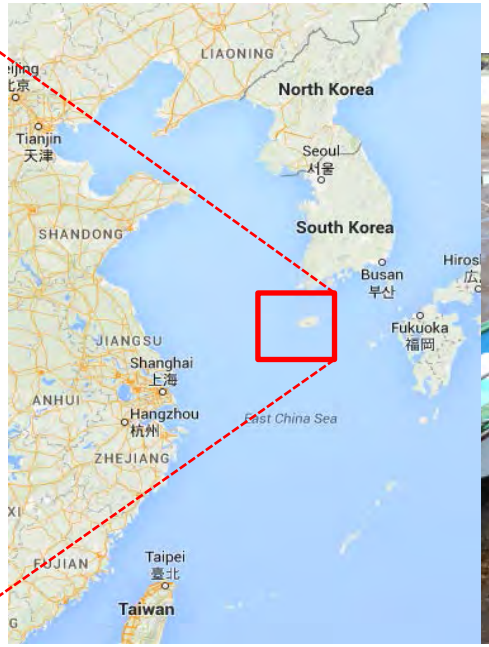
GOCI Operational Service : Asian'Sargassum (Sargassum horneri)

In Jan-Feb 2015, accumulated patches of 'Sargassum horneri' were found in coastal areas of Jeju island and southwest of Korea. GOCI image (bottom-left image) revealed that the floating algae patches were widely spread in the northern East China Sea.

Spectral signature of Sargassum patch is weak and barely visible using contrast in 745nm before atmospheric correction.)

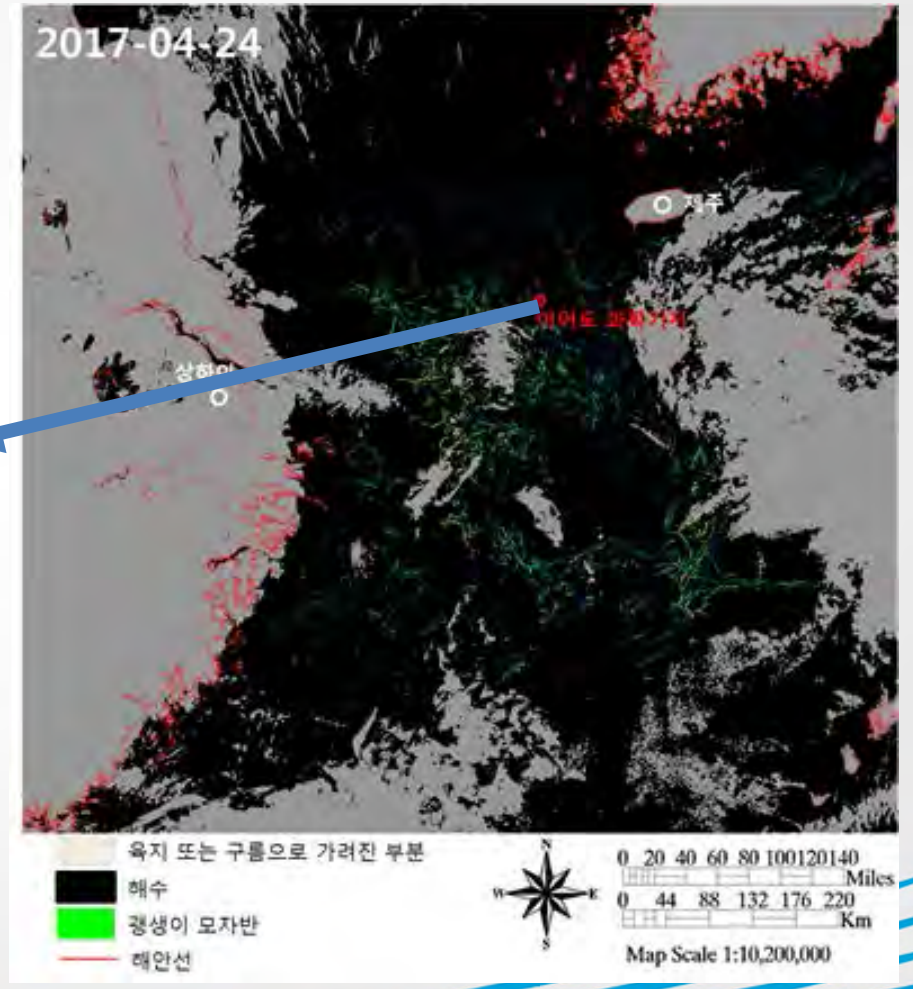




Sargassum horneri (Brown Algae)

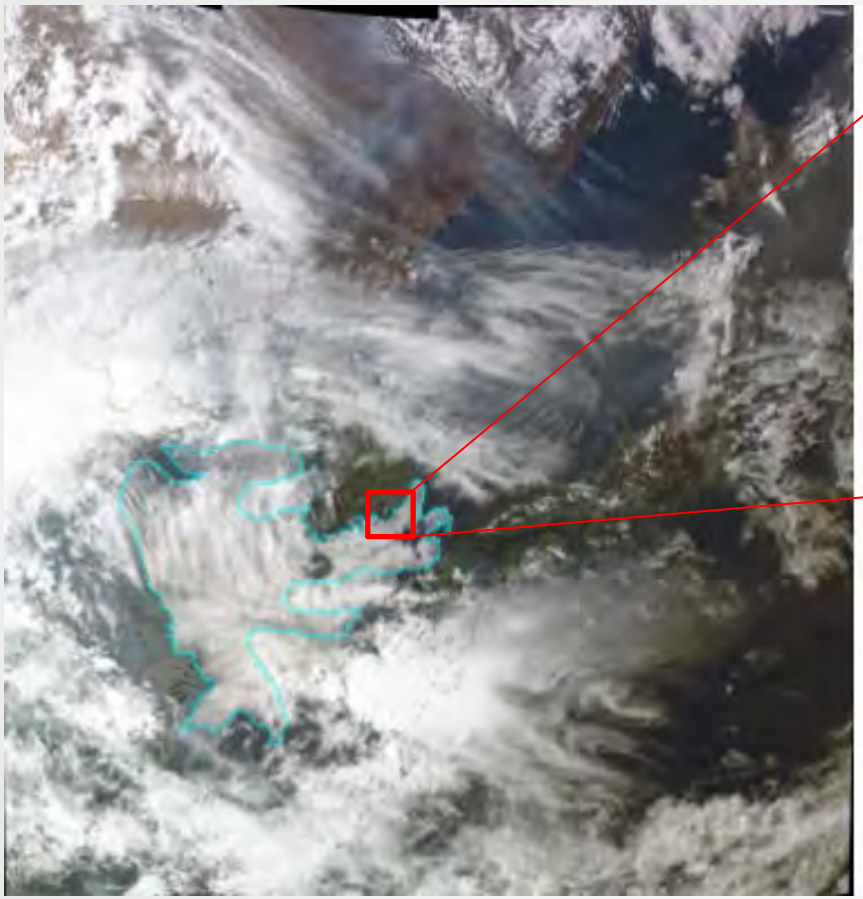
- Brown algae bloom on East China Sea (2017)

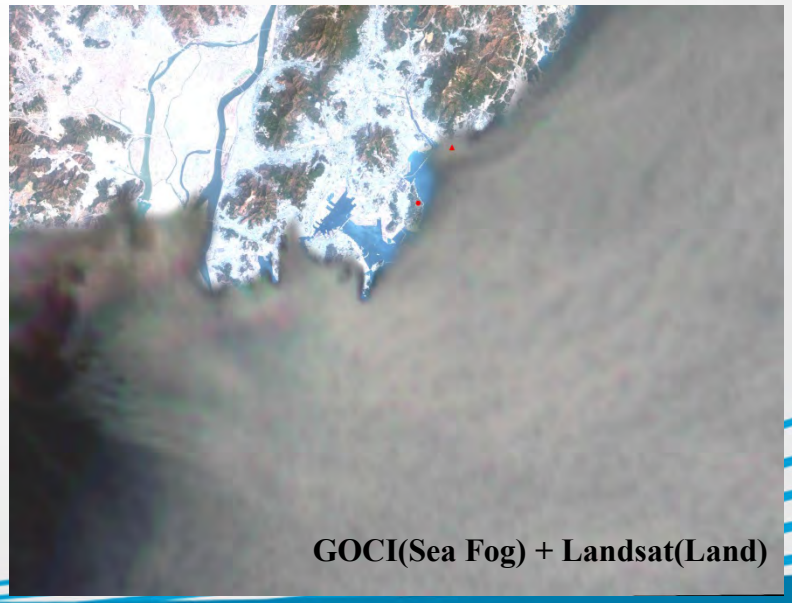
In-situ observation
from IEODO Ocean Research Station



Satellite based Observation: GOCI

GOCI Operational Service: Sea fog

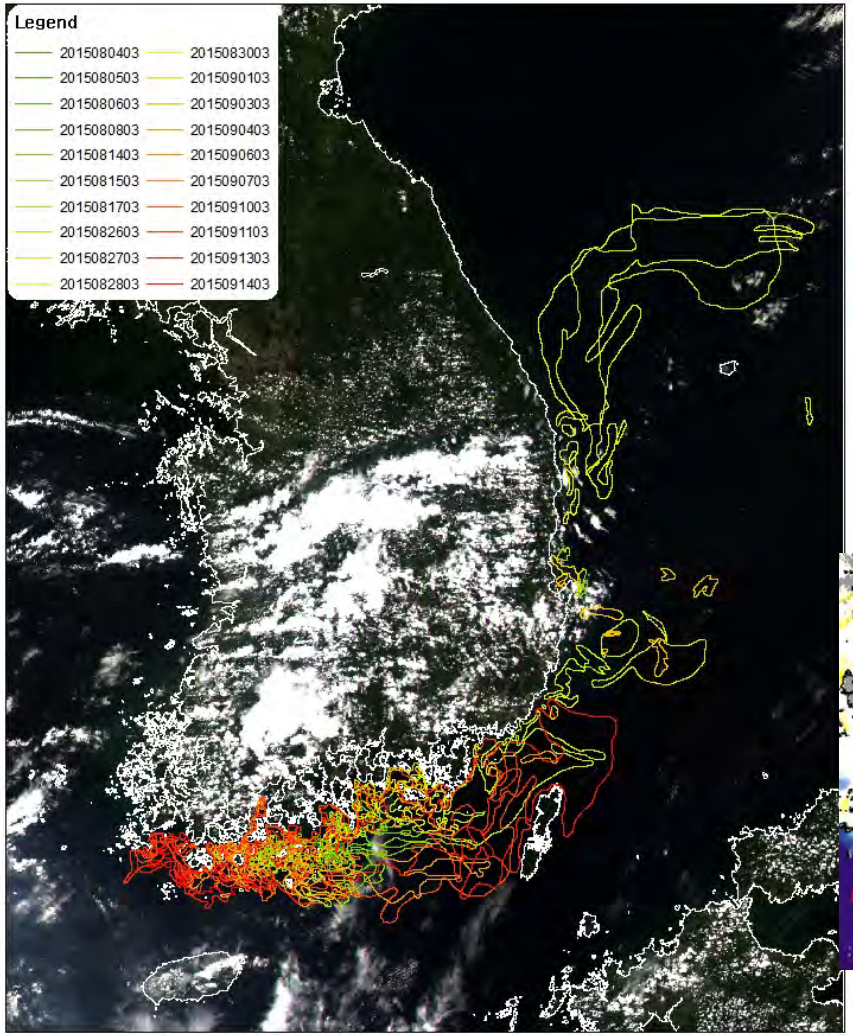




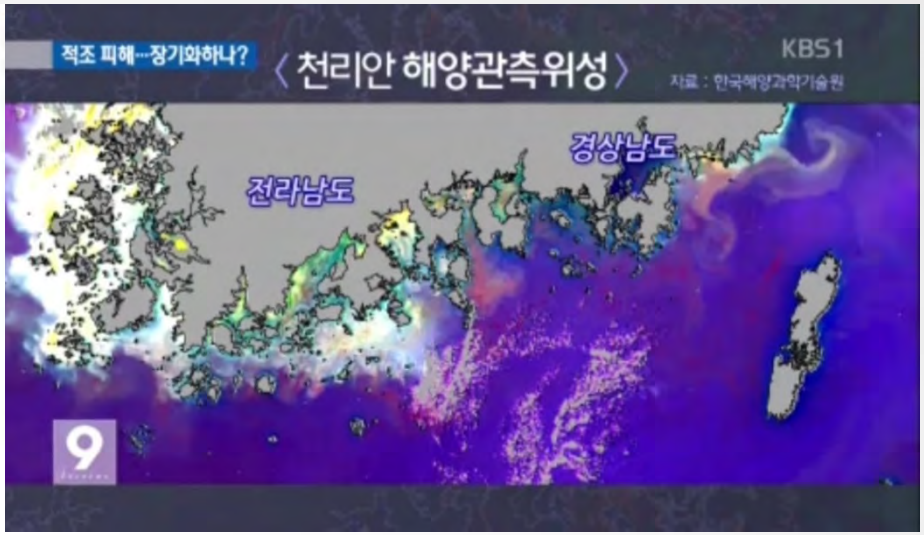
▲Sea fog area /
April. 16, 2017 (07 UTC)

