SUMMARY OF CALIBRATION AND VALIDATION FOR KOMPSAT-2

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ABSTRACT:

KARI has been doing Calibration and Validation (Cal/Val) activities for the KOMPSAT-2 (KOrea Multi-Purpose SATellite-2) after launch at July 28th 2006. The Cal/Val for KOMPSAT-2 has already been done to guarantee the requirements of KOMPSAT-2 Users, and we are doing more Cal/Val activities to enhance the KOMPSAT-2 image quality for Users. The content of KOMPSAT-2 Cal/Val defined before launch has been a little changed after launch. After launch, we could find out the new and different phenomenon from analyzing the KOMPSAT-2 image data directly. Firstly, we tried to define the status of KOMPSAT-2 (e.g. the sequence of MS band, Line of Sight, Pointing accuracy, etc.). Secondly, every KOMPSAT-2 Cal/Val parameter was validated, and then KOMPSAT-2 was calibrated with the validated and uploaded initial value of them (e.g. Non-Uniformity Correction table, Misalignment between body and sensor etc.). Finally, we have done to implement the KOMPSAT-2 image data processing system with the results of K2 Cal/Val (e.g. De-noise, MTF compensation, Metadata, Users Manual, etc.)

1. INTRODUCTION

1.1 Overview

After KOMPSAT-2 launched at July 28th 2006, the Cal/Val for KOMPSAT-2 image quality has been doing and implementing the KOMPSAT-2 image data processing system with it in KARI. Generally, because the present remote sensing satellite technique cannot satisfy user’s requirements for image quality, the Cal/Val for image quality must be carried out directly after launch before distributing the imagery to the users. In the broad concept of Cal/Val, the Cal/Val of the remote sensing satellite can be divided into two parts if we recognize the technical gap between the satellite technique and the users requirements; Cal/Val to validate and verify the requirements of satellite, and Cal/Val and image restoration to guarantee the image data quality for the users. The KOMPSAT-2 Cal/Val has been carried out with this concept. Before KOMPSAT-2 launched, KARI Cal/Val team had prepared and developed Cal/Val sites, equipments and Cal/Val code for KOMPSAT-2 in KARI’s own way. After launch, we can immediately understand the gap between the real Cal/Val and our own way from the new and different phenomenon and our mistakes form analyzing the KOMPSAT-2 image data. The first gap between them was the understanding of image quality for the users. We re-defined the KOMPSAT-2 Cal/Val according to them, and have done it in the first step of the KOMPSAT-2 Cal/Val, and now work to get better image quality of KOMPSAT-2 in the second step in KOMPSAT-2 normal operation phase.


1.2 KOMPSAT-2 basic specification

The next list explains mission orbit of the KOMPSAT-2;

- Sun synchronous orbit
- Altitude: 685.13km
- Inclination: 98.127°
- Local time of ascending node: 10:50 AM
- 180° phase difference with KOMPSAT-1
- Roll tilt: ±30°

The next list explains the specification of the MSC (Multi-Spectral Camera) of the KOMPSAT-2 main payload;
- Pushbroom imaging
- 20% duty cycle imaging per orbit
- Swath width: 15km±2%
- Effective Swath width: 13.6km
- 1m Panchromatic (1 ch.) & 4m Multi-spectral (4 ch.)

No. of Pixel
- PAN: 15000 pixel (3 CCD; 1 CCD = 5200 pixel x 32 TDI line)
- MS: 3792 pixel

No. of PAN line: 2 (two; Primary & Redundant)

Pixel size: 13x13 µm
- TDI line rate: up to 7100 lines/sec
- Radiometric resolution: 10 bits per pixel
- TDI (Time Delayed Integration): 32 lines
- Data compression: JPEG-like, 1:3.6 for PAN & Multi
- Non-uniformity correction before compressing
- Electric Gain setting
- Clear Aperture: 600mm
- FOV: ±0.62°

