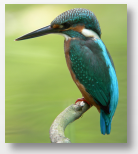
2012 HysplRI Science Workshop
October 16-18, 2012, Washington DC, US




Current Status of Hyperspectral Imager Suite (HISUI) Project

Jadeite

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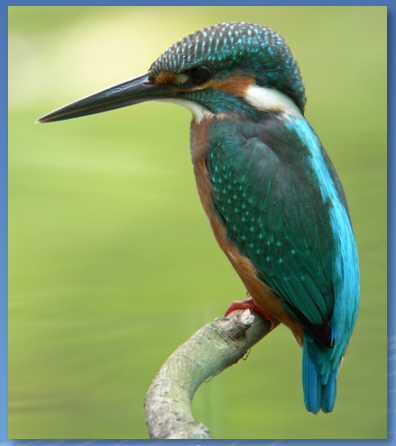
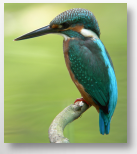


Kingfisher

Tsuneo Matsunaga[1], Akira Iwasaki[2], Satoshi Tsuchida[3], Jun Tanii[4], Osamu Kashimura[4], Hirokazu Yamamoto[3], and Shuichi Rokugawa[2]

[1] National Institute for Environmental Studies, [2] University of Tokyo,
[3] National Institute of Advanced Industrial Science and Technology, [4] Japan Space Systems



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

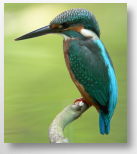
- **HISUI** is a future spaceborne instrument suite which consists of hyperspectral and multispectral imagers.

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

  1) OPS onboard JERS-1 satellite (1992 – 1998)
  2) ASTER onboard NASA's Terra satellite (1999 -)
  3) ASNARO (2012-)

- **HISUI** will be launched by H-IIA rocket in 2015 or later as one of mission instruments onboard JAXA's ALOS-3 satellite

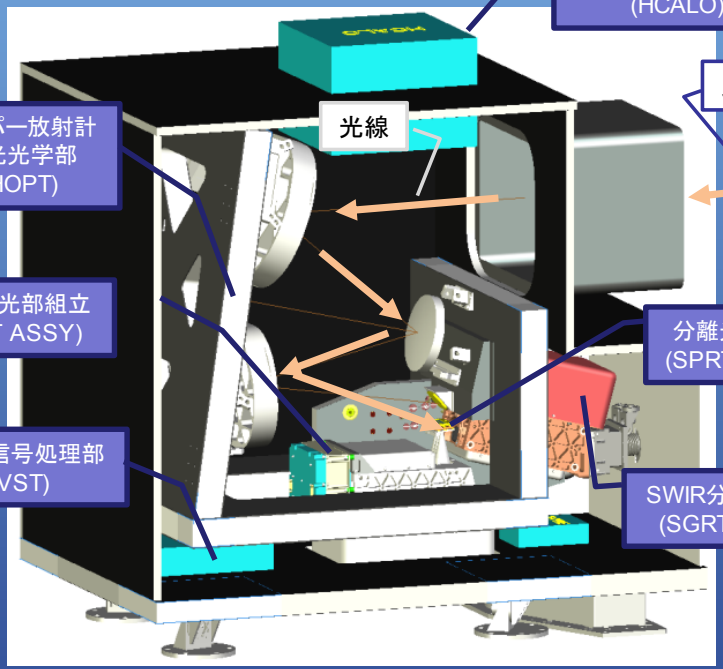
  1) ALOS (2006 - 2011) : Optical imagers (PRISM and AVNIR-2) and L-band SAR (PALSAR)
  2) ALOS-2 (2013 -) : L-band SAR (PALSAR-2) and a small thermal camera (CIRC)



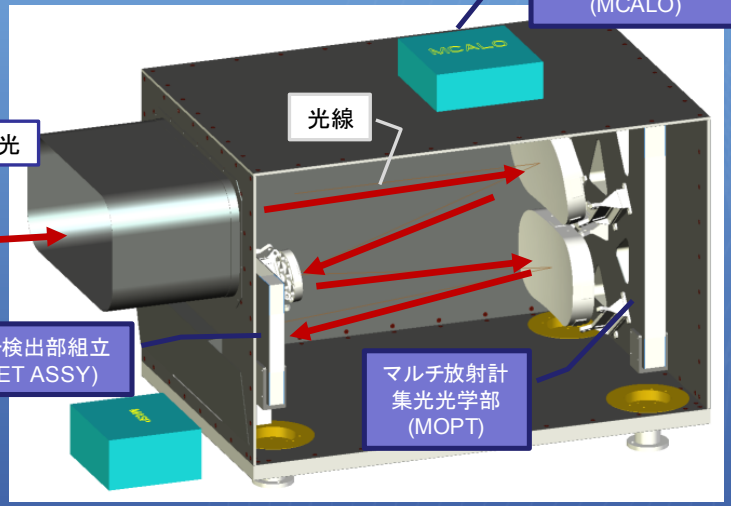
JAXA's ALOS-3 and HISUI

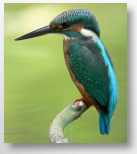
JAXA's ALOS-3

HISUI Hyperspectral Imager



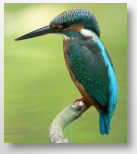
HISUI Multispectral Imager





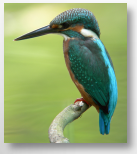
HISUI Specifications and Requirements

Parameter		Hyperspectral Imager	Multispectral Imager
Imaging Type		Pushbroom	Pushbroom
Spatial Resolution / Swath		30 m / 30 km	5 m / 90 km
Spectral	Bands	185	4
	Range	0.4 - 2.5 μm	0.45 -0.89 μm
	Resolution	10 – 12.5 nm	60 – 140 nm
SNR (30% albedo)		≥ 450 @620 nm ≥ 300 @2100 nm	≥ 200
MTF		≥ 0.2	≥ 0.3
Quantization		12 bits	12 bits
Data Compression		Lossless (70%)	Lossless (70%)
Pointing		Cross track, up to ± 3 ° (≈ ±30 km)	N/A



What's New

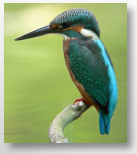
- Various tests for HISUI evaluation models were conducted.
- HISUI instrument CDR will be held in December 2012.
- HISUI GDS(Ground Data System) developers are being selected.
- FY2012 funding and FY2013 funding request
  - METI (Ministry of Economy, Trade, and Industry)
    = AIST, JSS
    = HISUI instrument and GDS
  - MEXT (Ministry of Education, Culture, Sport, Science and Technology)
    = JAXA
    = ALOS-3 spacecraft and launch



Funding : FY2011, FY2012, and FY2013

	METI (AIST and JSS)	MEXT (JAXA)
	HISUI instrument development and data processing	ALOS-3 satellite* development, launch, and operation
FY2011	4.0 B yen $50 M	-
FY2012	2.3 B yen $29 M	0.1 B yen $1.25 M
FY2013 (requested)	2.0 B yen $25 M	0.1 B yen $1.25 M

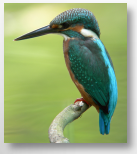
*ALOS-3 satellite bus will be same as that of ALOS-2 which is almost fully funded and will be launched in FY2013
http://www.kantei.go.jp/jp/singi/utyuu/yosan.html
http://www8.cao.go.jp/space/comittee/kaisai.html
$1 ≈ 80 yen



HISUI Schedule as of October 2012

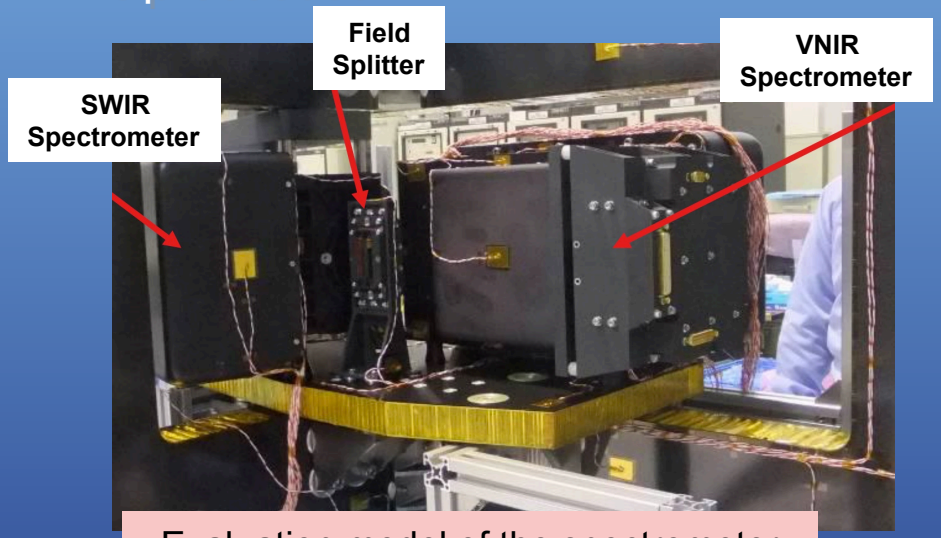
We are here.

