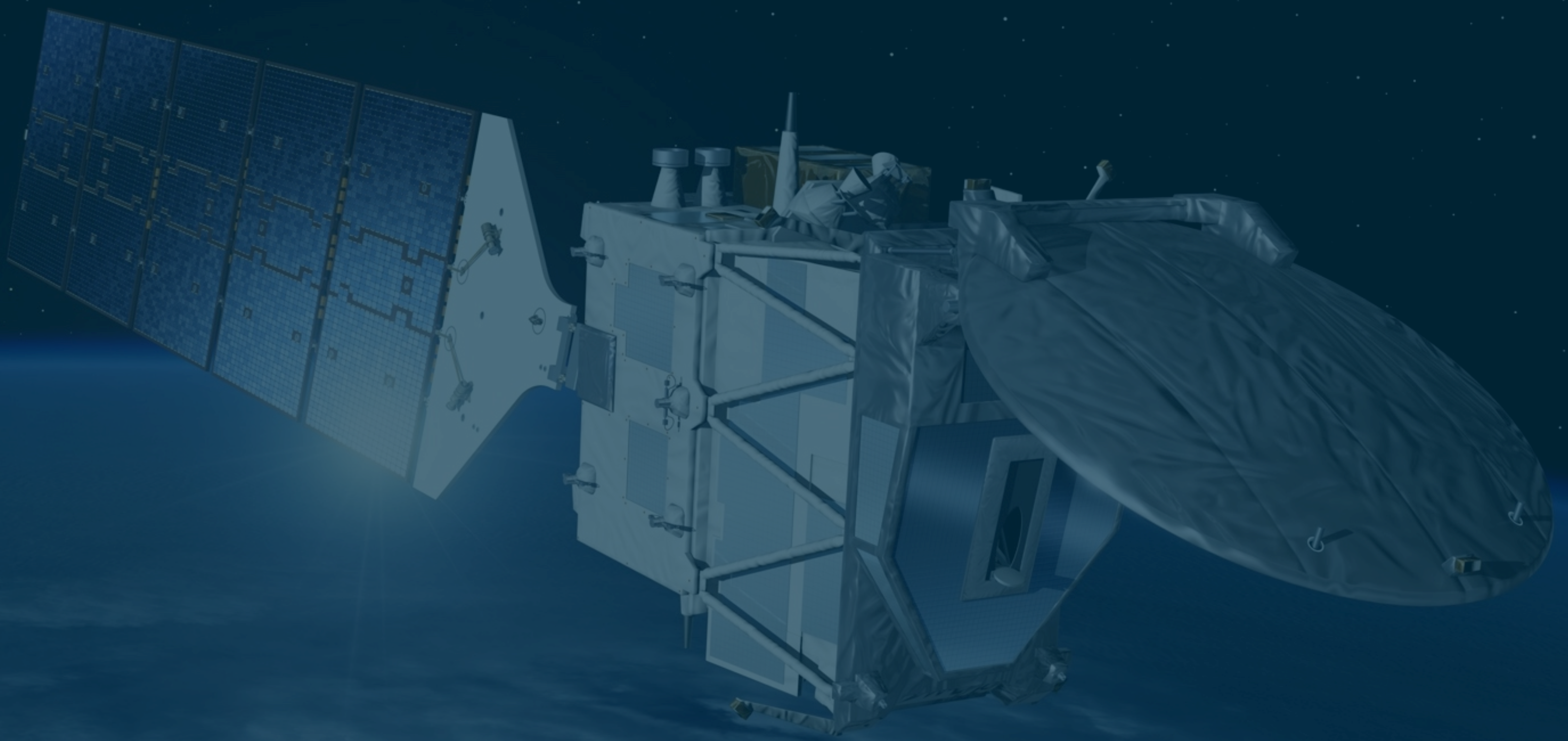

EarthCARE Optical Instruments In Orbit Characterisation, Calibration and Verification

2nd ESA EarthCARE Validation Workshop

Kotska Wallace, Mission and Optical Payload Manager

25-May-2021 (online)