PAN
- EFL: 9000mm
- Spectral region: 500nm - 900nm

MS Channel
- EFL: 2250mm
- Spectral region
  - MS1 (Green): 450nm ~ 520nm
  - MS2 (Blue): 520nm ~ 600nm
  - MS3 (NIR): 630nm ~ 690nm
  - MS4 (Red): 760nm - 900nm
The next list explains the specification of geometric part of KOMPSAT-2;
POD (Precision Orbit Determination) accuracy of 3m (3σ) with 1 day measurement data and IGS data.
Geo-accuracy
- Post-processing without GCPs: 80m CE90; monoscopic image of up to 26 degrees off-nadir case, after post-processing including POD, PAD and AOCS sensor calibration

2. OVERVIEW OF KOMPSAT-2 CAL/VAL

2.1 KOMPSAT-2 Cal/Val Parameters

The next table 1 is the list of KOMPSAT-2 Cal/Val parameters.

<table>
<thead>
<tr>
<th>Group</th>
<th>Parameter</th>
<th>Method</th>
<th>Cal/Val target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial</td>
<td>Focusing</td>
<td>Cal/Val</td>
<td>Edge, Mirror, Night Lamp</td>
</tr>
<tr>
<td></td>
<td>TDI</td>
<td>NDF</td>
<td>GCP DB</td>
</tr>
<tr>
<td></td>
<td>Gear</td>
<td>Gear</td>
<td>GCP DB</td>
</tr>
<tr>
<td></td>
<td>Line rate</td>
<td>MTF</td>
<td>GCP DB</td>
</tr>
<tr>
<td></td>
<td>Tarp</td>
<td>Imag</td>
<td>GCP DB</td>
</tr>
<tr>
<td></td>
<td>Night Lamp</td>
<td>MTF</td>
<td>GCP DB</td>
</tr>
<tr>
<td></td>
<td>AOCS</td>
<td>AOCS</td>
<td>GCP DB</td>
</tr>
<tr>
<td></td>
<td>MTF</td>
<td>MTF</td>
<td>GCP DB</td>
</tr>
<tr>
<td></td>
<td>Sun</td>
<td>Sun</td>
<td>GCP DB</td>
</tr>
<tr>
<td></td>
<td>Snow</td>
<td>Snow</td>
<td>GCP DB</td>
</tr>
<tr>
<td></td>
<td>Fog</td>
<td>Fog</td>
<td>GCP DB</td>
</tr>
<tr>
<td></td>
<td>Fuzzer</td>
<td>Fuzzer</td>
<td>GCP DB</td>
</tr>
<tr>
<td>Absolute Radiometric</td>
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<td>GCP DB</td>
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<td>Snow</td>
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<td></td>
<td>Fuzzer</td>
<td>Fuzzer</td>
<td>GCP DB</td>
</tr>
<tr>
<td></td>
<td>User Manual</td>
<td>Manual</td>
<td>GCP DB</td>
</tr>
</tbody>
</table>

Table 1. KOMPSAT-2 Cal/Val Parameters

The KOMPSAT-2 Cal/Val parameters are divided for 4 groups; Spatial, Radiometric, Geometric and For User. Each group has several parameters according to its property (Ryan 2003). ‘Interior Orientation’ of Geometric includes ‘Optical Distortion’ & ‘Registration’ and ‘CCD Geometry’. In Table 1, the blue items are the parameters to initialize the KOMPSAT-2 with Telemetry Command, the green items are the parameters to restore the KOMPSAT-2 performance, the yellow items are the parameters to validate, and the white items are product parameters for the end-users.

2.2 Cal/Val Site & Equipments

The next Table 2 is the list of KOMPSAT-2 Cal/Val sites and equipments.

