Status of GOCI-II development

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DEFENCE AND SPACE

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- Introduction
- Description of instrument design and main characteristics
- Development schedule
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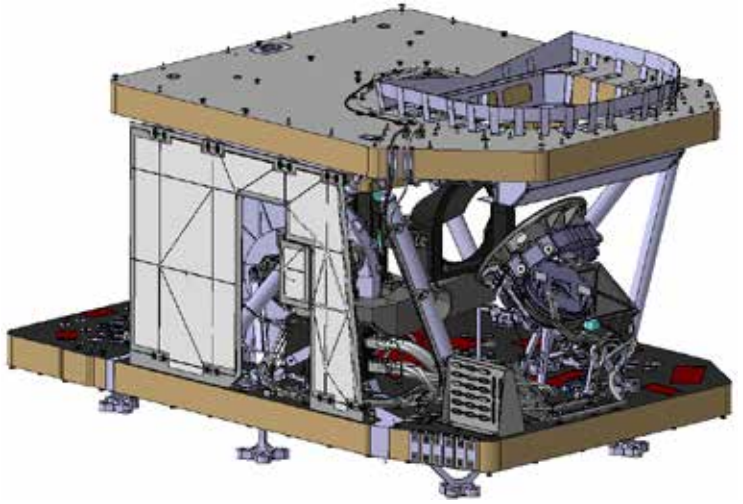
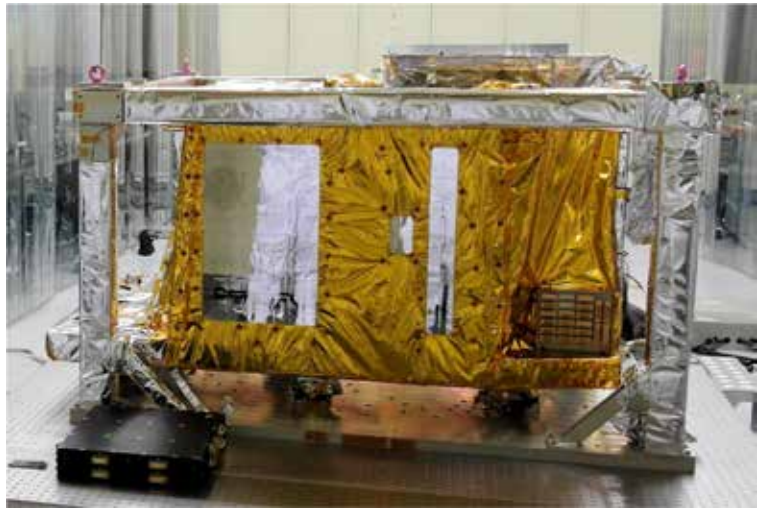




Comparison of GOCI-II and GOCI requirements

Requirements	GOCI	GOCI-II
Mission Life Time	7 years	10 years
Duty Cycle (Local Area : LA)	8 times / day	10 times / day
Duty Cycle (Full Earth Disk : FD)	-	1 time / day during day time
Observation Time	≤ 30 minutes for LA	≤ 30 minutes for LA ≤ 240 minutes for FD
Spatial resolution (GSD)	≤ 500 m @ center of Ref. LA (130°E, 36°N)	≤ 250 m @ Nadir (Ref. LA : 2.500 km x 2.500 km)
Spectral Range	400 nm – 900 nm (VIS, NIR)	370 nm – 900 nm (VIS, NIR)
Number of spectral bands	8 narrow bands (10 to 40 nm)	12 narrow bands (10 to 40 nm) 1 wide band for star imaging
SNR @ nominal ocean radiance	Between 750 and 1200	Between 750 and 1200
MTF @ Nyquist frequency	> 0.3	> 0.25
Calibration	Sun calibration (once / day)	Sun calibration (once / day) Moon calibration (once / month)
Autonomy	@ S/L level	24h (@ instrument level)

Spectral bands *(in red, new ones wrt GOCI)*

Band	Band Center	Band width	Primary Usage
B1	380 nm	20 nm	CDOM, absorbing aerosol correction
B2	412 nm	20 nm	CDOM, chlorophyll
B3	443 nm	20 nm	Chlorophyll absorption maximum
B4	490 nm	20 nm	Chlorophyll and other pigments
B5	510 nm	20 nm	Chlorophyll, absorbing aerosol in oceanic waters
B6	555 nm	20 nm	Turbidity, suspended sediment
B7	620 nm	20 nm	Phytoplankton species detection
B8	660 nm	20 nm	Baseline of fluorescence signal, Chlorophyll, suspended sediment
B9	680 nm	10 nm	Fluorescence signal
B10	709 nm	10 nm	Fluorescence base signal, atmospheric correction, suspended sediment
B11	745 nm	20 nm	Atmospheric correction, vegetation index
B12	865 nm	20 nm	Atmospheric correction, aerosol optical depth
B13	Wideband	>300 nm	Star Imaging for the INR performance

Filter Wheel : GOCI to GOCI-II

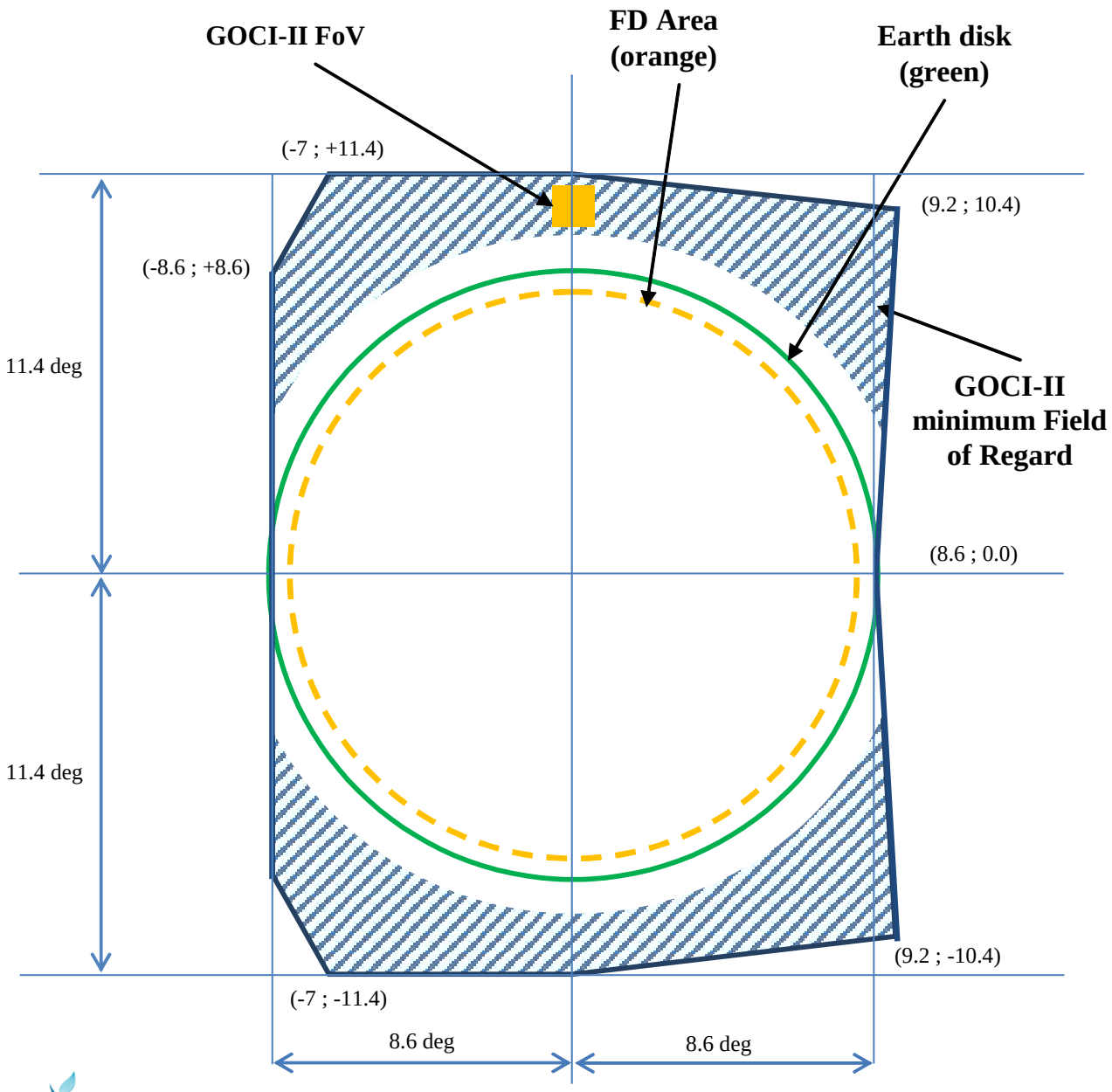
GOCI Filter Wheel

(8 filters + 1 dark position)

