Technology Developments in the German Earth Observation Programme

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EO Predevelopment Activities at the German Space Agency

Setup of the Mission Team in the Earth Observation Department

- Mission Preparation (Phase 0/A)
- Technology predevelopment
- Mission development and implementation (Phases B, C/D)
- Mission operation (Phase E)

} one integrated team

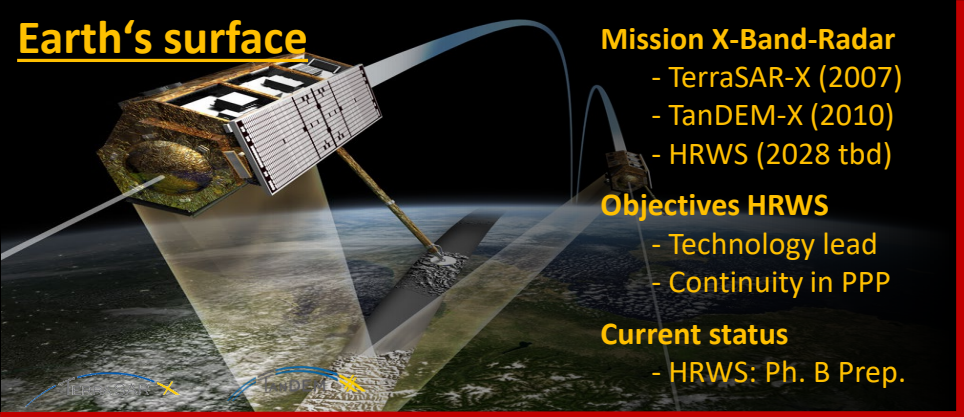
DLRs EO pre-development activities cover key technologies for EO instruments

- Imaging radiometers and spectrometers from visual to the thermal infrared
- LASER technologies for LIDARs and other applications
- X-Band RADAR

Priority is given to

- preparatory activities for planned national missions
- enabling technologies for potential future missions both national and in ESA context

Earth's surface

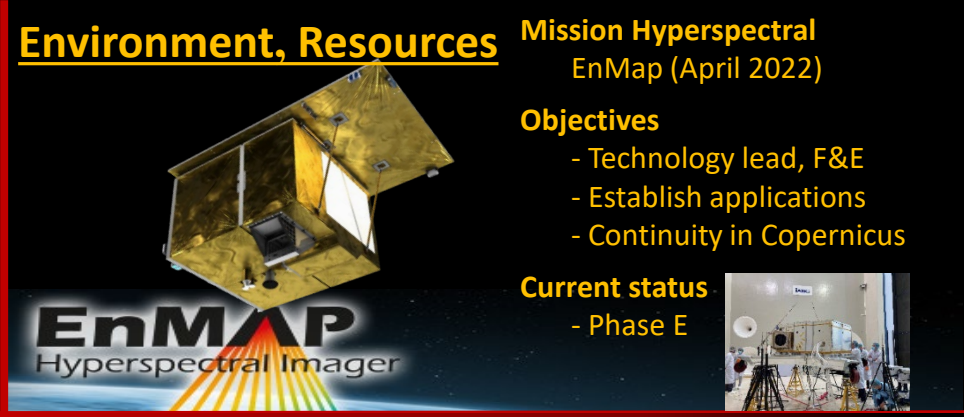


Mission X-Band-Radar
- TerraSAR-X (2007)
- TanDEM-X (2010)
- HRWS (2028 tbd)

Objectives HRWS
- Technology lead
- Continuity in PPP

Current status
- HRWS: Ph. B Prep.

