

## Current status of Hyperspectral Imager Suite (HISUI) onboard International Space Station (ISS)



**Jadeite**

翡翠

“HISUI” has two meanings in Japanese,  
names of a mineral and a bird.

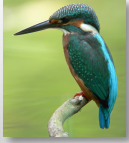


**Kingfisher**

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## What is **HISUI**? A Successor of Terra **ASTER**

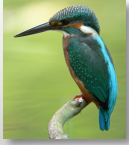


- **HISUI** is a future spaceborne hyperspectral imager being developed by Japanese Ministry of Economy, Trade, and Industry (METI) as its 4<sup>th</sup> spaceborne optical imager mission.

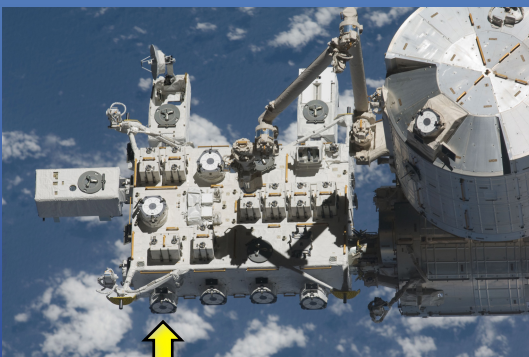
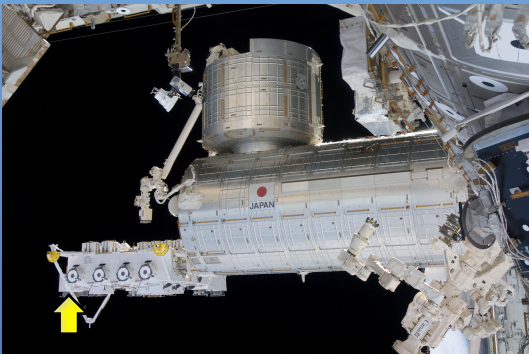
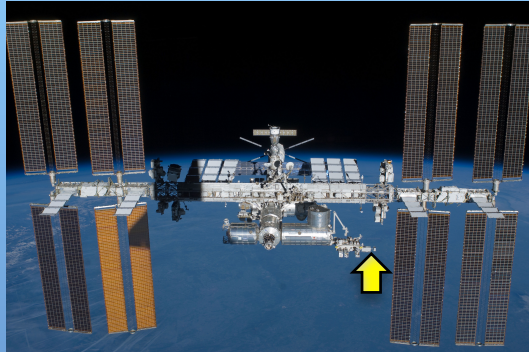
- 1) OPS onboard JERS-1 satellite (1992 – 1998)
- 2) ASTER onboard NASA's Terra satellite (1999 -)
- 3) ASNARO (2014-)
- 4) HISUI (2019 -)



- The objective of HISUI is to obtain data necessary to start full-scale application development of hyperspectral remote sensing for oil/gas/mineral resource exploration and other fields such as agriculture, forestry, and coastal issues.
- HISUI will be launched in 2019 and deployed on Japan Experiment Module (JEM) of International Space Station (ISS) for three year operation under collaboration with Ministry of Education, Culture, Sports, Science and Technology (MEXT) and JAXA.

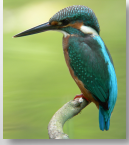


## HISUI Deployment on ISS JEM



- HISUI-Exposed Payload (**HISUI-ExP**) and HISUI-Mission Data Recorder - Pressurized Module (**MDR-PM**) will be delivered to ISS by Dragon / Falcon 9 cargo rocket in **2019**.
- HISUI-ExP will be attached to **Port #8** of JEM Exposed Facility (EF) as a nadir-viewing instrument. It also has support sensors such as a gyro, two star trackers, GPS receivers, and a mission data processor.
- MDR-PM will be installed in JEM-PM.
- HISUI data will be partially transmitted to ground stations ( $\approx 10$  GB/day  $\approx 30,000$  km<sup>2</sup>). The rest ( $\approx$  max. 300 GB/day  $\approx 900,000$  km<sup>2</sup>) will be recorded in removal media and shipped back to Earth by cargo ships three or four times a year.