<table>
<thead>
<tr>
<th>Target</th>
<th>Cal/Val Parameter</th>
<th>Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siemens</td>
<td>MTF</td>
<td>Goheung</td>
</tr>
<tr>
<td>Convex mirror, Simulated target</td>
<td>MTF, GCP</td>
<td>Portable</td>
</tr>
<tr>
<td>Night Lamp</td>
<td>MTF, PSF</td>
<td>Portable</td>
</tr>
<tr>
<td>Tarp</td>
<td>Radiometric, MTF</td>
<td>Portable</td>
</tr>
<tr>
<td>GCP target</td>
<td>Interior Orientation, Geo-accuracy, KPADS S/W, AOCS On-orbit sensor calibration, Planimetric, Registration</td>
<td>Daejeon, Goheung, Worldwide</td>
</tr>
</tbody>
</table>

Table 2. Cal/Val Equipments

For the KOMPSAT-2 Cal/Val works, we need the Cal/Val targets that can be imaged by KOMPSAT-2 MSC, and has made Siemens, tarp, convex mirror, night lamp and GCP target. Siemens target located at Goheung has been designed to validate MTF and PSF etc.

a. Siemens target

Figure 1. Siemens target at Goheung & KOMPSAT-2 image at Sep 1, 2006

b. Tarp target

Figure 2. Deployed Tarp target, KOMPSAT-2 image at Oct 1, 2006

c. Night Lamp

Night lamp (1KW) has been used to validate the MTF and PSF, SNR, Absolute radiometric Cal., etc.
GCP DB for the KOMPSAT-2 Geometric Cal/Val has been establishing at Daejeon, Goheung, Seosan, Gwangyang and Kimje in Korea located along with KOMPSAT-2 orbit pass before KOMPSAT-2 launch to calibrate and validate the KPADS S/W initialization, AOCS on-orbit Cal., interior orientation, exterior orientation, band-to-band registration and geo-accuracy check. 5 GCP DB sites have 200 ~ 300 GCPs with less than 10 cm accuracy.

Figure 4. (Five) GCP DB sites in Korea located along with KOMPSAT-2 orbit pass

2.3 Cal/Val Work Step

The next Figure 5 explains the KOMPSAT-2 Cal/Val work step after launch. IRPE means KOMPSAT-2 data processing system.

- Absolute radiometric Cal. & Image quality

3. THE RESULT OF CAL/VAL

3.1 Beginning results

After KOMPSAT-2 launch, the next Cal/Val parameters had been decided firstly:

- Primary TDI level: 43413 (PAN, Green, Blue, NIR, Red)
- Secondary TDI level: 32301
- Default PAN: PAN Redundant because of checking the image quality (Random & Pattern Noise)
- MS Color disposition
  - MS1: Green, MS2: Blue, MS3: NIR, MS4: Red
- Spilling

Figure 6. Spilling in K2 MSC image

- Line of Sight
  - MS2 (Blue) & MS4 (Red) → MS1 (Green) & MS3 (NIR) → PAN-R

Figure 7. Line of Sight in K2 MSC

- MSC Pixel definition as reflected on Ground

Figure 8. Line of Sight on Ground

- Check GSD (Ground Sample Distance)
• Fluctuation in MS2 & MS4
  There is sometime a fluctuation of even and odd pixel in MS2 and MS4 band. This has been removed by FFT method.

3.2 Non-Uniformity Correction (NUC)

3.3 Butting zone

KOMPSAT-2 MSC PAN has three CCDs of 5200 pixels. There are two butting zone between CCDs that decrease the brightness gradually. We found out some non-linearity in the butting zone, and developed three algorithms to reduce it; Scatter plot, BSM (Butting zone Smoothing Method) and Dispersion method. (for more detailed; Lee 2007)

4. CONCLUSION

For one-half year after KOMPSAT-2 launch, KARI Cal/Val team has carried out the Calibration and Validation to guarantee the image quality of KOMPSAT-2 MSC image data, so that the Users can take the KOMPSAT-2 image data with good image quality now. Nevertheless, there is much room for more enhancements of the image quality of the KOMPSAT-2 image data; MTFC, Reduce noise, Geo-accuracy, Band-to-Band registration, Absolute radiometric calibration, Users Manual, etc.

REFERENCE


Seo, D., 2008, KOMPSAT-2 direct sensor modeling and geometric calibration/validation, ISPRS2008