GOCI-II Filter Wheel

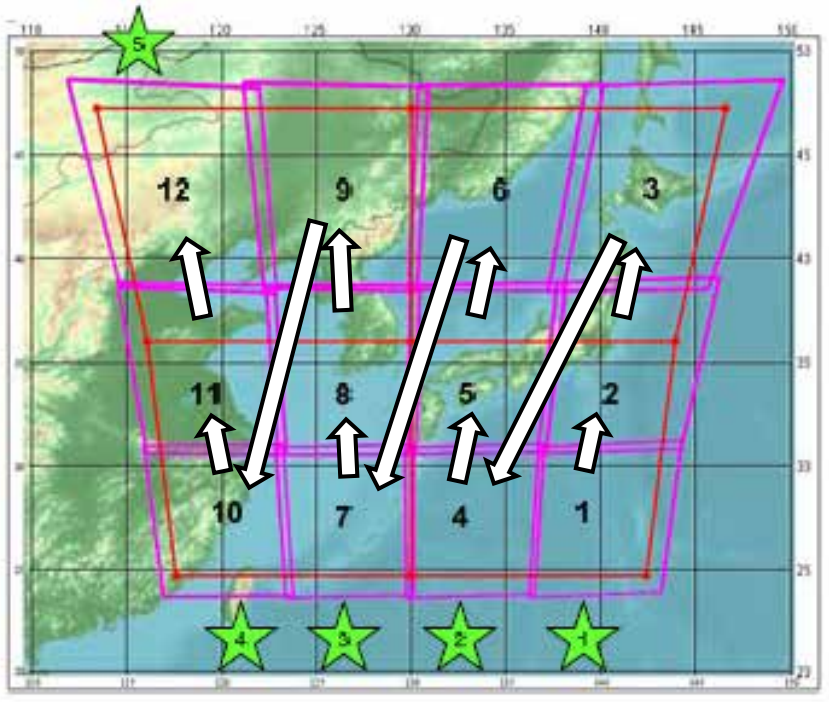
(12 nominal narrow band filters +
1 large band filter +
1 extra B9 filter + 1 dark position)

Field of Regard

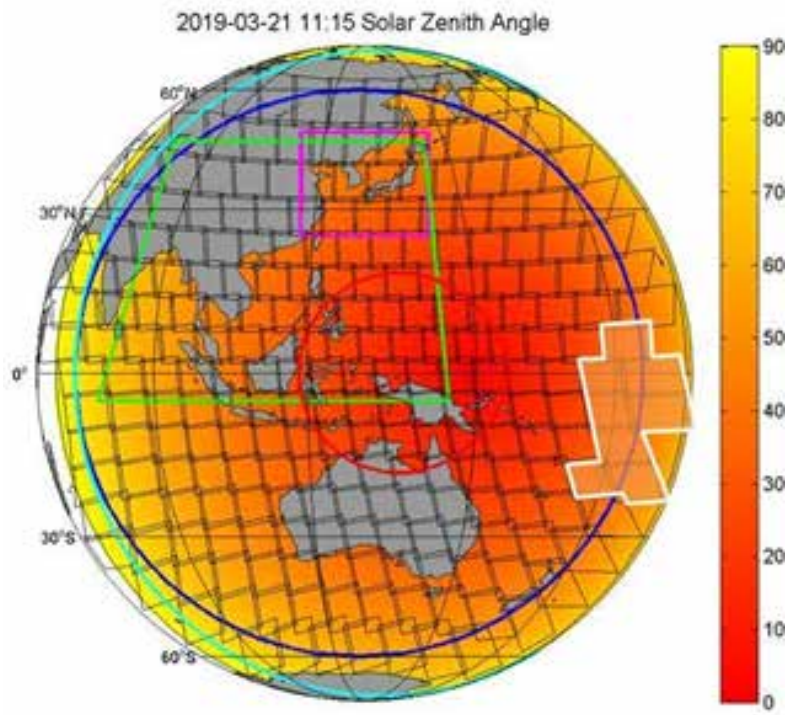


Dashed areas for Moon and Star imaging

Imaging modes



Reference LA imaging (12 slots) with 5 Star imaging

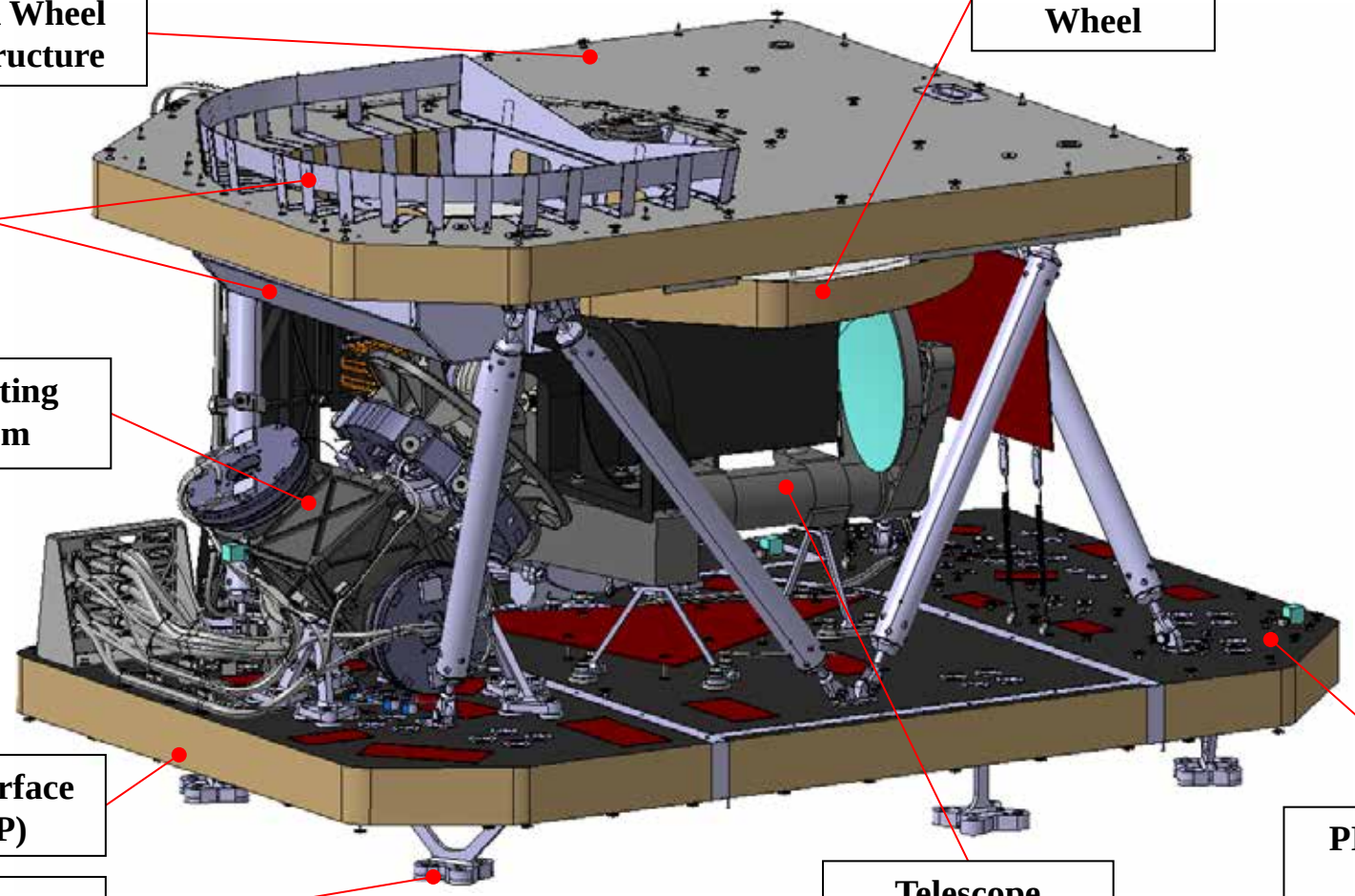


Full Disk imaging by less than 240 slots

- Image acquisition done slot by slot with 2 integration times :
  - large integration time for high SNR on Ocean scenes
  - low integration time for land and clouds scenes
- All data are downloaded to ground