# HISUI Specifications

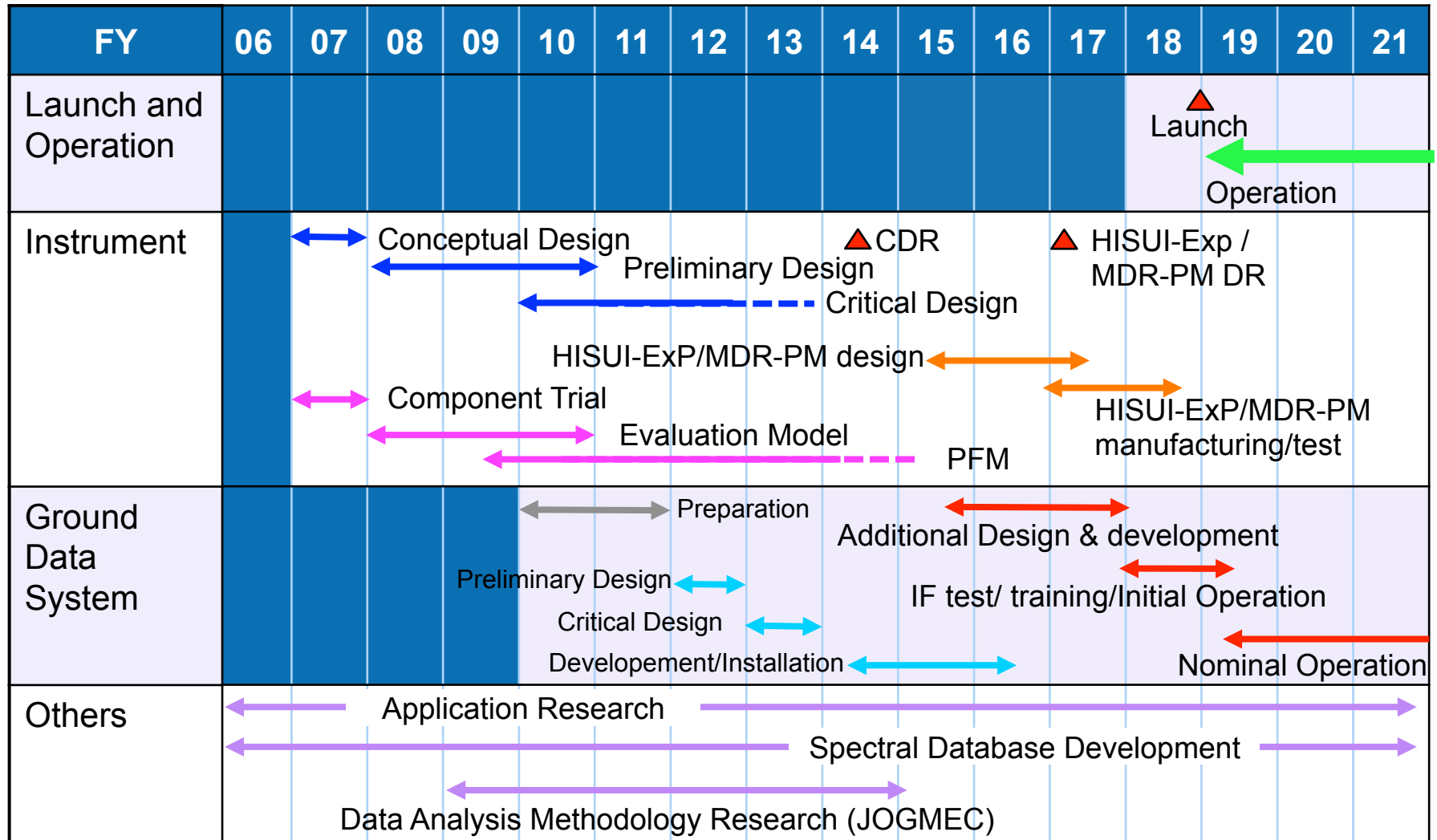


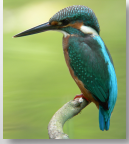
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Parameter		HISUI Specifications
Imaging Type / Spectral Dispersion		Pushbroom / Grating
Spatial Resolution / Swath		20 m (CT) x 30 m (AT) / 20 km
Spectral	Range / Bands	0.4 - 2.5 $\mu\text{m}$ / 185 bands
	Resolution	10 – 12.5 nm
SNR (30% albedo)		$\geq 450$ @620 nm $\geq 300$ @2100 nm
MTF		$\geq 0.2$
Dynamic Range		Saturated at 70% albedo
Spectral Calibration		VNIR : 0.2 nm   SWIR : 0.625 nm
Radiometric Calibration		Absolute : $\pm 5\%$ , among bands : $\pm 2\%$
Quantization / Data Compression		12 bits / Lossless (70%)
Telescope Diameter		$\approx 30$ cm
HISUI ExP Dimensions / Mass		$\approx 2.3 \times 1.5 \times 1.6$ m $\approx$ Nominal / Max 550 / 570 kg including Hyperspectral Imager ( $\approx 240$ kg)

