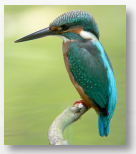
**2010 HysplRI Science Workshop**
**Aug 24-26, 2010  Pasadena**

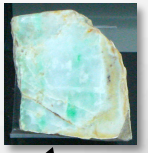



# HISUI
# Hyperspectal Imager Suite

## A Japanese Spaceborne Hyperspectral and Multispectral Remote Sensing Mission

Tsuneo Matsunaga (National Institute for Environmental Studies)
and
Akira Iwasaki (University of Tokyo), Osamu Kahimura (ERSDAC),
Kenta Ogawa(Rakuno Gakune Univ.),  Nagamitsu Ohgi (JAROS), and
Satoshi Tsuchida (AIST)

# HISUI : Jade or Kingfisher(Kawasemi)



Jadeite from Geological Musium, AIST

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www.moonmadness.jp/itoigawahisui.html

http://upload.wikimedia.org/wikipedia/commons/1/13/Alcedo_atthis_4_%28Lukasz_Lukasik%29.jpg

# "What's new" since 2009 HyspIRI Workshop

- Our mission was finally named!
- Calibration and ground data system studies were funded for FY 2010-2014.
- Working groups are being organized.
- Detailed design of the instrument is ongoing.
  CDR in FY2011
- Discussion with JAXA is ongoing.

# What is HISUI?
# A Successor of ASTER and ALOS AVNIR-2

- **HISUI** is a spaceborne instrument suite which consists of hyperspectral and multispectral imagers.

- **HISUI** is being developed by Japanese Ministry of Economy, Trade, and Industry (METI) as its third spaceborne optical imager mission.

  1) OPS onboard JERS-1 satellite (1992 – 1998)
  2) ASTER onboard NASA's Terra satellite (1999 - )

- **HISUI** will be launched by H-IIA rocket in 2014 or later as one of mission instruments onboard JAXA's ALOS-3 satellite

  1) ALOS (2006 -) : Optical imagers (PRISM and AVNIR-2) and SAR
  2) ALOS-2 (2013 -) : SAR

# Targets / Objectives of HISUI Mission

1) Global energy and resource related applications
   - Oil, gas, metal, ...
   - Observations for environmental assessments which are indispensable to resource developments

2) Other applications such as environmental monitoring, agriculture, and forestry

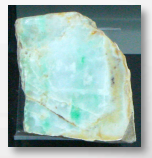
3) Promotion of domestic space and space utilization industry through wider applications of HISUI data

# Ministry of Economy, Trade, and Industry's HISUI Mission Team

- Mission leader and three deputy leaders
- Instrument development — JAROS / NEC Corp.
- Calibration and data processing — AIST / ERSDAC
  - Calibration WG — Ishii, AIST
  - Level 1 WG — Iwasaki, UT
  - Level 2 WG — Yamamoto, AIST
  - Operation and Mission Planning WG — Matsunaga, NIES
  - Archive WG — Nakamura, AIST
- Application research — ERSDAC

AIST : Advanced Institute for Industril Science and Technology,
ERSDAC : Earth Remote Sensing Data Analysis Center,
JAROS: Japan Resources Observation System and Space Utilization Organization,
NIES: National Institute for Environmental Studies, UT : University of Tokyo