FY	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Launch and Operation										ALOS-3 Launch	Lifetime = 5 years				
Instrument		Conceptual Design	Preliminary Design		Detailed Design		CDR			Integration with Satellite					
		Component Trial	Evaluation Model		PFM										
Ground Data System					Preparation		Selection of Contractors			Training/Initial Operation					
				Preliminary Design				Critical Design			Nominal Operation				
								Developement/Installation							
Others															
		Application Research													
		Spectral Database Development													
		Data Analysis Methodology Research (JOGMEC)													

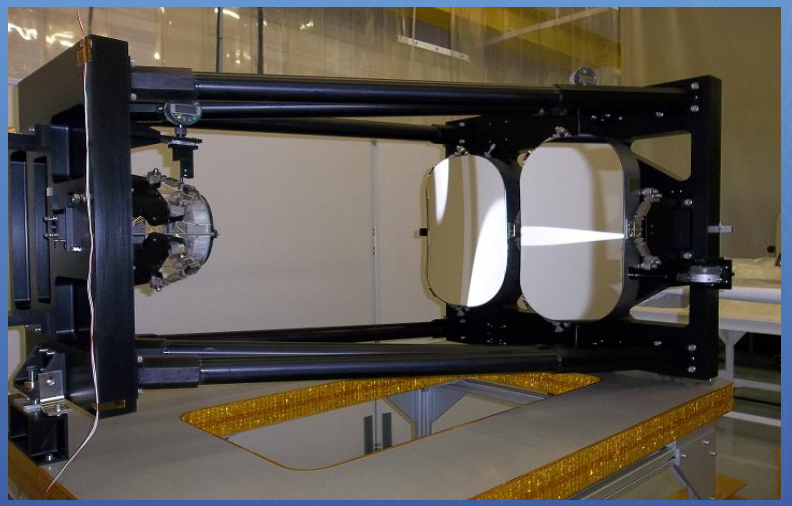


HISUI Instrument Development Status

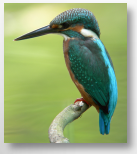
- March 26, 2012 : Tentative PFM design reflected from the test results of the evaluation model was reported.
- CDR will be held in December 2012.
- Manufacturing of some key components for PFM, such as telescope/ spectrometer of Hyperspectral Imager and telescope of Multispectral Imager, is proceeded.



Evaluation model of the spectrometer of Hyperspectral Imager

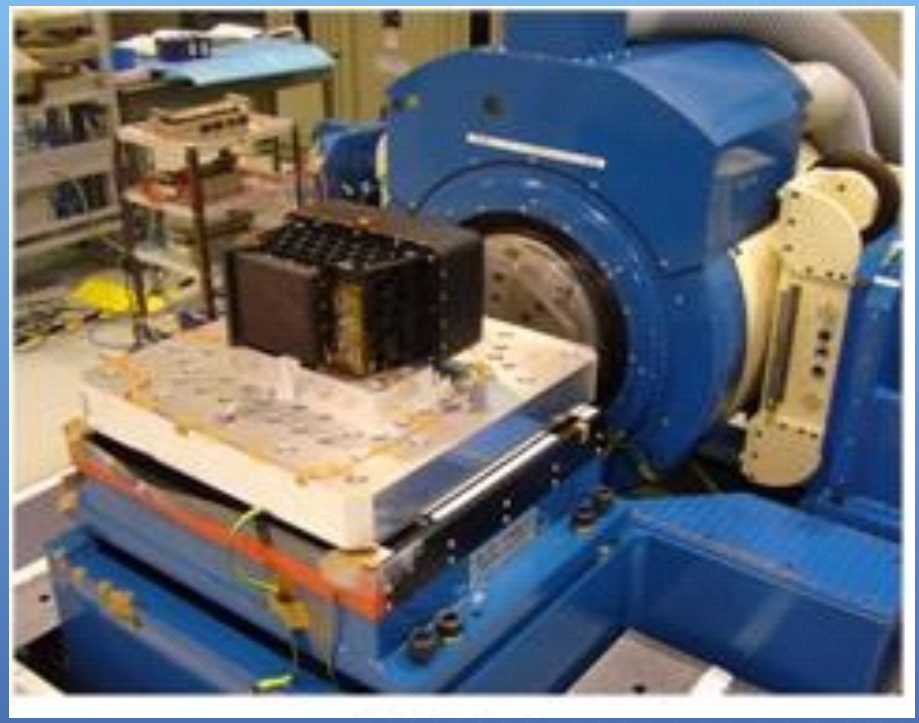


Telescope of Multispectral Imager for PFM

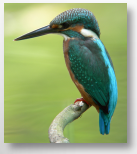


Thermal Vacuum and Vibration Tests of HISUI Hyperspectral Imager Evaluation Model

Thermal Vacuum Test



Vibration Test



HISUI Ground Data System(GDS) Development

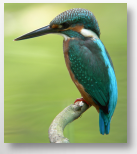
- HISUI GDS (ground data system) will be designed and developed based on ASTER and GEO Grid experiences.

http://gds.aster.ersdac.jspacesystems.or.jp
http://asterweb.jpl.nasa.gov/

http://www.geogrid.org/

- HISUI GDS development contractors will be selected soon.
  - Level 1 software developer was selected.
  - HISUI GDS integrator will be selected soon.

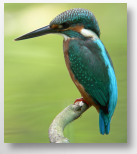
- Following softwares will be developed for HISUI GDS.
  - Level 1 processing
    - Ver. 1 in FY2013, and Ver. 2 in FY2014
  - Cloud detection / cloud mask for Level 1 product
  - Atmospheric correction for Level 2 product
  - Scheduler and Long-term operation simulator



HISUI Product List as of October, 2012

Name	Description	
Level 0	Raw data	
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	Atmospherically corrected surface spectral reflectance product generated from L1R/G with QA information. This product is for research purpose only and not validated.	

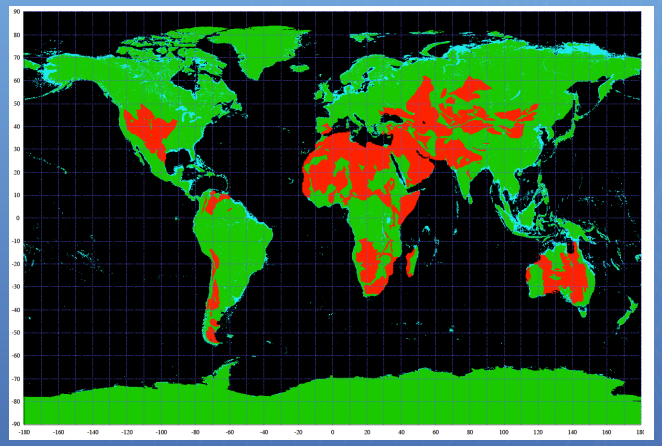
*The same product definitions will be applied to both Hyperspectral and Multispectral Imagers
** Cloud statistical data are attached to L1 and L2 products.