ISS altitude  $\approx 400$  km



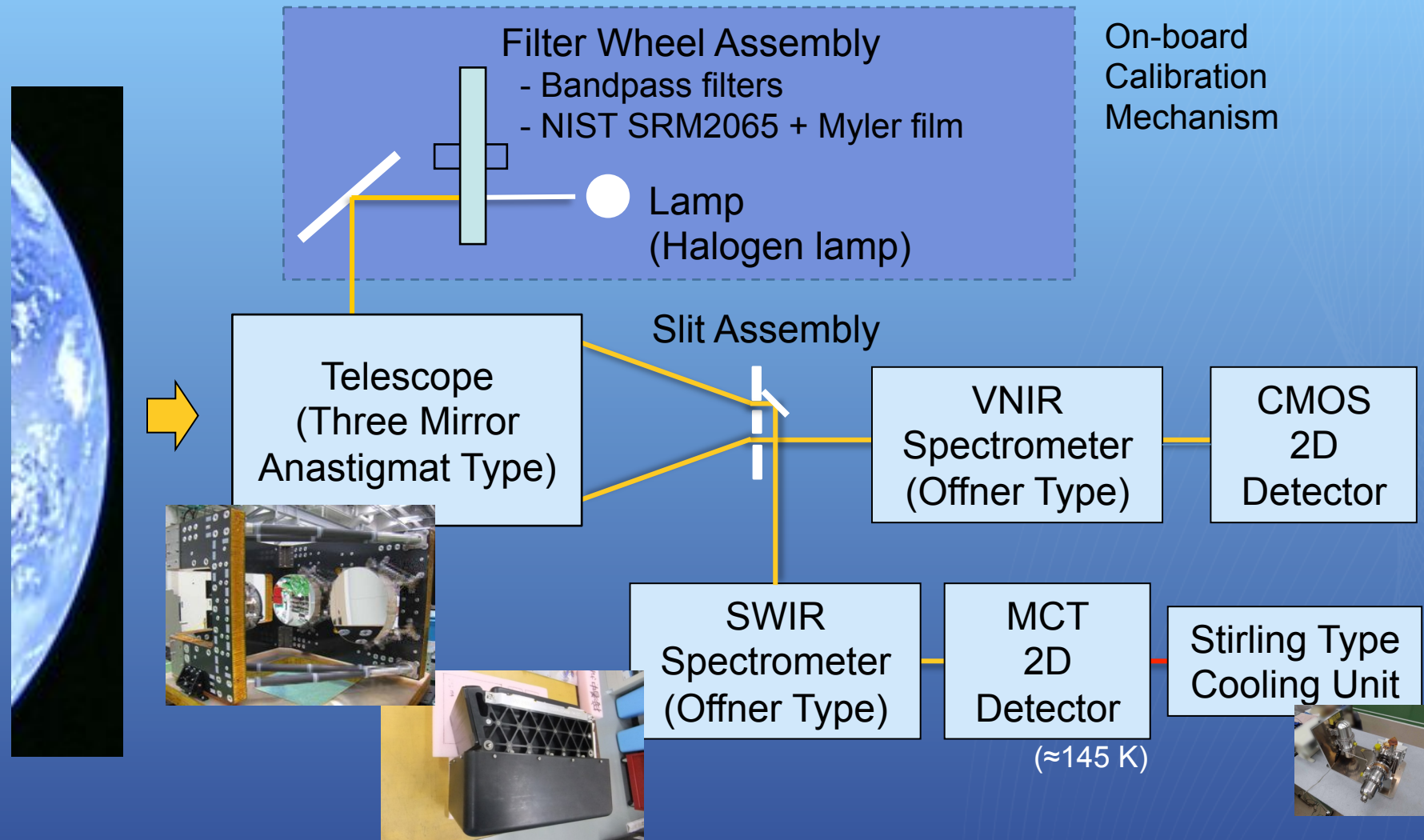


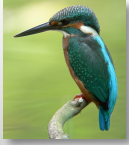


# Optical Diagram of HISUI Hyperspectral Imager

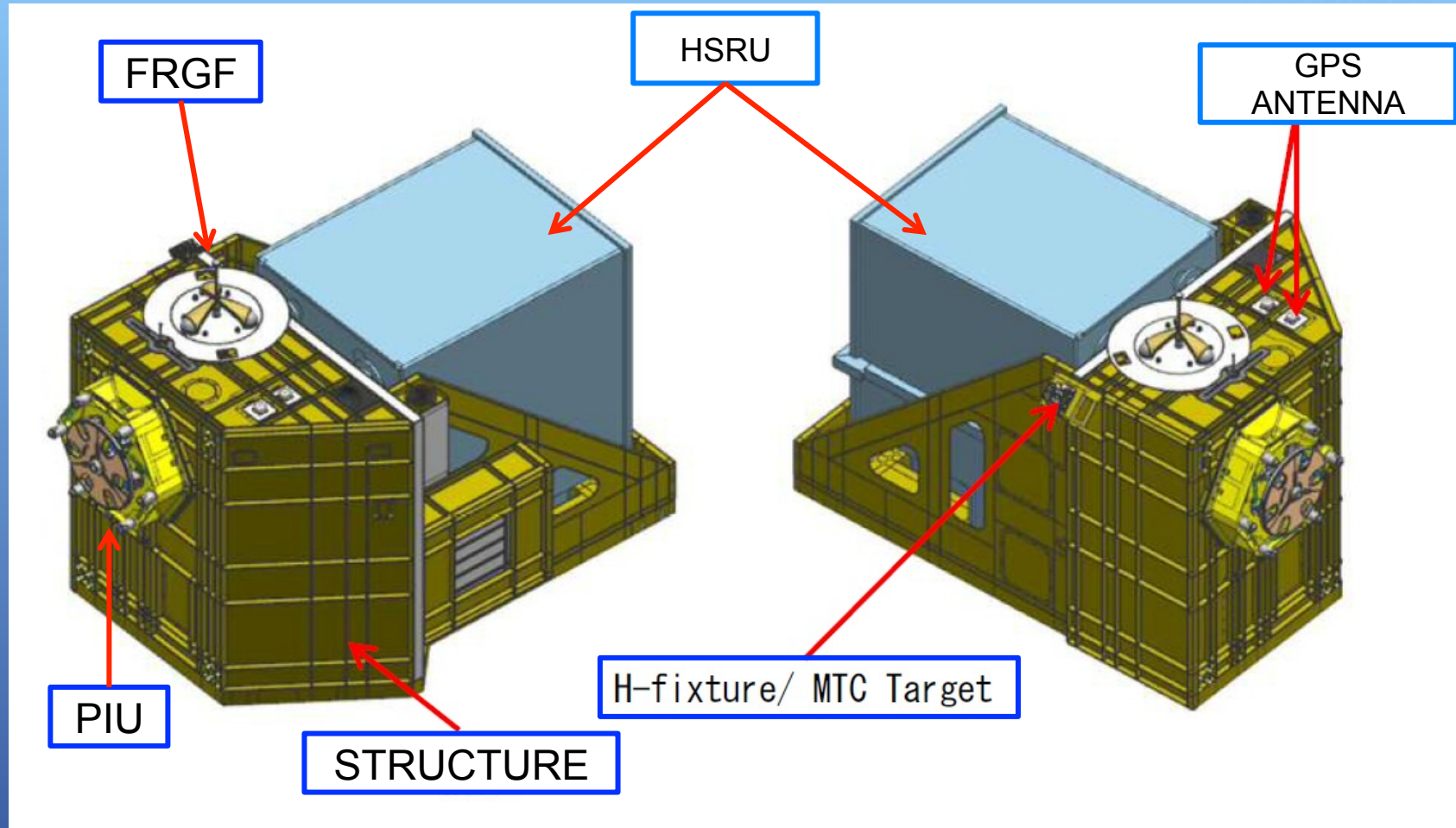


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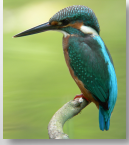
## HISUI Exposed Payload (HISUI-ExP)



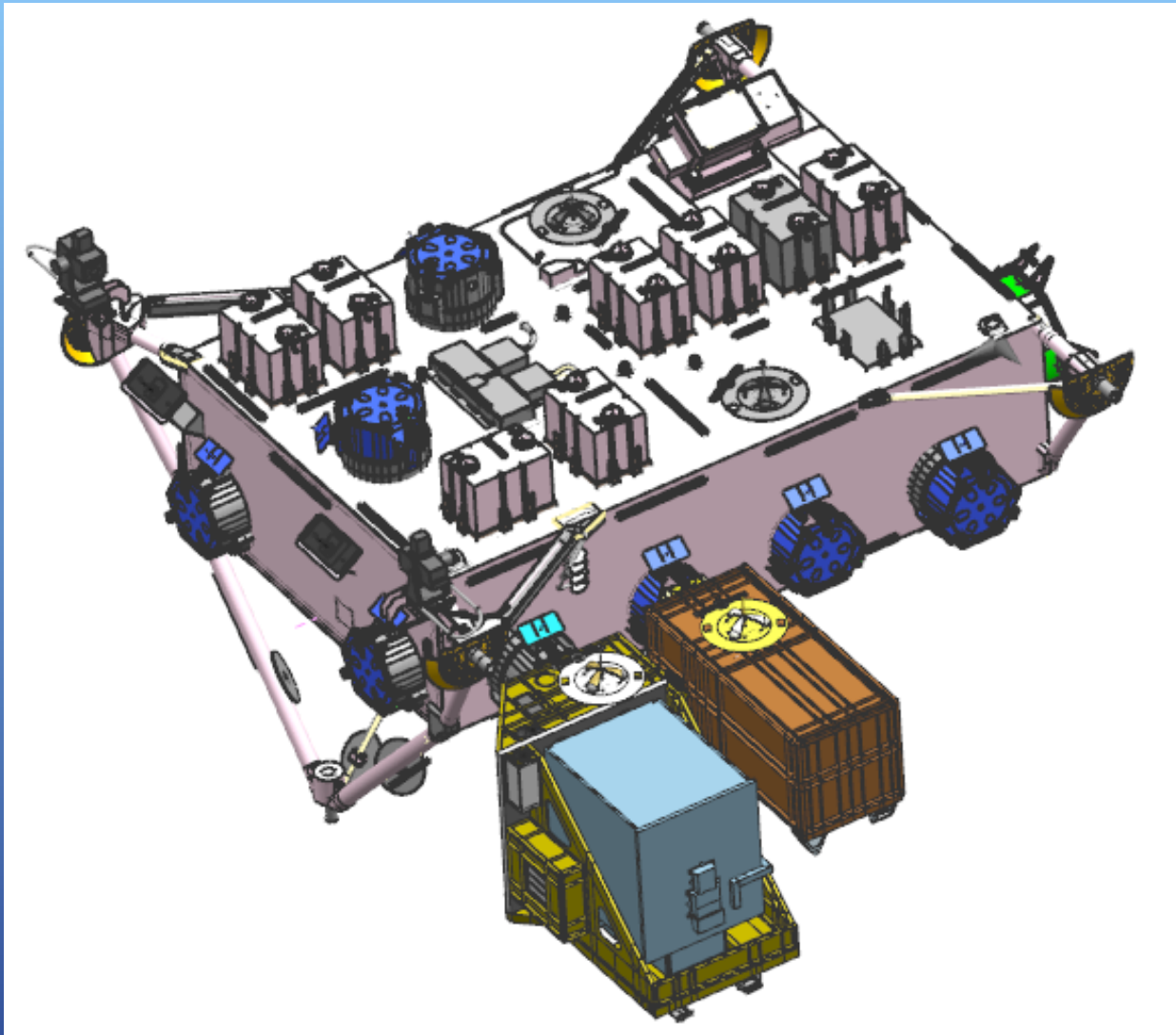
FRGF : Flight Releaseable Grapple Fixture  
MTC : Modified Truncated Cone