Content

Overview of in orbit commissioning activities

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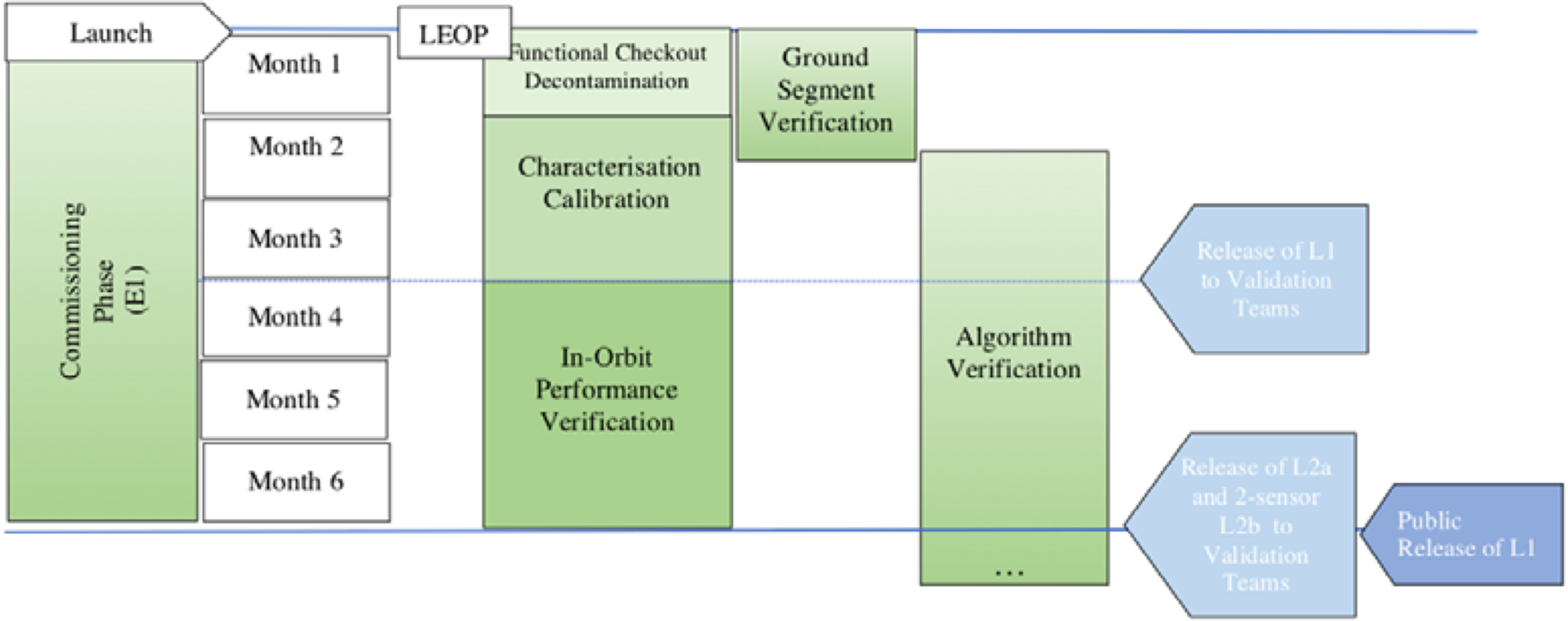
[ATLID → See following presentation from Georgios Tzeremes.]

Overview of in-orbit commissioning activities

EarthCARE commissioning phase 6 months, ending with In-Orbit Commissioning Review (IOCR):