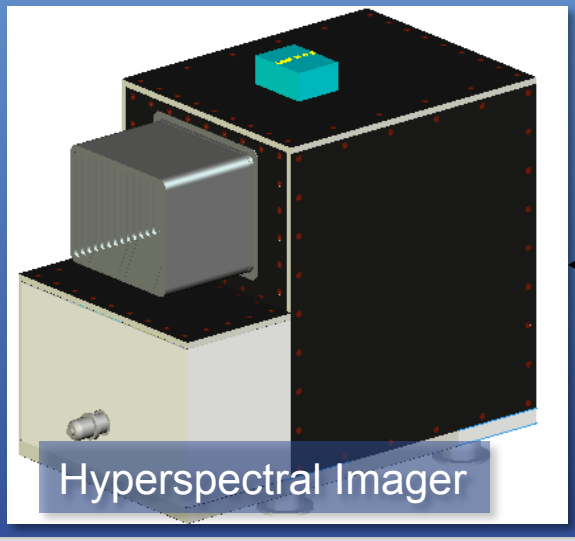
# HISUI Mission Schedule

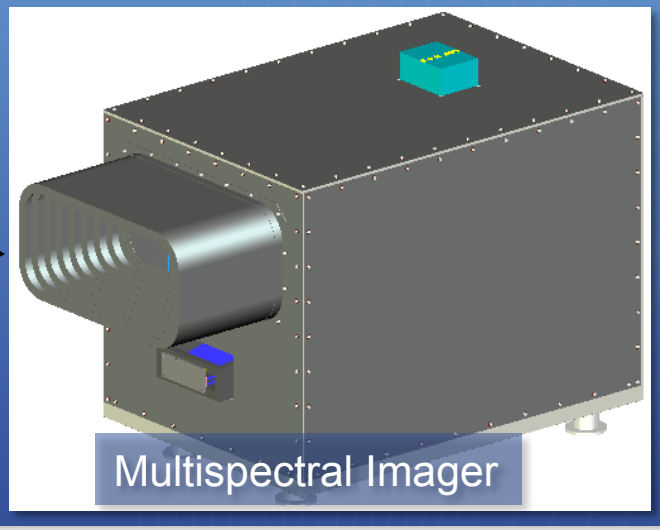


| | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | FY2011 | FY2012 | FY2013 | FY2014 |
|---|---|---|---|---|---|---|---|---|---|
| **Instrument Development (JAROS, NEC)** | | *Conceptual Design* | *Preliminary Design* | | *Detailed Design* | △ CDR | | | *Launch* |
| | | *Development Model* | | | *Proto Flight Model* | | | | |
| **Calibration and Data Processing (AIST, ERSDAC)** | | | | | *Calibration, Data processing, Ground data system, Operation mission planning, etc.* | | | | |
| **Application Research (ERSDAC)** | | *R&D for Data Utilization (oil&gas, mineral resources, agriculture, forest, environment, etc.)* | | | | | | | |
| | | *Design & Development of Spectral Database* | | | | | | | |

# JAXA's ALOS-3 and HISUI


HISUI



# HISUI Requirements: Hyperspectral Imager

| Parameter | | Requirement |
|---|---|---|
| Spatial Resolution and Swath Width | | 30 m and 30 km |
| Spectral | Bands | 185<br>(VNIR:57 SWIR:128) |
| | Range | 0.4 - 2.5 μm<br>VNIR:0.4-0.97 μm SWIR:0.9-2.5 μm |
| | Resolution | 10 nm (VNIR), 12.5 nm (SWIR) |
| Signal to Noise Ratio (30% albedo) | | ≥ 450 @620 nm<br>≥ 300 @2100 nm |
| MTF | | ≥ 0.2 |
| Dynamic Range | | ≥ 10 bits (current design=12bit) |
| Data Compression | | Lossless (70%) |
| Pointing Capability | | ≈ ±3 ° (±30 km) |