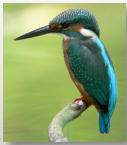
HSRU : HYPER Scanning Radiometer Unit  
PIU : Payload Interface Unit



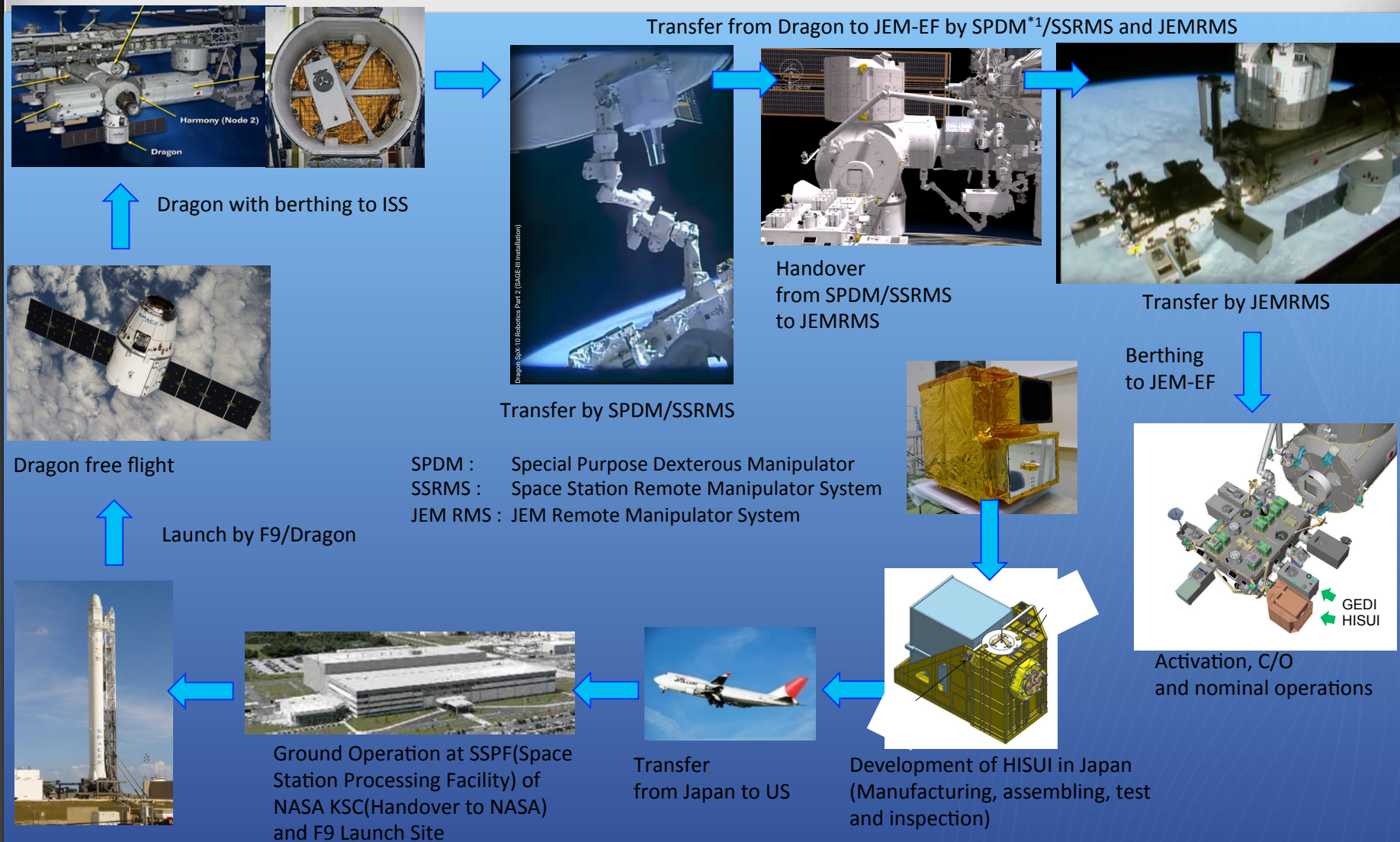


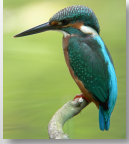
## HISUI ExP Attached to Port 8 of JEM EF





