Current Status of Hyperspectral Imager Suite (HISUI)

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What is **HISUI?**

**A Successor of Terra ASTER**

- **HISUI** is a future spaceborne hyperspectral and multispectral imager suite being developed by Japanese Ministry of Economy, Trade, and Industry (METI) as its 4th spaceborne optical imager mission.

1) OPS onboard JERS-1 satellite (1992 – 1998)
2) ASTER onboard NASA’s Terra satellite (1999 -)
3) ASNARO (2014-)
4) HISUI (2018 -)

- The objectives of HISUI are:
  1) Global energy and resource related applications
  2) Environmental monitoring, agriculture, and forestry
  3) Promotion of domestic space and space utilization industries

- HISUI project was started in 2007 and HISUI will be launched in **2018 or later.**

- Discussions with satellites/ground data system providers are **still** ongoing.
  - Implementation of the hyperspectral imager and the multispectral imager on separate platforms including medium or small satellites is being investigated.
HISUI Presentations at IGARSS 2014

1. TUP.U.1 : Ogawa et al., EFFECTIVE OBSERVATION PLANNING AND ITS SIMULATION OF A JAPANESE SPACEBORNE SENSOR: HYPERSPECTRAL IMAGER SUITE (HISUI)

2. TUP.D.22, Tashiro et al., GENERATION OF DEM AND ORTHOIMAGE OF BORNEO(KALIMANTAN) ISLAND USING ASTER

3. TUP.U.140 : Nakazawa et al., SUPER-RESOLUTION IMAGING USING REMOTE SENSING PLATFORM

1. WE1.09.4 : Matsunaga et al., CURRENT STATUS OF HYPERSPECTRAL IMAGER SUITE (HISUI)

2. WE1.11.5, Yokoya et al., AIRBORNE UNMIXING-BASED HYPERSPECTRAL SUPER-RESOLUTION USING RGB IMAGERY

3. WE3.09.1 : Tanii et al., Instrument Development Status and Performances of Hyperspectral Imager Suite (HISUI) – Onboard Data Correction

4. WE3.09.3 : Yamamoto et al., HISUI VICARIOUS CALIBRATION AND CAL/VAL ACTIVITIES

5. TH2.03.2, Takayama et al., OPTIMAL SEGMENTATION OF CLASSIFICATION AND PREDICTION MAPS FOR MONITORING FOREST CONDITION WITH SPECTRAL AND SPATIAL INFORMATION FROM HYPERSPECTRAL DATA
## HISUI Specifications and Requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hyperspectral Imager</th>
<th>Multispectral Imager</th>
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</thead>
<tbody>
<tr>
<td>Imaging Type</td>
<td>Pushbroom</td>
<td>Pushbroom</td>
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<tr>
<td>Spatial Resolution / Swath</td>
<td>30 m / 30 km</td>
<td>5 m / 90 km</td>
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<td>Spectral</td>
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<tr>
<td>Bands</td>
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<tr>
<td>Range</td>
<td>0.4 - 2.5 μm</td>
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<td>Resolution</td>
<td>10 – 12.5 nm</td>
<td>60 – 110 nm</td>
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<td>SNR (30% albedo)</td>
<td>≥ 450 @620 nm</td>
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<td>≥ 300 @2100 nm</td>
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<td>MTF</td>
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<td>Dynamic Range</td>
<td>Saturated at 70% alebdo</td>
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<tr>
<td>Spectral Calibration</td>
<td>VNIR : 0.2 nm</td>
<td>SWIR : 0.625 nm</td>
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<td>Radiometric Calibration</td>
<td>Absolute : ±5%, among bands : ±2%</td>
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<tr>
<td>Quantization</td>
<td>12 bits</td>
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<td>Data Compression</td>
<td>Lossless (70%)</td>
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<tr>
<td>Pointing</td>
<td>Cross track : ± 3 °</td>
<td>N/A</td>
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</table>

**HISUI**: A Japanese Spaceborne Hyperspectral and Multispectral Remote Sensing Mission
HISUI Hyperspectral Imager and Multispectral Imager

Telescope diameter ≈ 30 cm
Two grating spectrometers for VNIR and SWIR
Optical Schematics of HISUI Hyperspectral Imager

Filter Wheel Assembly
- Bandpass filters
- NIST SRM2065 + Myler film

Lamp
(Halogen lamp)

Telescope
(Three Mirror Anastigmat Type)

On-board Calibration Mechanism

VNIR Spectrometer
(Offner Type)

CMOS 2D Detector

SWIR Spectrometer
(Offner Type)

MCT 2D Detector

Stirling Type Cooling Unit
**HISUI Schedule as of July 2014**

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<tbody>
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<td>Launch and Operation</td>
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<td>Satellite Launch</td>
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**Legend:**
- Blue: Conceptual Design
- Blue dashed: Preliminary Design
- Blue dotted: Detailed Design
- Pink: Component Trial
- Magenta: Evaluation Model
- Orange: Integration with Satellite
- Red: Preparation
- Red dashed: Selection of Contractors
- Red double arrow: Nominal Operation and Training/Initial Operation
- Magenta double arrow: Data Analysis Methodology Research (JOGMEC)
- Green: Satellite Launch
- Green double arrow: Lifetime = 5 years
- Green triangle: CDR
- Green double triangle: PFM
The critical parts of FM, such as the telescope, the spectrographs and the detectors, have been manufactured and the integration & tests of the instruments are ongoing.