# HISUI Requirements: Multispectral Imager

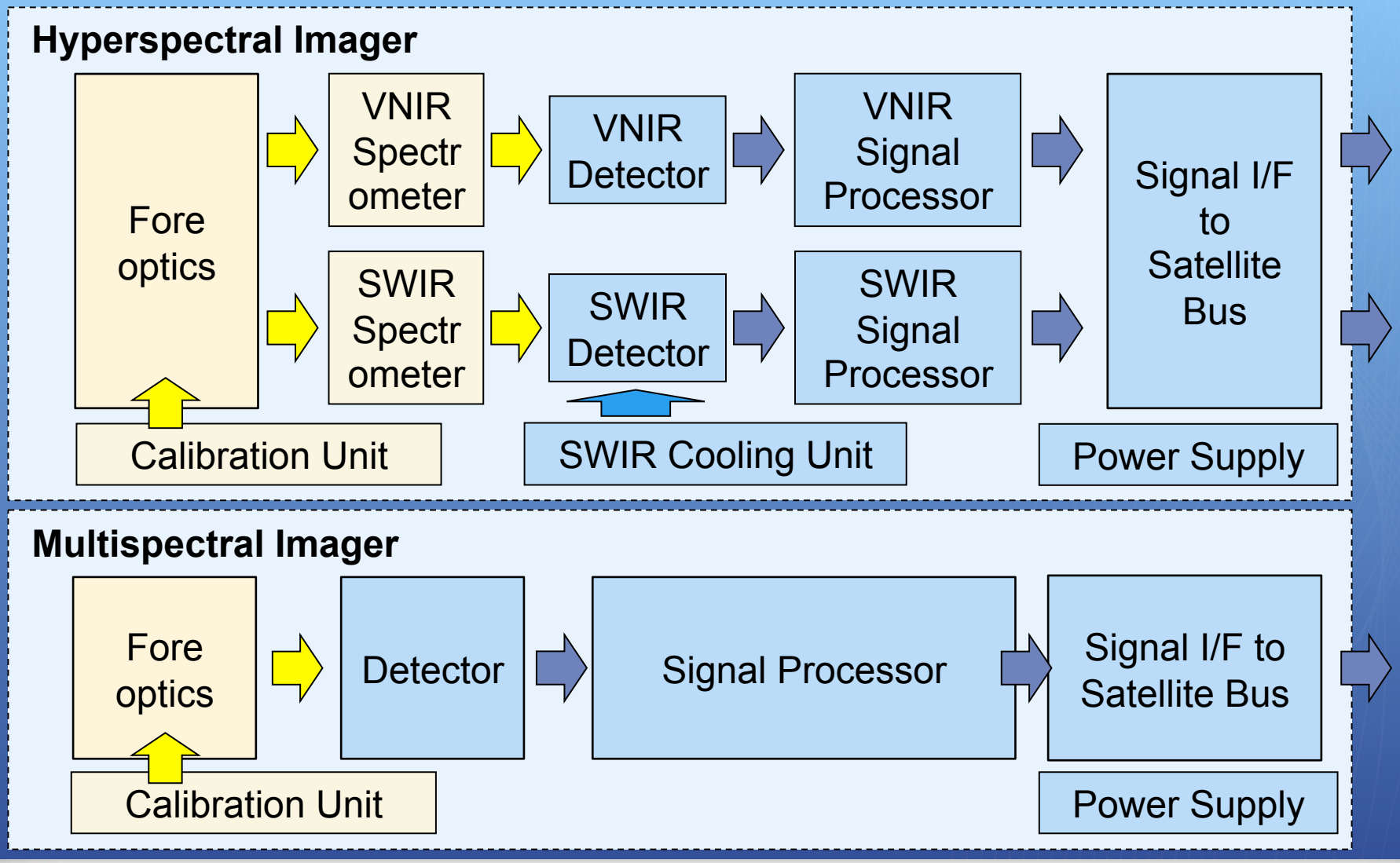
| Parameter | Requirement |
|---|---|
| Spatial Resolution and Swath Width | 5 m and 90 km |
| Number of Bands and Spectral Coverage | 4 and 0.45 – 0.90 μm |
| Signal to Noise Ratio (30% albedo) and MTF | ≥ 200 and ≥ 0.3 |
| Dynamic Range | ≥ 8 bits<br>(current design = 12bits) |
| Data Compression | Lossless (70%) |

# Specification of JAXA's ALOS-3 and Panchromatic Stereo Camera

| | |
|---|---|
| Orbit Type and Altitude | Sun Synchronous, ≈ 620 km |
| Local Time At Descending Node | 13:30 (TBD) |
| Orbits per Day | 15 orbits/day (TBD) |
| Repeat Cycle and Interval between Orbits | 60 days and 45 km(TBD) |
| Launch Vehicle | H II-A |
| Downlink Capability | 800 Mbps (TBD) |
| Onboard Storage | > 200 GB (TBD) |

| Parameters of JAXA's Panchromatic Stereo Camera | Requirement |
|---|---|
| Spatial Resolution and Swath Width | 0.8 m(nadir) and 50 km |
| Data Compression | Lossy (22%) |

# HISUI Functional Block Diagram



# Optical Schematics of HISUI Hyperspectral Imager

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

Lamp
(Halogen lamp)

On-board Calibration Mechanism

Telescope (Three Mirror Anastigmat Type)

Slit Assembly

VNIR Spectrometer (Offner Type)

CMOS 2D Detector

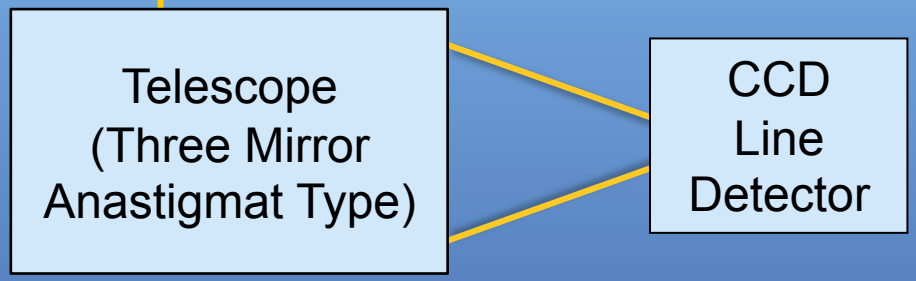
SWIR Spectrometer (Offner Type)

