Present Status of GOCI/COMS and GOCI-2

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Korea Ocean Satellite Center, KORDI
Pre-Launch Status of GOCI/COMS
Korea Ocean Satellite Center, KORDI

Satellite Configuration

- Geostationary satellite
- Mass at launch: 2500 kg
- Design life time: 10 years
- Operational life: 7.7 years from launch
- Launcher: Ariane 5

Solar Array

TMTC S band antenna

MODCS S band antenna

MODCS L band antenna

MI: Meteorological Imager

Earth Direction

Ka band antenna

GOCI: Geostationary Ocean Color Imager

IRES: Infra-Red Earth Sensor
GOCI Instrument Design

- Overview of GOCI Instrument
  - Shutter wheel & Mechanism
  - Pointing Mirror & Mechanism
  - Optics
  - Filter wheel & Mechanism
  - Detector & FEE
  - PIP
  - IEU

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<table>
<thead>
<tr>
<th>Volume</th>
<th>1.39m x 0.89m x 0.85m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>&lt; 84kg (including IEU)</td>
</tr>
<tr>
<td>Power</td>
<td>&lt; 100W (including thermal control)</td>
</tr>
</tbody>
</table>
• Number of bad sensor pixels
  => Not meeting Radiometric Requirements
    - KORDI’s Request: should be reduced to 0.01%, not 0.1%.
    - Status: 0.01% confirmed by Test Results

• 2nd Diffuser (Diffuser Aging Monitoring Device) size
  - KORDI’s Request: DAMD should be identical to solar diffuser to monitor the aging.
  - Status: Small sized (half of diameter) 2nd diffuser is implemented replaced from calibration plate.
Radiometric calibration

- Accuracy requirement: < 4%
  -> lower than 3.8% (Solar calibration only)

GOCI Radiance Calculation Equation

$$L = \frac{1}{T_{int}} \frac{S}{\sigma} \left( 1 - \frac{b S^2}{\sigma^2 + b S^2} \right) \left( 1 + \frac{b S^2}{\sigma^2 + b S^2} \right)$$

- Identification of error sources
  - On-ground characterization parameters
    - Diffusion factor of SD
    - FMD of DAMD
  - In-orbit operation environment
    - Reflectivity variation of pointing mirror
    - Gain variation during one day
    - Offset variation during one slot imaging
    - System noise (SNR)
    - SD aging factor estimation error
    - DAMD aging
  - GOCI radiometric model error
  - Simplification of nonlinearity due to dark current

- Analytic calculation of estimation error
  - Derivation error propagation coefficients from radiance equation
  - Error source estimation from On-ground test results achieved at GOCI level and equipment level
  - Then
  - Calculation of radiance estimation error using propagation coefficients and error

- Validation of analytic method through GOCI simulation model
  - Simulation of Sun radiance acquisition with GOCI for single pixel (using GOCI simulation model)
  - Simulation of Sea radiance acquisition with GOCI for single pixel (using GOCI simulation model)
  - Radiance calculation using simulated GOCI signals
  - Extraction of radiance estimation error using simulation results (1000 times)

Comparison between analytical result and simulated result
Shipment to Korea

- GOCI has shipped to Korea in Nov. 24, 2008
GOCI/COMS Integration

- GOCI has been successfully integrated into COMS in KARI / Korea
- GOCI/COMS final ground test campaign is on going in KARI.
Following Activities

- Launch Schedule: Nov. 2009
- Launch Vehicle: Ariane–V (ESA)
  - Location: Kourou Space Center, French Guiana

Korea Ocean Satellite Center, KORDI
GOCI-2
(2010 –2016)
Multiple purpose GEO satellite(A & B)  

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COMS

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Meteorological satellite (MI-2)
Ocean payload (GOCI-2) 60M$
Atmospheric chemistry payload

Communication payload
Meteorological payload
Ocean payload(GOCI)

• Data Collection System(DCS ?)