# HISUI-ExP's Journey from Ground to ISS JEM EF

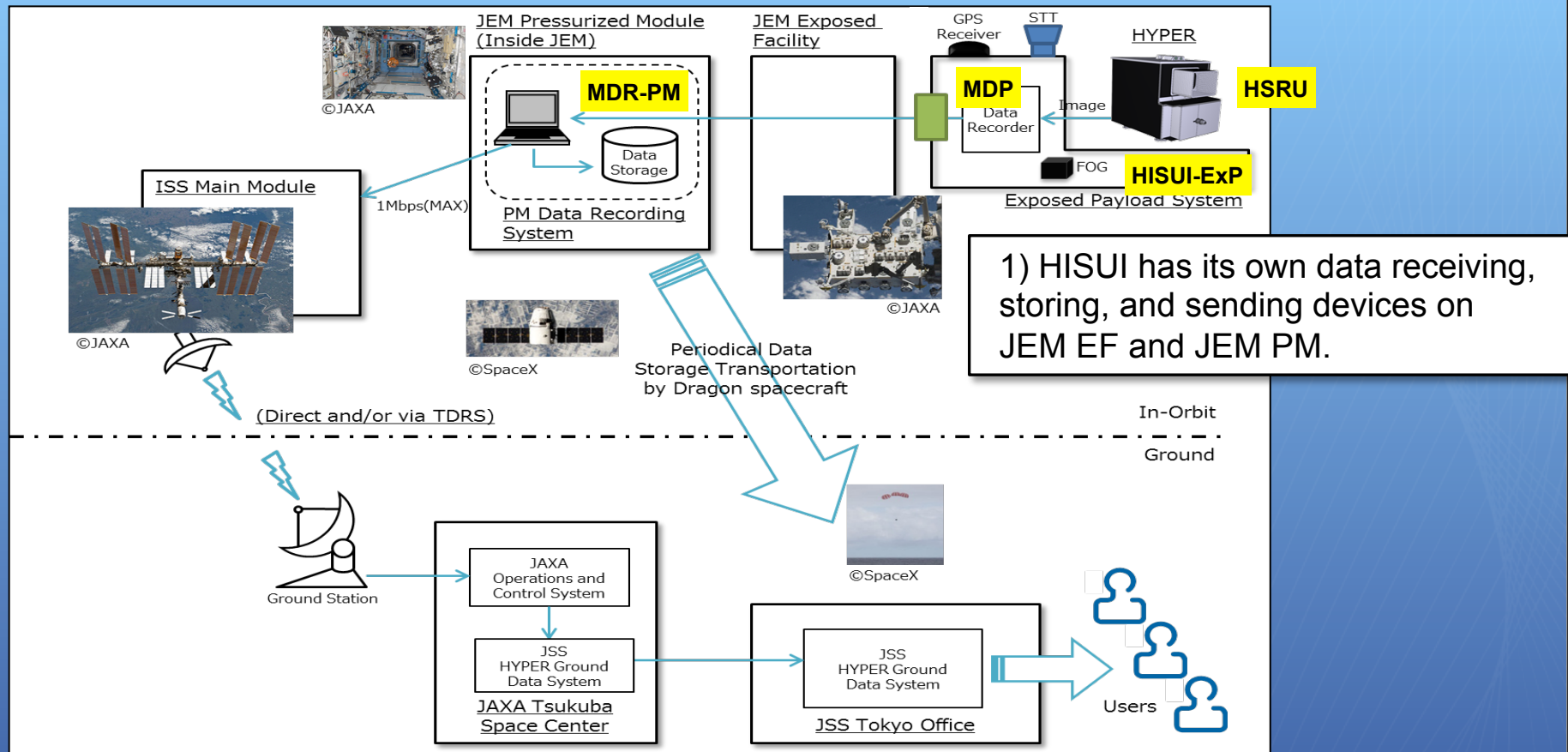




# HISUI Data Flow

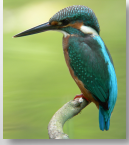


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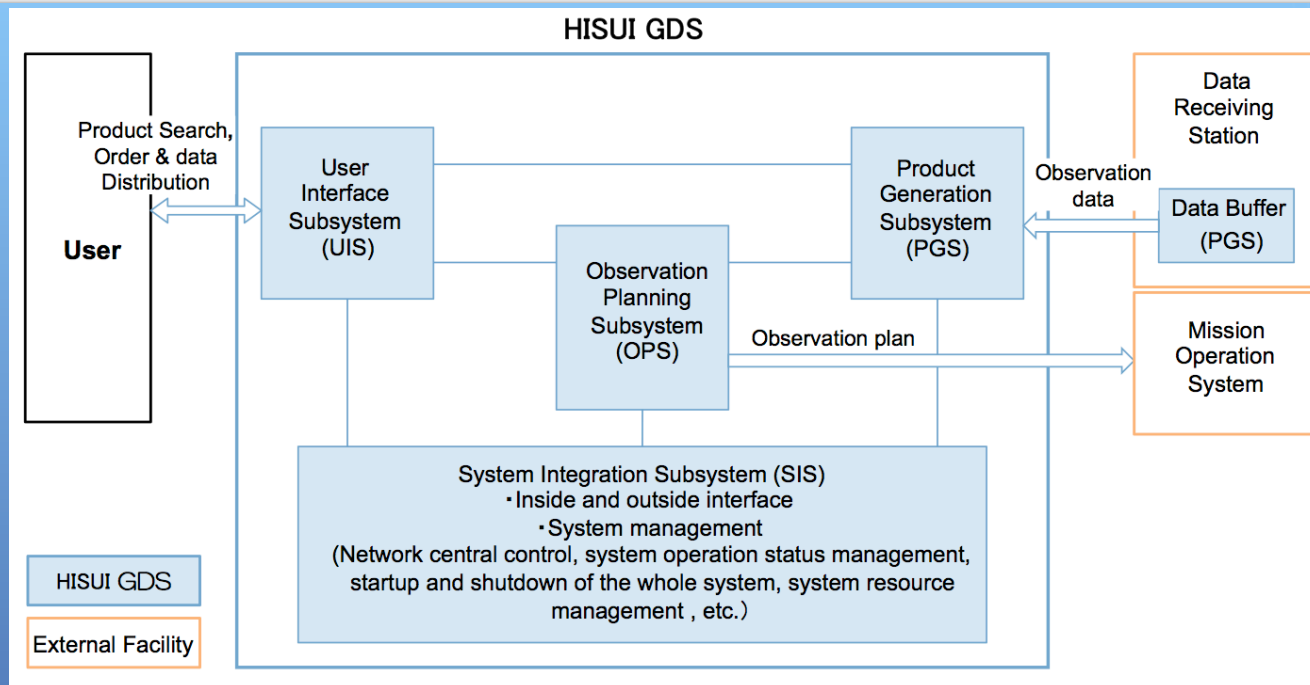


2) HISUI data sent from EF device are recorded on the removable media in MDR-PM. ( $\approx 300$  GB/day) (TBD). After recording, the media are planned to be shipped from ISS to the ground 3 or 4 times per year (TBD). In addition, the limited amount of HISUI data are transmitted from ISS to the ground station in near-real time.