MCT 2D Detector

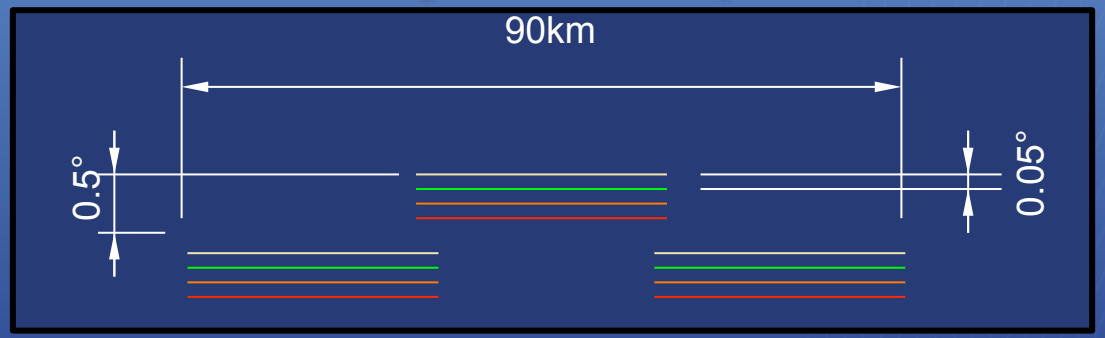
Stirling Type Cooling Unit

# Optical Schematics of HISUI Multispectral Imager

On-board Calibration Mechanism


FPA : 4 line CCD array with the band pass filters on the each chip



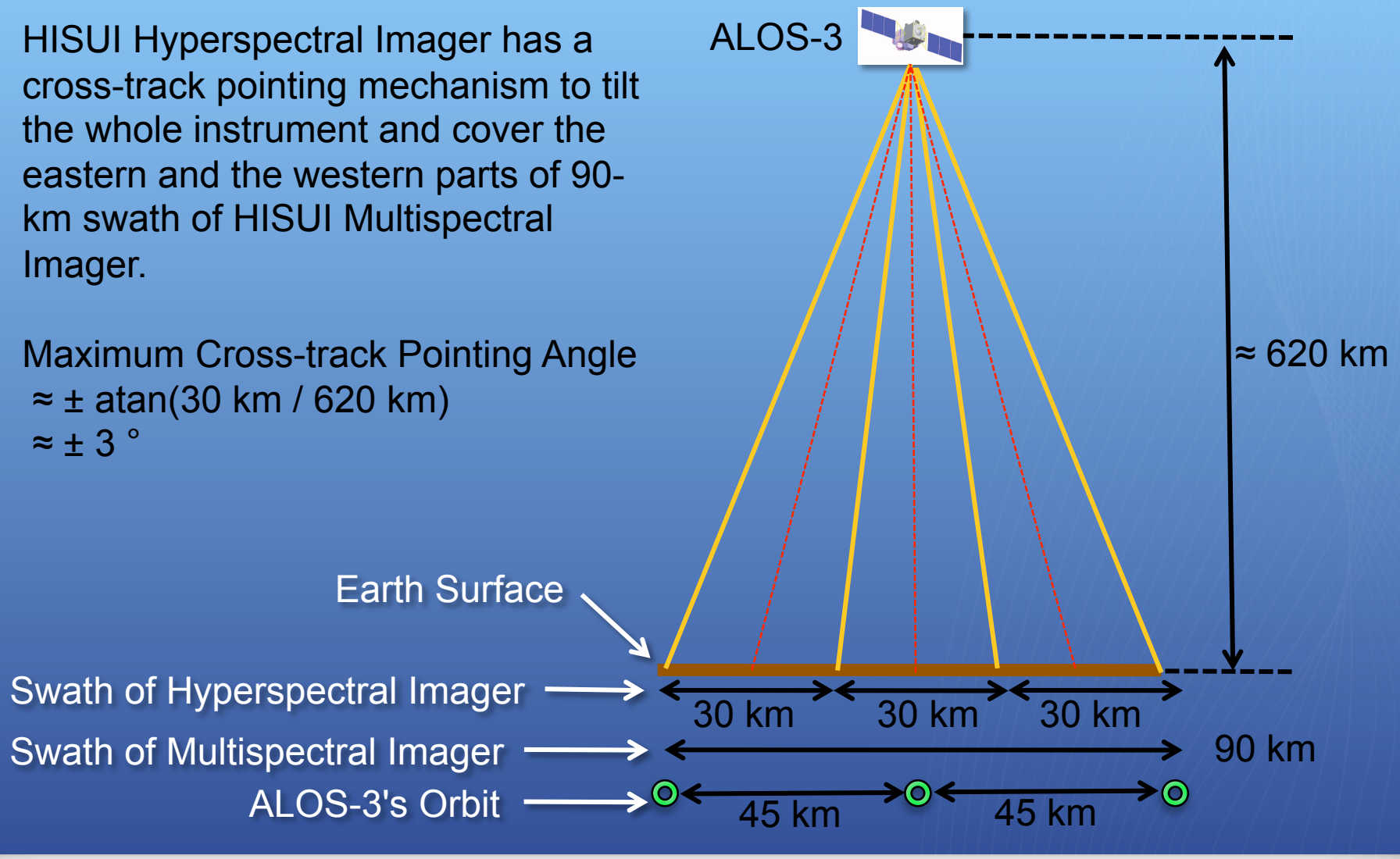
# Operation of HISUI

- Maximum operation time
  - 15 min / orbit and 15 orbits / days for each imagers
- Target observation + (semi) global mapping
  - Plus disaster mode and calibration mode
  - Nighttime hyperspectral SWIR observation