=> Confirmed by Ministries
Under evaluation for funding / National scientific committee
GOCI–2 Mission Requirements

- **Main Mission**
  - Succession and expansion of the GOCI–1 missions

- **Newly assigned Mission to GOCI–2**
  - Establishment of Ocean Observation System to monitor long–term climate change with Full Disk Observation.
  - Environment Monitoring for the efficient management of coastal waters with High Resolution(GSD 250m) Local Area Observation.
GOCI-2
User Requirements and Feasibility Study
GOCI-2 User Requirements

• Key Requirements
  - Spectral Band : 13 bands (cf. GOCI = 8 Bands)
  - Resolution(GSD) : 250m & 1km (cf. GOCI = 500m)
  - Temporal Resolution : every 1 h & 12–24h
  - Observation Coverage
    • Local Area(GOCI Coverage) – GSD: ~250m
    • Full Disk Coverage – GSD: ~1000m
  - Nighttime Observation
    • Additional Panchromatic Filter
      - Panchromatic Filter (400~900nm)
      - Dedicated Low Noise Detector for Nighttime Observation

Korea Ocean Satellite Center, KORDI
Coverage

- Monitoring of the Global/Local ocean environment
### GOCI-2 User Requirements

- **Comparison with GOCI**

<table>
<thead>
<tr>
<th></th>
<th>GOCI</th>
<th>GOCI-2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orbit type</strong></td>
<td>GEO</td>
<td>GEO</td>
</tr>
<tr>
<td><strong># of Bands</strong></td>
<td>8</td>
<td>13</td>
</tr>
</tbody>
</table>
| **Spatial Resolution** | 500m x 500m               | 250m x 250m  
|                  |                              | 1km x 1km                   |
| **Coverage**     | Local Area (Korean Peninsula) | Local Area & Full disk     |
| **SNR**          | ~1000                       | ~ 1500                      |
| **Temporal Resolution** | 1 Hour                    | 1 Hour  
|                  |                              | 12–24H                      |

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=> Due to low spatial resolution, ocean contamination by land signal can’t be applicable.

Korea Ocean Satellite Center, KORDI
Feasibility Study

- **Spectral Bands Requirements**
  - 13 Bands (GOCI: 8 Bands)
  - Nighttime Observation, Enhanced Atmospheric Correction Accuracy

<table>
<thead>
<tr>
<th>Band</th>
<th>Heritage</th>
<th>Band Center</th>
<th>Band Width</th>
<th>Nominal Radiance</th>
<th>Maximum Ocean Radiance</th>
<th>Saturation Radiance</th>
<th>Maximum Cloud Radiance</th>
<th>NEdL</th>
<th>SNR</th>
<th>Primary use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GOCI-B1</td>
<td>412nm</td>
<td>20nm</td>
<td>100.0</td>
<td>150.0</td>
<td>152.0</td>
<td>601.6</td>
<td>0.100</td>
<td>1000</td>
<td>Yellow substance and turbidity</td>
</tr>
<tr>
<td>2</td>
<td>GOCI-B2</td>
<td>443nm</td>
<td>20nm</td>
<td>92.5</td>
<td>145.8</td>
<td>148.0</td>
<td>679.1</td>
<td>0.085</td>
<td>1090</td>
<td>Chlorophyll absorption maximum</td>
</tr>
<tr>
<td>3</td>
<td>GOCI-B3</td>
<td>490nm</td>
<td>20nm</td>
<td>72.2</td>
<td>115.5</td>
<td>116.0</td>
<td>682.1</td>
<td>0.067</td>
<td>1170</td>
<td>Chlorophyll and other pigments</td>
</tr>
<tr>
<td>4</td>
<td>(KGOCI)</td>
<td>520nm</td>
<td>20nm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>GOCI-B4</td>
<td>555nm</td>
<td>20nm</td>
<td>55.3</td>
<td>85.2</td>
<td>87.0</td>
<td>649.7</td>
<td>0.056</td>
<td>1070</td>
<td>Turbidity, suspended sediment</td>
</tr>
<tr>
<td>6</td>
<td>(KGOCI)</td>
<td>625nm</td>
<td>20nm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>GOCI-B5</td>
<td>660nm</td>
<td>10nm</td>
<td>32.0</td>
<td>58.3</td>
<td>61.0</td>
<td>589.0</td>
<td>0.032</td>
<td>1010</td>
<td>Baseline of fluorescence signal, Chlorophyll, suspended sediment</td>
</tr>
<tr>
<td>8</td>
<td>GOCI-B6</td>
<td>685nm</td>
<td>10nm</td>
<td>27.1</td>
<td>46.2</td>
<td>47.0</td>
<td>549.3</td>
<td>0.031</td>
<td>870</td>
<td>Atmospheric correction and fluorescence signal</td>
</tr>
<tr>
<td>9</td>
<td>GOCI-B7</td>
<td>745nm</td>
<td>20nm</td>
<td>17.7</td>
<td>33.0</td>
<td>33.0</td>
<td>429.8</td>
<td>0.020</td>
<td>860</td>
<td>Atmospheric correction and baseline of fluorescence signal</td>
</tr>
<tr>
<td>10</td>
<td>(KGOCI)</td>
<td>765nm</td>
<td>20nm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Aerosol Properties, Atmospheric Properties</td>
</tr>
<tr>
<td>11</td>
<td>GOCI-B8</td>
<td>865nm</td>
<td>40nm</td>
<td>12.0</td>
<td>23.4</td>
<td>24.0</td>
<td>343.8</td>
<td>0.016</td>
<td>750</td>
<td>Aerosol optical thickness, vegetation, water vapor reference over the ocean</td>
</tr>
<tr>
<td>12</td>
<td>905nm</td>
<td>40nm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Atmospheric Properties, Cloud Properties</td>
</tr>
<tr>
<td>13</td>
<td>650nm</td>
<td>500nm</td>
<td>6.5E-6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Night Band (Night time fishing boat activities)</td>
</tr>
</tbody>
</table>