- CDR of Multispectral Imager : 7 July 2014 (done)
- CDR of Hyperspectral Imager : October 2014
HISUI GDS consists of the four subsystems:

- Observation and Planning Subsystem (OPS)
- Product Generation Subsystem (PGS)
- User Interface Subsystem (UIS)
- System Integration Subsystem (SIS)

GDS’s preliminary design was finished in FY2012, and its detailed design was finished FY2013. Currently GDS development is ongoing.
## HISUI Product List as of July, 2014

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 0</td>
<td>Raw data</td>
</tr>
<tr>
<td>Level 1A</td>
<td>Raw DN product with all radiometric calibration coefficients. Spatial resampling is not applied.</td>
</tr>
<tr>
<td>Level 1R</td>
<td>Top-of-atmosphere spectral radiance product. Spatial resampling is not applied.</td>
</tr>
<tr>
<td>Level 1G</td>
<td>Geometrically corrected / orthorectified top-of-atmosphere spectral radiance product. Inter-telescope registration, parallax correction, and keystone property are considered. Spectral continuity between VNIR and SWIR are considered.</td>
</tr>
<tr>
<td>Level 2</td>
<td>Atmospherically corrected surface spectral reflectance product generated from L1R/G with QA information. This is Science Product for research purpose and not validated.</td>
</tr>
</tbody>
</table>

*The same product definitions will be applied to both Hyperspectral and Multispectral Imagers*

**Cloud statistical data are attached to L1 and L2 products.
HISUI Onboard and Level 1 Processing

- Spectral binning, radiometric calibration, and smile corrections are carried out on orbit.
- Level 1 processing at GDS include scene cutting, radiometric degradation correction, keystone correction, geometric correction, and VNIR-SWIR parallax correction using DEM.
- The development of Level 1 data processing software for GDS started in 2013.
Calibration:
HISUI project has calibration plans which include not only pre-launch calibration but also other calibration methods.

- Onboard Calibration: Calibrated using the calibration device on satellite
- Vicarious Calibration: Calibrated by simultaneous ground measurement
- Cross Calibration: Calibrated using other satellite instruments
- Lunar Calibration (TBD): Calibrated by viewing the moon (stable radiance)*


Level 2 Processing:
HISUI atmospherically corrected surface reflectance products will be generated for both of multispectral and hyperspectral imagers as science products. HISUI atmospheric correction algorithm will use Dark Pixel method with MODTRAN5 code. CEOS recommended solar irradiance spectrum (Thuillier 2002) and NewKurucz (SUN01kurucz2005) will be adopted as HISUI Irradiance model. Validation plans for HISUI atmospheric correction algorithm is to be discussed.
Vicarious Calibration in Australia

Lake Lefroy (LLF)

Field Campaign on Nov 26, 2013

ASTER image Captured on Nov 26, 2013
Lunar Reflectance Model based on SELENE Spectral Profiler data

**Spectral Profiler Lunar Reflectance Model**
- 530 – 1600 nm, $\Delta \lambda = 6 – 8$ nm
- $0.5^\circ \times 0.5^\circ$ grid interval
- $\rightarrow$ 1~2 pixel size of ASTER/VNIR

Radiometric cal. with M3 and ROLO:
See Pieters et al., Icarus, 2013

Photometry: See Yokota et al., Icarus, 2011

Lunar radiance under any Sun-Moon-Earth geometry can be calculated by this model.

April 13, 2003  April 15  April 18
HISUI Operation and Mission Planning: Overview

- **HISUI OPS** (Observation Planning Subsystem) will automatically create command tables based on data acquisition requests (DARs), their priorities, and available resources such as instrument operation time and data downlink capability.

- DAR is valid until cloud free images of the target area are obtained.

- HISUI DAR categories (draft)
  - **Priority area mapping**
    - Including oil/gas/metal resource exploration areas
  - **Periodical observation**
    - Monthly, seasonal, and annual observations including protected areas and land glaciers
    - Nighttime SWIR fire/volcano observation
  - **Emergency / disaster observation**
  - **Calibration / validation observation**
    - Including vicarious and lunar calibration
  - **Global mapping** (using remaining resources)
    - All land surface and shallow coastal regions
  - **Engineering observation**

Example of HISUI Priority Map
- **Red** = Priority areas for oil/gas/metal resources,
- **Green** = Other land,
- **Light blue** = Shallow coastal zones shallower than 30 m.
HISUI Operation and Mission Planning: Status

- HISUI OPS is being developed as one of subsystems of HISUI GDS.

- Long term operation simulation tool was developed. Terra MODIS global 1-km daily cloud mask dataset for three years is used in the simulation.

- Use of cloud climatology statistics in HISUI scheduling will increase long-term cloud-free coverage as much as a few percents.

Probability of cloud free days at 10:30 am local time in 2011 based on Terra MODIS data.

The number of cloud free images in 5 years. White areas = no cloud free images. (150FB/day)
HISUI Hyperspectral Imager Long-term Operation Simulation: 150 Gbyte/Day

**Priority Areas**

- **Global Mapping**

**Land Ice (GLIMS*)**

- GLIMS:

**IUCN**–defined Protected Areas

**Global Land Ice Measurements from Space**

**International Union for Conservation of Nature**
Since FY2007, to promote the use of HISUI data, Japan Space Systems has been conducting various application studies using the airborne hyperspectral data in Asia-pacific regions.

### Field Research Themes

**Field** | **Research Themes**
--- | ---
**Oil/Gas /Mineral Resources** | Oil spill classification
| Exploration of various type of mineral deposits
| Identification of minerals
**Agriculture** | Paddy yield, quality and growth
| Wheat yield, quality and growth
| Pasture grass yield and classification
| Extraction of illicit crop cultivation
| Estimation of soil salinity
**Environment** | Carbon dynamics in tropical peatland
| Detection of coral bleaching and recovery
Thank you

Contact: matsunag@nies.go.jp