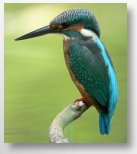
HISUI Operation and Mission Planning

- HISUI commands will be uploaded to ALOS-3 every two days. HISUI scheduler will automatically create 2-day 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 are obtained.

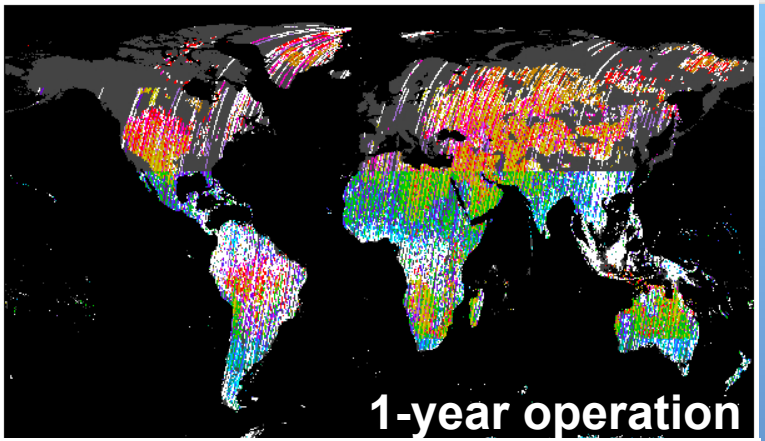
- HISUI DAR categories (draft)
  - Priority area mapping
    - Including oil/gas/metal resource exploration and development areas
  - Periodical observation
    - Monthly, seasonal, and annual observations
    - Including nighttime fire/volcano observation
  - Emergency / disaster observation
  - Calibration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

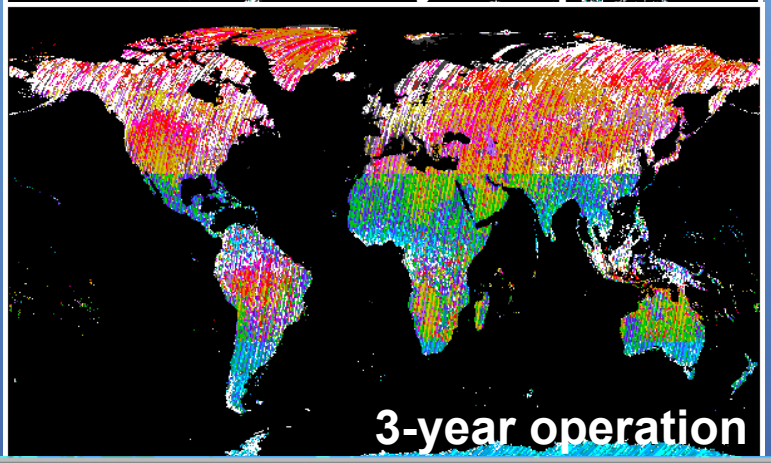


Red = Priority areas for oil/gas/metal resources, **Green** = Other land, Light blue = Shallow coastal zones shallower than 30 m.

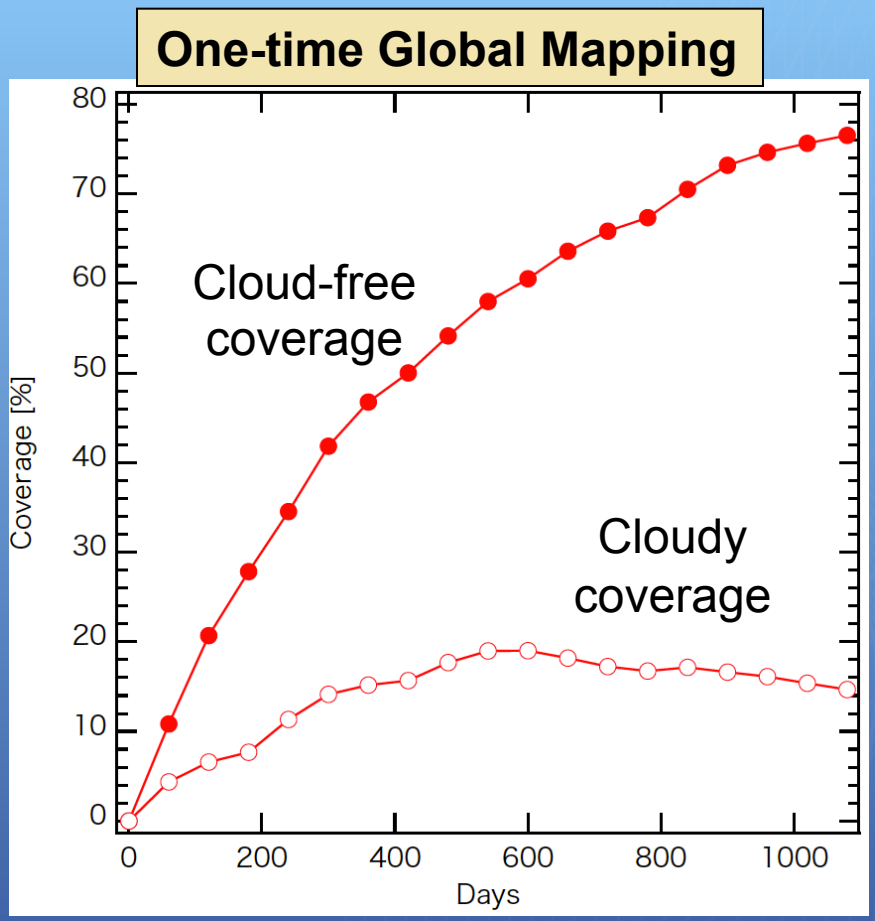


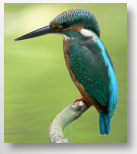
HISUI Hyperspectral Imager Long-term Operation Simulation : 150 Gbyte/Day





Color indicates the month of cloud free observation. Gray = no observation. White = Cloudy image only.