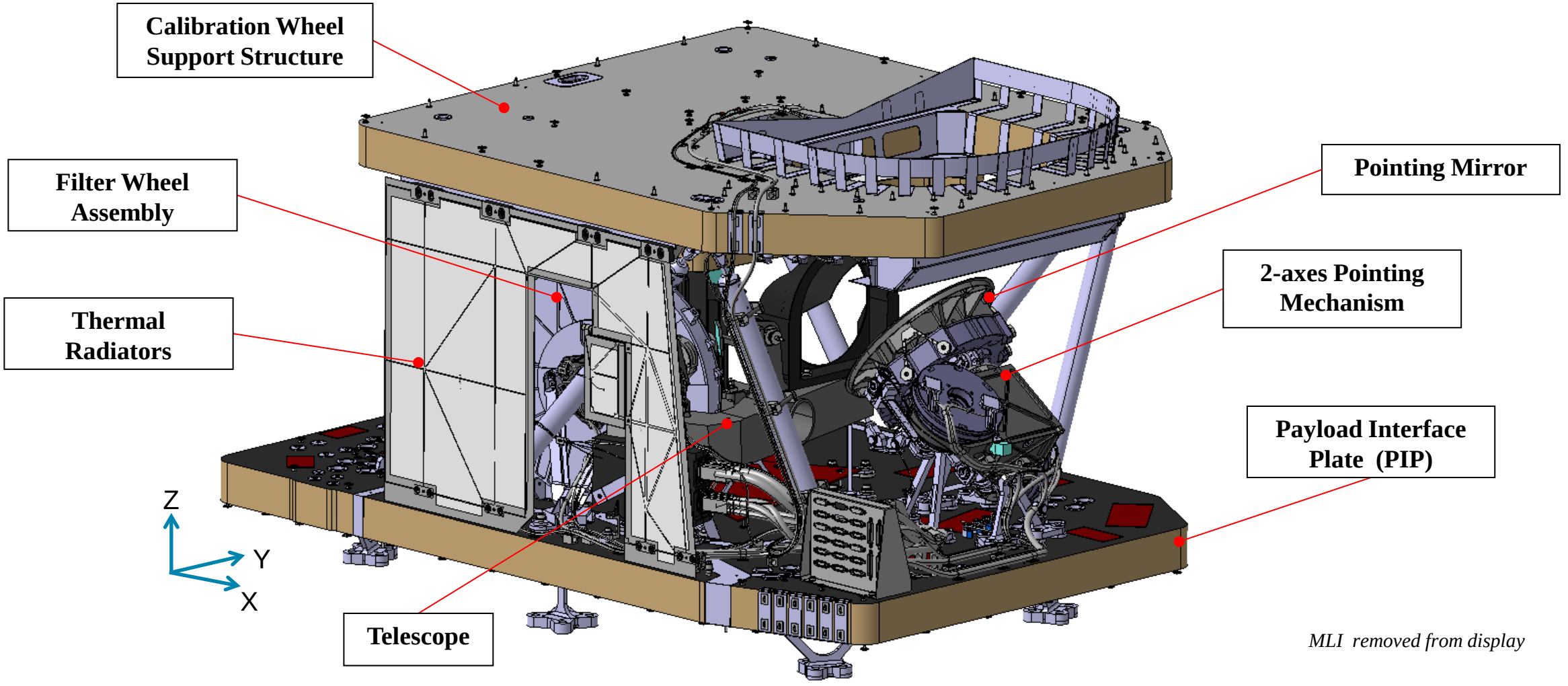
MLI removed from display

GOCI-II Design overview (1/3)



Overall dimensions : X 1520 mm, Y 1005 mm, Z 908 mm

GOCI-II Design overview (2/3)

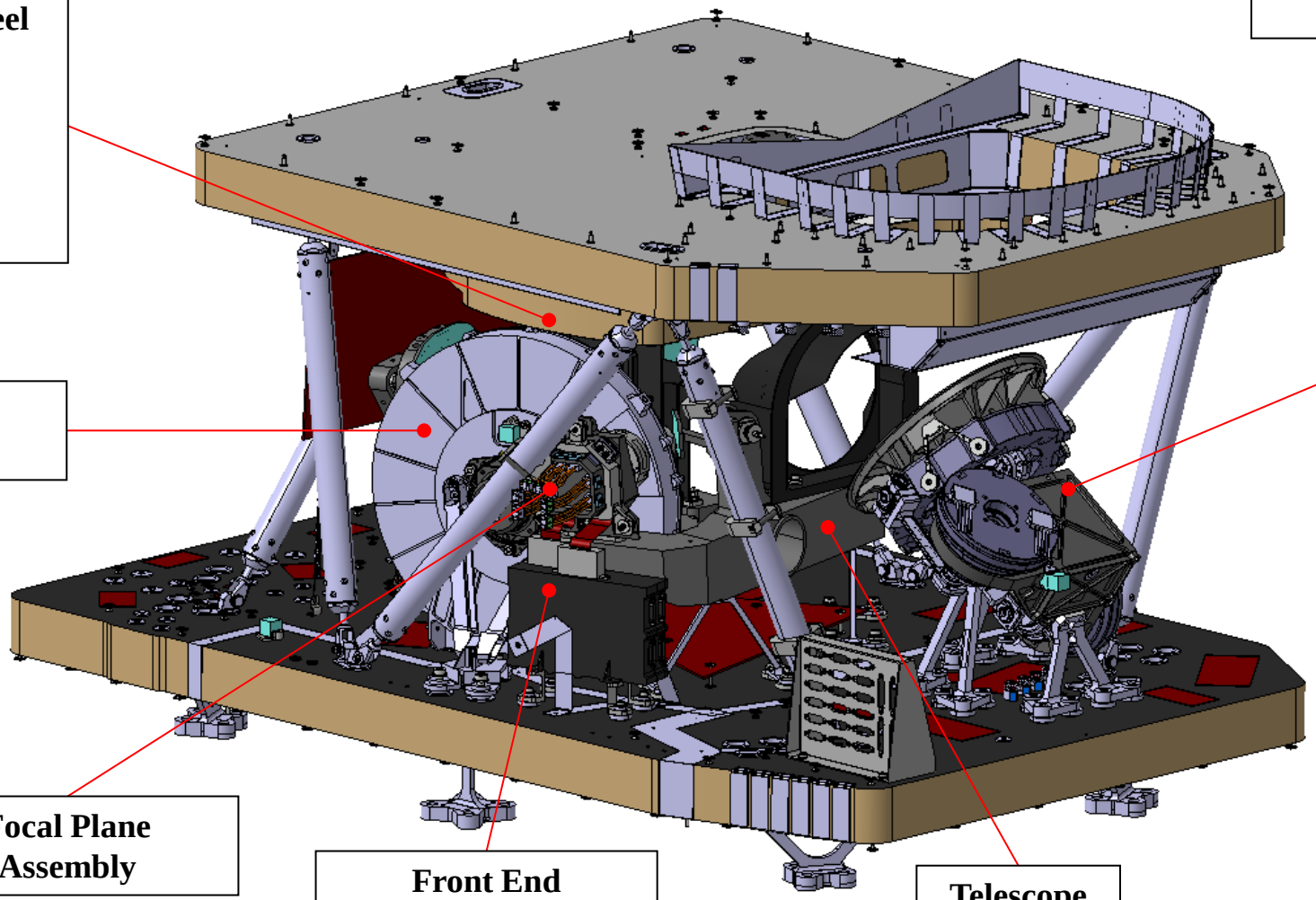


MLI removed from display

Overall dimensions : X 1520 mm, Y 1005 mm, Z 908 mm

GOCI-II Design overview (3/3)

Calibration Wheel Assembly
4 positions:
- **Open**
- **Close**
- **Main diffuser**
- **Second diffuser**



Calibration Wheel Assembly

Filter Wheel Assembly

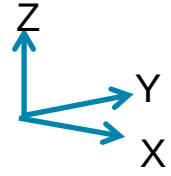
2-axes Pointing Mechanism

Focal Plane Assembly

Front End Electronics

Telescope

MLI, radiators and harness removed from display



GOCI-II Development schedule

- Answer to Request for Proposal in March – April 2013
  - Selection of Airbus D&S
- Contract signature and project kick off in July 2013