Environment, Resources



Mission Hyperspectral
EnMap (April 2022)

Objectives
- Technology lead, F&E
- Establish applications
- Continuity in Copernicus

Current status
- Phase E

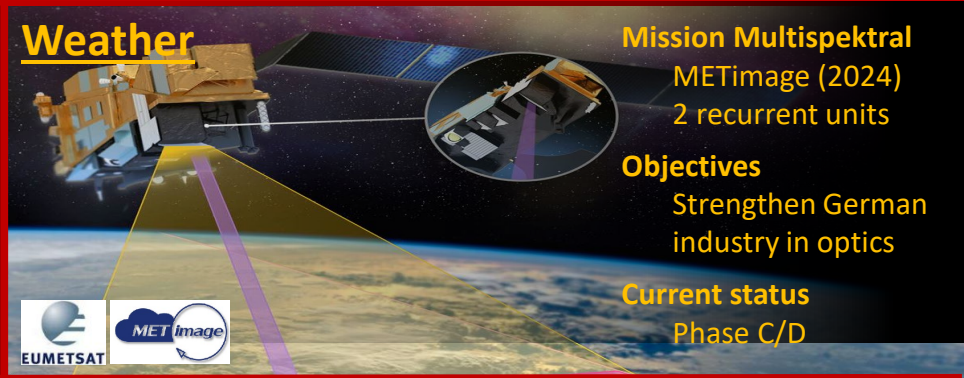
Climate

Mission LIDAR
Merlin (2027

Objectives
Measurement of global CH4-concentration

Current status
Phase C/D

Weather



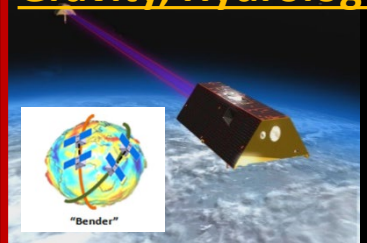
Mission Multispektral
METimage (2024)
2 recurrent units

Objectives
Strengthen German industry in optics

Current status
Phase C/D

DLR **Deutsches Zentrum für Luft- und Raumfahrt**
German Aerospace Center

Gravity, Hydrology

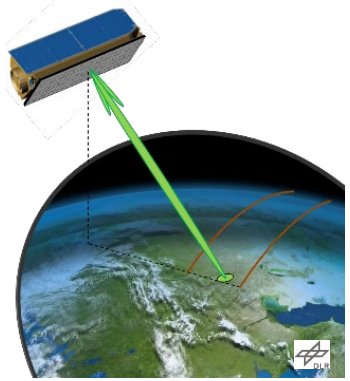


Mission Laserlink/Platform
GRACE FO (2018)

Objectives GRACE-I
Continuity to GRACE FO
Collaboration with NASA/ESA

Current status
Phase A

SAR Technology



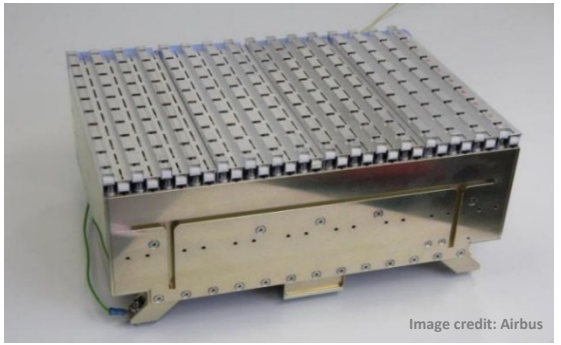
Radar Instrument Development

Radar architecture designed for digital beamforming

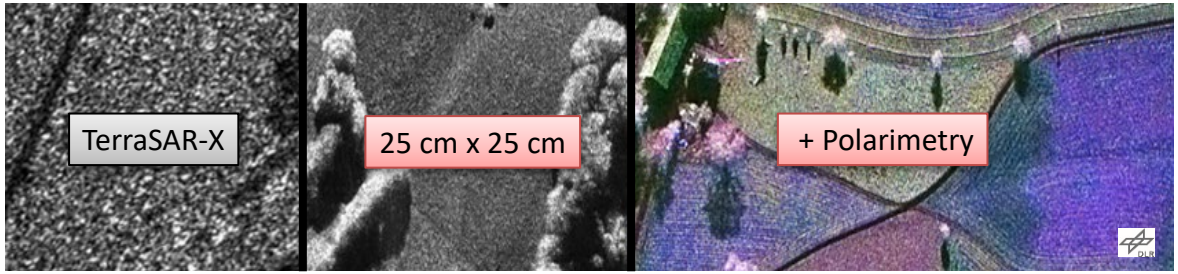
Development of TEM* radiators and electronics