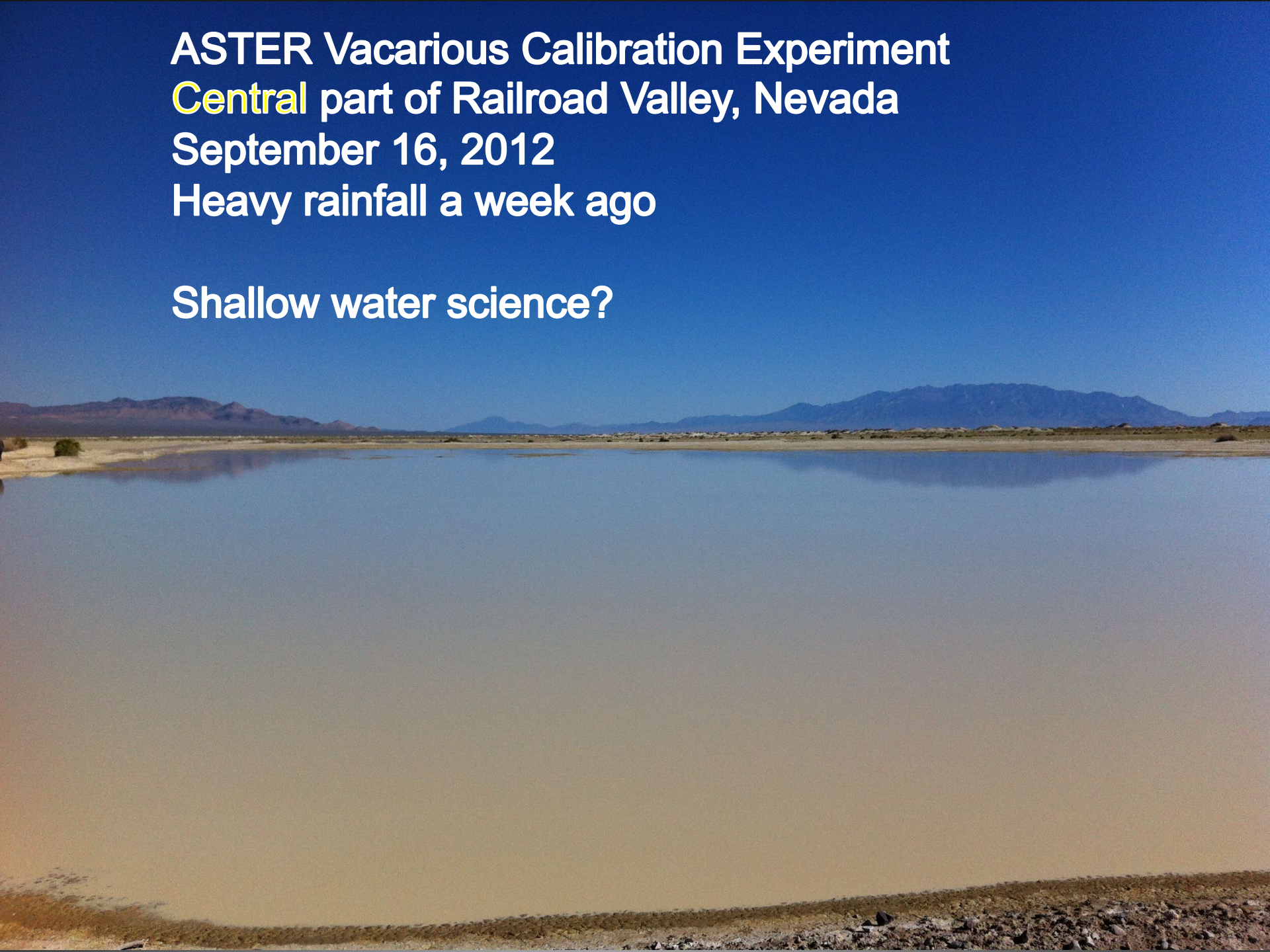


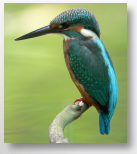


HISUI Radiometric and Spectral Calibration

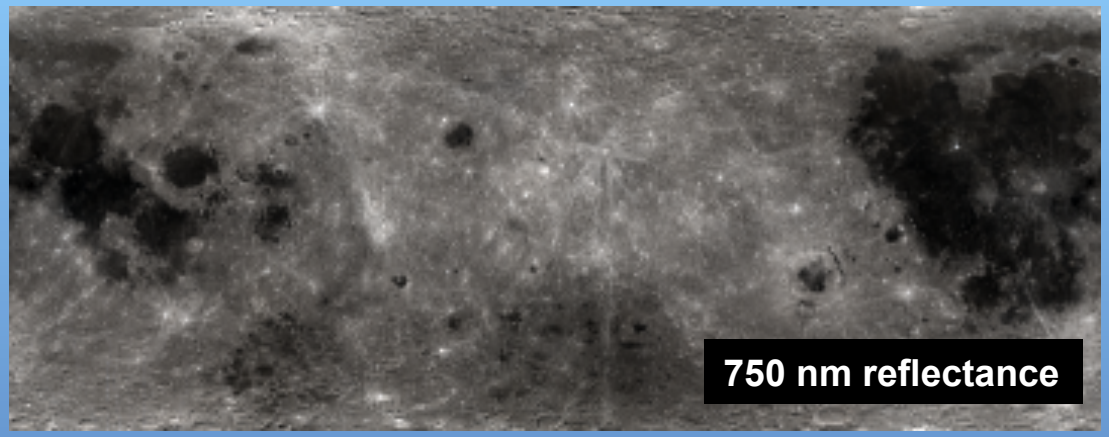
- Before launch
  - Rigorous labratory measurement / instrument characterization
- After launch
  - Onboard calibration using lamps and filters
    - ASTER uses lamps
    - NIST filter
  - Cross calibration with other spaceborne instruments
  - Vacarious calibration
    - ASTER experiments at RRV and other US sites since 1996
    - West Australia experiment in Nov. 2012.
  - Lunar calibration
    - New lunar reflectance model generated from SELENE data

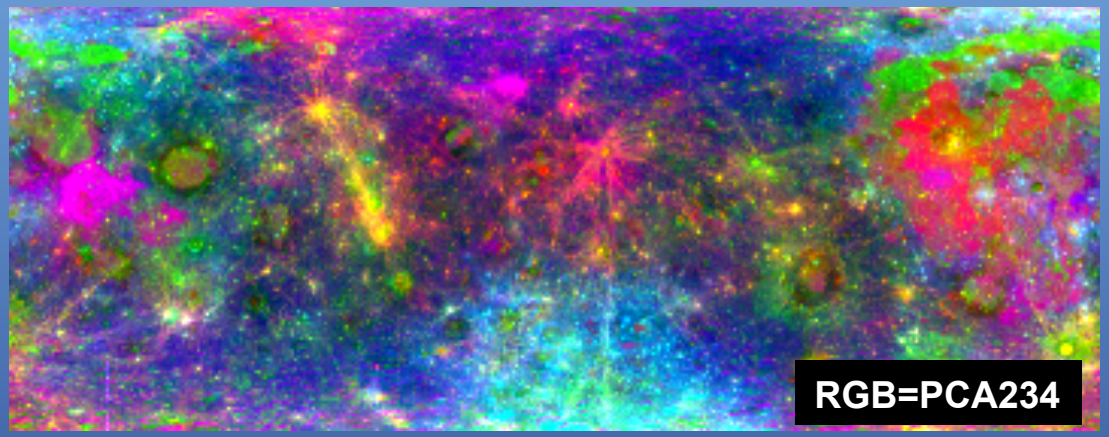

ASTER Vacarious Calibration Experiment
Southern part of Railroad Valley, Nevada
September 16, 2012


ASTER Vacarious Calibration Experiment
Central part of Railroad Valley, Nevada
September 16, 2012
Heavy rainfall a week ago
Shallow water science?



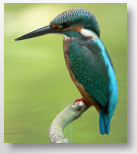
Lunar Global Reflectance Model Generated from SELENE Spectral Profiler Data





Photometrically corrected surface spectral reflectance (0.5 – 1.6 μm, 184 bands) cube generated from SELENE Spectral Profiler data.

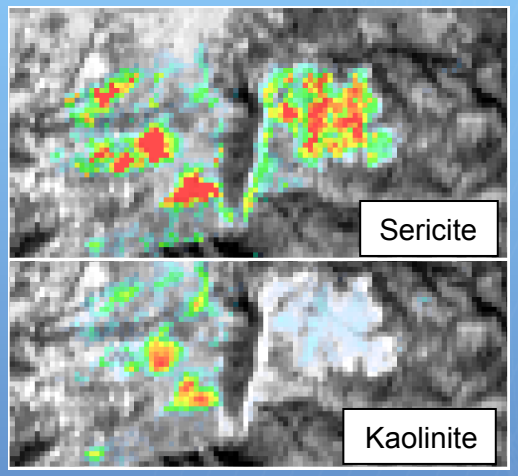
- Yokota et al. (2011), Lunar photometric properties at wavelengths 0.5–1.6 μm acquired by SELENE Spectral Profiler and their dependency on local albedo and latitudinal zones. Icarus, 215, 639-660
- Kouyama et al. (2012) Planned HISUI radiometric calibration using the lunar reflectance model from SELENE Spectral Profiler data, 2012 AGU Fall Meeting

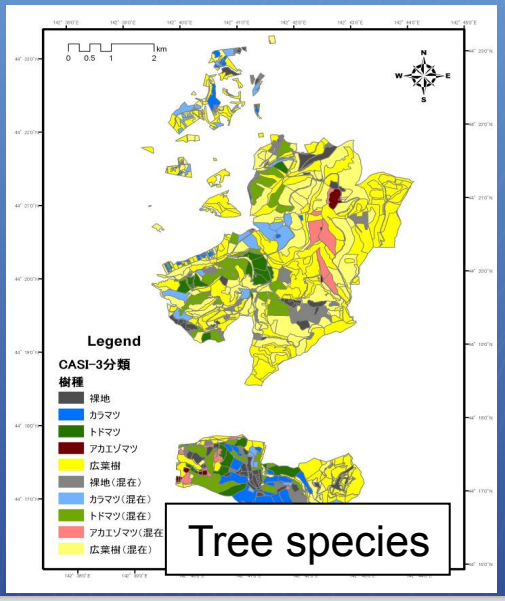


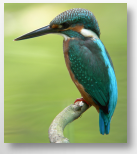
Application Studies Funded by JSS

- JSS has been funding several research projects proposed by private companies to build capacity to utilize hyperspectral data and facilitate future applications of HISUI data in private sectors.