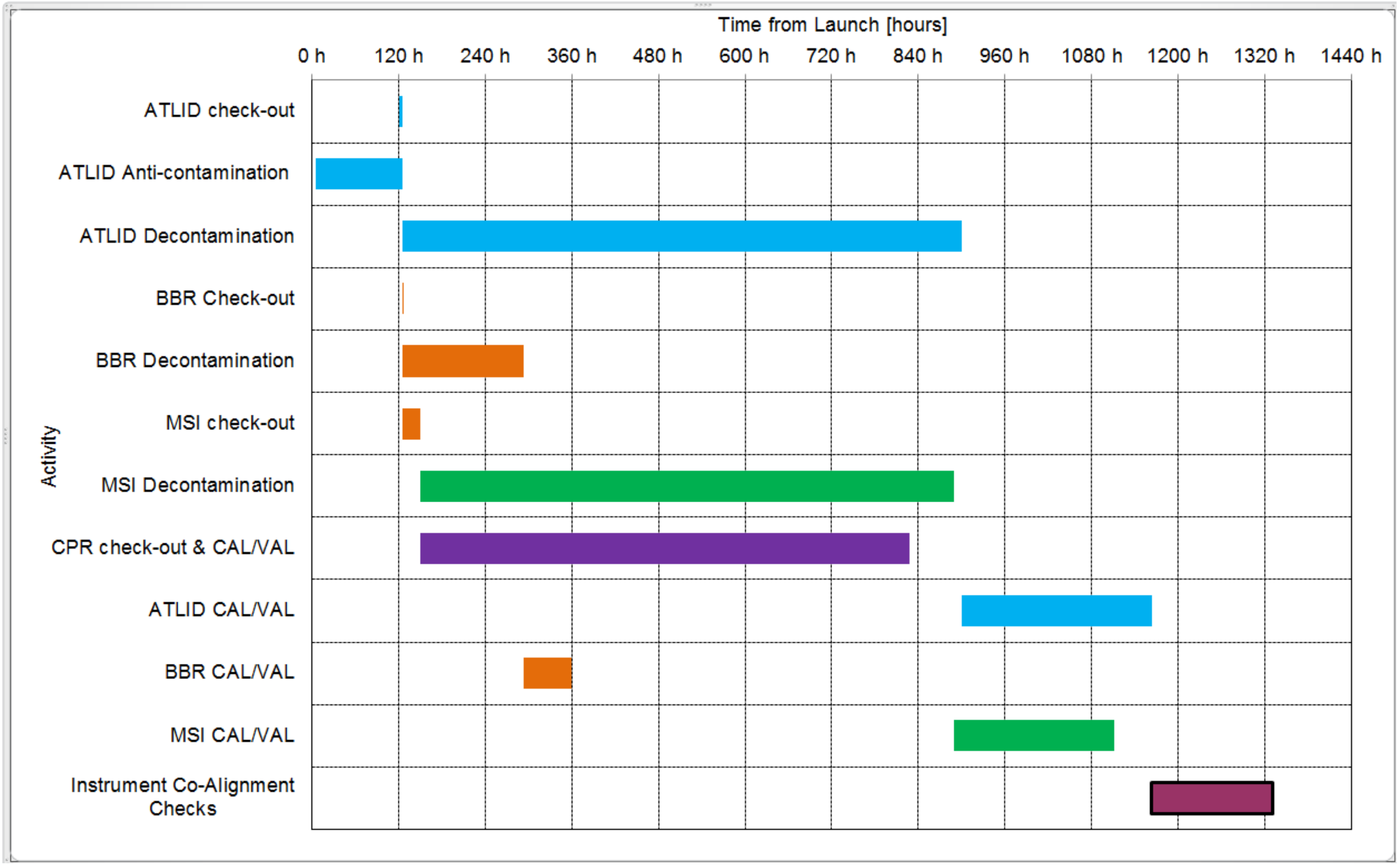
- Achieve final reference orbit.
- Complete platform functional verification, health checks, instruments switch-on & decontamination.
- Verification of ground segment (interfaces, data flow, processing, archiving, mission planning).
- Instruments in-orbit characterisation, calibration and in-orbit performance verification.
  - Instrument health, function, calibrations, optimisation of settings and verification of expected performance.
    - (Limited to nominal instrument side, i.e. no redundancy check out.)
  - Check of instrument co-registration using land marks or terrain elevations.
  - Product *verification (i.e. consistency checks etc., not using external correlative data.)*
    - L1 algorithms by industry and any processor updates implemented by ESA.
    - L2 algorithms by L2 expert teams.
- Teams at ESA (Project, Flight Operations Segment, Payload and Data Ground Segment), JAXA Ground Segment, Industry Satellite and Instrument Teams, Validation Teams, ECMWF

Overview of IOCV activities - indicative timeline



- Validation of data products and processing algorithms is initiated during the commissioning phase
- 1st product releases for each of the 4 instruments in coordination with ESA project, mission management & JAXA (individual products, followed later by multiple products view of same scene)