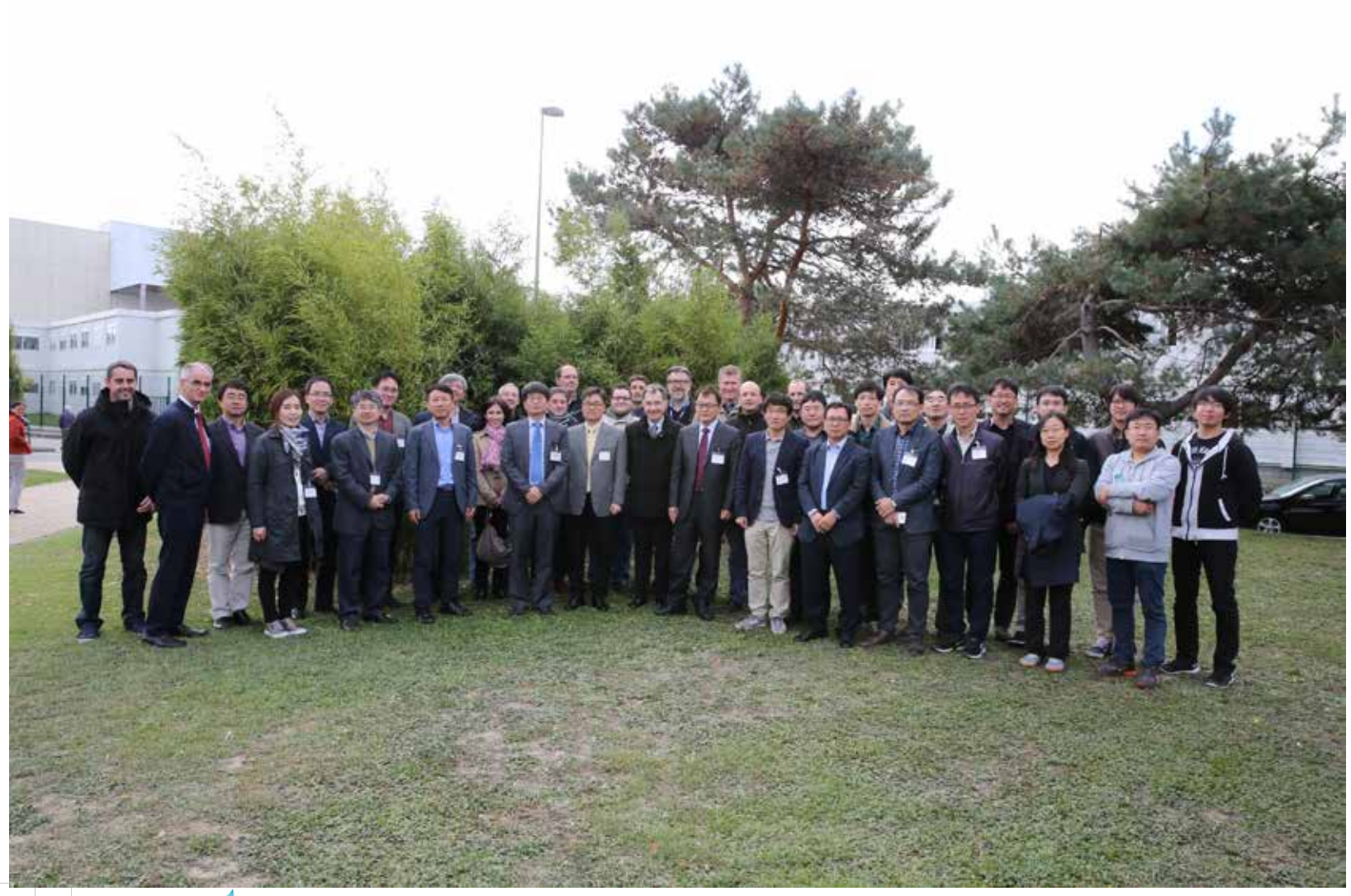
- System Design Review: October 2013

- Preliminary Design Review: mid 2014
- Critical Design Review: October 2015

- Test Readiness Review: December 2016
  - Start of performance tests in Airbus Toulouse facilities
- Pre-Environmental test Review: end June 2017
  - End of tests in Toulouse => agreement for shipment to Korea

With involvement of a Korean Joint Development Team dispatched in Toulouse

GOCI-II Joint Team (@ CDR in Toulouse)



GOCI-II Development schedule

- Transportation to Korea (end June 2017)
- Four months of intensive tests in KARI facilities (Daejon)
  - Environmental tests (EMC, vibration, TV)
  - Radiometric and calibration tests
- Pre-Shipment Review (delivery): end October 2017

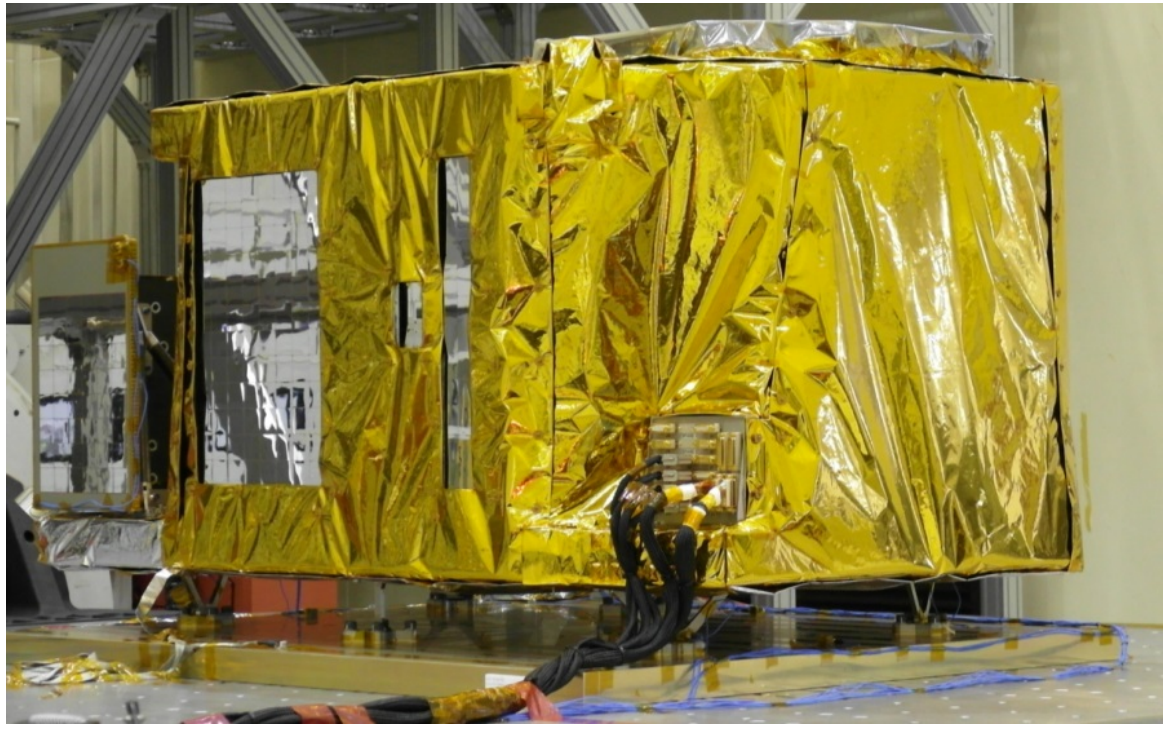
With about 10 engineers from Airbus dispatched in Korea

- Instrument integration and test at GK2B S/L level
  - Instrument electronics coupling with S/L electronics: done
  - Mechanical instrument mounting: done
  - S/L tests : functional (done), environmental
- Launch: early 2020
- In orbit tests

With remote support from Airbus team + physical attendance when necessary

GOCI-II sensor unit at delivery

GOCI-II sensor unit, inside on-ground supporting structure, with electronics



GOCI-II sensor unit with harness connected

GOCI-II Performance tests (1/3)

Test	Comment
Functional tests	Verification and validation of all functional requirements and interfaces with the S/L. The on-board firmware implements a self test for quick good health verification of the main functions (mechanisms, imaging, thermal control).
Pointing tests	Characterization of the Pointing Models: (1) command model for pointing at a given target and (2) Line of Sight calculation from given Pointing Mechanism encoder telemetries
Radiometric tests	Determination of the instrument gain and non linearity for all spectral bands (from input radiance to instrument output in LSB and reciprocally) Test done in Toulouse with Airbus Integrating Sphere and in KARI with KARI I.S.
Polarization test	Measure of the instrument sensitivity to polarized input light
MTF and co-registration tests	The MTF is a measure of the instrument resolution (contrast). The co-registration corresponds to the co-alignment of the spectral bands LoS. These performances are sensible to air effects => the real performances are measured in vacuum.