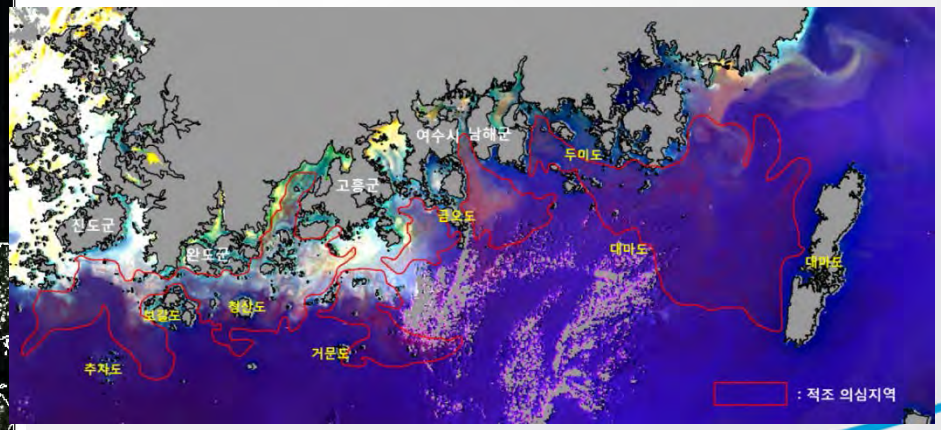
GOCI(Sea Fog) + Landsat(Land)

GOCI Operational Service : Red Tide



▲ Red tide areas (Aug 04~Sept. 14, 2015)





▲ Korean Press(GOCI Lw composite image, Sept. 11, 2015)

KORUS-OC in 2016

- Korea-US Joint Field Campaign for Ocean Color
- Participants
  - ROK : KIOST
  - US : 5 institutes* led by NASA/GSFC
    *NASA/GSFC, LARC, NRL, University of New Hampshire,
    University of Massachusetts Boston, City University of New York, Columbia University
- Period : 2016/05/20 ~ 06/06 with R/V Onnuri
- Data workshop : 2017/04/19-21 @ Portland, OR
- Research subjects :
  - Satellite observation of diurnal ocean variability
  - Algorithmic issues for geostationary ocean color sensor

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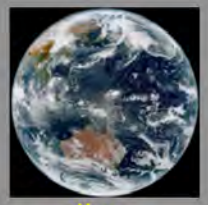
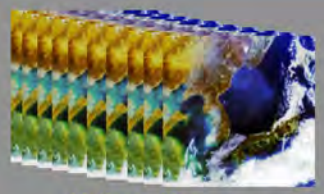
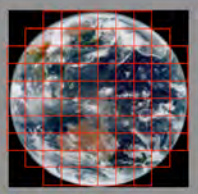
Development Status of GOCI-II

Specification Comparison between GOCI and GOCI-II

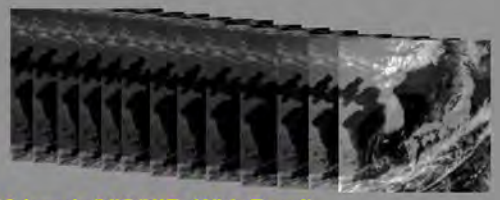
More accurate spatial resolution with full-disk mode

GOCI	GOCI-II	
		
500m	250m Local Area	1km Full-disk

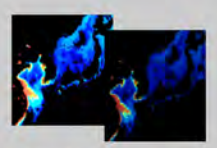
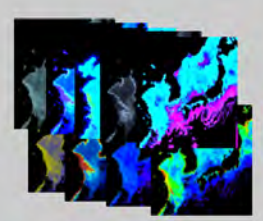
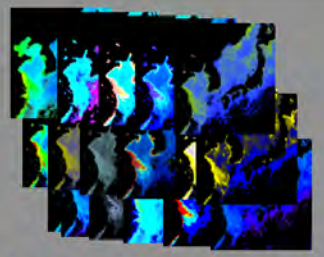
More frequent observation

		
8 times/day	10 times/day Local Area(Event)	1 times/day Full-disk

5 more bands

	
8 bands(VIS/NIR)	13 bands(VIS/NIR, WideBand)

Much more diversities (Level 2 Products)

GOCI total 13 products	GOCI-II 26 products
	
2 kinds (ex. nLw)	4 kinds (ex. Rayleigh-corrected da Basic Products(LV2A)
	
9 kinds (ex. CHL)	17 kinds (ex. Fishery Information) Ocean Products(LV2)
	
2 kinds (ex. NDVI)	5 kinds (ex. Aerosol type) AtmosLandProducts(LV2)

· diversity of ocean products like sea ice, sea fog, fishery information, redtide information, ocean front, etc

· Increasing the ability of real-time analysis of coastal/oceanic environmental change more than 250 meter scale
· Enhancing the monitoring of fishery environment and the monitoring of ocean/meteorological disasters

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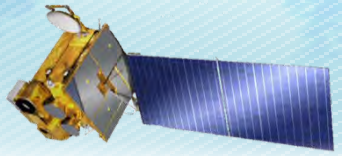
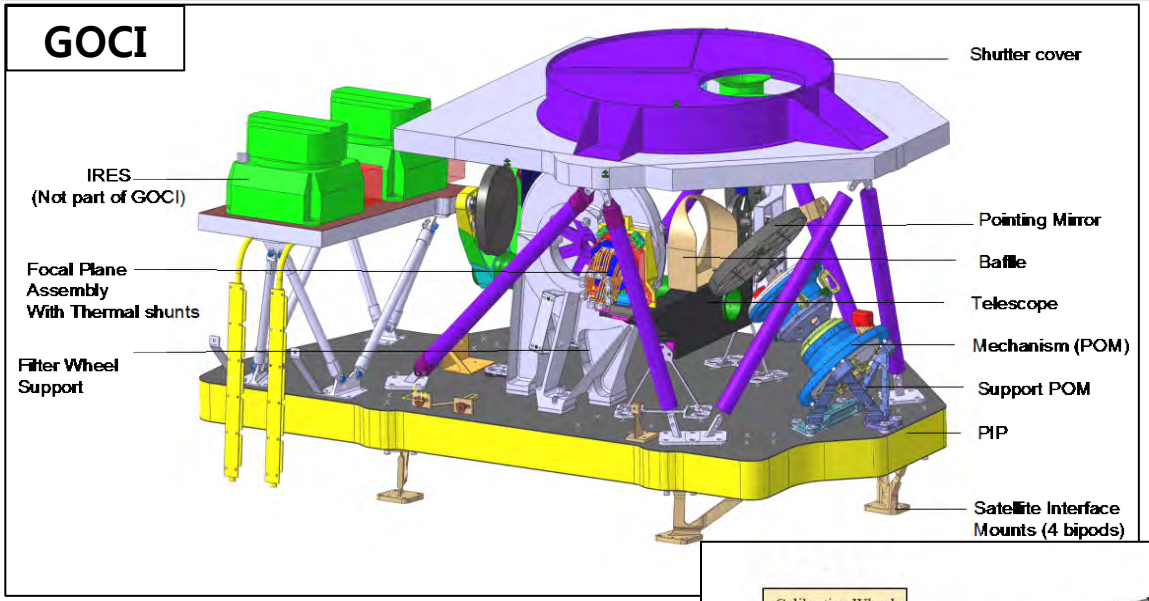
Main Unit Overview

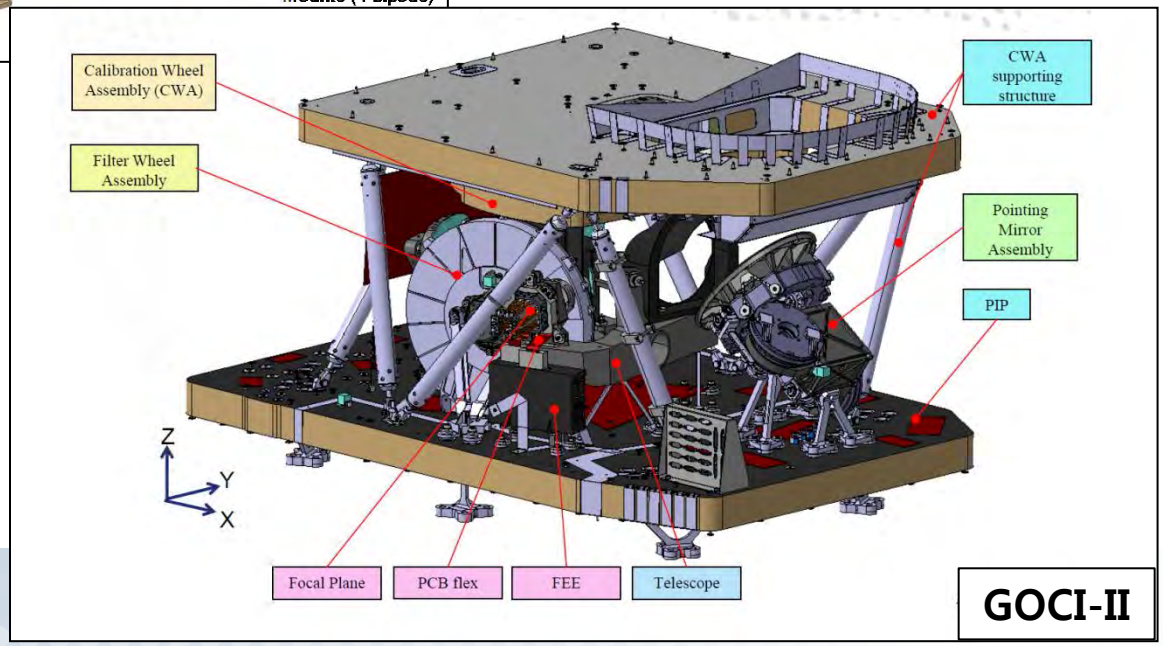


GOCI



- **Dimension is similar to GOCI except the width**
  - **Width : ~ 50 % increase**
- **Mass is almost two times**

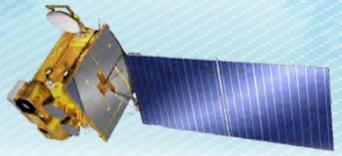
	GOCI	GOCI-II
Dimension	1015 x 888 x 854 mm^2	1,520 x 1,000 x 891 mm^2
Main Unit mass	78.5 Kg	140 Kg
Overall mass	83.3 Kg	150 Kg



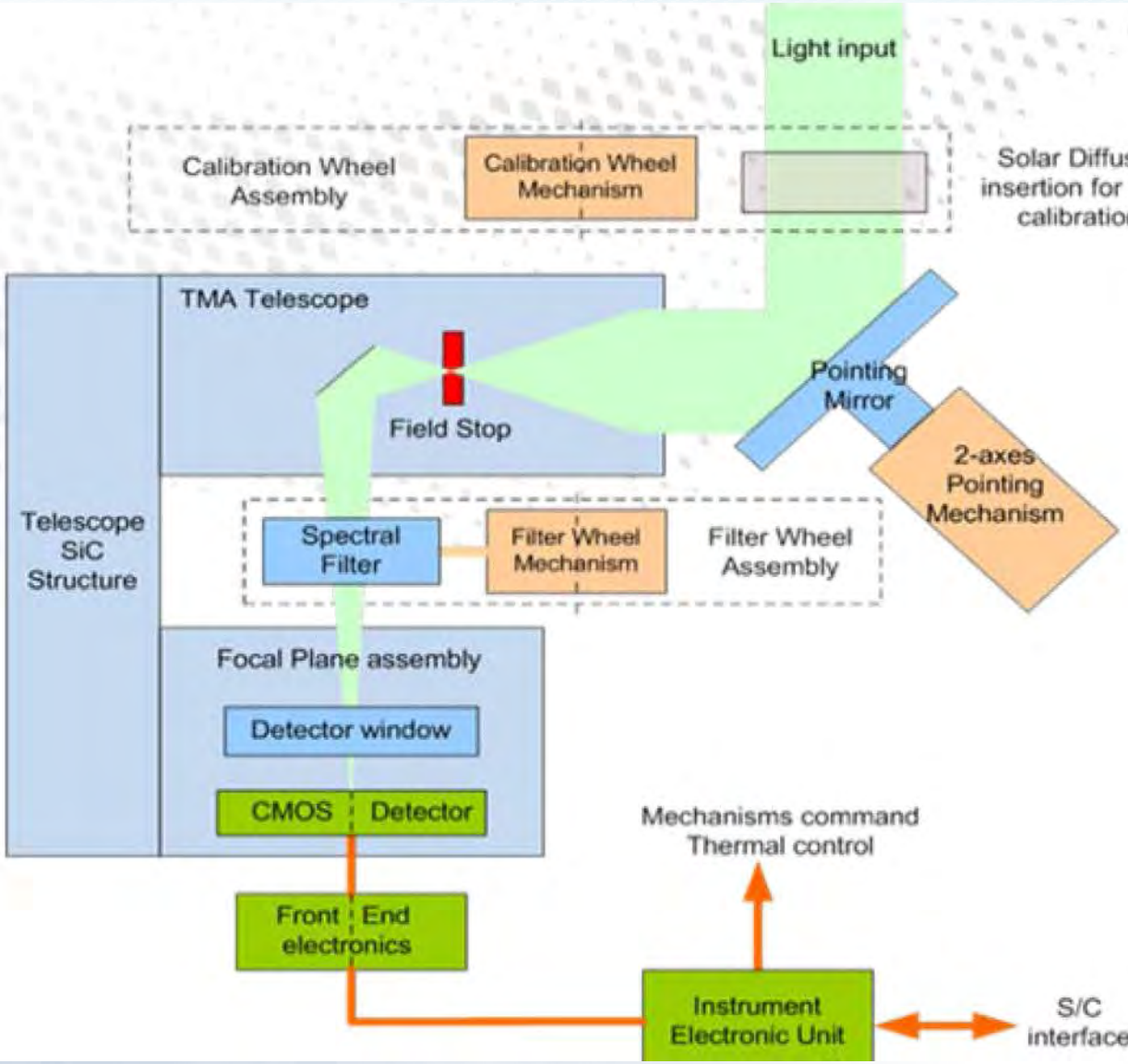
GOCI-II

CWA	Calibration Wheel Assembly
FEE	Front End Electronics
PIP	Payload Interface Plate
POM	POinting Mechanism
STA	Star Trackers Assembly