Radiance: W/m²/µm/sr

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Feasibility Study

• 5 additional bands and Full Disk Coverage
  - Technical impact
    • Long integration time
    • Increased Data: 9 times larger than GOCI
    • Increased data transmitting rate: 9 times larger than GOCI
  - Solution
    • Data communication band: L-band to X-band
      => X band: about 23 time faster than L-band
      -> Feasible

* GOES-R(X-Band): 140Mbps (A. Krimchansky et. al, 2006)
* GOCI(L-Band): 6.2Mbps, MI(L-Band): 2.6Mbps

=> Required transfer rate: ~ 60Mbps
Feasibility Study

• How to accomplish the resolution with GSD 250m
  - Solution with modifying GOCI design

  • Reduced CCD Pixel Size: 14.81 -> 7.0μm
    - Heritage: BIRD satellite- 7μm pixel size CCD [payload: WAOSS-B]

  • Increased Aperture Size (14cm -> 30cm)
    - To compensate SNR & MTF degradation due to reduced pixel size and increasing light gathering power

<table>
<thead>
<tr>
<th>구분</th>
<th>KAI-16000</th>
<th>GX-20</th>
<th>WFC3</th>
<th>GOCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
<td>Kodak (Japan)</td>
<td>Samsung (Korea)</td>
<td>E2V (UK)</td>
<td>E2V (UK)</td>
</tr>
<tr>
<td>Type</td>
<td>CCD</td>
<td>CMOS</td>
<td>CCD</td>
<td>CMOS</td>
</tr>
<tr>
<td>Pixel</td>
<td>4,872×3,248</td>
<td>4,672×3,104</td>
<td>2x2051x4096</td>
<td>1,415x1,431</td>
</tr>
<tr>
<td>Pixel Size</td>
<td>7.4μm×7.4μm</td>
<td>5.0μm×5.0μm</td>
<td>15.0μm×15.0μm</td>
<td>14.81μm×11.53μm</td>
</tr>
<tr>
<td>Detector Size</td>
<td>36.1×24.0mm</td>
<td>15.6x23.4 mm</td>
<td>62.1x61.4mm</td>
<td>18.1x22.1 mm</td>
</tr>
<tr>
<td>Spectral Range</td>
<td>400~900nm</td>
<td>400~900nm</td>
<td>200~1000nm</td>
<td>400~900nm</td>
</tr>
</tbody>
</table>

Korea Ocean Satellite Center, KORDI
Feasibility Study

- **Nighttime Observation**
  - 1 band observation (Panchromatic Filter; 400~900nm)
  - Light energy required: ~ 1000 times /GOCI

(NFRDI)
Feasibility Study

- How to increased Light gathering power and efficiency
  - Panchromatic Filter (400–900nm) : (~15 times)
  - Increased Max. Integration time (only 1 band / 5 times)
  - Increased Electronic gain in amplifier(2 time)
  - High S/N CCD (2 times lower NEdL)
  - Larger Aperture size (4 times)

=> 1200 times higher incident power / Feasible
Preliminary Design of GOCI-2

: Is it possible to fabricate FOV-selectable (Local Area, Full Disk) Ocean Sensor?

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GOCI–2 Pre Design : 3 Options

- **Key Issue :**
  - How to fabricate the optical system which offers FOV selection function for Local Area and Full Disk Observation?