  - Area and frequency of (semi) global mapping depend on allocated downlink capability.
- Hyperspectral Imager and Multispectral Imager can be operated separately or simultaneously .
- Cross-track pointing for Hyperspectral Imager to fill gaps between orbits.

# Cross-track Pointing of HISUI Hyperspectral Imager

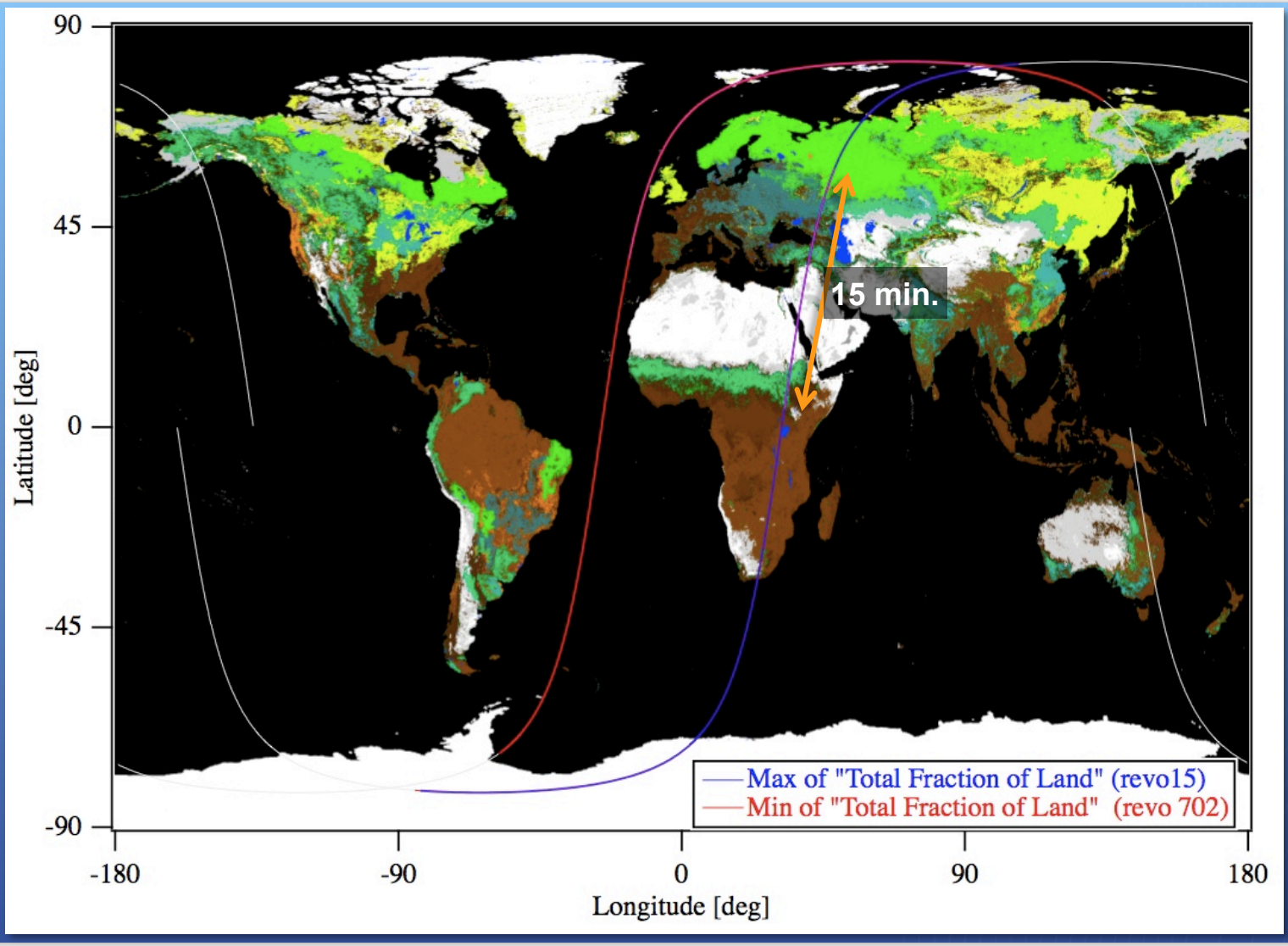
HISUI Hyperspectral Imager has a cross-track pointing mechanism to tilt the whole instrument and cover the eastern and the western parts of 90-km swath of HISUI Multispectral Imager.