GOCI-II Functional Architecture



Overall instrument architecture and operation principles inherited from GOCI



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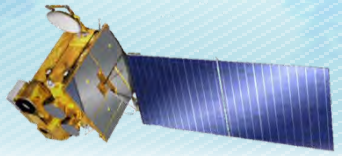
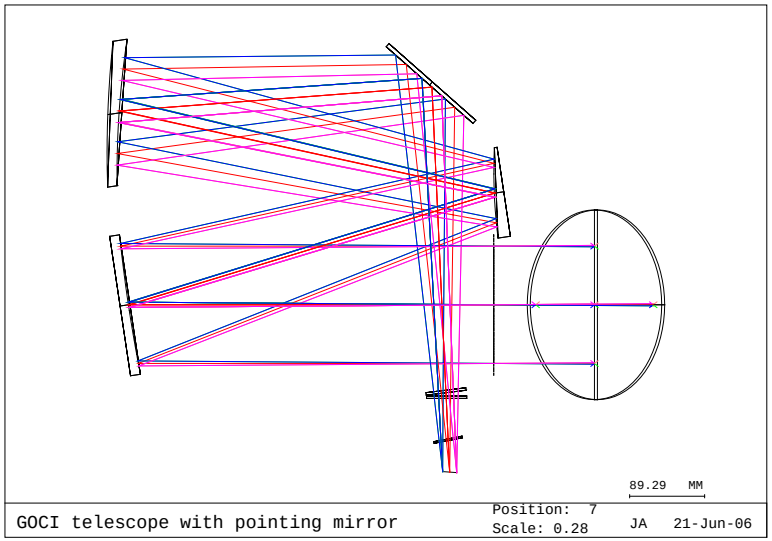
GOCI-II Optical Layout

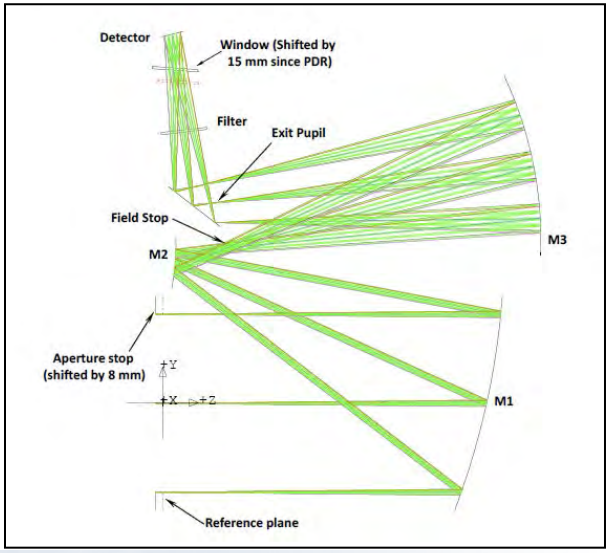


- **A Korsch Three Mirror Anastigmat has been chosen for its compactness and good optical performances.**
  - **Three aspheric mirrors allow a good correction of the 3 principal aberrations which are the spherical aberration, the coma and the astigmatism, including the field curvature (Petzval).**

	GOCI	GOCI-II
Telescope type	Three Mirror Anastigmat	
Pupil diameter	140 mm	200 mm
Instrument Focal Length	1171 mm	982 mm
Intermediate Image Plane	X	O



GOCI Optical Layout



GOCI-II Optical Layout

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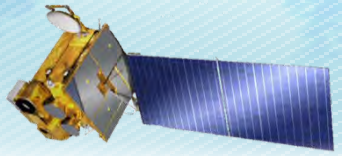
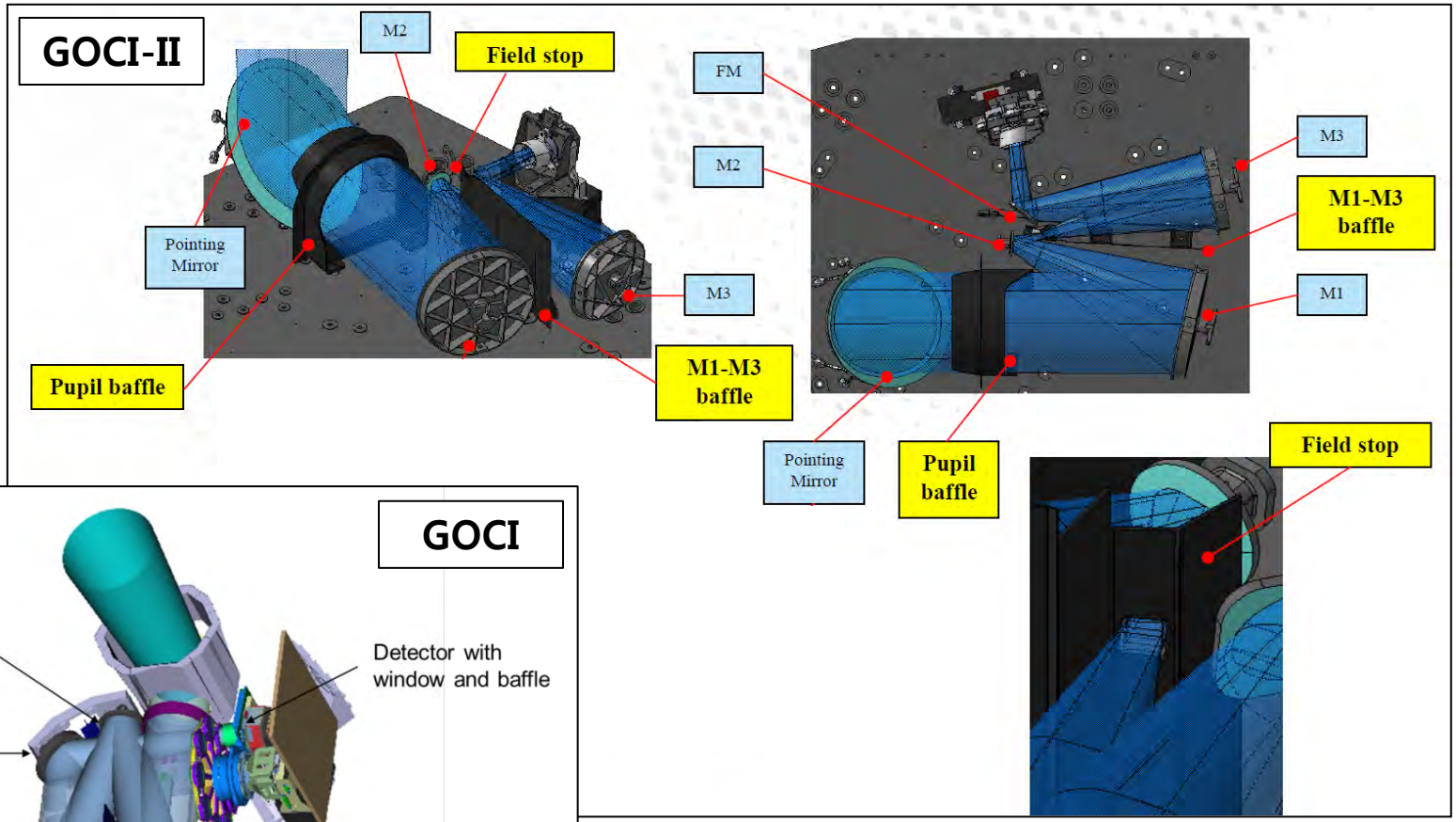
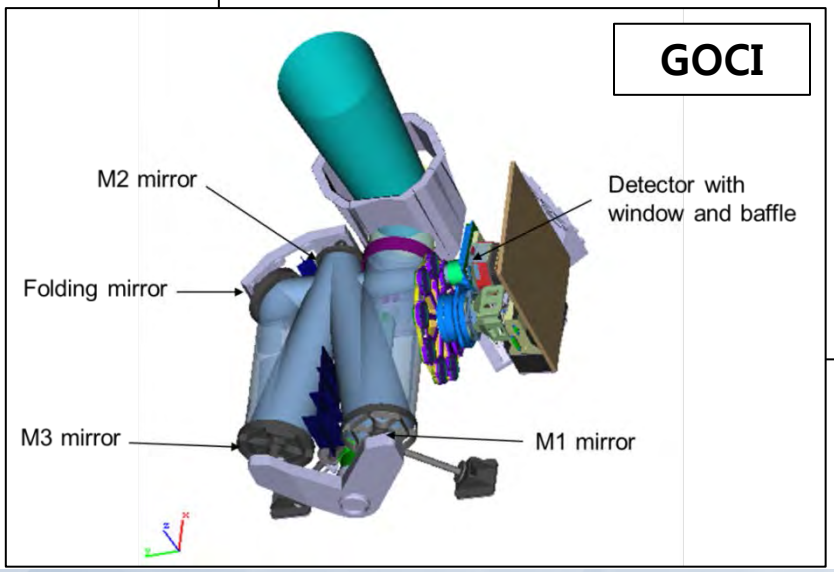
GOCI-II Optical Configuration







◆ **GOCI-II : Field stop**

- **Block the Unwanted Light from the out of FoV**

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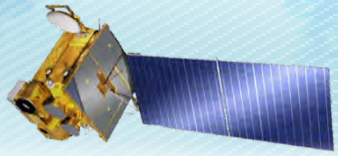
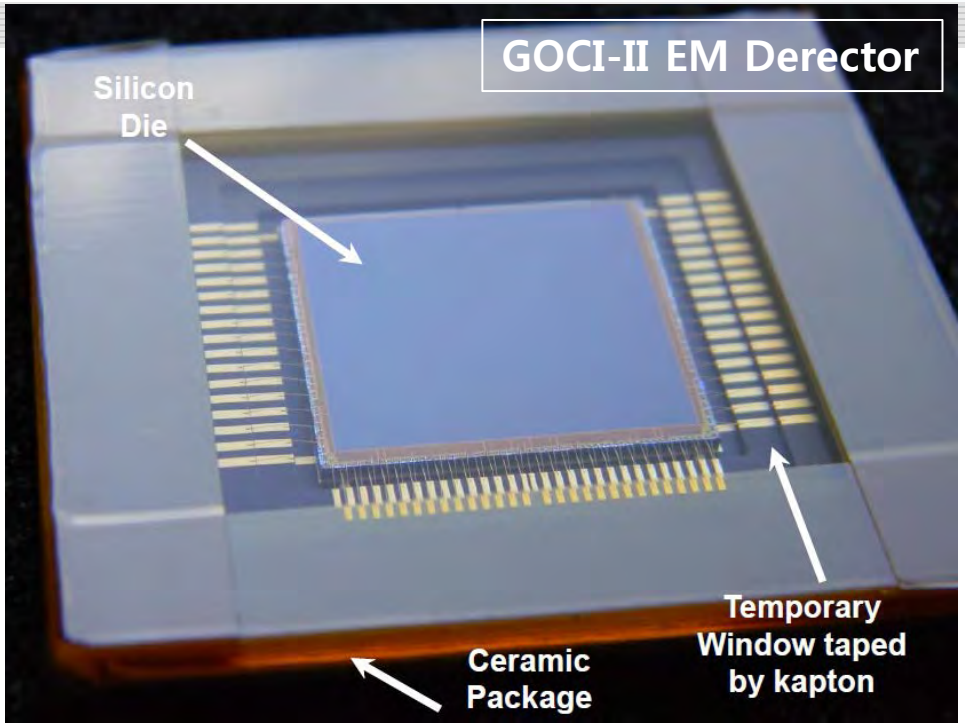
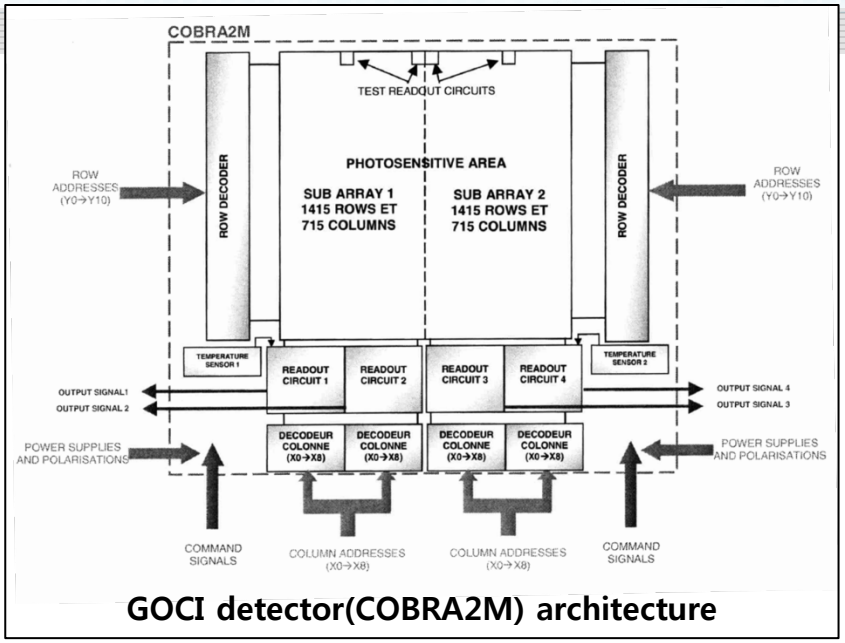
GOCI-II Detector