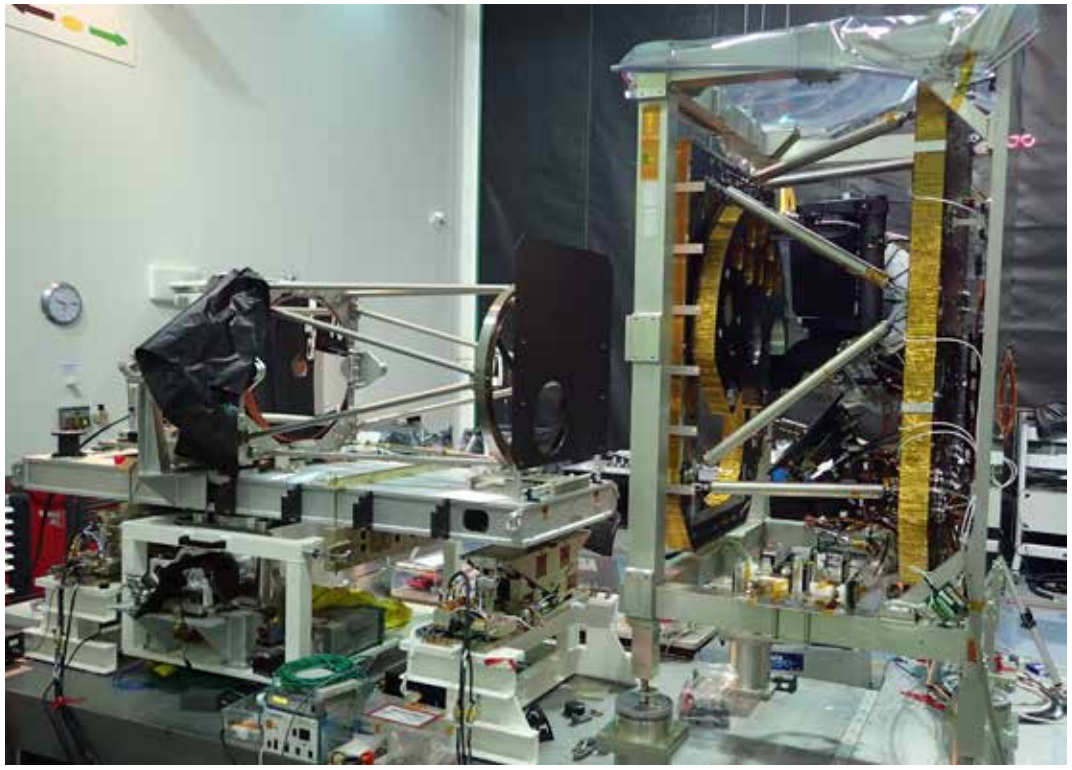
GOCI-II Performance tests (2/3)

Test	Comment
Spectral tests	Instrument spectral response is calculated from accurate measures at component level (filters in particular). Measurements at instrument level introduced as end-to-end verification.
Straylight tests	Measurement of the ghost and spurious light reaching the detector and determination of a correction model if the straylight exceeds the target
ISRD tests	Measurement of the Inter Slot Radiance Discrepancy (ISRD) and determination of a correction model if the ISRD exceeds the target
Calibration tests	Characterization of the solar diffuser (model of radiance diffused inside the instrument as a function of the sun irradiance and sun position). Test done in KARI with KARI's sun simulator
Reference test	A reference test made of a sub set of functional, radiometric and pointing tests has also been defined and run several times to check good health of the instrument at different stages of the test sequence (before / after transportation to Korea; before / after vibration test; before delivery)

GOCI-II Performance tests (3/3)

Test	Comment
EMC tests (conductive and radiative)	Verification that the instrument is not sensible to electromagnetic perturbations coming from the S/L and reciprocally that the instrument do not generate electromagnetic perturbations towards the S/L
Mass & CoG measurement	Mass measurement and Center of Gravity determination
Vibration tests	Verification that the instrument withstands the mechanical loads during launch (sine vibrations and acoustic tests)
Thermal Vacuum test	Functional and performance tests in representative thermal and vacuum environment => validation of the instrument thermal control, of the radiometric performances at nominal detector temperature and of the MTF & coregistration performances

Typical test configurations



Test configuration with Collimator OGSE for
- Spectral
- MTF
- Registration
- Straylight in the field

Test configuration with Integrating Sphere for
- Straylight out of field
- Radiometry
- ISRD
- Polarisation

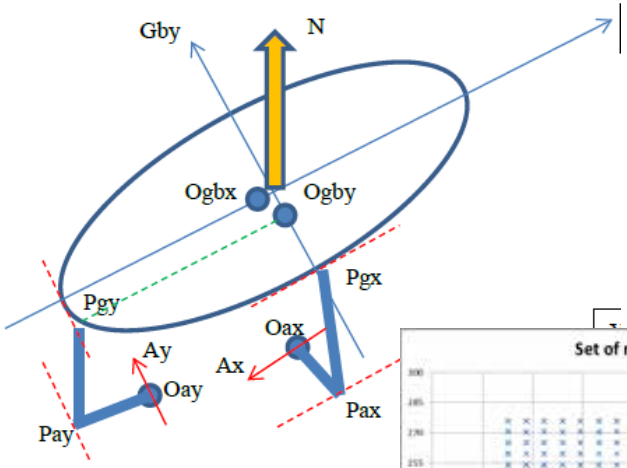
Test results – Pointing tests

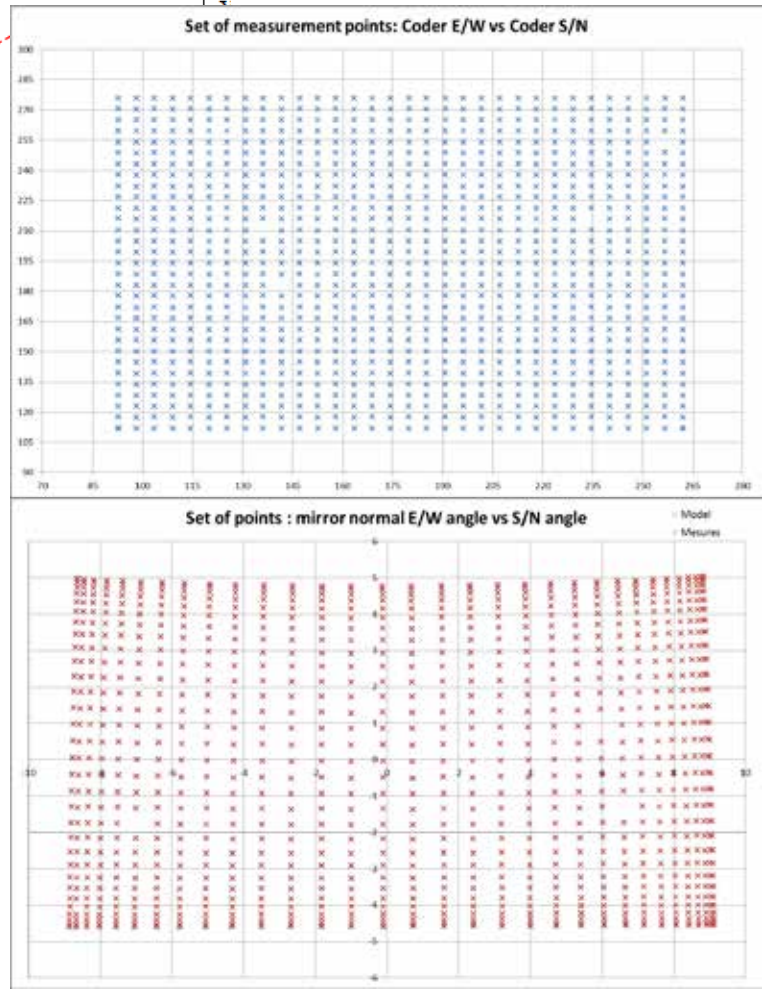
- Pointing model : combination of
  - Ø Focal plane model (Los for each pixel before reflection on Pointing Mirror): includes optical distortion
  - Ø Pointing Mirror Normal model (orientation of PM normal as function of actuator coder angles): Measurement with Laser Tracker over full useful range: residual model error< 10 µrad rms