- Past and current research projects include:
  - Mineral identification and quantification
  - Coral reef monitoring
  - Wheat/rice yield estimation
  - Forest maintenance
  - Narcotic plant detection

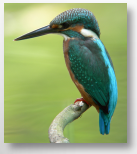




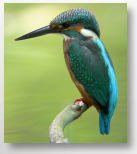


Summary

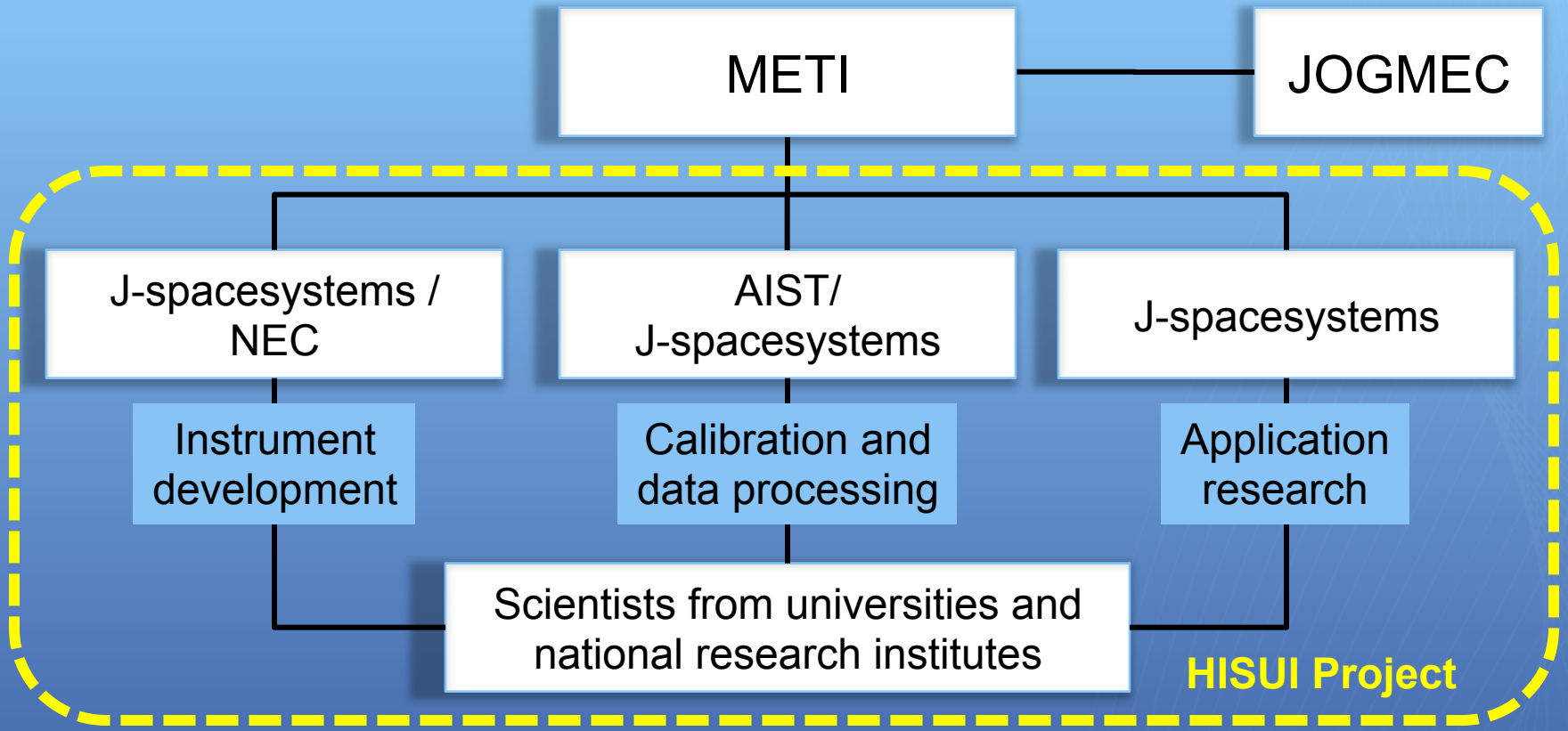
- HISUI is a Japanese imaging suite with hyperspectral and multispectrral imagers. It will be launched in FY 2015 or later as one of mission instruments of JAXA's ALOS-3.
- HISUI instrument will have CDR in December 2012 and be completed in FY2013.
- Contractors of HISUI GDS will be selected soon.
- HISUI's operation and mission planning studies are ongoing.
  - Scheduler development
  - Long term mission simulation using actual cloud data
- Preparations for HISUI vacarious and lunar cal. are also ongoing.
- METI and MEXT/JAXA are still discussing HISUI data policy.



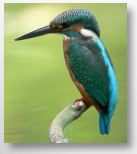
Thank you



HISUI Project Structure as of April 2012



METI : Minstry of Economy, Trade, and Industry
JOGMEC : Japn Oil, Gas, and Metals National Corporation
J-spacesystems: Japn Space Systems (established in April, 2012)
NEC : NEC Corporation
AIST : National Institute of Advanced Industrial Science and Technology



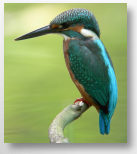
Objectives of HISUI Mission

Objectives of HISUI Mission

1) Global energy and resource related applications
   - Exploration of oil, gas, and metal resources
   - Environmental assessments of oil/gas fields and mines.

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

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



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

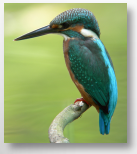
VNIR Spectrometer (Offner Type)

CMOS 2D Detector

SWIR Spectrometer (Offner Type)