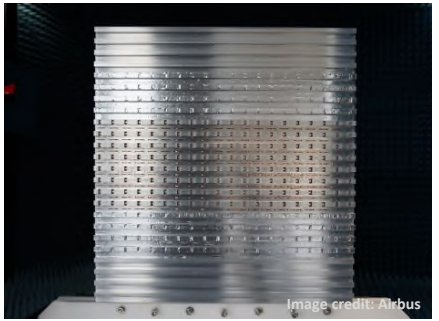
Adapted for Signal Bandwidth of 1200 MHz available for SAR civil applications in X-Band

Highest resolution and best image quality



Integrated Front-End Demonstrator

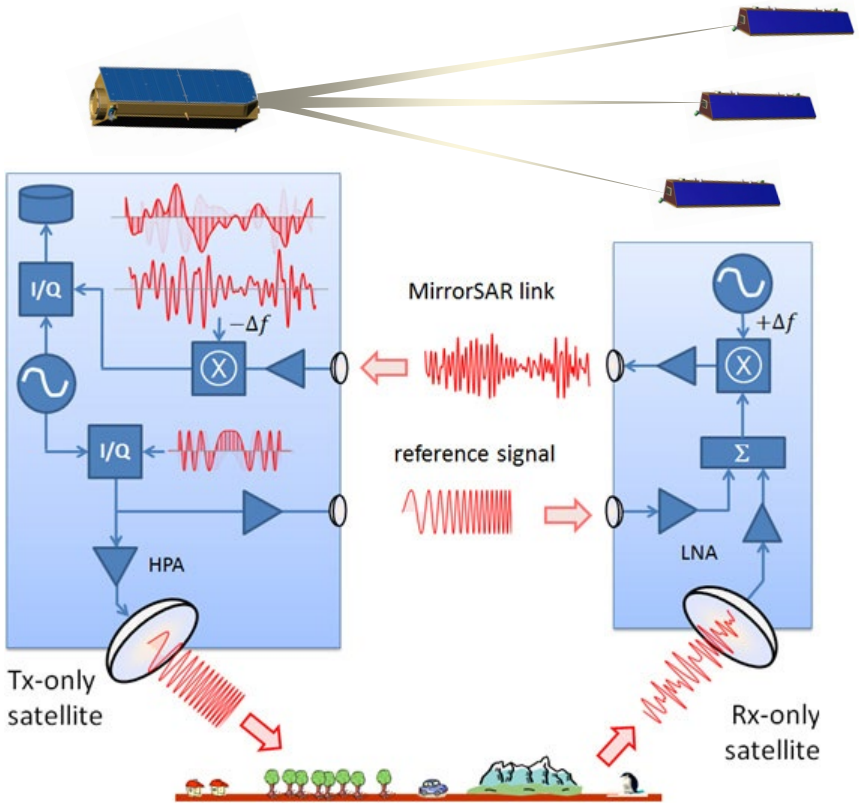




TEM Radiators

* TEM = Transverse Electromagnetic

MirrorSAR Concept



G. Krieger, M. Zonno, J. Mittermayer, A. Moreira, S. Huber, M. Rodriguez-Cassola: "MirrorSAR: A Fractionated Space Transponder Concept for the Implementation of Low-Cost Multistatic SAR Missions". EUSAR 2018. ISBN 978-3-8007-4636-1

- Main satellite sends signals to the ground and reference signals to the companions
- The companions receive the reference signal and superimpose it on the radar echo from the ground
- The resulting signal is frequency shifted and radiated back to the main satellite
- The additional frequency shift is reversed and down-converted to baseband
- The demodulated signal is then digitized, stored in memory, and later transferred to the ground

MIRROR SAR

DLR

Enmap – the Environmental Mapping and Analysis Program

EnMAP is Germany's first spaceborne hyperspectral satellite with the goal to monitor and characterise the Earth's environment on a global scale. EnMAP serves to measure and model key dynamic processes of the Earth's ecosystem.