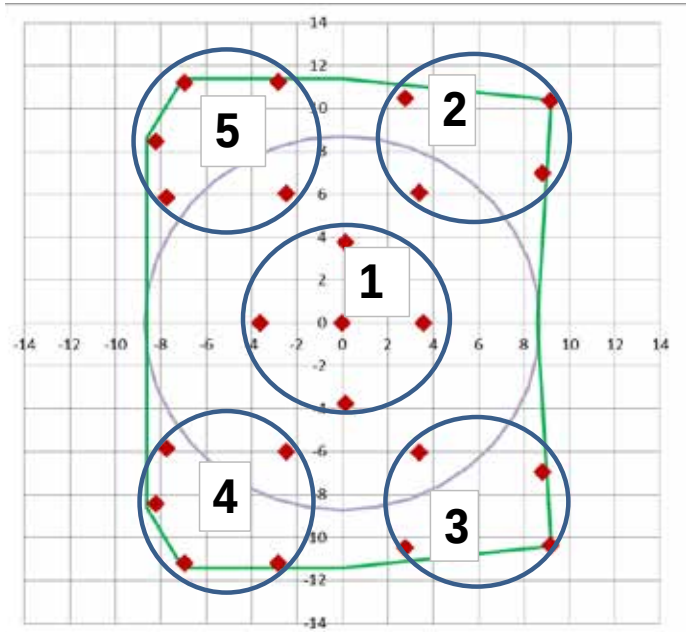
- End-to-end Pointing model verification within Field of Regard with theodolites

- All results consistent with measurement accuracy

- **Confirmation of validity of the model and of the associated parameters**







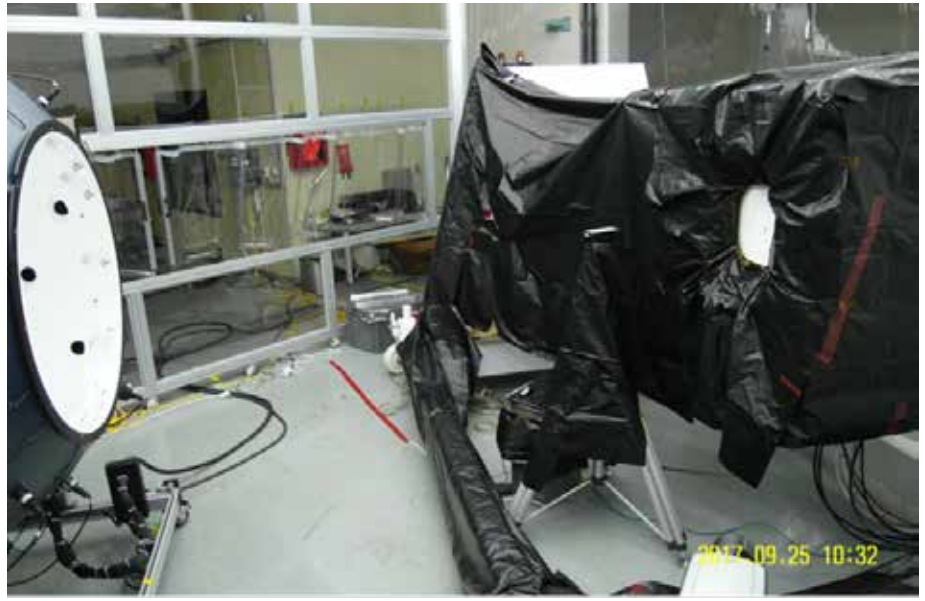
Test results – Radiometric tests

- Radiometric tests have been performed in two steps
  - in Airbus with Airbus Integrating sphere
  - in KARI for Absolute Radiometric tests with KARI I.S.
  - Both set of measured gain parameters are consistent

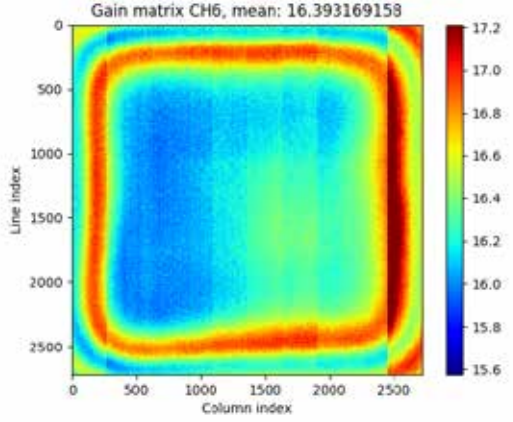
- **All tests results are compliant:**
  - Accurate radiometric model for input radiance restitution (3rd order model with 2 non linearity coefficients)
  - High gains values ensuring compliance to SNR requirements

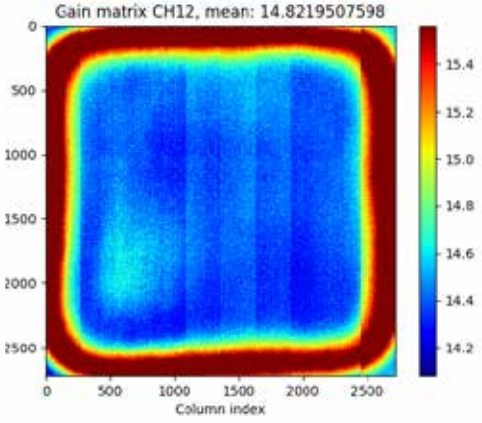
- Determination for each spectral band of nominal integration times and numbers of accumulations for in-orbit operations

- Measurement also of gain variation with Angle of Incidence on Pointing Mirror => correction coefficients determined



Instrument with black cover to avoid straylight

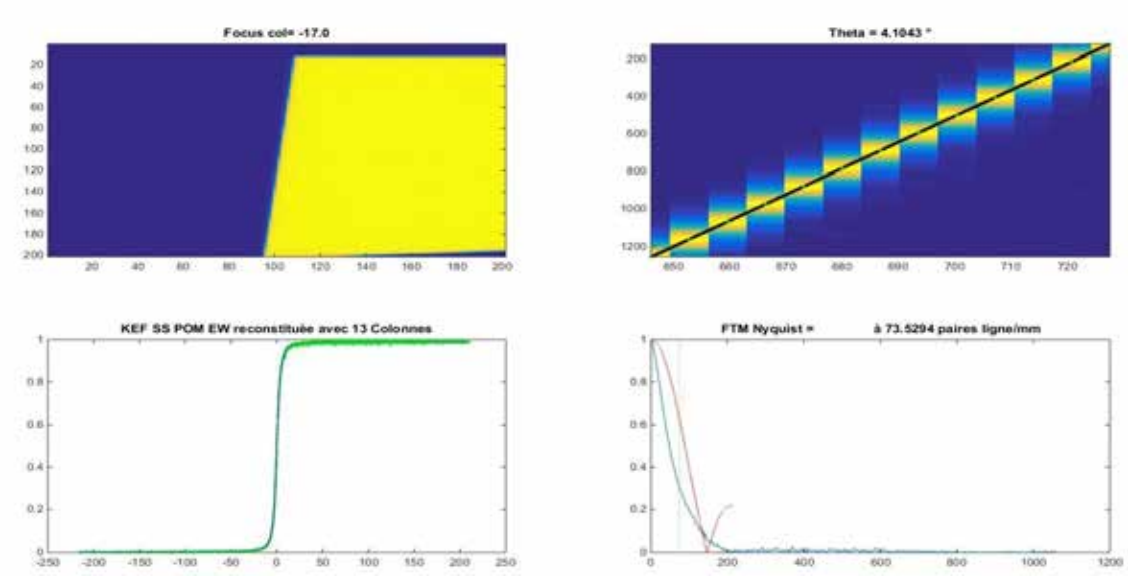




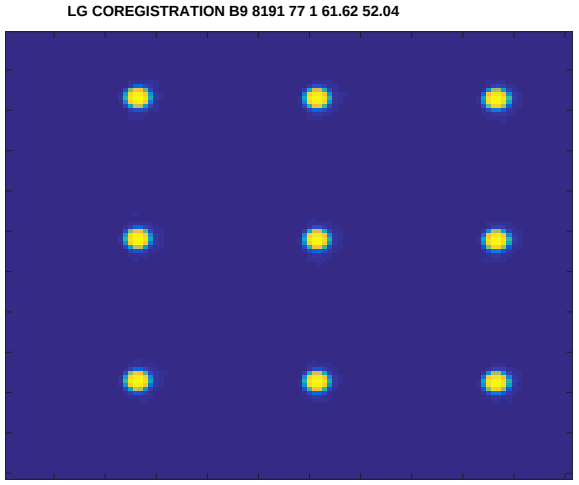
Test results – MTF and co-registration tests

- MTF & Co-registration tests have been performed during TV test, in KARI

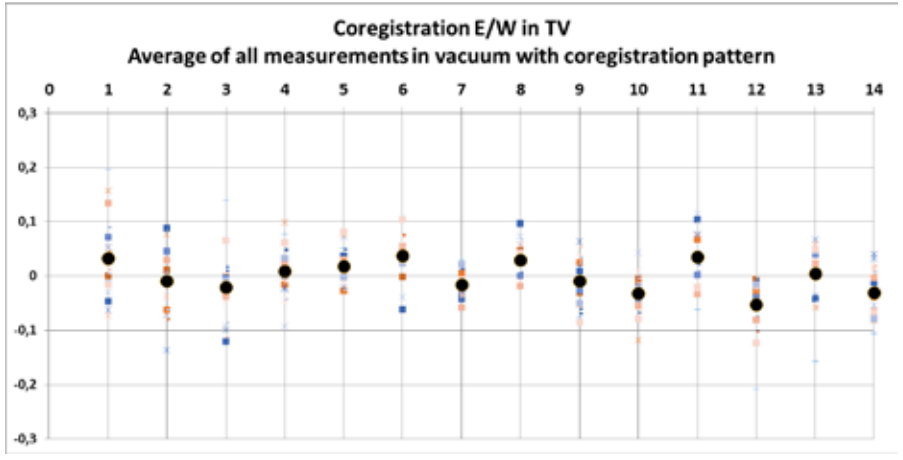
- **Tests results :**
  - Performances compliant for all bands in both E/W and S/N directions
  - Capability to adjust performance (focus) by changing M1 temperature has been shown during TV tests.