Overview of IOCV activities - instruments timeline



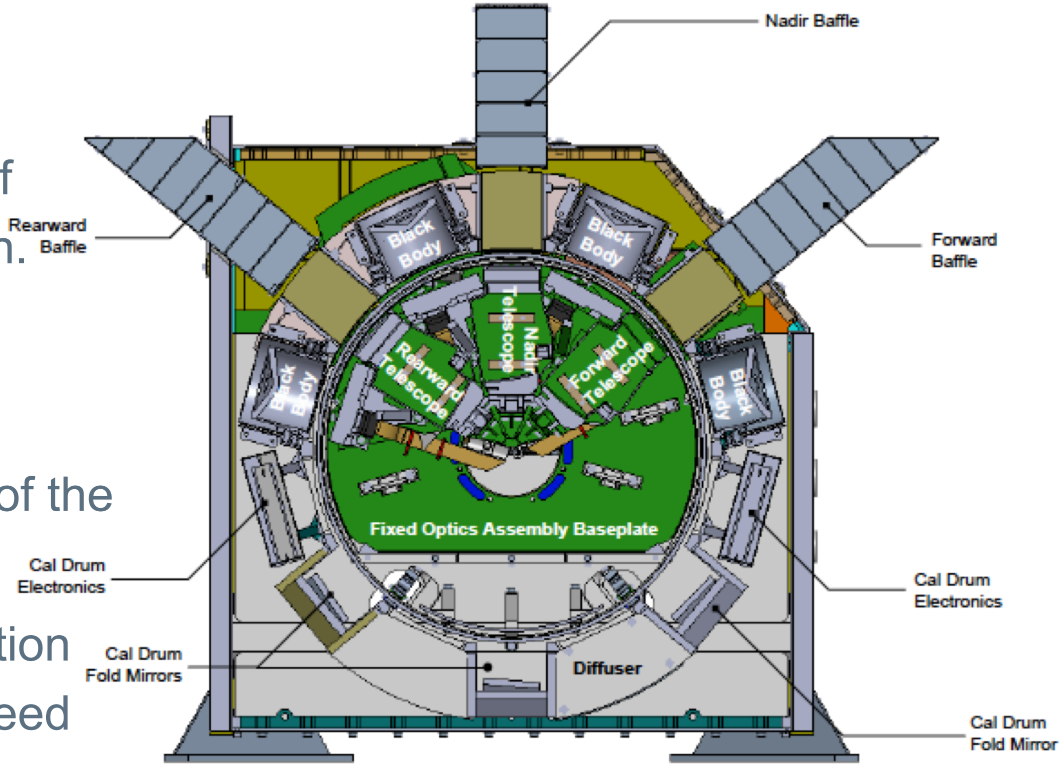
BBR calibration concept

LW and SW data from 3 telescopes; LW data retrieved via subtraction of SW from TW channel.

- Requires knowledge of the instrument and scene spectral response.
  - Unfiltering can be enhanced with use of MSI data to improved the scene spectral correction factor

BBR calibration approach:

- TW: Two point calibration using hot & cold blackbodies
  - Performed on-board automatically, every 90 s, for removal of signals offset (instrument self emission) & gain determination.
- SW: SW aging data from solar illuminated diffusor.
  - Collected over 30 orbits, every 2 months.
  - Monitor Photo Diodes in the telescope baffles assess aging of the diffuser and filter.
  - L1B products used to plot SW gain ratio, LW spectral correction factor and filter transmission for expert assessment of any need to update CCDB parameters (review every 6 months)



BBR IOCV concept

During Commissioning:

- Switch on, decontamination (12 hr), health status check (telemetry in limits), functional check (mode changes, mechanism movements etc.)
- Detector raw data check (comparison of raw mode and processed output in the instrument ISP to verify on-board DSP.)
- LW performance check from standard L1b data product (gain, LW radiance noise, gain stability).
  - Possible updates to blackbody power, calibration interval.
- SW calibration collects data for in-flight reference and any update of calibration parameters
  - Performance check compares data against Visible Calibration (VisCal) system on-ground reference characterization and calibration 2 months later (MPD noise and collection of in-flight aging reference SW gain ratio, LW spectral correction factor and filter transmission)
- Detector linearity check via swap of powers to hot and cold BBs over several hours with instrument continuous operation
  - Repeated 6 monthly, although no linearity change is expected