Key Mission Parameters:

Spatial resolution and coverage

- Swath width 30 km with GSD 30 m nadir
- 5,000 km total swath length acquisition per day
- ± 30° off-nadir pointing for fast target revisit (≤ 4 days)

Spectral range

- 420 nm to 950 nm (VNIR), 6.5 nm resolution
- 950 nm to 2450 nm (SWIR), 10 nm resolution

Mission Life Time & Orbit

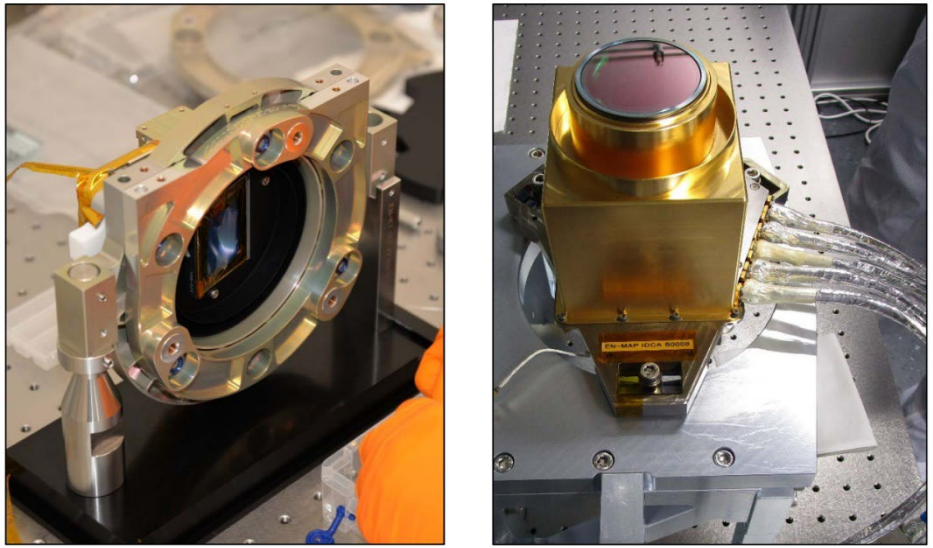
- Successful Launch on April 1st 2022
- commissioning phase is ongoing
- 5 years of operation
- LEO Sun-synchronous, LTDN 11:00 hrs

See also Session B6.03.1, Wednesday 10:40

EnMAP: detectors

- VNIR Sensor Assembly
  - Supplier: DLR Institute of Optical Sensor Systems
  - Low-noise CMOS image sensor
  - Spectral range: 420 -1000 nm
  - Sampling distance: 6.5 nm
  - Size: 1024 x 2128 sensitive pixel

- SWIR Sensor Assembly (nominal & redundant)
  - Supplier: AIM
  - MCT-IR-Hybrid with Si-based ROIC; Pulse tube cooling (150K)
  - Spectral range: 900 -2450 nm
  - Sampling distance: 10 nm
  - Size: 1024 x 256 sensitive pixel