Maximum Cross-track Pointing Angle
≈ ± atan(30 km / 620 km)
≈ ± 3 °

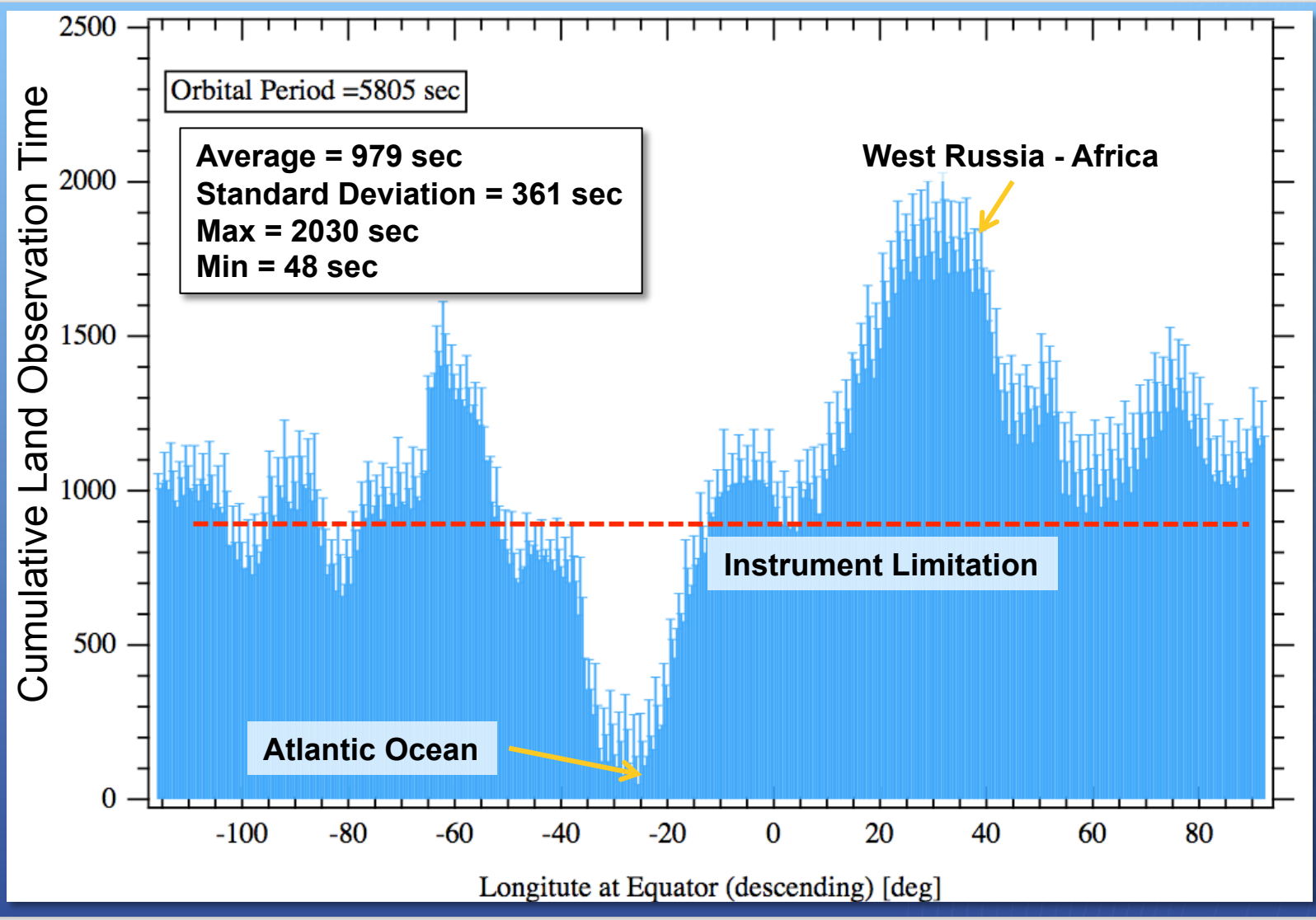


# ALOS-3's Orbits and Land Observation

Blue and Red : maximum and minimum land fraction orbits
white : nightside



# Cumulative Land Observation Time per Orbit of HISUI Hyperspectral Imager



# ALOS-3 and HISUI
# Data Amount and Downlink

| | Data Rate (70% Comp.) | Maximum Observation Time per Orbit | Maximum Data Amount per Orbit | Maximum Data Amount per Day |
|---|---|---|---|---|
| HISUI - Hyper | 0.4 Gbps | 15 min. | 46 Gbyte | 690 Gbyte |
| HISUI - Multi | 1 Gbps | 15 min. | 110 Gbyte | 1600 Gbyte |

| | Downlink Speed | Downlink Time per Day | Data Amount per Day |
|---|---|---|---|
| Ground Station | 800 Mbps | 20 min. | 120 Gbyte |
| Relay Satellite | 800 Mbps | 220 min. | 1320 Gbyte |

- HISUI will share ALOS-3's downlink capability with JAXA's panchromatic camera.
- Discussion on downlink capability **allocation** is ongoing between METI and JAXA

# HISUI Product List (TBR)

| Name | Description | |
|---|---|---|
| Level 1R | Raw DN product with all radiometric calibration coefficients. Spatial resampling is not applied. Smile properties and spectral continuity between VNIR and SWIR are considered. | |
| Level 1G | Geometrically corrected top-of-atmosphere spectral radiance product. Inter-telescope registration, parallax correction, and keystone property are considered. (Orthorectified product is under consideration) | |
| Level 2 | Surface spectral reflectance product generated from L1R/G with QA information. | |

*Definitions of products are common between hyperspectral and multispectral imagers

# Brief Introduction of HISUI Working Groups

# Calibration Working Group
## Chair : Juntaro Ishii (AIST)

- Upgrading of the proven calibration system of ASTER
- Member: AIST, Univ. Tokyo, JAROS
- ***Foremost tasks***
  - Radiance scale based on standard blackbody sources traceable to the SI unit
  - Application of the newly developed M-C eutectic high temperature fixed point blackbody above 1100°C
  - Effective calibration method for atmospheric absorption bands
  - Uncertainty analysis conformable to GUM