- **Option 1 : Modified GOCI Design**
- **Option 2 : WFOV with additional optics (2D frame)**
  - ZORO Type Telescope (Korean Design)
- **Option 3 : WFOV with scanning (1D push broom)**
  - ABI(Advanced Baseline Imager) Type Imager
Option 1. Modified GOCI Design

- Technical Requirements for Full Disk (WFOV)
  
  -> Relay Optics with Beam Splitter
  
  -> Larger Aperture Size, etc.

GOCI has no space for additional optics (Relay Optics, Beam Splitter, etc.)

Re-Design is required for Full Disk Observation.

Feasible Design for FOV switching optics

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Option 2. ZORO Type Telescope

- ZORO type Reflective Telescope
  - Simultaneous NFOV & WFOV Observation
  - Front-end Reflective Telescope + Relay Optics

<table>
<thead>
<tr>
<th>Type</th>
<th>Wavelength</th>
<th>Focal Plane (diagonal)</th>
<th>FOV</th>
<th>EFL</th>
<th>f/# (EPD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrow Visible</td>
<td>500-750nm</td>
<td>43.33mm</td>
<td>1.27°×0.84°</td>
<td>1630mm</td>
<td>5.1 (320mm)</td>
</tr>
<tr>
<td>Wide Visible</td>
<td>500-750nm</td>
<td>43.33mm</td>
<td>3.7°×2.2°</td>
<td>670mm</td>
<td>10.0 (67mm)</td>
</tr>
</tbody>
</table>
GOCI vs GOCI-2 (ZORO)

• GOCI:
  - 500 m in spatial resolution
  - Aperture of 140 mm in diameter
  - 14 microns in pixel size

• GOCI-2 ZORO Type (draft)
  - 150–250 m in spatial resolution
  - Aperture of 300 mm in diameter
  - 7 microns in pixel size
Option 3. ABI Type Telescope

- Full Disk observation with scanning
  - One of the most feasible solution for Full Disk acquisition
    - 16 bands in Visible and IR
    - SNR : 300
    - FPA : 1D Push Broom
    - Aperture : 27 cm
Conclusion

1. GOCI-2 will have full disk coverage with higher resolution and 5 more bands than GOCI.
2. By the result of the tentative study, all user requirements are feasible.
3. Detailed feasibility study and system design will be followed.
4. For the Full Disk Coverage, dedicated optical design is Required.
5. All of GOCI-2 Pre designs have a possibility to be selected as GOCI-2 Design.
6. In-depth technical feasibility study and trade-off will be followed.
GOCI-1 data distribution policy
### GOCI Data Characteristics

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Related S/W</th>
<th>Description</th>
<th>size</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOCI RAW</td>
<td>GDAS &amp; IMPS/DM</td>
<td>Received packet data from satellite</td>
<td>769MB</td>
<td>X</td>
</tr>
<tr>
<td>GOCI L0</td>
<td>IMPS/DM</td>
<td>Slot Image data + Dark Calibration Data</td>
<td>634MB</td>
<td>X</td>
</tr>
<tr>
<td>GOCI L1A</td>
<td>IMPS/PMM</td>
<td>Radiometric corrected data in IRCM</td>
<td>994MB</td>
<td>X</td>
</tr>
<tr>
<td>GOCI INRSM input file</td>
<td>IMPS/PMM</td>
<td>INRSM input data same as L1A</td>
<td>994MB</td>
<td>X</td>
</tr>
<tr>
<td>GOCI INRSM output file</td>
<td>IMPS/INRSM</td>
<td>INRSM output data. Whole image data with geometric correction</td>
<td>994MB</td>
<td>X</td>
</tr>
<tr>
<td>GOCI L1B</td>
<td>IMPS/PMM</td>
<td>Rearranged whole image data including header information</td>
<td>~994MB</td>
<td>O</td>
</tr>
<tr>
<td>GOCI L1B region</td>
<td>GDPS/GOCI Regional Data Generation Module</td>
<td>L1B subscened data to pre defined regions</td>
<td>994MB~</td>
<td>O</td>
</tr>
<tr>
<td>GOCI L2</td>
<td>GDPS/L2 Generation Module</td>
<td>Bio/physical data applied ocean analysis algorithm</td>
<td>~3.5GB</td>
<td>O</td>
</tr>
<tr>
<td>GOCI L2 region</td>
<td>GDPS/GOGI Regional Data Generation Module</td>
<td>L2 subscened data to pre defined regions</td>
<td>~3.5GB</td>
<td>O</td>
</tr>
<tr>
<td>GOCI L2 LRIT</td>
<td>GDPS/Sample Image Generation Module</td>
<td>Three kinds of GOCI small image data for LRIT distribution (CHL, SS,DOM)</td>
<td>10MB</td>
<td>O</td>
</tr>
<tr>
<td>GOCI L1B/L2 Browsing image</td>
<td>GDPS/Browsing Image Generation Module</td>
<td>Very small insight image data for searching/browsing L1B/L2 in GDDS (200x200, 1000x1000)</td>
<td>40KB</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1MB</td>
<td>O</td>
</tr>
</tbody>
</table>

