EUMETSAT

User Preparation for Next-Generation Satellite Missions on MTG and EPS-SG

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EUMETSAT

International TOVS Conference (ITSC-24)
Tromsø, Norway, 16 - 22 March 2023

Launch of Meteosat Third Generation-Imager (MTG-I1)

Credit: ESA, CNES, Arianespace

20:30 UTC, 13 December 2022
On Ariane-5 launcher
From Kourou, French Guiana

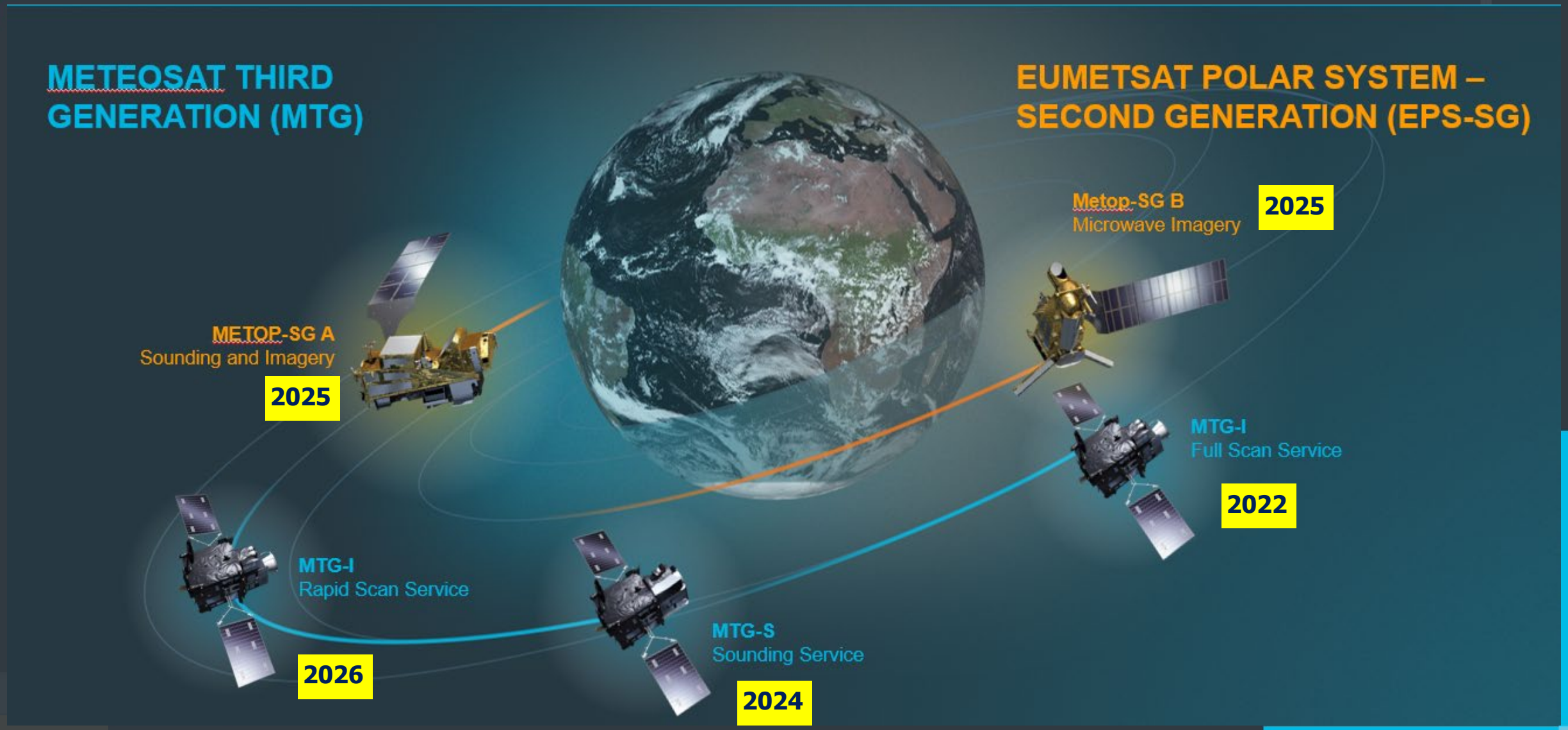
ESA launch video

ESA MTG-I1 launch sequence animation

MTG + EPS-SG

EUMETSAT FUTURE FOCUS: TWO HIGHLY INNOVATIVE PROGRAMMES

EUMETSAT



Status: March 2023

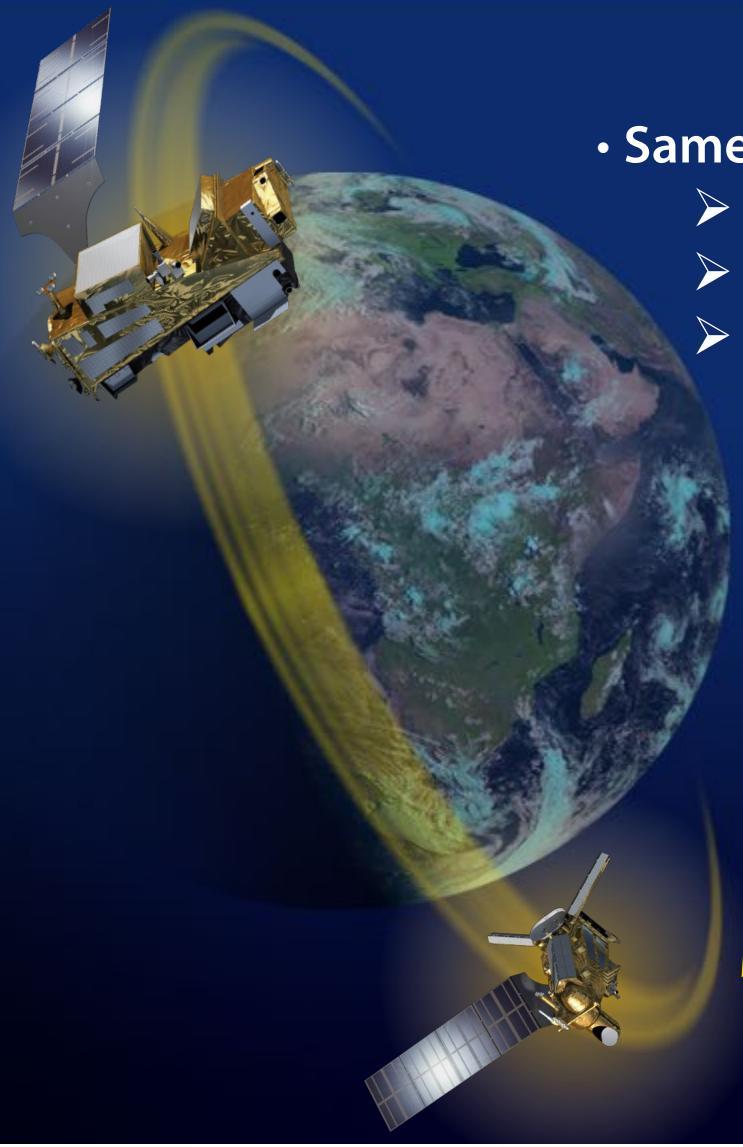
MTG imaging and sounding missions

- Imagery mission implemented by two MTG-I satellites:
  - Full disc imagery every 10 minutes in 16 bands
  - Fast imagery of Europe every 2.5 minutes
- Lightning Imager (LI)

- Hyperspectral infrared sounding mission
  - 4D weather cube: temperature, water vapour, O_3, every 30 minutes over Europe
- Air quality monitoring and atmospheric chemistry in synergy with Copernicus Sentinel-4 instrument

EPS-SG full operational configuration

Metop-SG A
Sounding & Optical Imaging



- Same orbit as Metop
  - sun-synchronous
  - 832 km mean altitude
  - 09:30 local equator crossing time