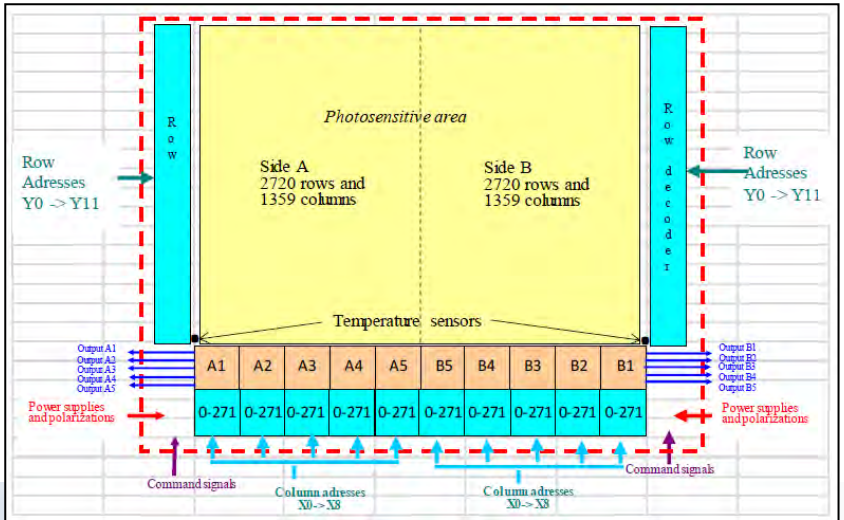




	GOCI	GOCI-II
Detector	CMOS 2 Mpixels	**CMOS 7.39 Mpixels**
Detector array	1415 rows x 1432 columns	**2720 rows x 2718 columns**
Detector size	16.5 x 21.0 mm^2	**18.5 x 18.5 mm^2**
Pixel size	11.53 x 14.81 μm^2	**6.8 x 6.8 μm^2**



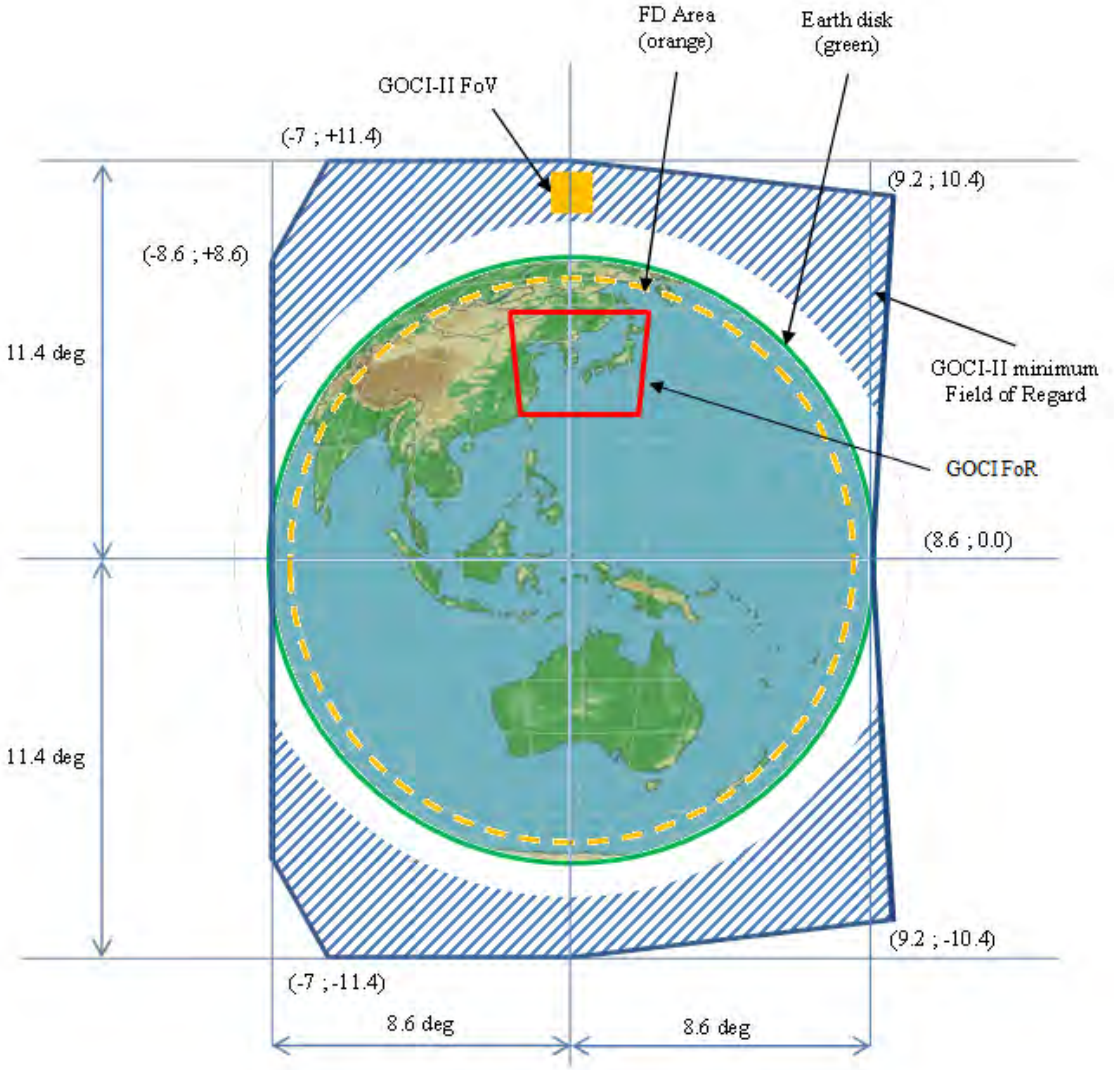
GOCI detector(COBRA2M) architecture



GOCI-II detector(LARGO7M) architecture

Field of Regard

- **Targeted Field of Regard**
- **SN FoR (±11.4 deg)**
  - 8.7 deg Earth Disk
  - 1.1 deg Instrument FoV set as margin
  - 1.1 deg useful FoV for moon and star
  - 0.5 deg margin for pointing bias
- **EW FoR (±8.6 deg)**
  - 8.06 deg FD area
  - 0.5 deg margin for pointing bias



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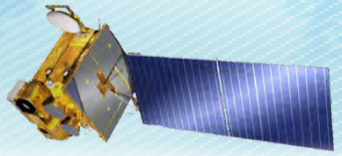
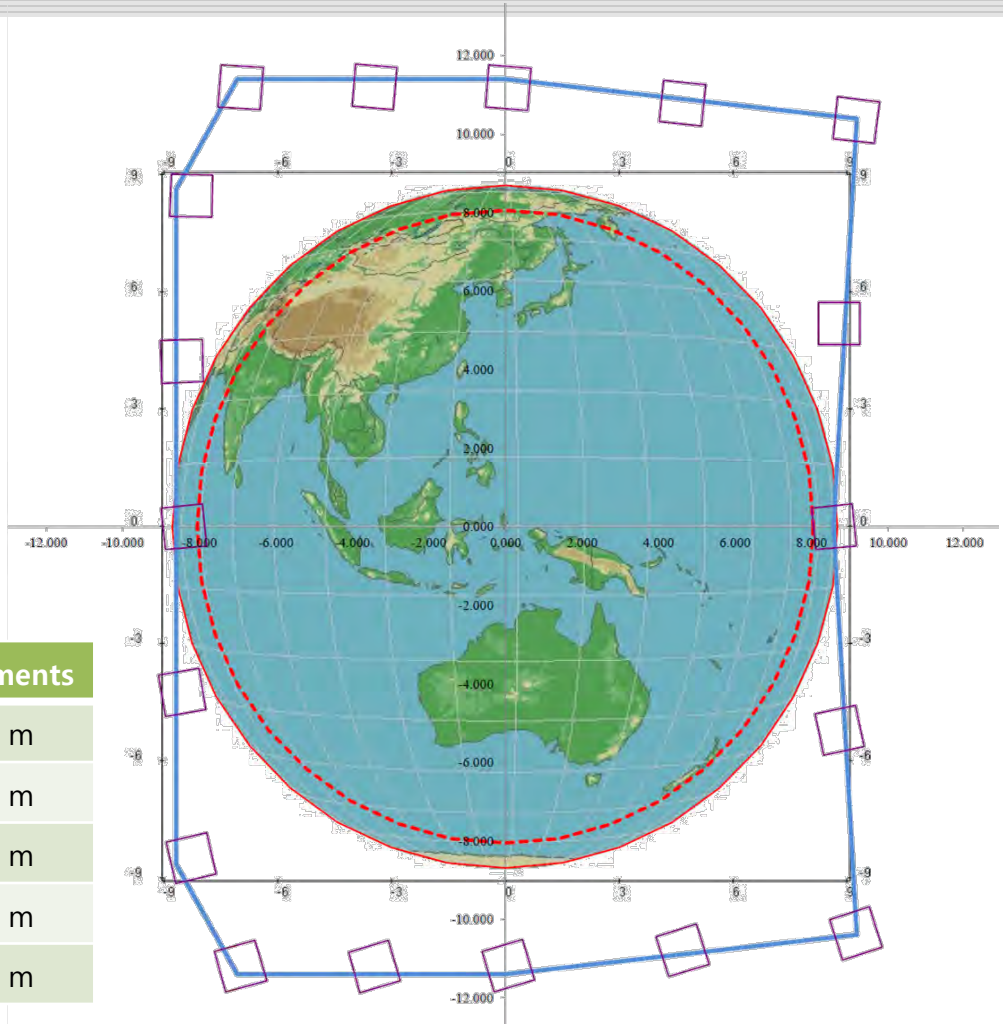
Field of Regard coverage



- **Range of gimbal angles:**
  - x(N/S): -8.20 deg and +8.20 deg
  - y(E/W): -4.40 deg and +4.30 deg

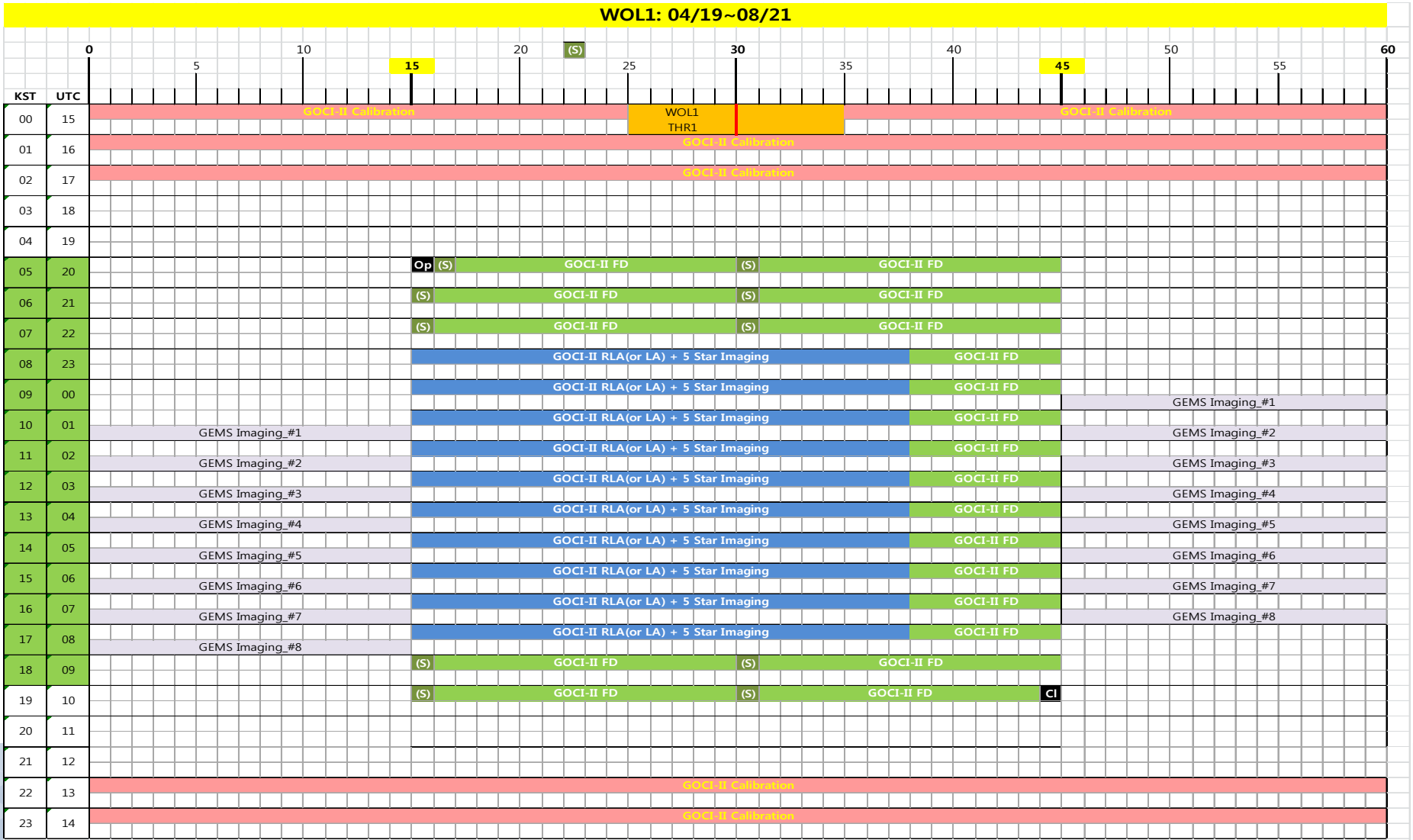
- **eGSD (m)**
  - 247 m at (130°E, 0°N)
    - spec < 250m
  - 299 m at RLA center
    - spec < 301m
  - < 364 m over RLA
    - spec < 371m



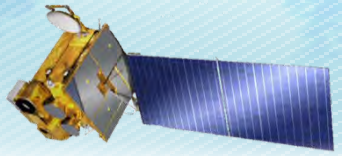
Local Area	GOCI	GOCI-II	Requirements
At center	481	299	< 301 m
At North-East corner	587	364	< 371 m
At North-West corner	575	359	< 371 m
At South-West corner	440	274	< 371 m
At South-East corner	449	278	< 371 m