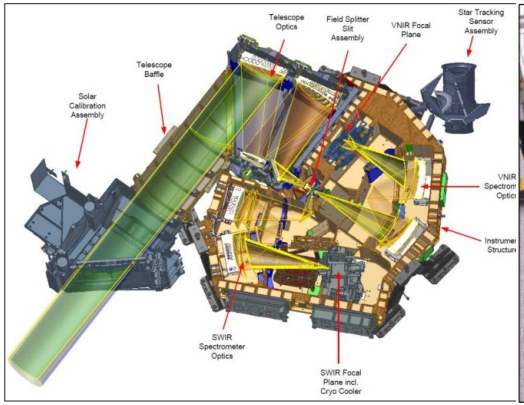


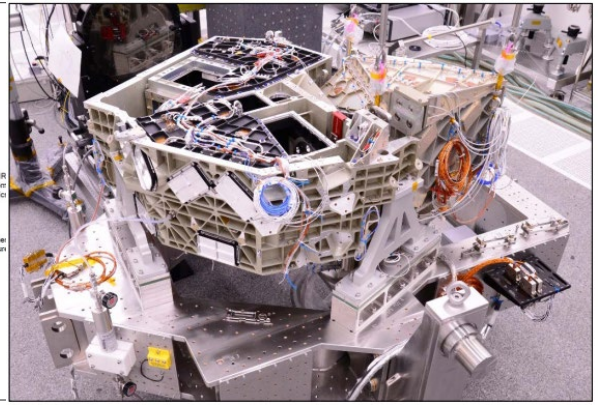
Left: VNIR-FPA flight model before integration into the instrument optics unit. Right: SWIR-FPA qualification model in the FPA electro-optical test lab at OHB. (1)

(1) Proc. SPIE 11180, International Conference on Space Optics — ICSO 2018, 1118007 (12 July 2019); doi: 10.1117/12.2535926

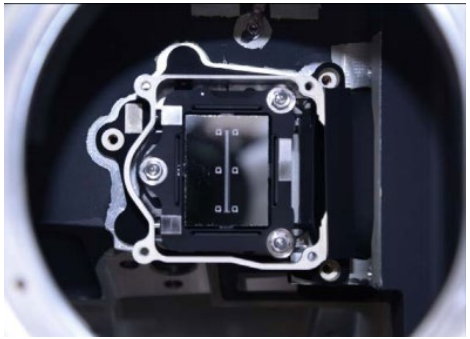
EnMAP: optics

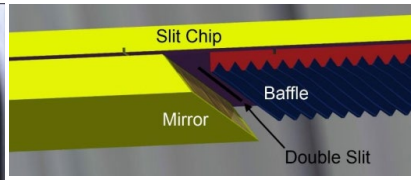
- mirrors: Fraunhofer Institute for Applied Optics and Precision Engineering IOF
- prismen: Berliner Glas
- entrance double slit (FSSA): Fraunhofer Institute for Microengineering and Microsystems IMM
- integration/alignment: OHB System AG



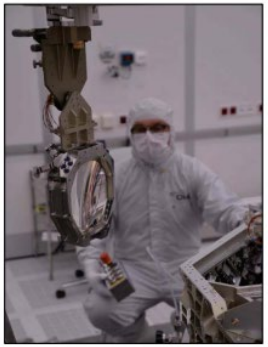


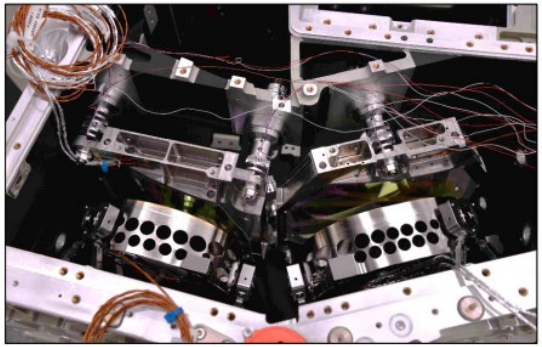
Schematic view (left) and setup (right) of the main components of the EnMAP double-spectrometer instrument concept (2).





Left: Field splitter slit assembly (FSSA) flight model after integration into the instrument optics unit (2). Above: Schematic of the integral silicon assembly showing slit chip, deflecting mirror and micro structured baffel (1).





Left: Integration of a prism assembly inside the instrument optics unit using a precision insertion tool. Right: SWIR spectrometer compartment inside the instrument optical unit. Photograph shows the two mirrors and prisms in Offner configuration after placemen (2).