**KOSC Data Management System Data Size**

one-time :11.4GB / one-day : 114GB / one-month: 3.4TB / one-year: 41.64T
Fundamental concept of GOCI distribution

Subject
- Making access and acquirement to GOCI data rapidly and easily for increasing data usability and activating its practical applications

Swiftness/Ease of Access and Acquirement

Increase Use Efficiency

Greatest applications

Distribution
- GOCI is the earth-observing satellite data for public usage.
- Public purpose usage have priority to commercial usage.

Use of public purpose (high priority)

Public /Commercial Use (Overseas)

Authority
- KOSC(KORDI) have only Intellectual property of GOCI data and distribution right (except special contract with KOSC).
KOSC and SOC

<table>
<thead>
<tr>
<th>Korea Ocean Satellite Center (KOSC: KORDI)</th>
<th>Satellite Operation Center (SOC: KARI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Major Subject</strong></td>
<td><strong>Satellite Operation</strong></td>
</tr>
<tr>
<td>- Mission scheduling</td>
<td>(mission and orbit determining)</td>
</tr>
<tr>
<td>- Satellite data receiving and archiving</td>
<td></td>
</tr>
<tr>
<td>- Standard data processing service</td>
<td></td>
</tr>
<tr>
<td>- Sensor optical calibration</td>
<td></td>
</tr>
<tr>
<td><strong>Minor Subject</strong></td>
<td><strong>- data backup of before L1B(limited)</strong></td>
</tr>
<tr>
<td>- data backup and distribution of L1b later</td>
<td></td>
</tr>
<tr>
<td>- Cal/Val of L2</td>
<td></td>
</tr>
<tr>
<td>- User support/training</td>
<td></td>
</tr>
</tbody>
</table>

**Korea Ocean Satellite Center (KOSC: KORDI)**
- Image Data Acquisition & Control System (IDACS)
  - GOCI
    - Raw Data Reception
    - Data Pre-processing
- GOCI Data Processing System (GDPS)
  - GOCI Data Distribution
  - GOCI Level 2 Processing
  - Radiometric CAL/VAL

**Meteorological Satellite Center (MSC: KMA)**
- Image Data Acquisition & Control System (IDACS)
  - MI
  - Raw Data Reception
  - Data Pre-processing
  - LRIT/HRIT Generation & Transmission

**Satellite Operation Center (SOC: KARI)**
- Satellite Ground Control System (SGCS)
  - Tracking, Telemetry, & Commanding
  - S/C operation
  - Mission Planning
  - Orbit Determination
  - Satellite Simulation

**Communication Test Earth Station (CTES: ETRI)**
- Satellite Communication
- Ka-band Communication Payload Monitoring and Control
GOCI Data Distribution Policy

Public purpose distribution

Domestic users

• Free distribution: public interest & research (except commercial purpose)
• Distribution data type: GOCI L1B ~ Level 2
• Data access: Online distribution (possible offline request)
  Near real time distribution: at least within 2 hours
• Redistribution is not authorized except national institutes (NFRDI)

Korea Ocean Satellite Center, KORDI
GOCI Data Distribution Policy

Public purpose distribution

Foreign users

- **Free distribution**: Research (PI registration) & public interest
- **Commercial distribution**: industry, case of regular data service & processing
- **Distribution data type**: GOCI L1B ~ Level 2
- **Data access**: Online distribution (possible offline request)
  - Delayed mode distribution: within 1-3 days (to avoid line traffic)
- **Redistribution** is not authorized (except special contract with KOSC/KORDI)
- **Direct receiving station**: Possible with mutual agreement between 2 countries

Korea Ocean Satellite Center, KORDI