Daily Operation Timeline

◆ WOL1 (04/19~08/21)

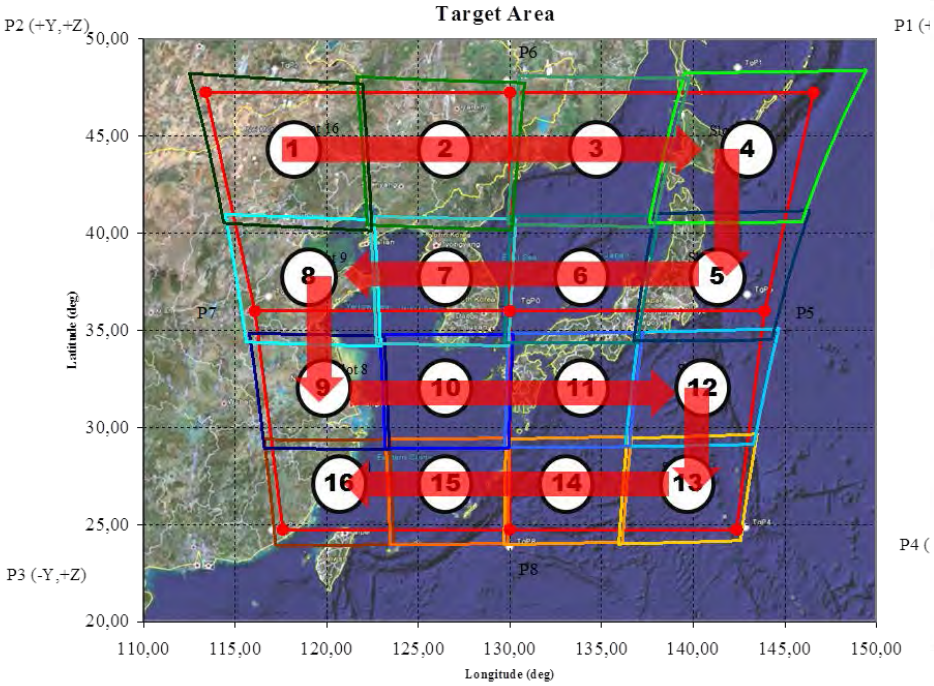


Mission Operation Plan

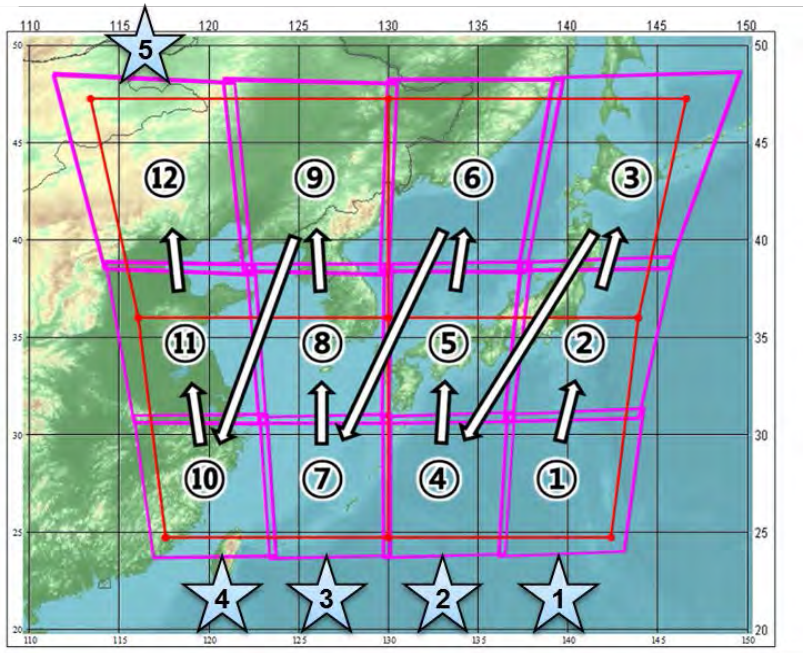


◆ Reference Local Area (RLA)

- **Baseline for slot imaging acquisition**
  - **Column-by-column Raster scan**
  - **South to North within a column, East to West between column**
  - **For the reduction of ISRD (Inter Slot Radiance Discrepancy) in operation level**

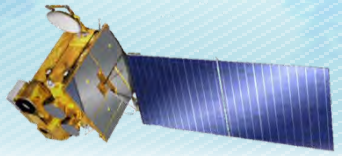


GOCI Local Area coverage by 16 slots



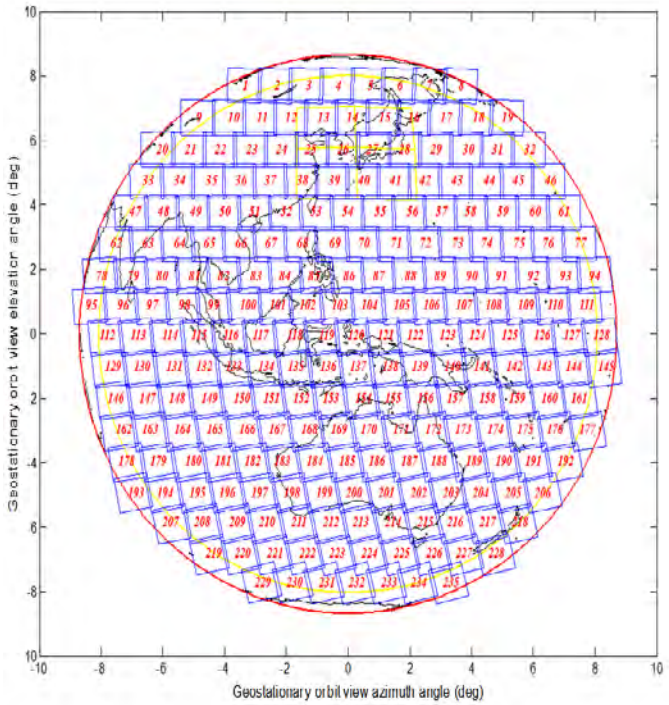
GOCI-II Reference Local Area coverage by 12 slots

Mission Operation Plan

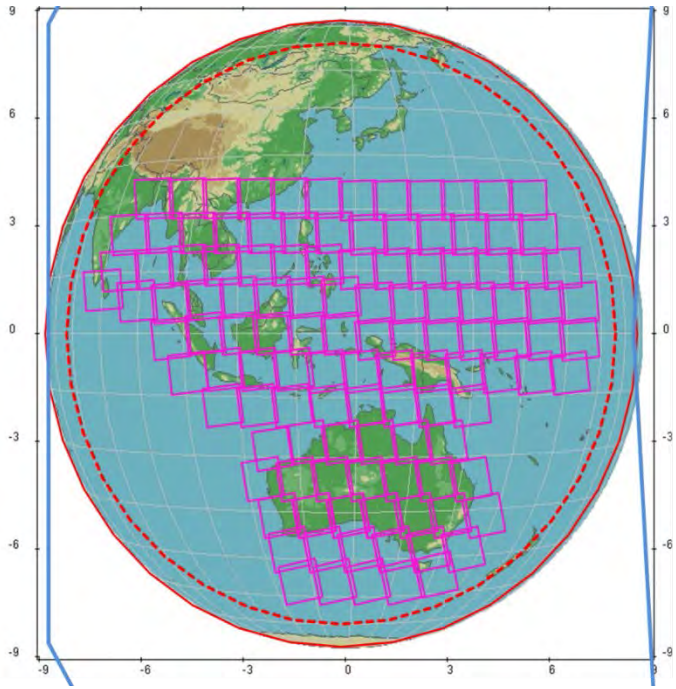


◆ Full Disk (FD)

- **Baseline for FD imaging operation**
  - **FD consists 240 slots (1 minute for 1 FD slot image acquisition)**
  - **1 FD image acquisition per day with 15 imaging sequences from 05:15AM to 19:45PM is planned**
  - **Instead of FD, 2 EA image acquisitions per day is in the status of discussion (TBD)**



FD(Full Disk) with ~ 240 Slots <TBD>

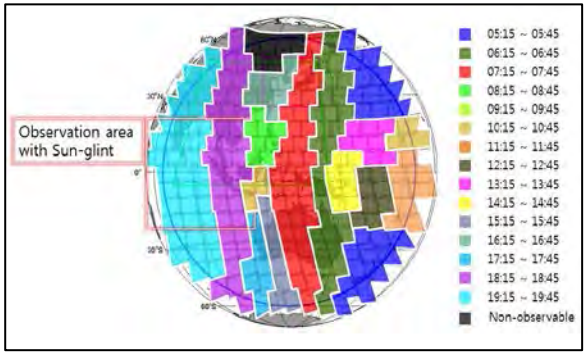


EA(Extended Area) with 120 Slots <TBD>

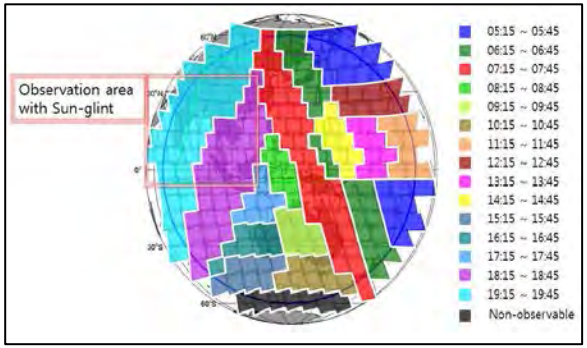
Mission Operation Plan

Full Disk (FD)

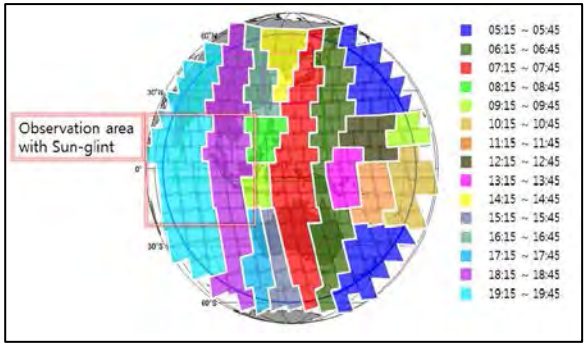
- Circle field of ±60° longitude and latitude centered at the spacecraft nadir
- The Imaging time for FD < 240 minutes
- FD operation conditions
  - Effective range of Solar Zenith Angle (SZA) : < 80 degs
  - Effective reflectance range for avoiding Sun glint : < 0.01 sr-1



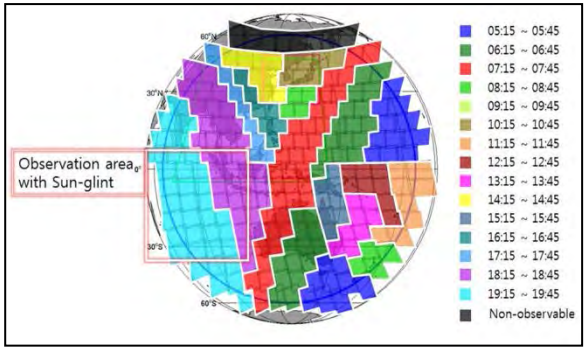
FD Slot Acquisition Sequence Baseline @ Vernal Equinox (WOL3)



FD Slot Acquisition Sequence Baseline @ Summer Solstice (WOL1)

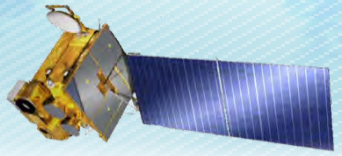


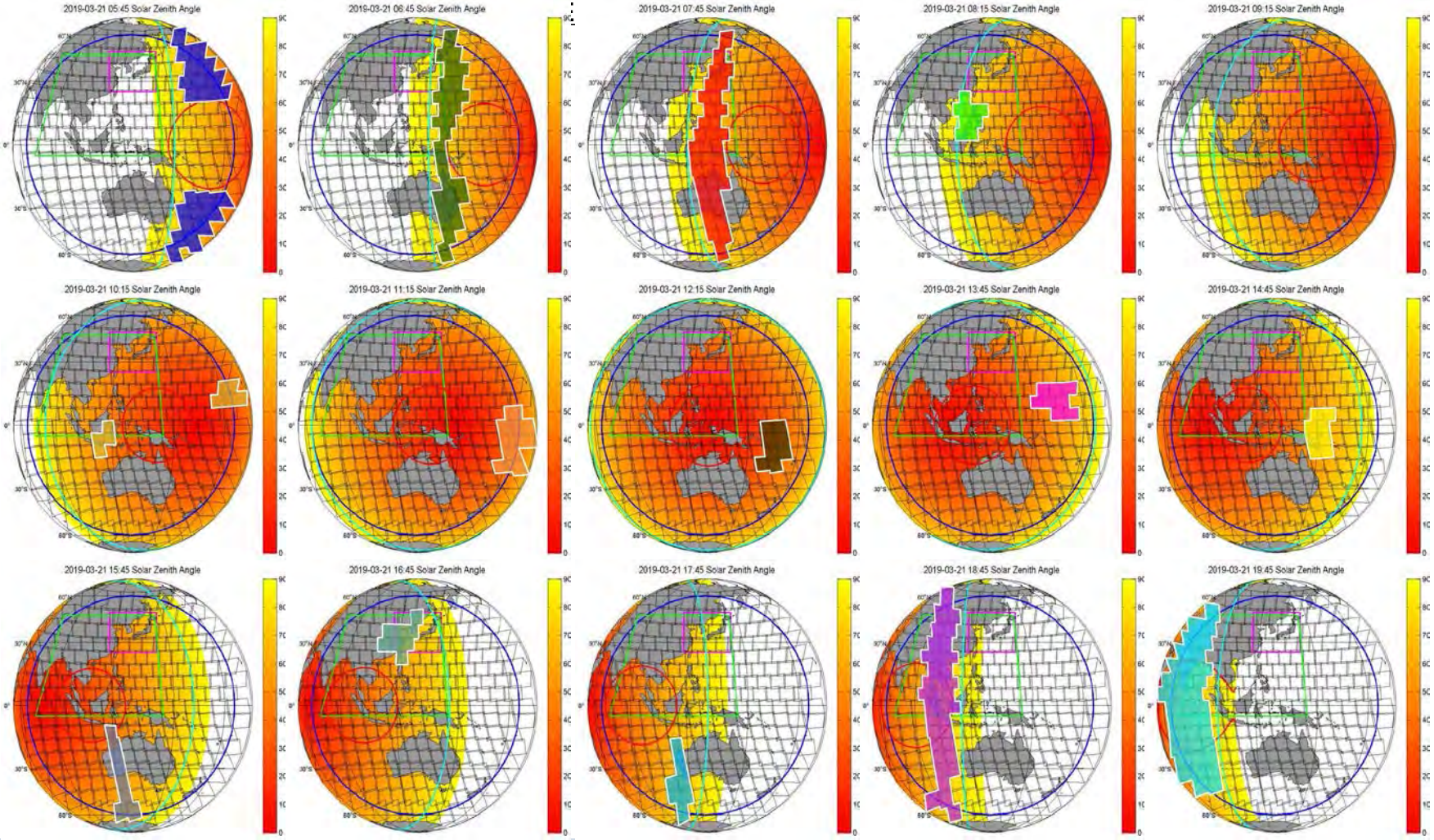
FD Slot Acquisition Sequence Baseline @ Autumnal Equinox (WOL2)