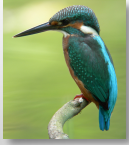


# HISUI Ground Data System (GDS) Status



HISUI GDS consists of the four subsystems:

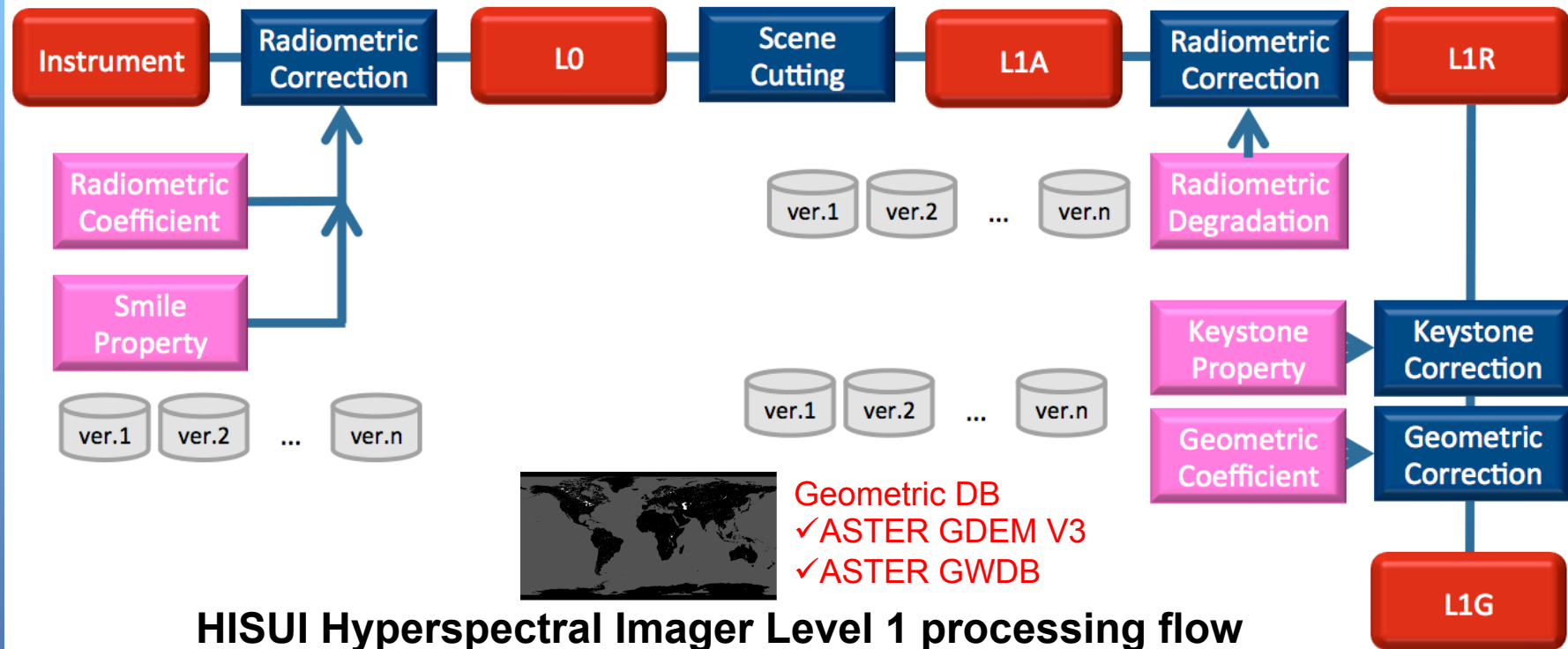
- Observation and Planning Subsystem (OPS)
- Product Generation Subsystem (PGS)
- User Interface Subsystem (UIS)
- System Integration Subsystem (SIS)



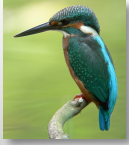
# HISUI Onboard and Level 1 Processing



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- 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, cloud detection, and VNIR-SWIR parallax correction using DEM.



## HISUI Product List as of July, 2017

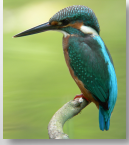


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Name	Description	
Level 0	Raw data	
Level 1A	Raw DN product with all radiometric calibration coefficients. Spatial resampling is not applied.	
Level 1R	Top-of-atmosphere spectral radiance product. Spatial resampling is not applied.	
Level 1G	Geometrically corrected / orthorectified top-of-atmosphere spectral radiance product. Parallax correction, keystone property, and spectral continuity between VNIR and SWIR spectrometers are considered.	
Level 2	Atmospherically corrected surface spectral reflectance product generated from L1G with QA information. This is Science Product for research purpose and not validated.	

\* Cloud statistical data are attached to L1 and L2 products.





# ISS HISUI Operation and Mission Planning



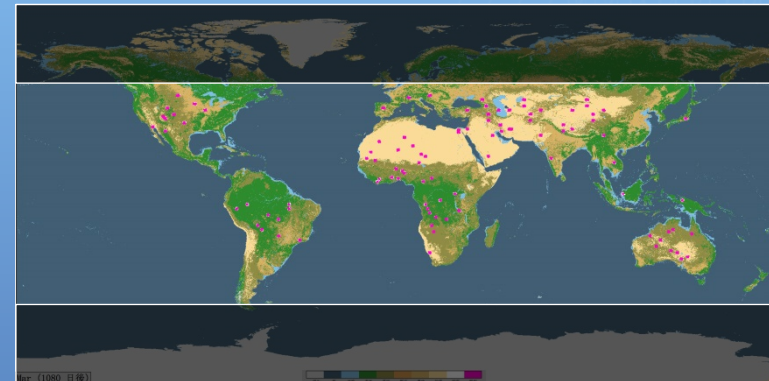
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HISUI OPS (Observation Planning Subsystem) will automatically create operation timing tables based on data acquisition requests (DARs), their priorities, and available resources such as instrument operation time and data downlink capability.

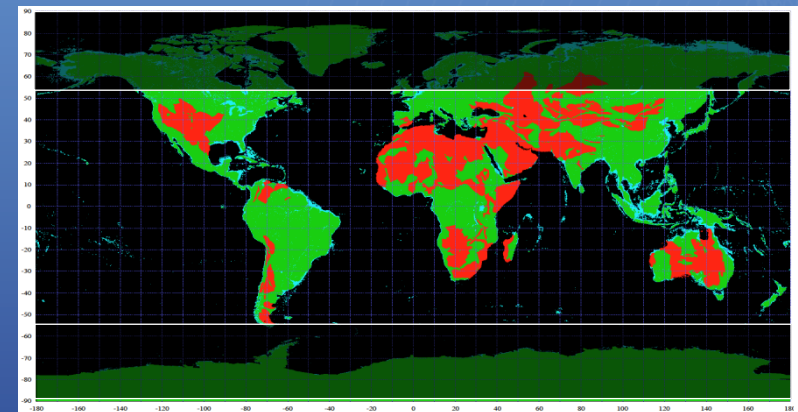
DAR is valid until cloud free images of the whole target area are obtained.