Recorded Knife edge image and processing



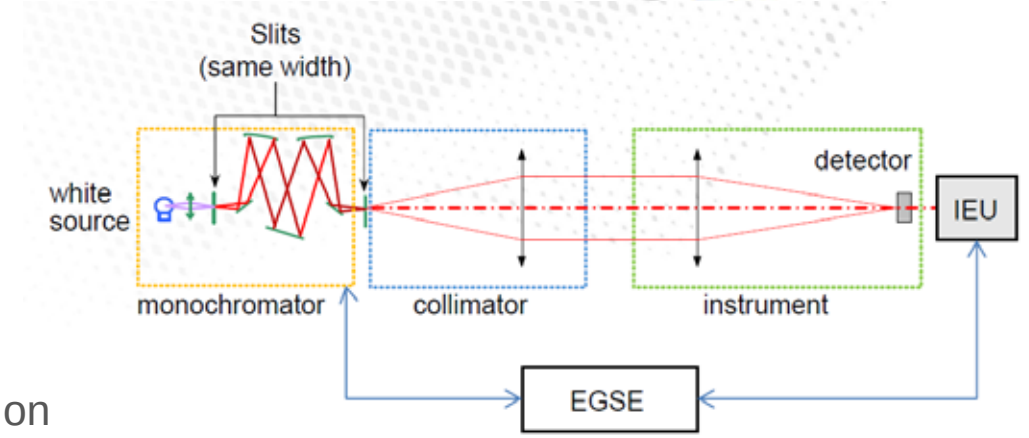
Coregistration pattern



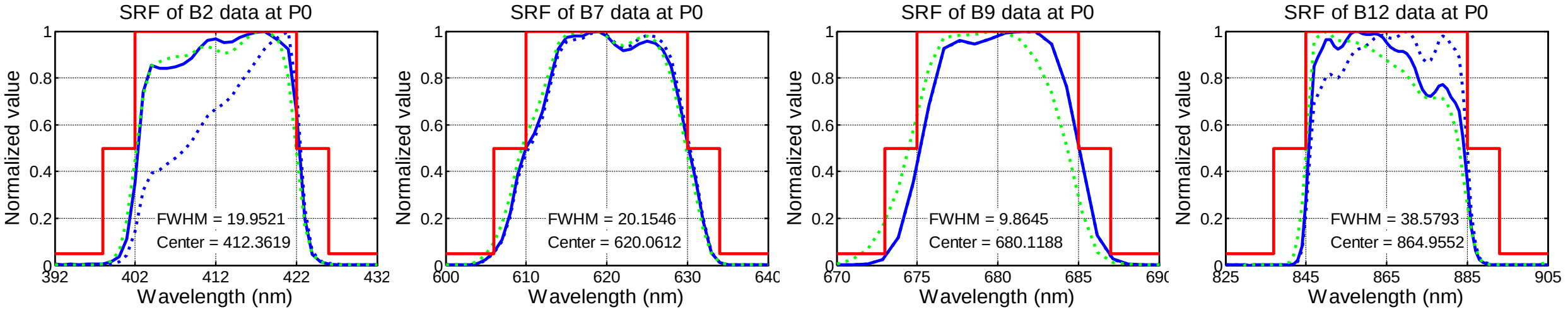
Test results – Spectral tests

- Spectral tests have been performed in Airbus Toulouse
  - Measurement at ambient with a collimator equipped of a monochromator at focal plane

- **Tests results**
  - Measurements for all bands are consistent with predictions based on spectral measurements performed on filters and mirrors
  - Performances are compliant with requirements.

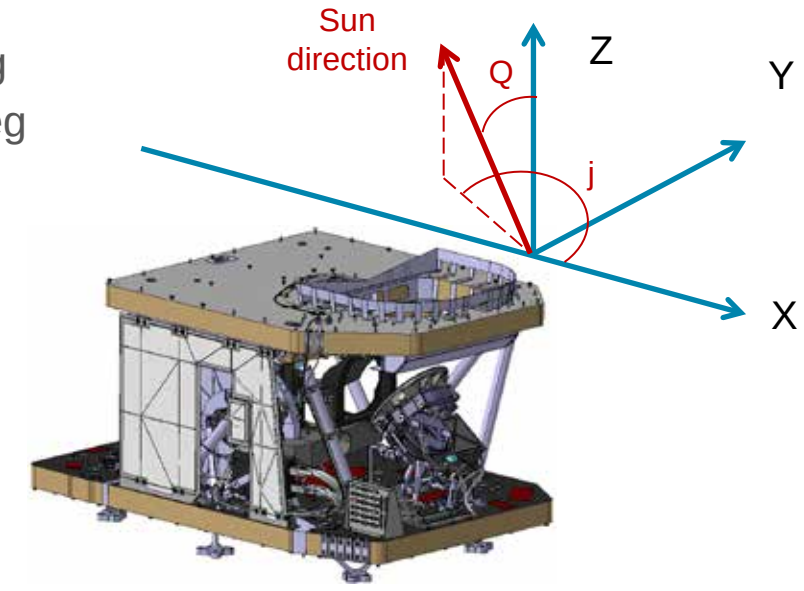


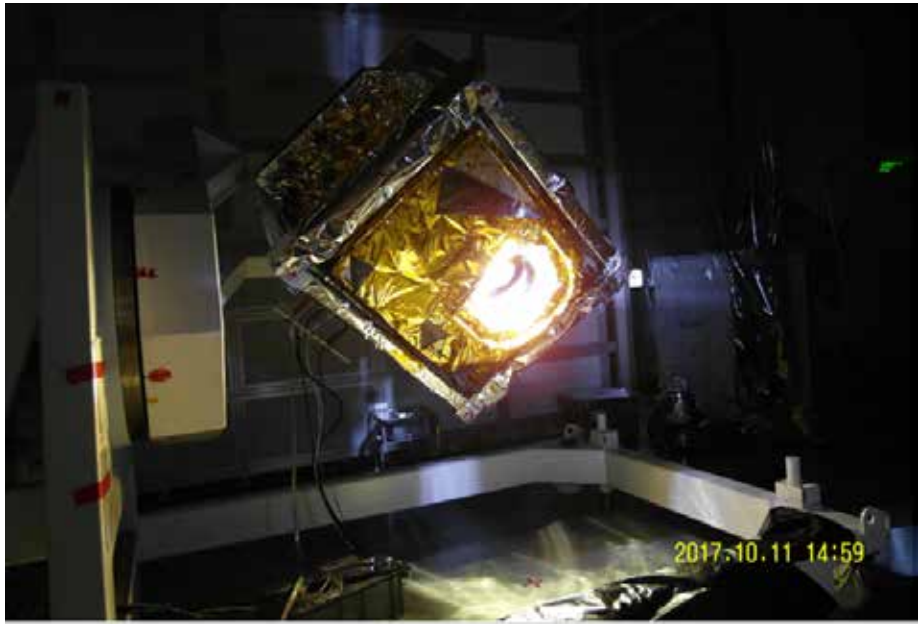
< Spectral Test configuration >



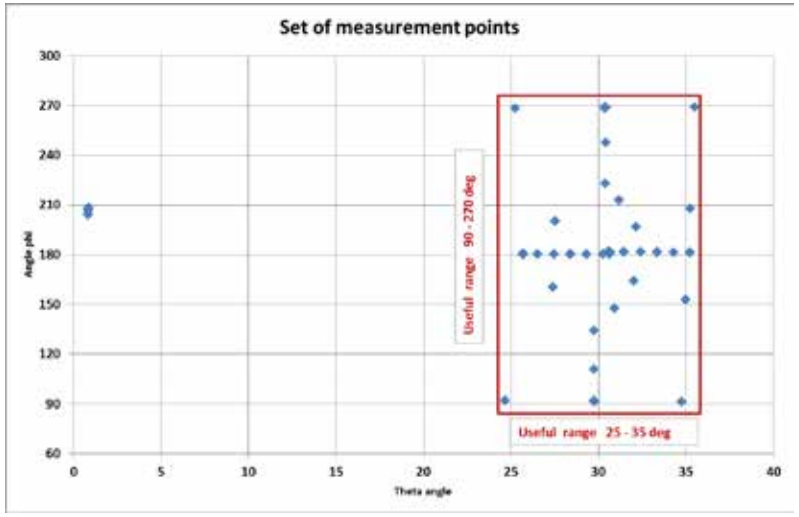
Test results – Calibration tests

- Calibration tests have been performed in KARI using KARI's Sun Simulator
  - Characterisation of Main diffuser diffusion function
  - Measurement of the ratio main diffuser / secondary diffuser
  - Useful range:
    - Q 25 – 35 deg
    - j 90 – 270 deg