BBR key calibration parameters

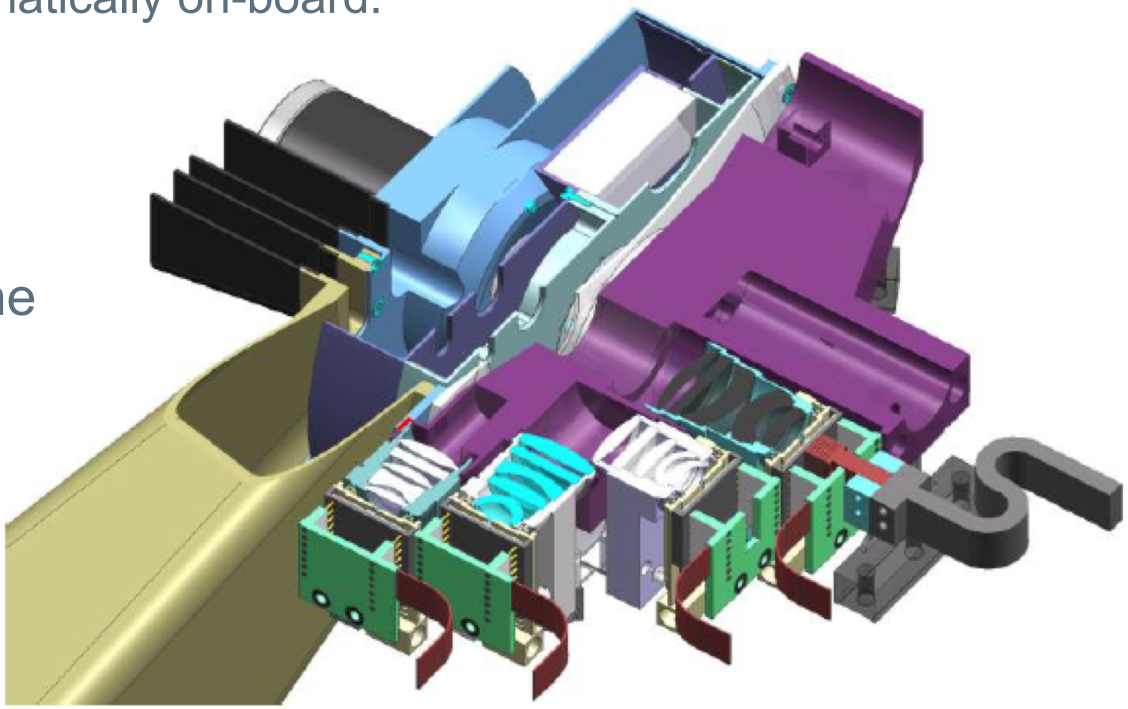
	measured pre-flight	measured in-flight	applied in-flight	Data frequency
SW gain ratio, B	✓	Derived from BBR_SOL_1B	✓ CCDB	Collect 2 mo, assess 6 mo
LW spectral correction factor, A	✓	Derived from BBR_SOL_1B	✓ CCDB	Collect 2 mo, assess 6 mo
SW filter transmission, $<\tau>_{SW}$	✓	Derived from BBR_SOL_1B	✓ CCDB	Collect 2 mo, assess 6 mo
Detector linearity	✓	BBR_LIN_1B	✓ CCDB	6 mo
Detector gain, G_{LW}	✓	Derived from BBR_LIN_1B	✓ CCDB	90 s
TW calibration interval	✓	Derived from BBR_LIN_1B	On-board	90 s
Offset and gain stability	✓	Derived from BBR_LIN_1B	✓ CCDB	90 s
MPD noise	✓	BBR_SOL_1B	✓ CCDB	Collect 2 mo, assess 6 mo

MSI calibration concept – VNS camera

Pushbroom onto 4 detectors, calibration of data to radiance units.

- One SWIR-2 aperture and a second aperture for Visible, NIR and SWIR-1 channels.