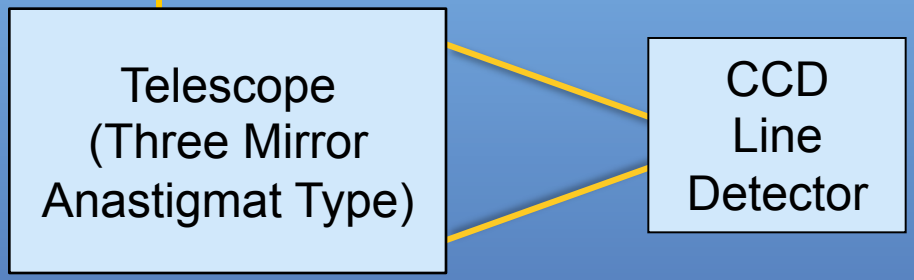
MCT 2D Detector

Stirling Type Cooling Unit

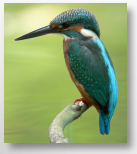


Optical Schematics of HISUI Multispectral Imager

On-board Calibration Mechanism



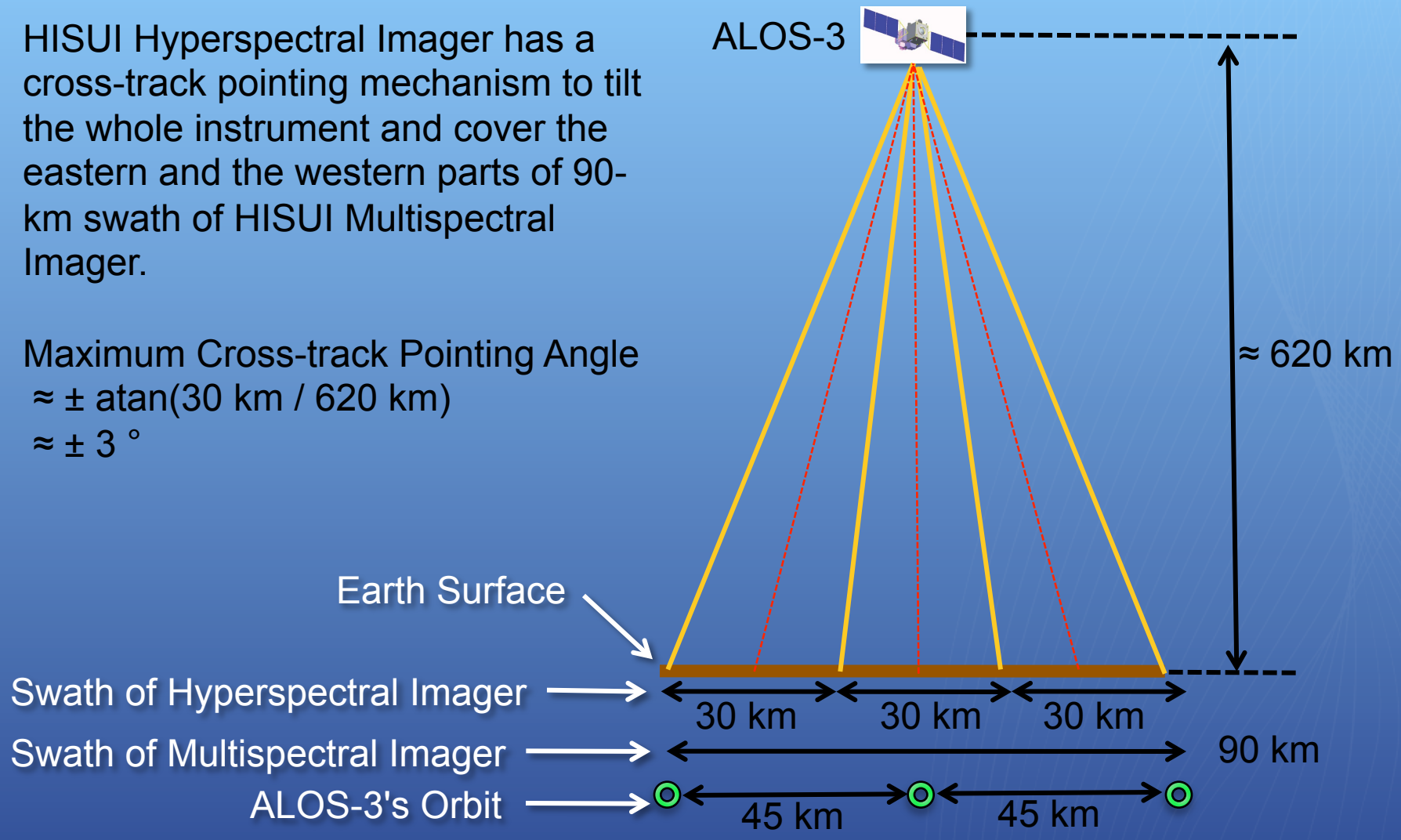
FPA : 4 line CCD array with the band pass filters on the each chip

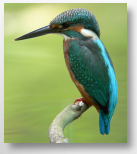


Cross-track Pointing of HISUI Hyperspectral Imager

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 °



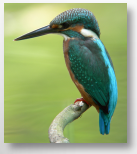


Specification of JAXA ALOS-3 and Panchromatic Stereo Camera

JAXA ALOS-3	Requirement
Orbit Type and Altitude	Sun Synchronous, 618 km
Local Time At Descending Node	10:30
Orbits per Day	15 orbits/day
Repeat Cycle and Interval between Orbits	60 days and 45 km
Data Downlink	800 Mbps to a ground station and a data relay satellites. Max. 1.3 TB/day

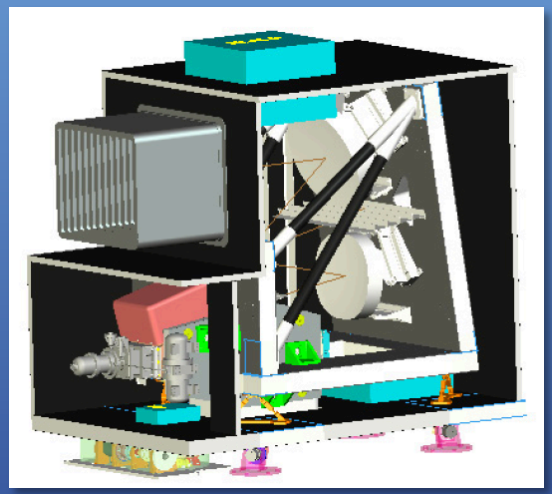
JAXA PRISM-2	Requirement
Spatial Resolution and Swath Width	0.8 m(nadir) and 50 km
SNR and MTF	>200 and >0.1
Quantization	11 bits
Data Compression	JPEG2000