FD Slot Acquisition Sequence Baseline @ Winter Solstice (WOL3)

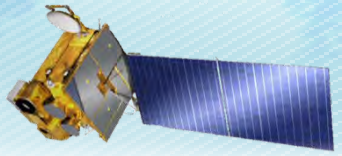
Full Disk (FD)





Korea Ocean Satellite Center

Radiometric Calibration

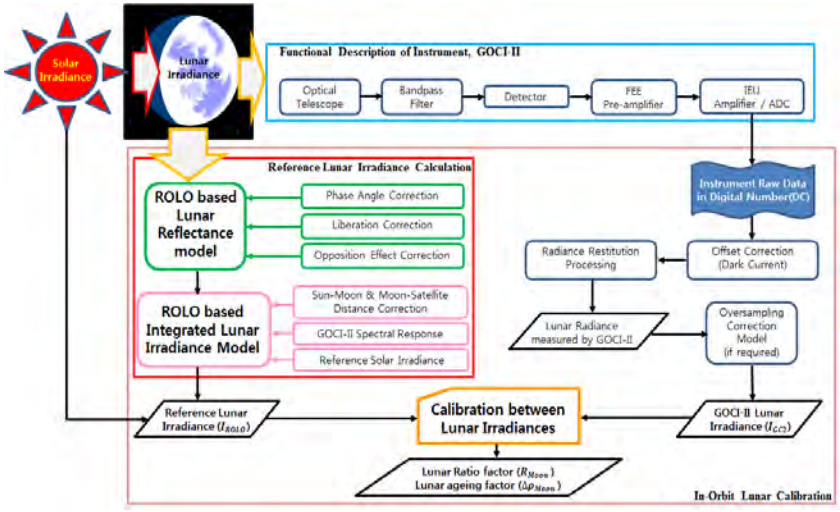


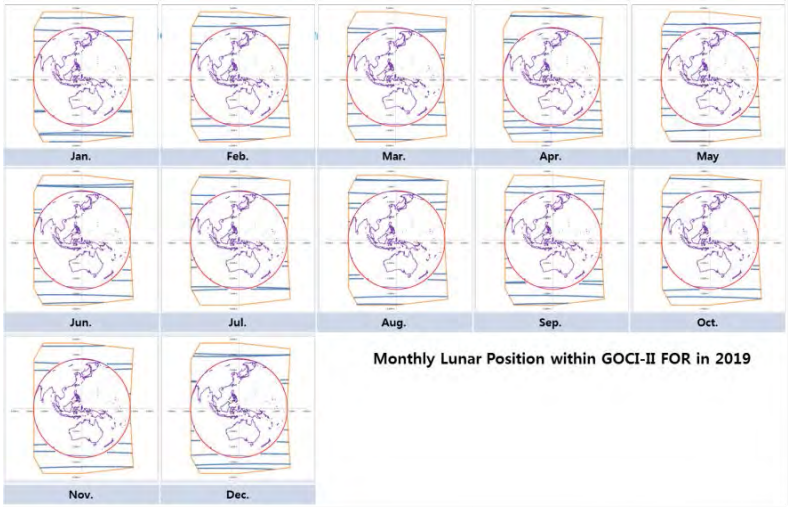
In-Orbit Radiometric Calibration Methods

- Solar Calibration with Solar Diffuser & 2nd Diffuser
  - Diffusers have to lambertian characteristics
- Monthly Lunar Calibration
  - Calibration methods based on ROLO (RObotic Lunar Observatory) model

Absolute Radiometric Accuracy (incl. measurement uncertainty)

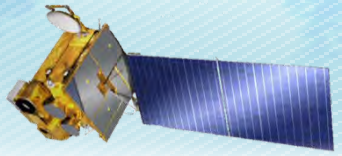
- In-orbit verification : Less than 4%
  - at the nominal radiance and maximum cloud radiance
- On-ground verification : Less than 3%





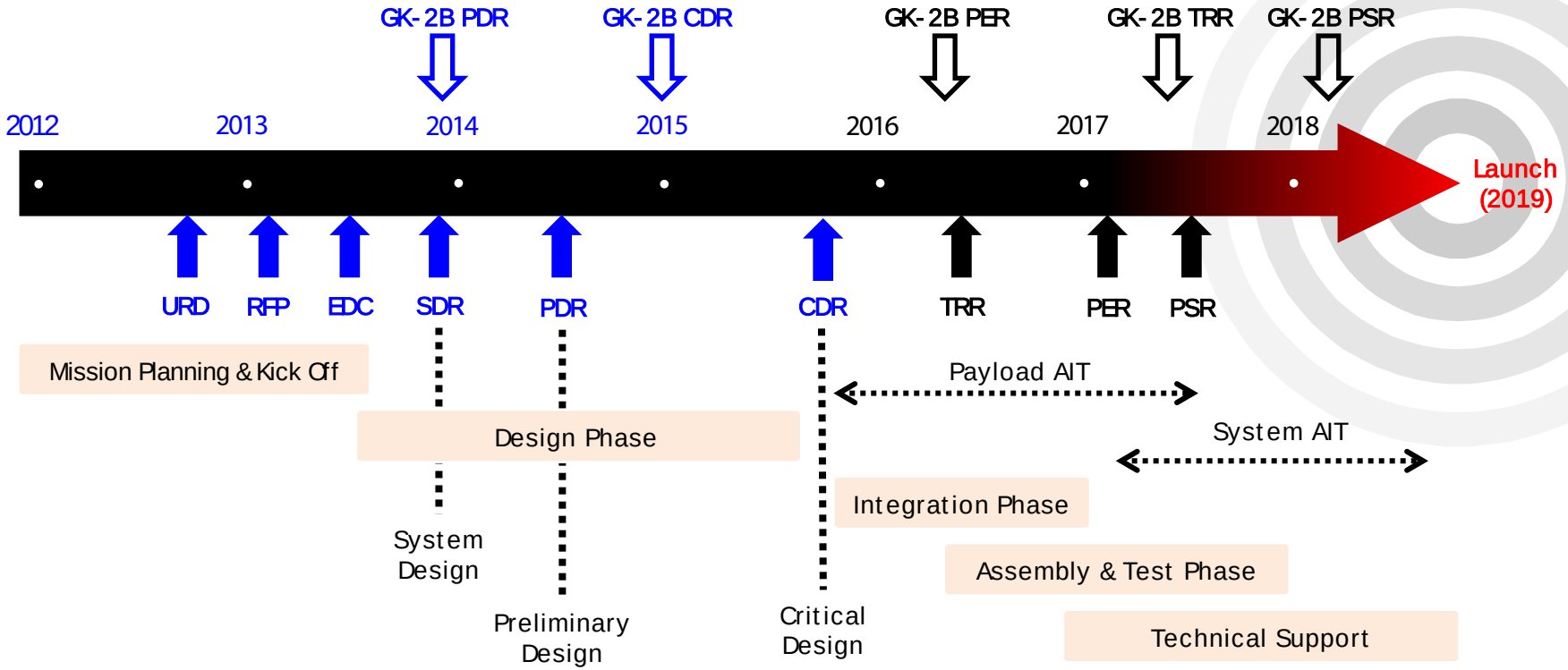
Monthly Lunar Position within GOCI-II FOR in 2019

GOCI-II Development Milestones



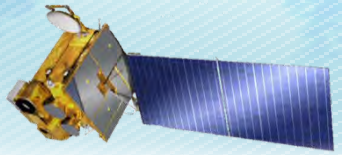
Joint Development by KIOST, KARI & Airbus DS

- **Development :**
  - **Payload system - Development Company(AIRBUS D&S) + KARI/KIOST team**
  - **Bus system - KARI**
- **Supervising : KIOST**