  - Reliable on-board radiometric / wavelength calibration methods

# Calibration Working Group

- Vicarious and cross calibration
  - New Approaches to vicarious calibration and cross calibration methodologies for HISUI
    - To revise the methodology for the large absorption region and high spectral resolution
  - Field survey of suitable test sites for VC in Australia
  - Field campaigns for VC at U.S. and Australia test sites
  - Strengthening of collaboration with foreign research institutes

# Level1 Working Group
## Chair : Akira Iwasaki (Univ. Tokyo)

- Heritage of ASTER Level-1 Data Processing
- Member: AIST, ERSDAC, JAROS
- *Radiometric → Level-1R Product*
  Radiometric parameters are delivered by instrument team
  All radiometric coefficients are included in Level-1R data
  Smile properties must be considered
  Spectral continuity between VNIR and SWIR
- *Geometric → Level-1G Product*
  Data fusion of multi-telescope system
  Parallax correction for line sensor arranged in parallel
  Keystone properties must be considered
  Orthorectified data product is under consideration

# Level2 Working Group
## Chair : Hirokazu Yamamoto (AIST)

- **Members:** AIST, Masao MORIYAMA (Nagasaki U.)

- ***Level-1R/Level-1G Product → Level-2 Product***
  - ✓ L2 algorithm will convert from L1R/L1G radiance to surface reflectance, which will be based on MODTRAN.
  - ✓ Irradiance model used in this module is TBD.
  - ✓ Terrain correction is TBD.
  - ✓ Products will include QA information
  - ✓ Orthorectified surface reflectance will be generated if Level-1G orthorectified radiance is available.

- ***L2 product validation***
  - ✓ Intercomparison among other satellite sensors by conversion from narrow bands to broad bands will be conducted.
  - ✓ Ground-based validation is TBD.

# Operation and Mission Planning (OMP) WG
## Chair : Tsuneo Matsunaga (NIES)

- Member : Matsunaga, Yamamoto (NIES)
  Kashimura, Kato, and Tachikawa (ERSDAC)
  Ogawa (Rakuno Gakuen Univ.)

- Missions of OMP WG
  1) Make long and short term observation and data processing plans
  2) Design HISUI's scheduling and mission achievement reporting system. ERSDAC will implement HISUI's OMP system based on the WG's design.