GOCI-II illuminated by Sun Simulator

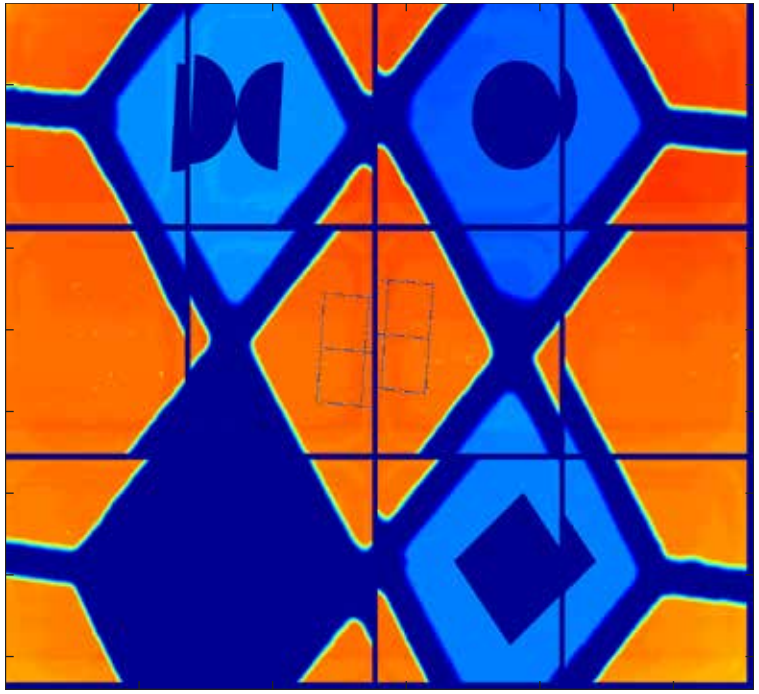


- **Tests results**
  - Tests confirmed low sensitivity to sun angle as expected from diffuser sample test results (quasi-lambertian properties)
  - Diffuser model derived from the test results Ldiff = r (Q, j).Esun.cos(Q)/p

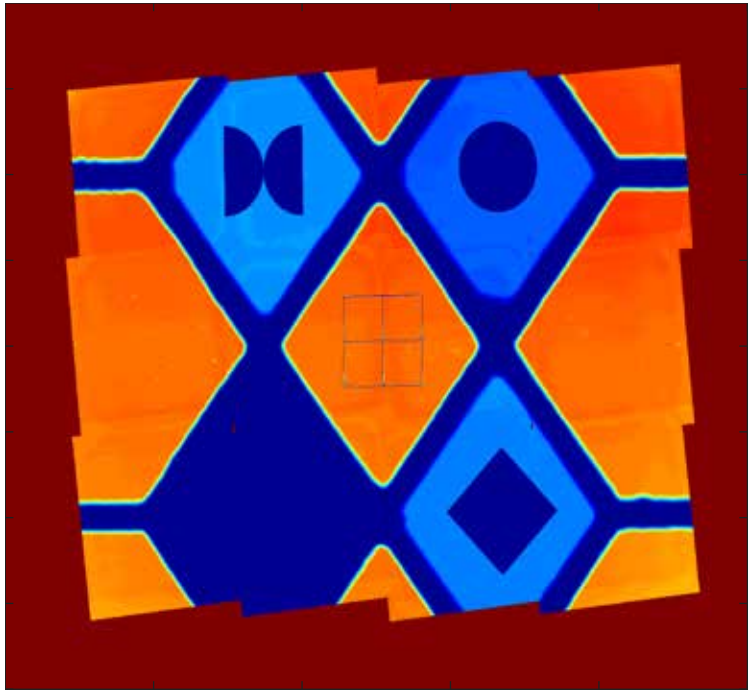
Full Imaging Test results (1/2)

- Acquisition of a test image in 12 slots in AUTONOMOUS mode (as in orbit)
- Raw image (12 slots – left) and reconstructed image (right) using Pointing Law
  - Ø only offset correction applied below

IEUA#4 Full Image B4 HG 8100

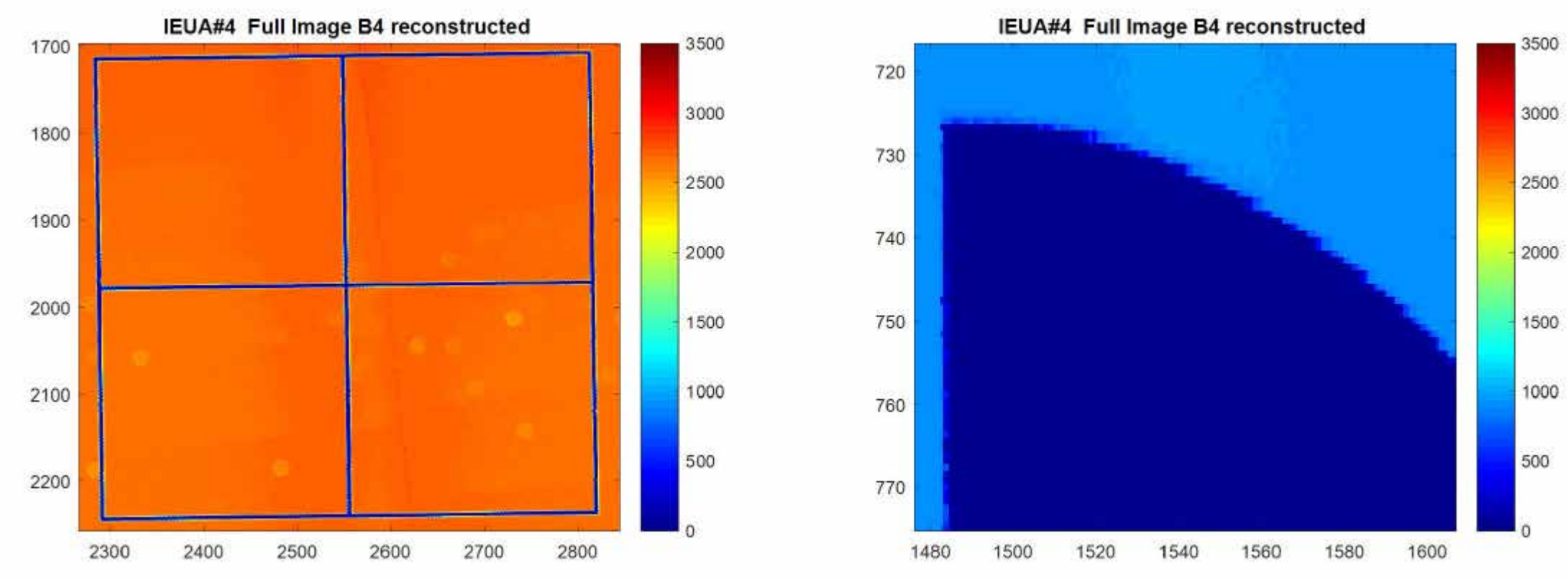


IEUA#4 Full Image B4 reconstructed



Full Imaging Test results (2/2)

- Zoom on overlap areas showing that pointing model is OK
  - Ø only offset correction applied below



Conclusion

- GOCI-II has been successfully submitted to a complete performance and environmental tests campaign
- No anomaly has been observed at GOCI-II level during the environmental test campaign
- GOCI-II high level of peformance has been confirmed.
- Test campaign has been successfully completed by KARI, KIOST and Airbus Joint Development Team with support of KARI team in charge of facilities: great thanks to all !
- GOCI-II is now integrated on the satellite and follows the test sequence at satellite level

On the road for launch early 2020

Thank you

AIRBUS