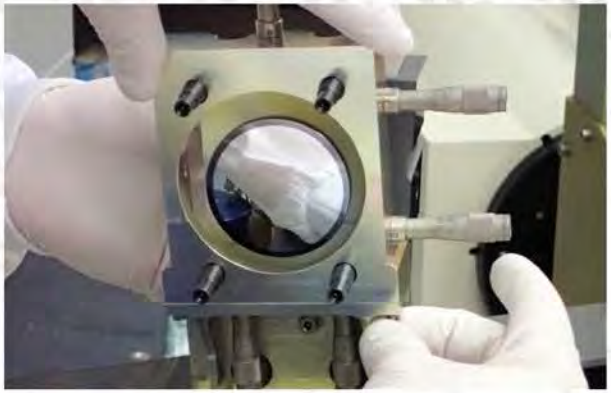


Korea Ocean Satellite Center

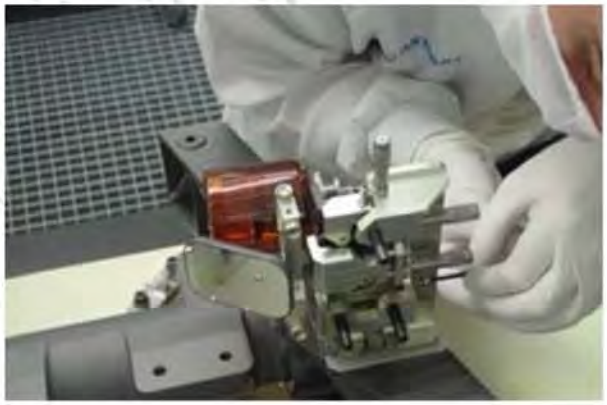
GOCI-II Integration



Structure installation on CMM

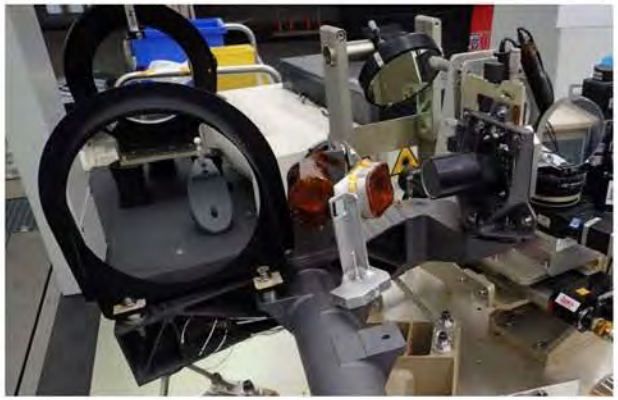


M2 alignment

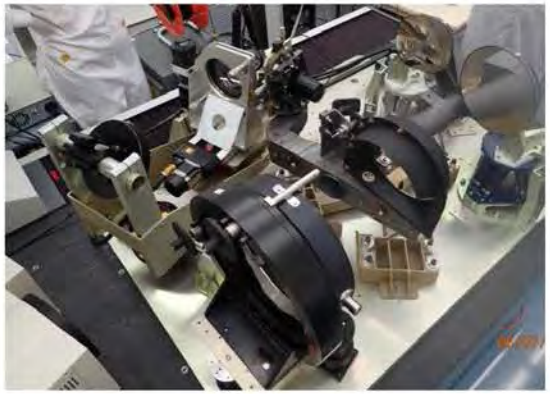


FM alignment

Focal grid and tool with DCW
FLW alignement

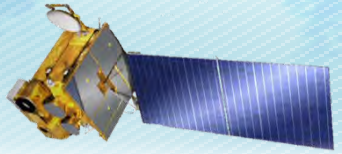


Pupil and FS tool alignment



Interferometer setup and ACFlat alignment

GOCI-II Integration



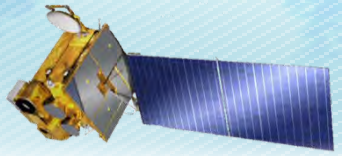
M1& M3 alignement

PIP preparation

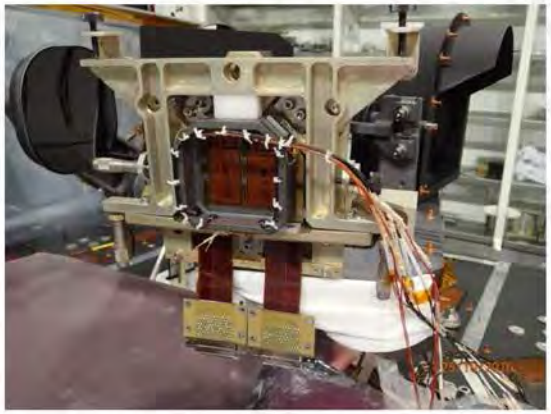
Telescope transfer on PIP

Telescope alignment on PIP

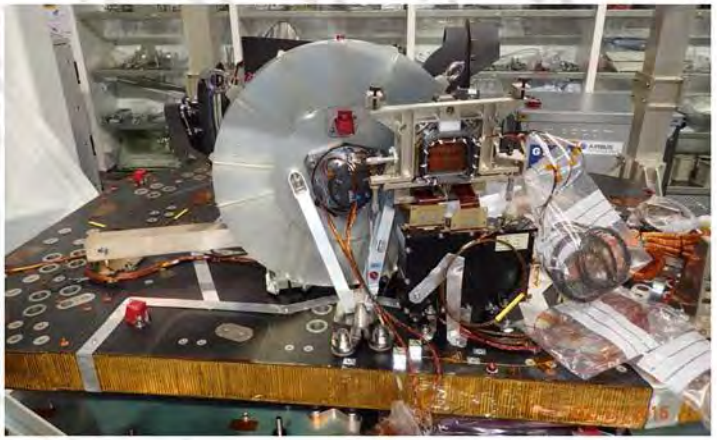
GOCI-II Integration



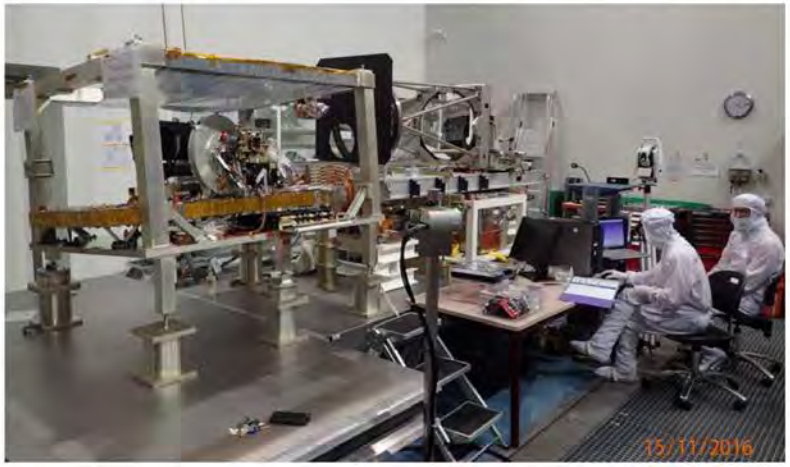
PFM model_AIT sequences for FPA alignment



FPA assembly and alignment to nominal

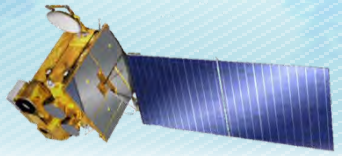


FEE and FWA assembly and alignment

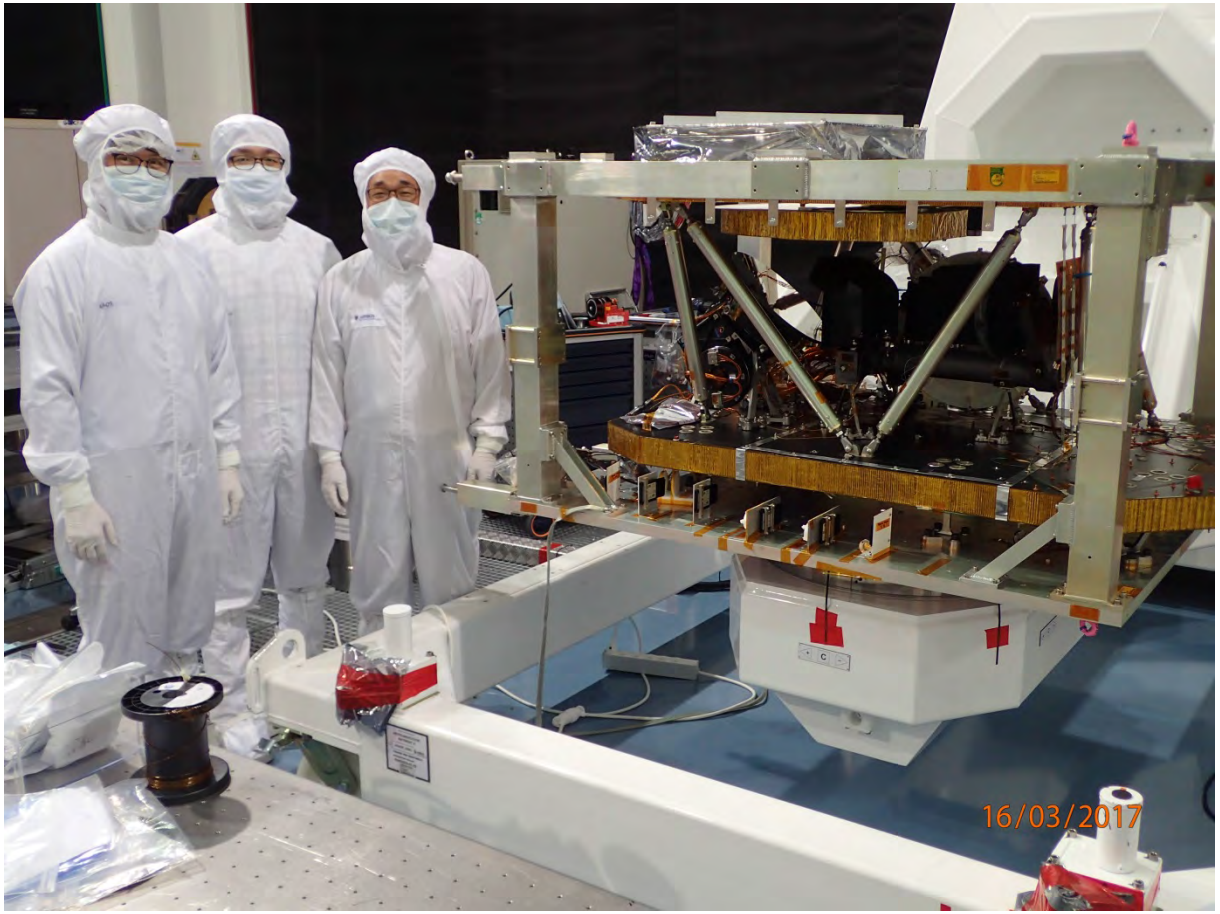


FPA final alignment
with collimator

Development Status – Latest picture

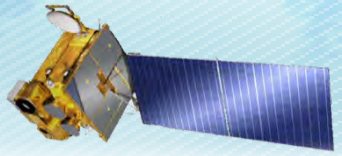


◆ Current status of GOCI-II payload (‘17.03.16)



- All payload was aligned and assembled completely.
- MLI will be covered before out-of stray light and radiometric test.
- After all test sequence in France is finished, PER will be held at Mid of June.
- Environmental test is planned in the KARI facility at the GODIK phase.

GOCI-II Spectral Response Test_Accomplished



◆ Spectral Response Function test

- **Spectral Response Function with respect to the measurement locations**

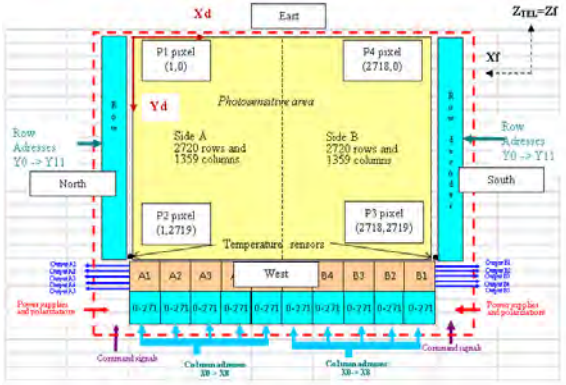
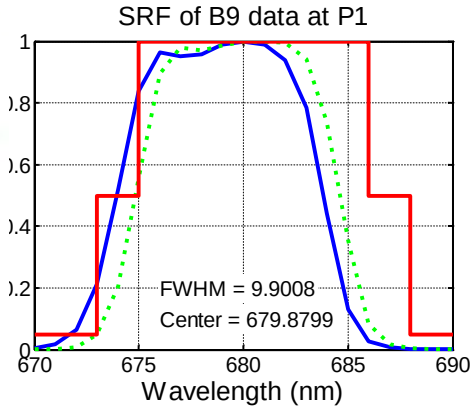
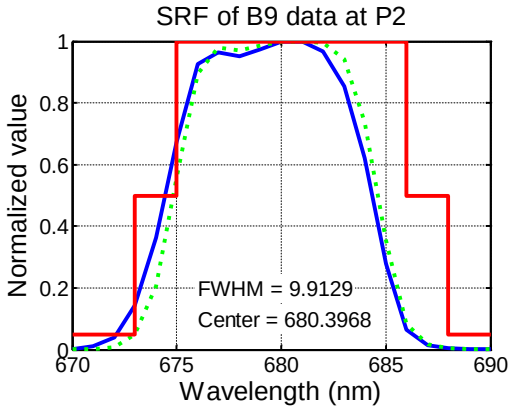
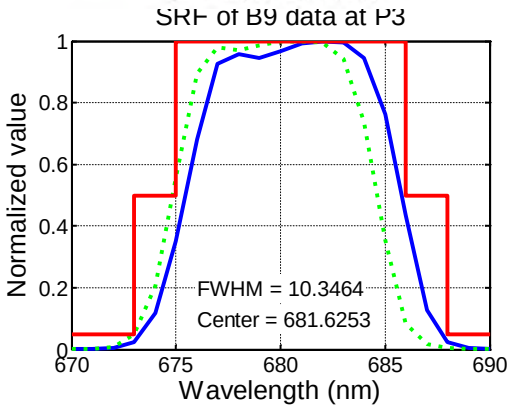
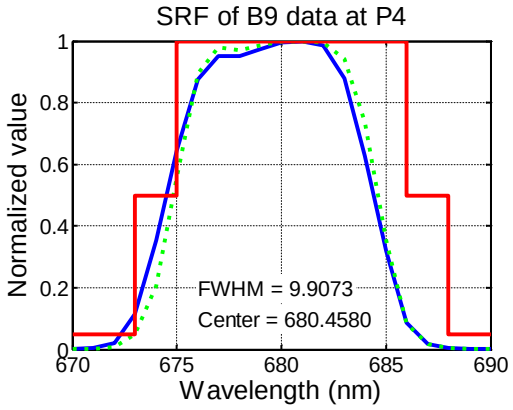


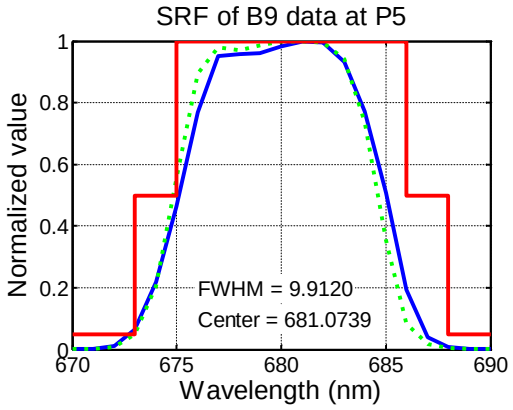
Figure 4.9-4: Focal Plane and Detector Frames (view from optical side; i.e. from -Zd)