* Matsunaga, Kato, and Tachikawa are members of ASTER OMP WG.

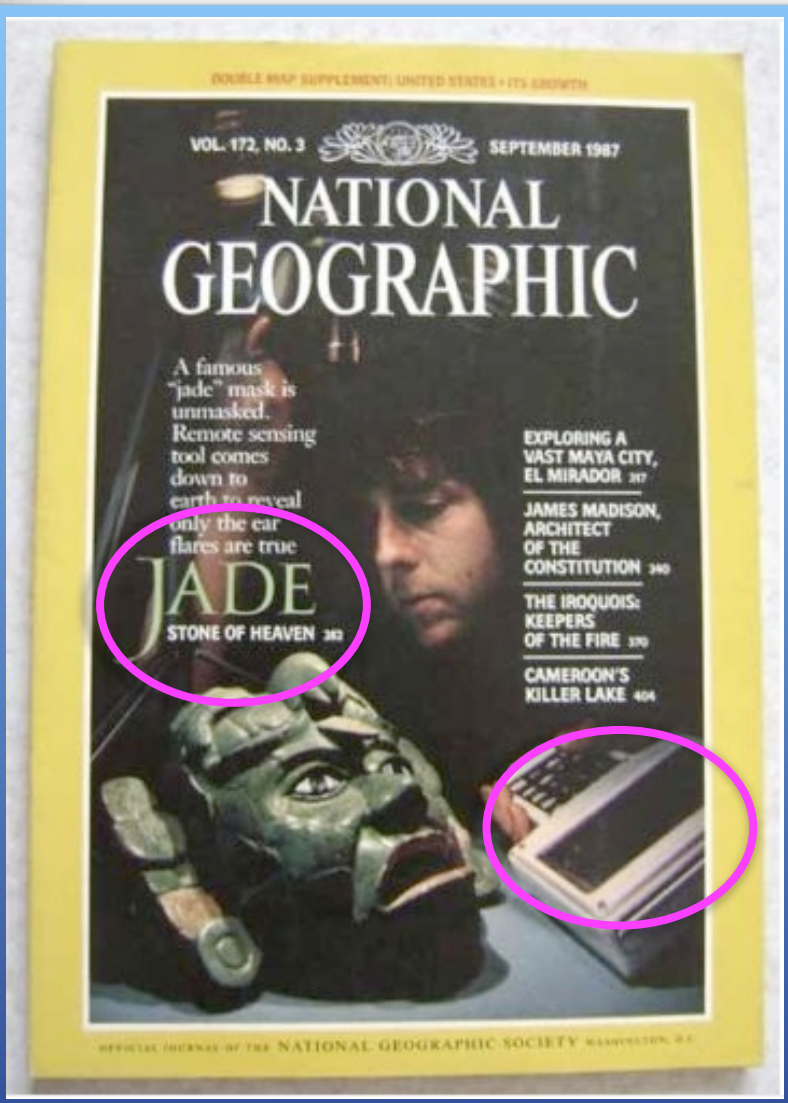
# Archive Working Group
## Chair : Ryosuke Nakamura (AIST)

- Design versatile OGC standard framework for satellite data processing system (= GEO grid)
  http://www.geogrid.org/en/index.html
- Implementation of HISUI's ground system with GEO Grid
- Member: AIST, ERSDAC
- Prompt delivery of L1R , L1G and higher level products
- Possible data fusion with JAXA's panchromatic camera and other hyperspectral imagers

# HISUI Frequently Asked Questions

- HISUI and Hyper-X
  - Hyper-X is a project proposed by a group of private companies to operate a spaceborne hyperspectral imager transferred from Japanese government for commercial purposes.
  - No decisions have been made regarding full or partial privatization of HISUI yet.
- Data Policy
  - No decisions have been made yet.
- Orbit of ALOS-3 satellite
  - Discussion with JAXA is ongoing
- International Collaboration
  - METI/EnMAP telecon, AIST/CSIRO/ERSDAC joint vicarious calibration in west Australia ...

# Wanted!
# September 1987 Issue of National Geographic




"Brian Curtiss, a geochemist who received his Ph.D. from University of Washington and a postdoctoral appointment at Caltech, joined CSES. He was featured on the cover of National Geographic for his work on identifying jade artifacts using reflectance spectroscopy."
(http://cires.colorado.edu/about/history/06.html)

Curtiss, Brian, "Visible and near-infrared spectroscopy for jade artifact analysis," in F.W. Lange (ed.) Precolumbian Jade: New Geological and Cultural Interpretations (Salt Lake City: University of Utah Press, 1993), pp. 73-81.

# Thank you