## HISUI DAR categories (draft)

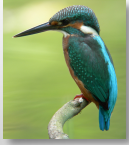
- Important Observation
  - Engineering request
  - Calibration / Validation
  - Emergency / Disaster
- Verification Observation (local area)
  - Individual application / verification sites
- Priority Region Mapping
  - Oil/gas/metal resource exploration regions
- Global Mapping (using remaining resources)
  - All land surface and shallow coastal regions



Tentative DARs for Verification Observation



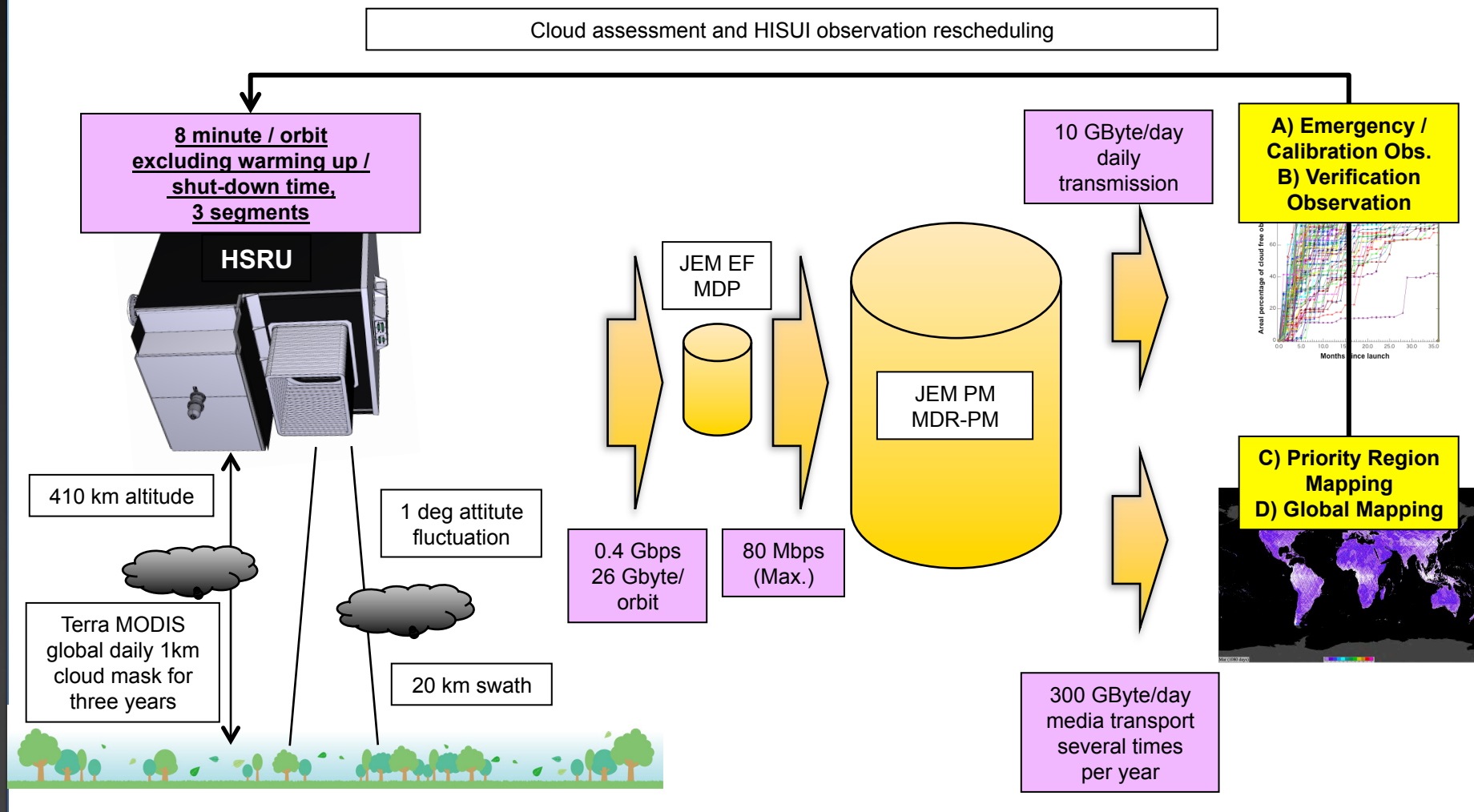
Areas for Priority Region and Global Mapping

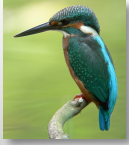


# HISUI Long-term (3 years) Operation Simulation Setup



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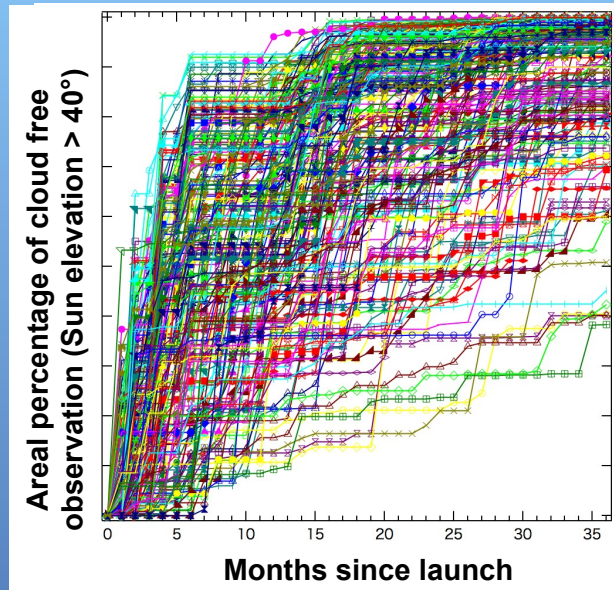


# HISUI Long-term (3 years) Operation Simulation Results



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## Tentative 200 Verification Targets