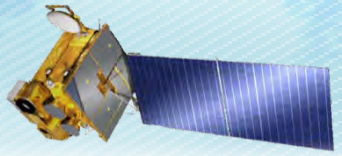






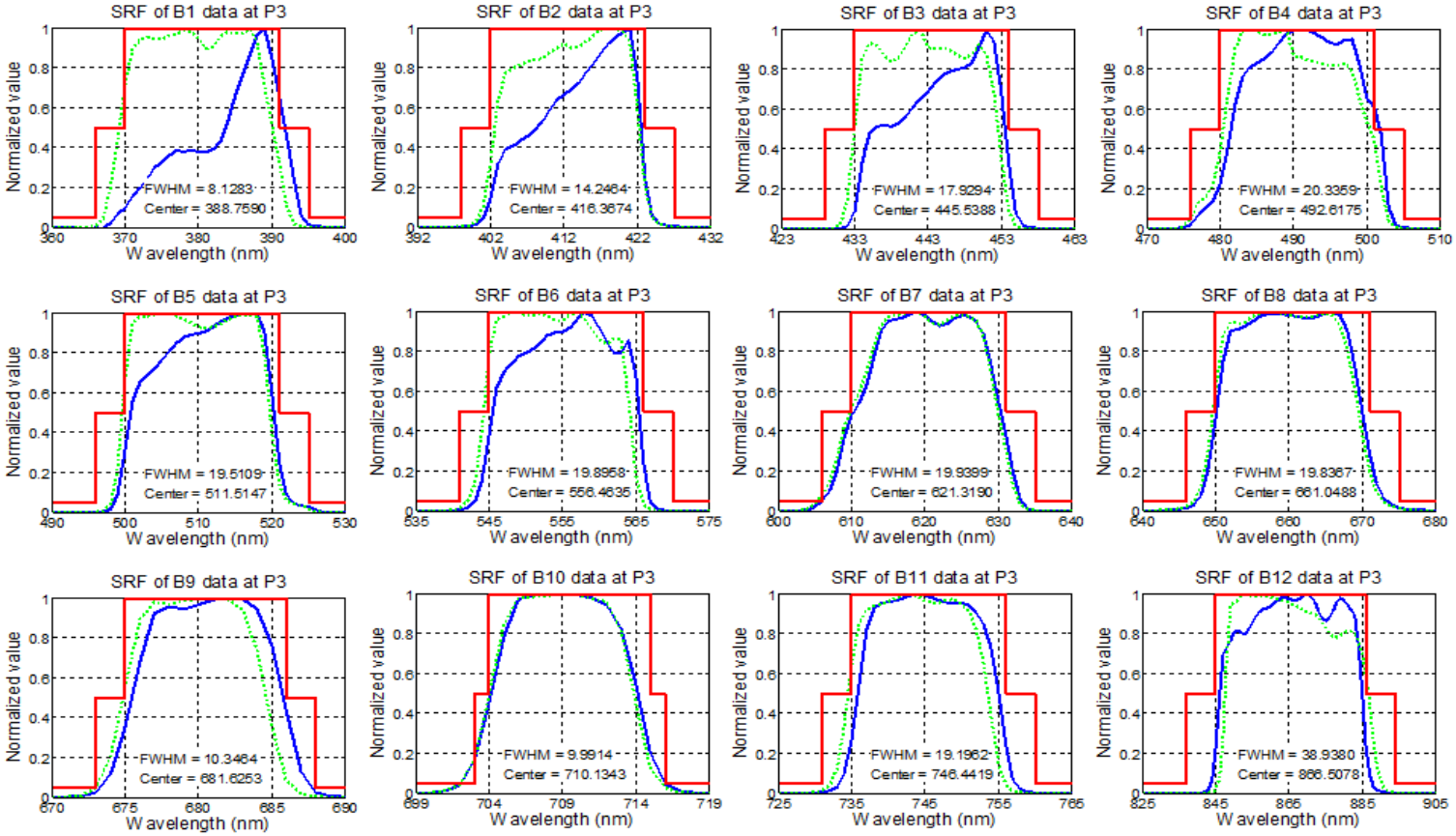
Requirement Analysis Measurement

GOCI-II Spectral Response Test_Accomplished

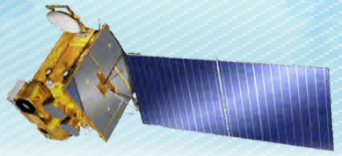


◆ Spectral Response Function test

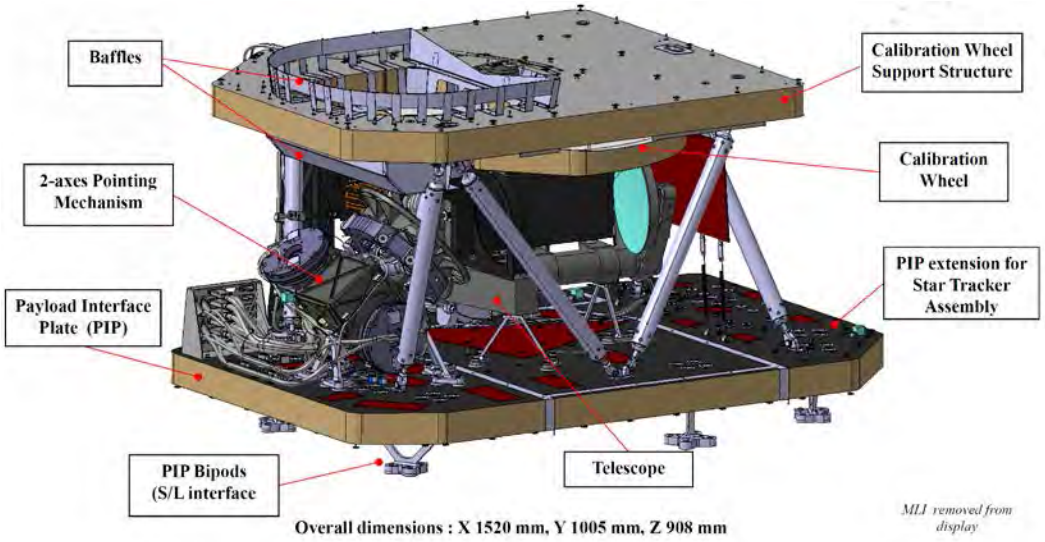
- **Comparison with estimation and measurement results**

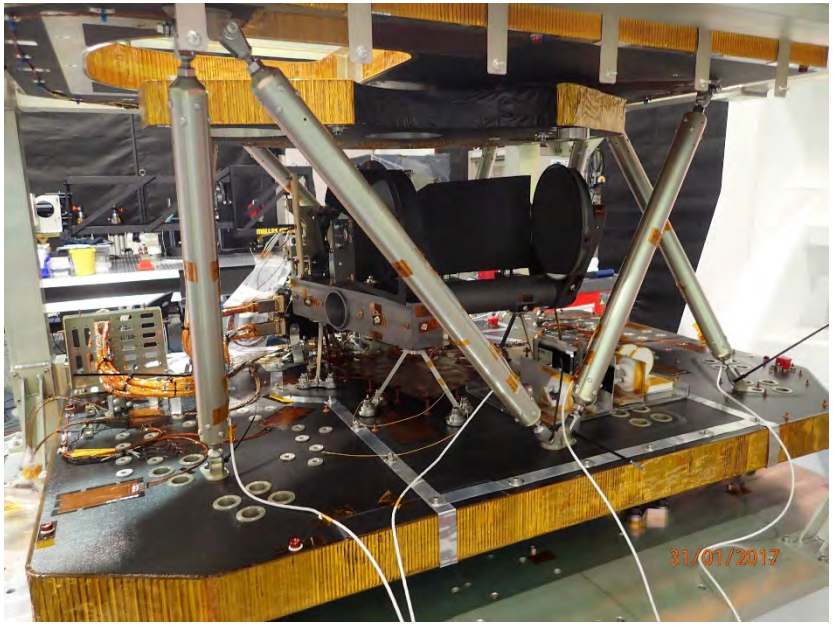


Future Plan

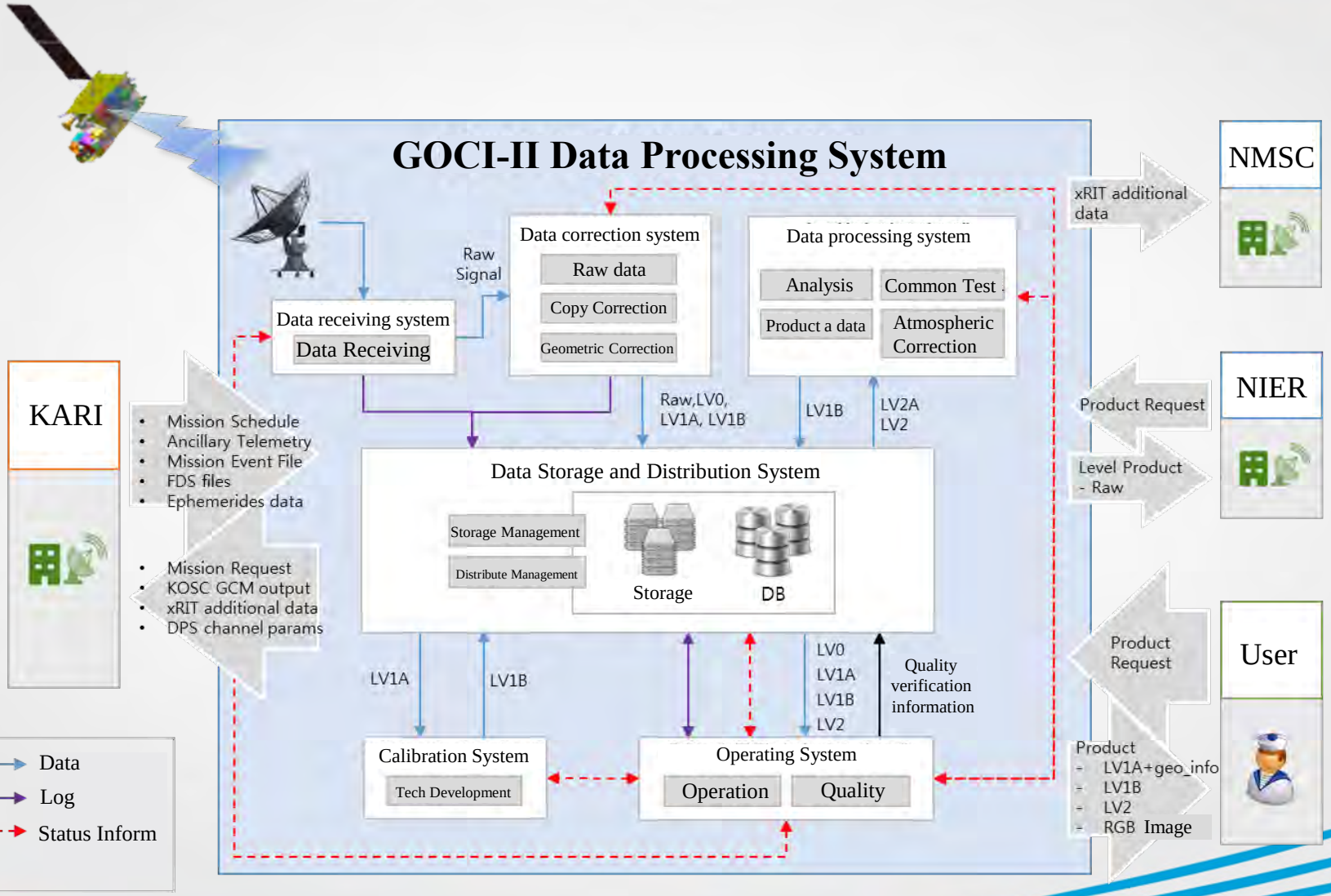


- Integration of GOCI-II is successfully accomplished and GOCI-II is in the preparation of pre-flight test campaign from mid Feb.
- The data service of GOCI-II will be started around 2019.

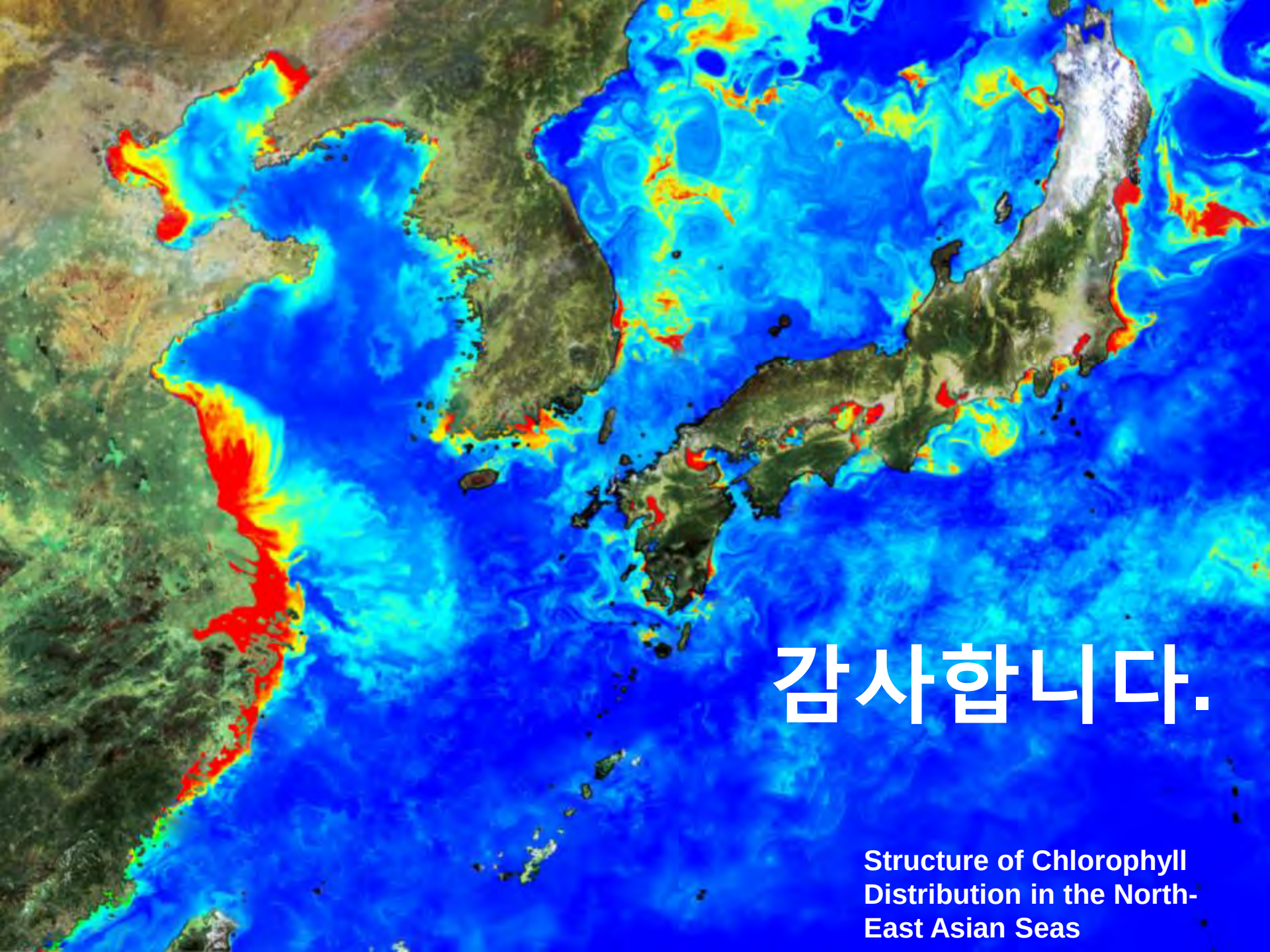




GOCI-II : Data Processing System



Relocation of KIOST (Busan, Korea)



Structure of Chlorophyll Distribution in the North-East Asian Seas