(2) Proc. SPIE 11180 — ICSO 2018, 1118067 (12 July 2019); doi: 10.1117/12.2536142
(3) Proc. SPIE 11180 — ICSO 2018, 1118011 (12 July 2019); doi: 10.1117/12.2535956

MERLIN French-German Climate Mission

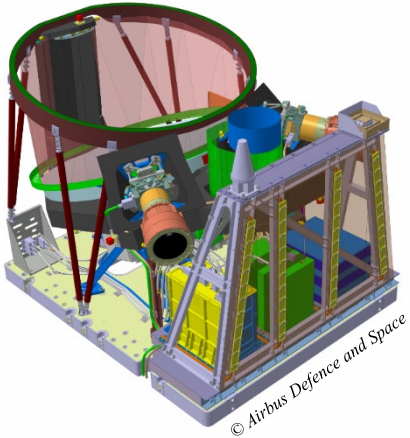
Gefördert durch:
Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

Status

- Phase C successfully finished in 2020
- Phase D in progress

Upcoming major milestones

- Laser flight model ready in 2024
- Payload flight model ready in 2026
- Satellite ready for launch in 2027
- 3 years of operation



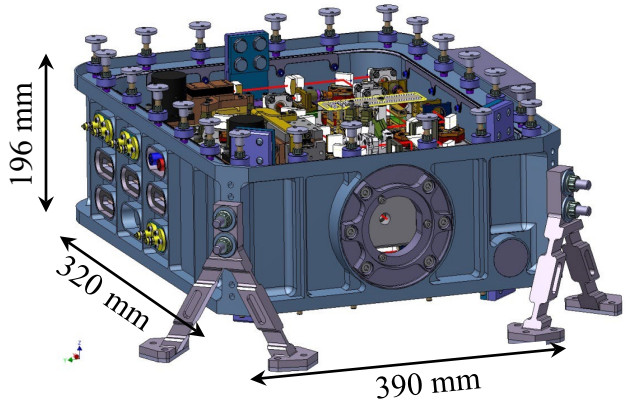
MERLIN will …

… be the first space-borne Methane IPDA LIDAR…
… globally measure XCH4 at day and night
… enable higher accuracy for flux modelling
… improve our knowledge on the important greenhouse gas CH4 cycle

DLR cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

LIDAR/Laser Technology – MERLIN Laser Transmitter

- **Output: pulses of 9 mJ at 1645 nm** from a seeded **Optical Parametric Oscillator** (OPO)
- OPO **pumped at 1064** nm by a two-stage single-frequency Nd:YAG consisting of a rod **master oscillator** and a slab **power amplifier**
- **Adhesive-free mounting** of the optical components by new mounting technologies



Fraunhofer ILT AIRBUS DEFENCE & SPACE

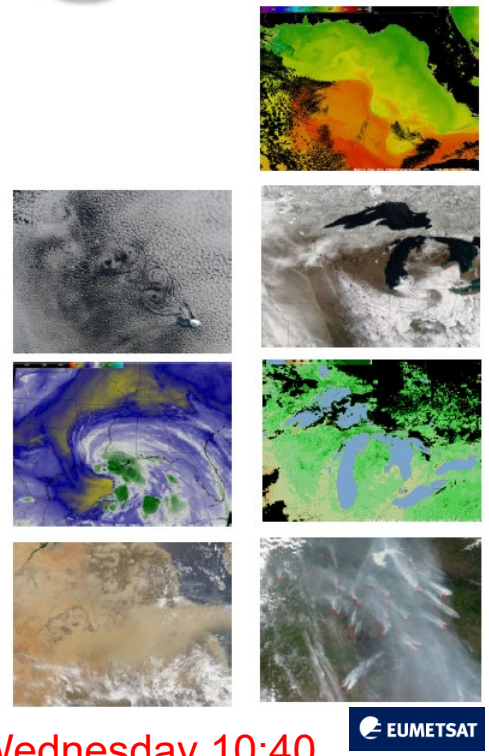
- Hermetically sealed **pressurized housing to avoid vacuum-related laser-induced damage**
- **Thermal control: Mini Loop Heat Pipes** directly attached to all heat sources inside the housing
- **Based on** highly efficient Future Laser (**FULAS**) concept (joint ESA and DLR Space Agency activity)