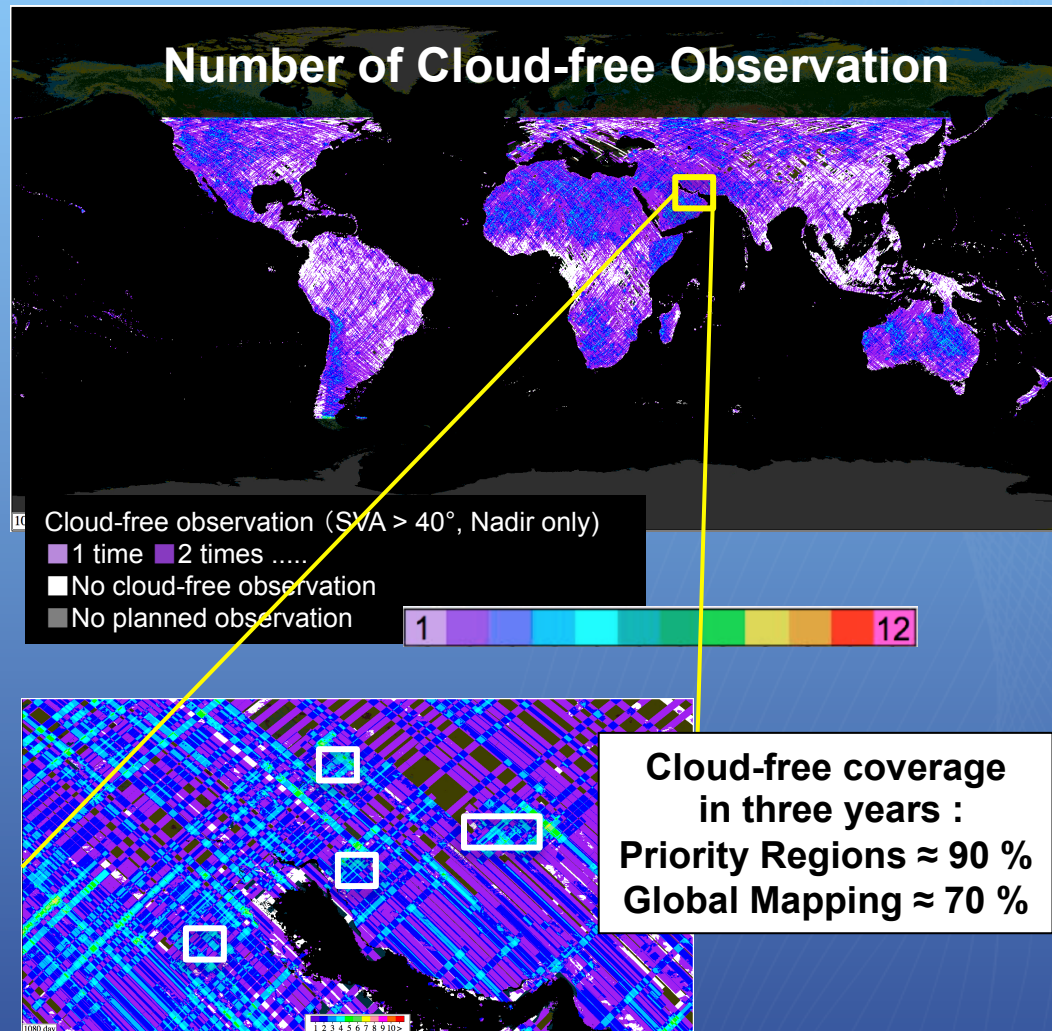


Completed targets*	
Sun Elevation > 40°, Cloud free > 95%	
1 <sup>st</sup> year	1
2 <sup>nd</sup> year	51
3 <sup>rd</sup> year	113**

\*Target size = 100 x 100 km

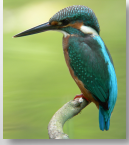
\*\*3<sup>rd</sup> year = 175 with

Sun Elevation > 30° / Cloud free > 85 %.



(Source : 170616)





## Other Earth Observing Instruments onboard ISS around 2020



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### GED1 :

Provide the first global, high-resolution observations of **forest vertical structure** using a lidar.

To be deployed on the ISS in 2019

### ECOSTRESS :

Measure **the temperature of plants** and use that information to better understand how much water plants need and how they respond to stress.

To be deployed on ISS in 2018

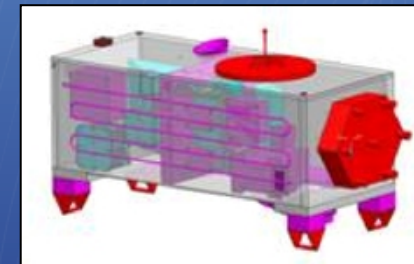
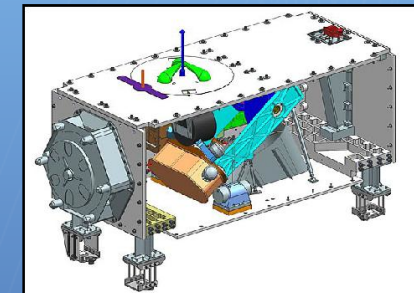
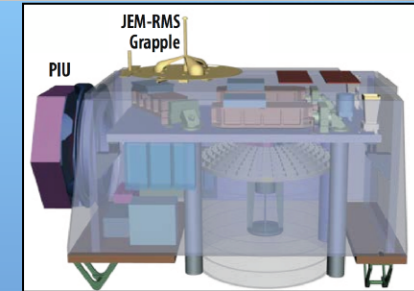
### DESI :

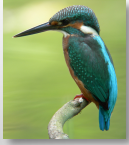
Provide **VNIR hyperspectral data with high spectral resolution (2.3 nm)**. One of instruments attached to MUSES.

To be deployed on ISS in 2017.

### OCO-3 :

Investigate the distribution of **atmospheric carbon dioxide** and **Fluorescence from terrestrial vegetation**.





# Synergy of Five Earth Observing Instruments onboard ISS



**ECOSTRESS**

land surface temperature  
emissivity

height, volume, leaf area index

**GEDI**



GEDI LIDAR

**OCO-3**

solar induced fluorescence, atmospheric column CO<sub>2</sub>

water use efficiency

surface roughness

aboveground biomass

**HISUI**

**HISUI** Hyperspectral Imager Suite

species canopy traits, nutrients

**Cross Cal.**

**DESIS**

evapo-transpiration

plant stress (temp & water)

carbon sink potential, disturbance ecology

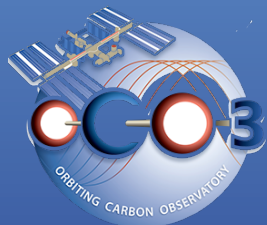
canopy functional traits

root depth

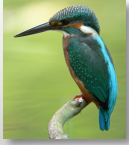
carbon residence time

carbon use efficiency

light use efficiency, nutrient use efficiency



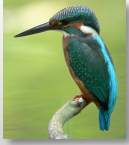
Butterfly diagram by J. B. Fisher



## HISUI Data Policy and Research Announcement



- HISUI data policy is under consideration.
- For collaborators and research announcement investigators, priority observation, priority downlink, and distribution for their requested areas will be given for free.
- The archived data will be provided for free to other science users with some conditions (e.g. submission of reports to HISUI Project).
- HISUI Research Announcement will be issued for domestic users first. HISUI RA for overseas users will be issued later.



Thank you

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