http://www.eorc.jaxa.jp/ALOS/conf/workshop/alos3_ws3/ALOS3_1_1_Imai_Hiroko.pdf

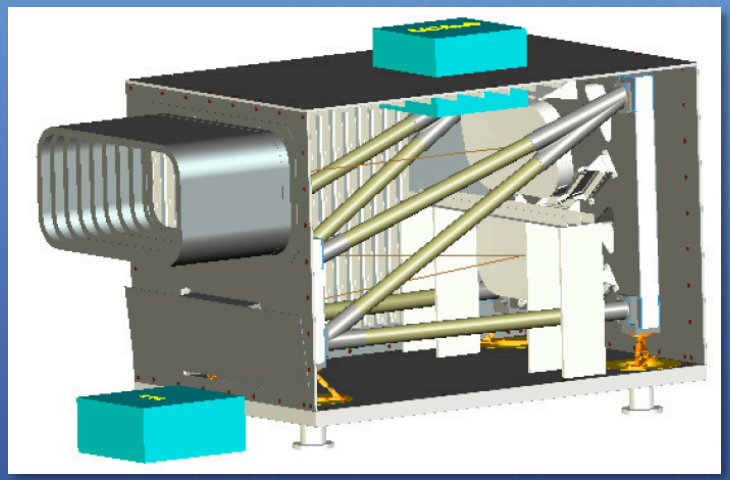


JAXA's ALOS-3 and HISUI

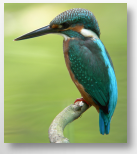
HISUI



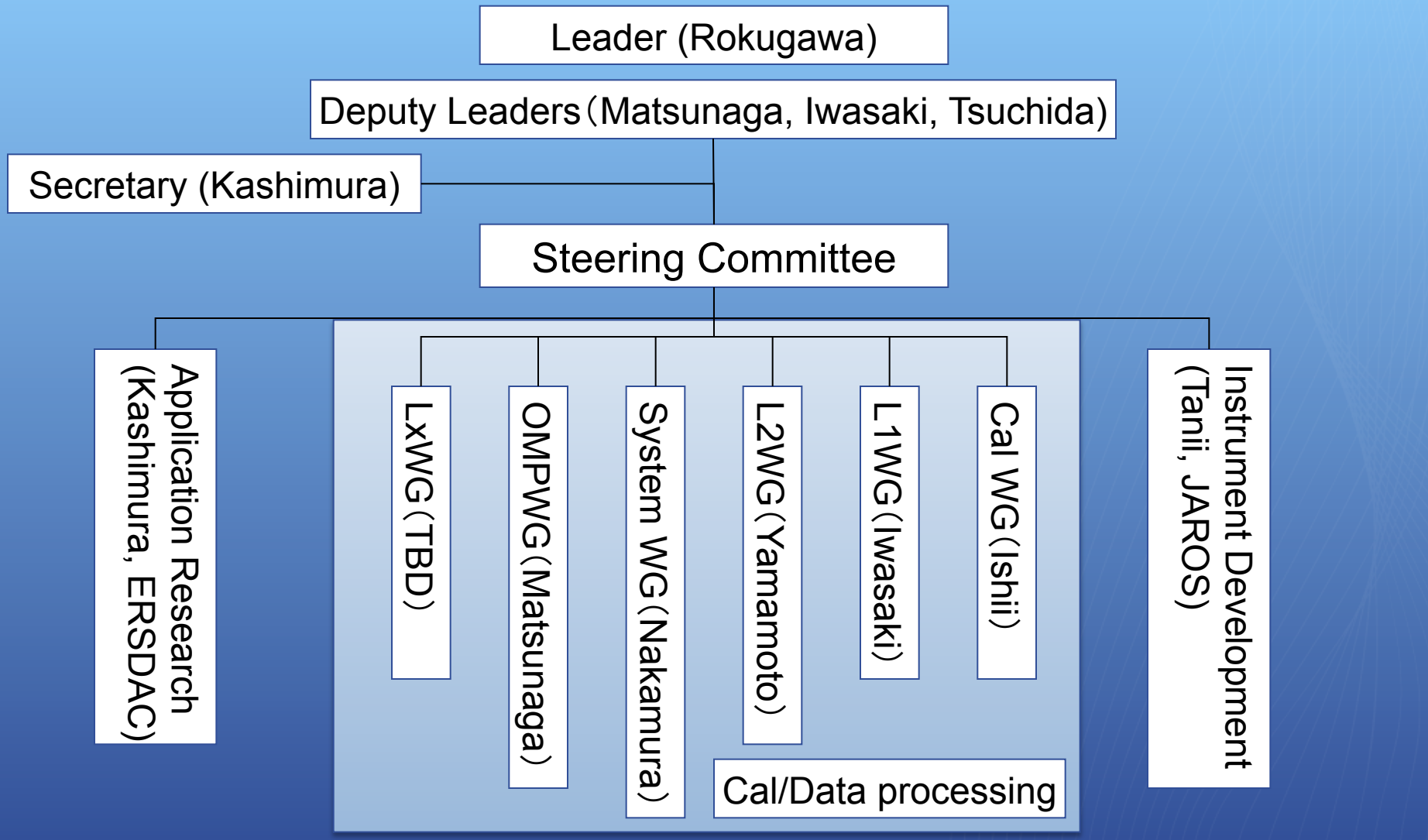
Hyperspectral Imager

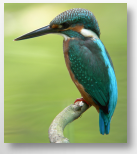


Multispectral Imager



HISUI Project Team and Working Groups





HISUI Functional Block Diagram

Hyperspectral Imager

Fore optics

VNIR Spectrometer

VNIR Detector

VNIR Signal Processor

SWIR Spectrometer

SWIR Detector

SWIR Signal Processor

Signal I/F to Satellite Bus

Calibration Unit

SWIR Cooling Unit

Power Supply

Multispectral Imager

Fore optics

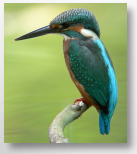
Detector

Signal Processor

Signal I/F to Satellite Bus

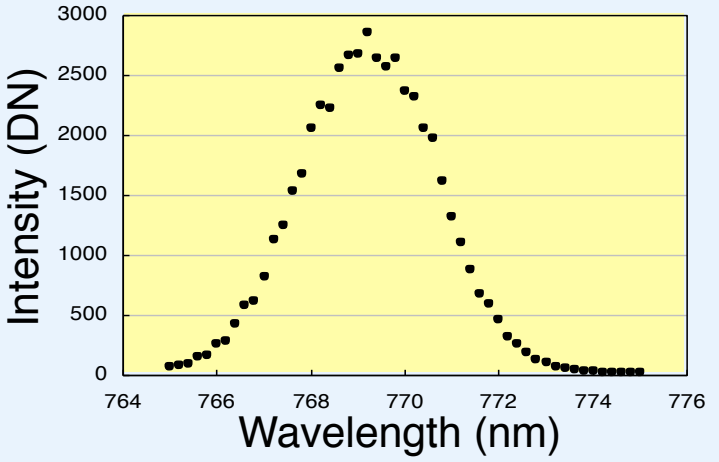
Calibration Unit

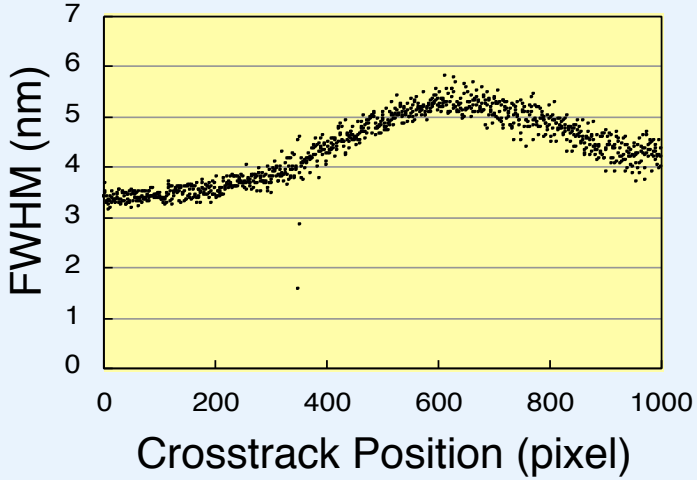
Power Supply

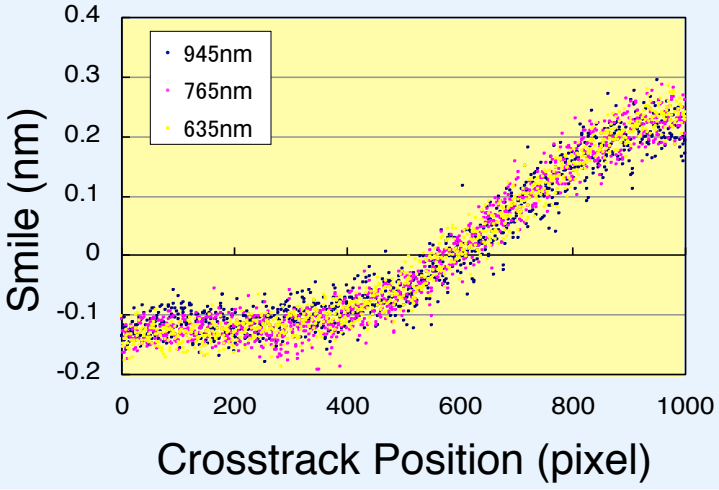


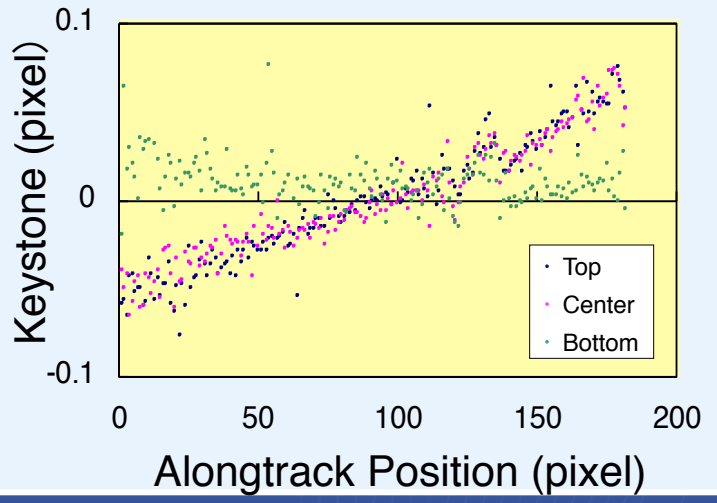
Instrument Development

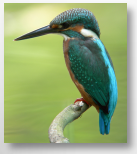
Characterization of VNIR Spectrometer Engineering Model











HISUI and ALOS-3
Data Amount and Downlink

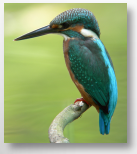
	Data Rate (70% Comp.)	Maximum Observation Time per Orbit	Maximum Data Amount per Orbit	Maximum Data Amount per Day
HISUI - Hyper	0.4 Gbps	15 min.	46 Gbyte	690 Gbyte
HISUI - Multi	1 Gbps	15 min.	110 Gbyte	1600 Gbyte