DLR

METimage

METimage will provide high quality imagery data

- High resolution cloud products including microphysical analysis
- Sea, land, and ice surface temperature
- Vegetation, snow coverage, and fire monitoring products
- Aerosol products
- Polar atmospheric motion vectors
- Support the EPS-SG sounders, particularly:
  - Geolocation, Cloud characterisation, and scene inhomogeneity

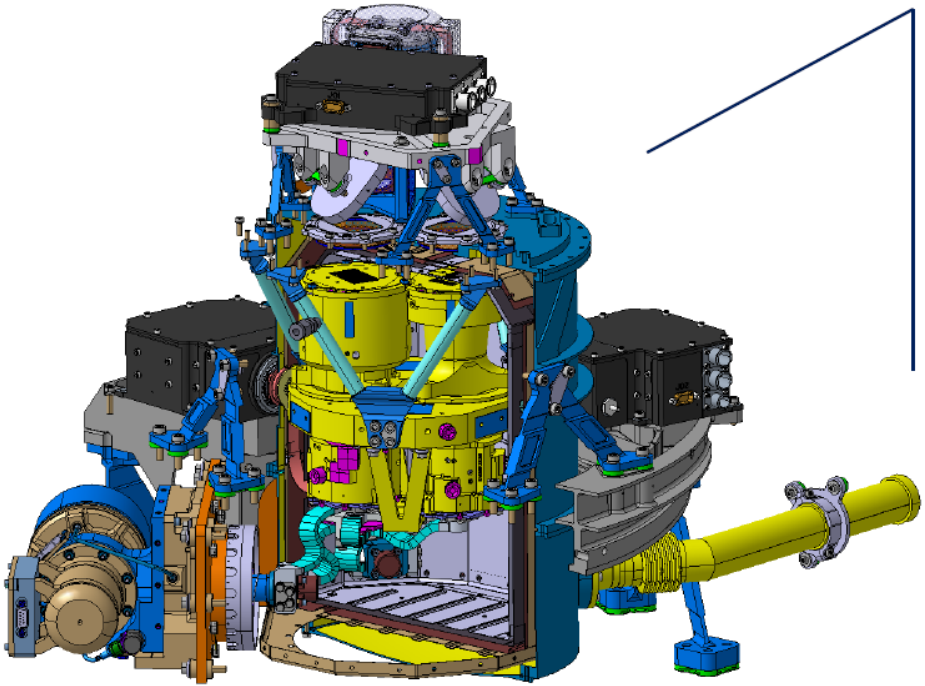


METimage is a scanning optical imaging radiometer

- Full Earth Coverage within 1 day
- 2670 km swath – 500 m ground resolution
- 20 spectral channels 430 nm – 13,5 µm
- 2-point calibration, both solar and thermal
- METimage PFM delivery is planned for January 2024
- Key instrument and Germany´s contribution to the MetOp-SG programme
- Funded by the German Ministry for Digital and Transport
- DLR-EUMETSAT co-operation

See also Session B5.01.2, Wednesday 10:40

Cryogenic Subsystem – key element of METimage



Cryogenic Sub System (CGSS)

IR detectors
VIS detector
Relay Optic and IR Filter
VIS Filter
Beamsplitter
Folding Mirrors
Cryostat Windows
Thermal Link Assembly
Cryo Cooler
Front End Electronic PIEs

Summary & Outlook

- **DLR Space Agency prioritized in the past years technology developments for the implementation of national missions**
  - Phase C/D projects: EnMAP, MERLIN, METimage
  - Technology projects: Preparation of new generation X-Band SAR missions

- **Preparation of new technology development and mission preparation programme**
  - Setup of new programme after the successful EnMAP Launch and the finalization of the development phase of MERLIN and METimage
  - Lessons learnt from phase C/D projects
  - Programme definition is ongoing
  - The goal is to prepare key technologies and mission concepts to allow for a new national EO mission in the timeframe 2026 (start of phase B)