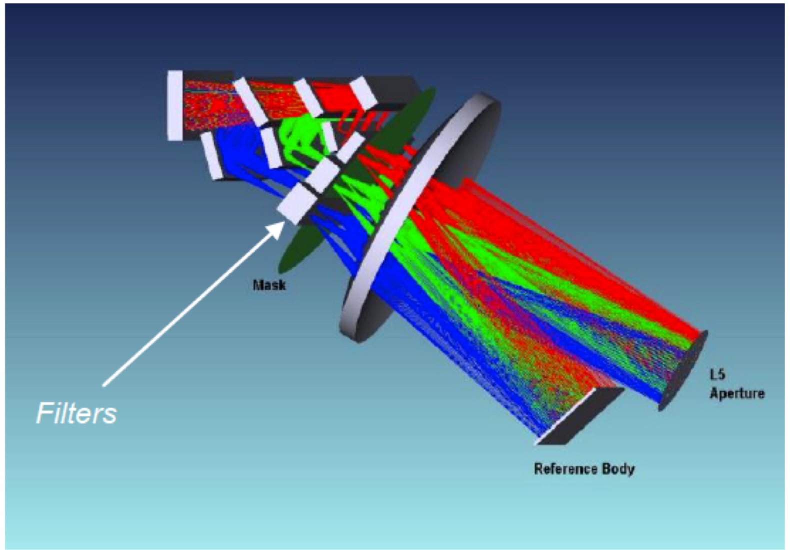
- Daily two point calibration against a solar illuminated diffusor and the closed shutter.
  - Closed shutter to collect dark signal, in order to characterise detector fixed pattern offset & noise; generated flat field will be activated and subsequently applied automatically on-board.
  - Daily bright scene calibration using one pair of solar illuminated diffusors in front of the two camera apertures (data monitored to track performance degradation.)
- Monthly diffusor pair used to monitor degradation of the diffusors (data to correct long term drift in diffusor performance.)
- Specific L1b calibration data products generated for monitoring.



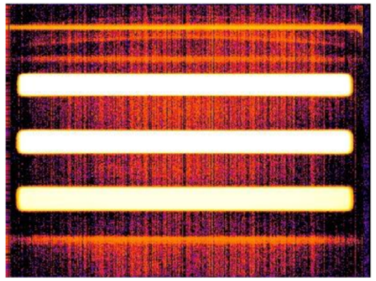
MSI calibration concept – TIR camera

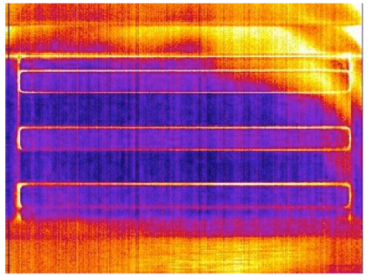
Pushbroom with 3 channels dispersed onto a single detector, calibration of data to brightness temperature.

- Increases sensitivity using 19 rows of Time Delay Integration, applied automatically on-board.
- A 4th reference channel collects data from a detector view of the internal optics, which the ground processor averages & subtracts from scene channel signals to correct for thermal drift & detector noise.



- Daily two point calibration against the cold scene and an internal blackbody.
  - TIR views the cold space port to characterise the detector fixed pattern offset and noise; flat field generated will be activated and subsequently applied automatically on-board.
  - TIR views the internal blackbody to monitor sensitivity changes.
- Specific L1b calibration data products generated for monitoring.





MSI IOCV concept

During Commissioning:

- Switch on, decontamination (30 days), health status check (telemetry in limits), functional check (mode changes, Active Thermal Control, mechanism movements etc.)
- Calibrations collect and apply VNS and TIR flat fields.
- TIR raw mode operation to collect reference in-flight TIR detector pixel map (no TDI.)
- VNS performance check from standard L1b data products and collection of in-flight reference (detector characteristics, diffusor references).
- TIR performance check from standard L1b data products and collection of in-flight reference data (detector characteristics, checks for sensitivity to detector temperature and bias voltages, relay lens temperature, bench and case temperature, cold space mirror self emission)

MSI key calibration parameters

	measured pre-flight	measured in-flight	applied in-flight	Data frequency
Flat fields; TIR, VNS	✓	Stored in ICU	On-board via TC	daily
VNS diffusor datasets daily, monthly; detector noise, responsivity	✓	MSI_SD2_1B, MSI_SD1_1B	✓ CCDB	daily, monthly
VNS closed shutter datasets; flat field, image statistics	✓	MSI_DRK_1B	✓ CCDB	daily
TIR calibration products BB & CS views; detector noise, responsivity, flat field	✓	MSI_BBS_1B	✓ CCDB	daily
TIR sensitivity; detector bias V, detector temp., relay lens temp., bench temp., case temp.	✓	MSI_TRF_1B	✓ CCDB	daily
TIR cold space mirror offset	✓	TIR_CSM_OFFSET	✓ CCDB	daily
Gain corrections; TIR, VNS	✓	TIR_GAIN_CORR, VNS_RAD_CORR	✓ CCDB	daily

ATLID calibration concept and IOCV

→ See presentation of Georgios Tzeremes

Thank you for your attention.

Questions?