	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

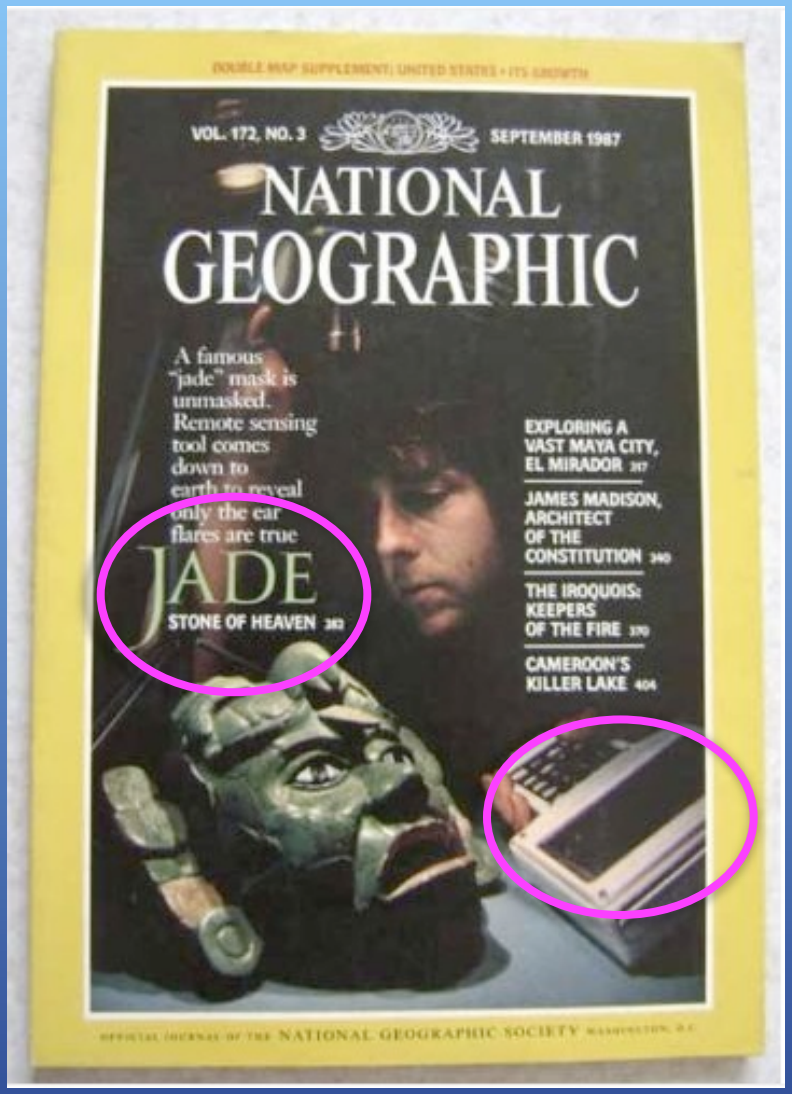
- HISUI will share ALOS-3's downlink capability with JAXA's panchromatic camera.
- Allocation of ALOS-3 downlink capability to HISUI is a critical issue.

Timeline of HISUI Project

	FY2006	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016
Instrument Develop-ment(NEDO/ JAROS/NEC)		*Conceptual Design*	*Preliminary Design*		*Detail Design*		△ CDR				
				Evaluation Model		△ Tentative PFM Design					
						PFM					
In-flight Verification (TBD)									*Integration*	**Launch**	
							Development of Data Receiving / Instrument Monitoring System			*Inflight verification*	*Nominal operation*
Application Research (METI/ ERSDAC)			*Application Research*								
			Developement of Spectral Database								
Metal Resource Exploration (METI/ JOGMEC)				*Developement of Data Analysis Methodologies*							
Calibration /Data Processing (METI/ AIST/ ERSDAC)					*Research on calibration and data processing*						
					Ground Data System Study						
					Operation / Mission Planning Study						



Jadeite and PIDAS (Portable Instantaneous Display and Analysis Spectrometer) September 1987 Issue of National Geographic



Putting jade to the test with light

MAYA MASTERPIECE, a mosaic funeral mask from a Tikal tomb in Guatemala (opposite, below) was thought by archaeologists to be jade. When author Fred Ward had strong doubts, Mary Lou Ridinger, an archaeologist who mines Guatemalan jade, visually identified as jadeite only the two-part ear flares (below right), believing some stones to be a jadeite-diopside mix.

The GEOGRAPHIC then financed a test with a portable instantaneous display and analysis spectrometer (PIDAS)—here operated by geologist Brian Curtiss (above) of the Center for the Study of the Earth from Space. Developed for Caltech by the Jet Propulsion Laboratory and funded by the W. M. Keck Foundation, PIDAS is normally used for earth-science studies. Now it has a new application—analyzing valued artifacts.

Spectrometers that measure reflected light can be used to identify minerals by their wavelength signatures. But other laboratory spectrometers are immobile; test material must be brought to them. Scrapings taken for other modes of testing would deface an art object. The 67-pound PIDAS can go to a test site and construct signatures of very small objects—harmlessly.

In Guatemala City the Maya mask was compared with test signatures of jadeite and jade look-alikes (graphs, above and below). Ward's intuition and Ridinger's eye were confirmed: Only the ear flares are jadeite.

WITH FLYING COLORS, other museum objects passed the PIDAS jade examination, among them this Maya mosaic portrait jar (left). It was found in the eighth-century tomb of Double-Comb, the gifted ruler who brought the city-state of Tikal to its cosmopolitan zenith, before its sudden and mysterious demise.

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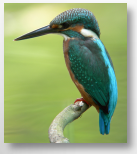
Curtiss, Brian, "Visible and near-infrared spectroscopy for jade artifact analysis," in F.W. Lange (ed.) Precolumbian Jade: New Geological and Cultural Interpretations (Salt Lake City: University of Utah Press, 1993), pp. 73-81.



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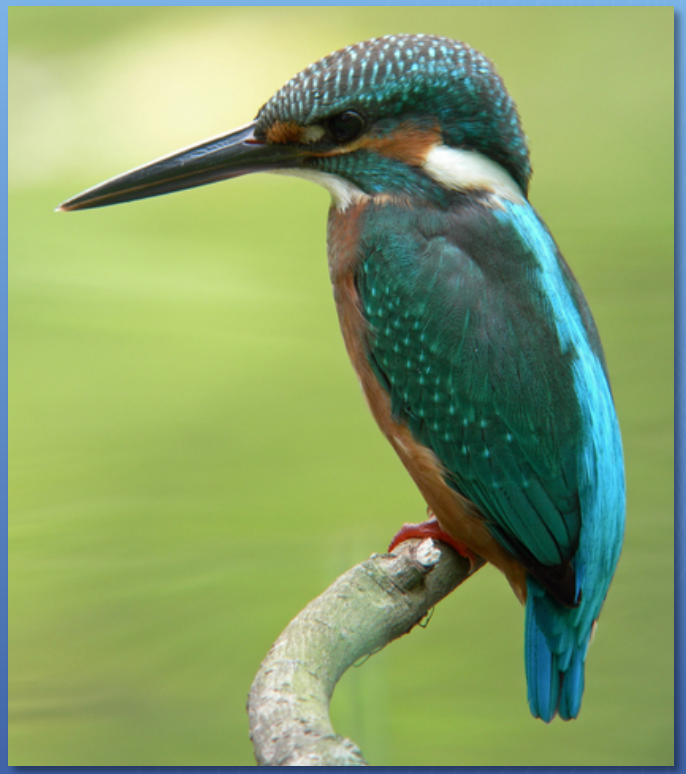

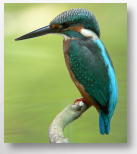

Jadeiteの写真

産総研の地質標本館にある岩石サンプルを産総研の中村良介さんが撮影したもの。