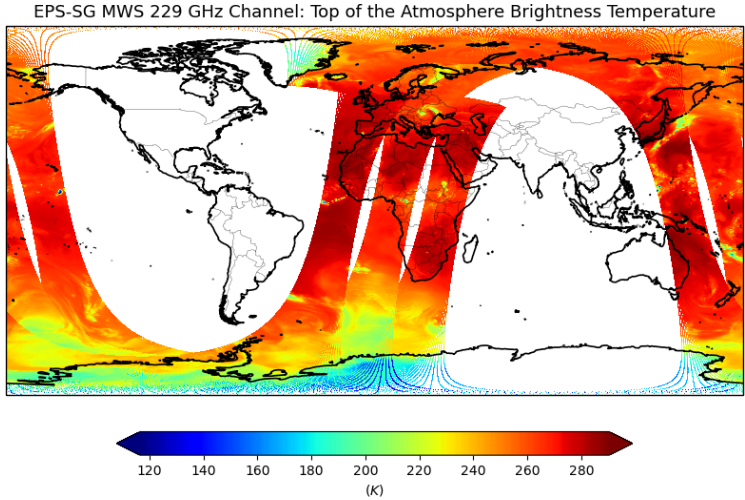
Metop-SG B
Microwave Imaging and Sounding

EPS-SG mission capabilities

Main Payload	Enhanced Capabilities	Innovative Capabilities
High-Resolution Infrared Sounding (IASI-NG)	Better information of temperature and humidity profiles	More trace gases and their vertical profiles
Microwave Sounding (MWS)	Enhanced spatial over-sampling	Ice-cloud info in support of water-vapour profiling
Radio Occultation Sounding (RO)	Large increase of number of radio-occultations	Tracking of Galileo, Beidou and QZSS signals
Copernicus Nadir viewing UV/VIS/NIR/SWIR Sounding (Sentinel-5)	Drastic increase of spatial resolution	Additional trace gas measurements; CO_2 being studied
VIS/IR Imaging (METimage)	Better radiometric and spatial resolution	Far more variables measured with higher accuracy
Scatterometry (SCA)	Higher spatial resolution and coverage	Cross polarisation for higher wind speeds
Multi-viewing, -channel, -polarisation Imaging (3MI)	New mission	Aerosol parameters
Microwave Imaging (MWI)	New mission	Precipitation observations
Ice Cloud Imaging (ICI)	New mission	Cloud microphysics parameters

Test Data for user familiarisation

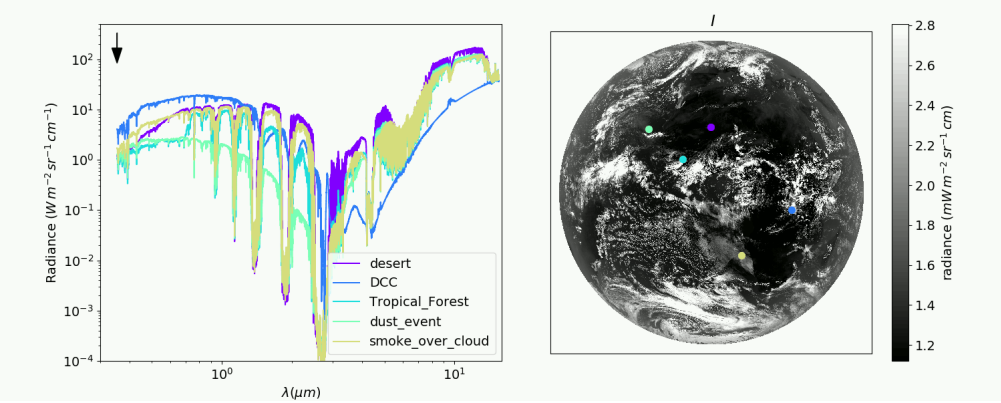
- **Pre-launch test data provide information on content, format and size, primarily for format familiarisation, system testing and science investigations**



- **Following EPS-SG test data has been released**
  - **Three consecutive orbits, netCDF format, in-line with latest processing specifications**

EPS-SG Test Data
MWS L1-L2
RO L1
METimage L1 + L2 + CM
3MI L1b + L1c + L2 MAP
S5 L1 + L2
IASI-NG L1C+L1D + L2
MWI – ICI L1 + L2
SCA L1B

- A set of EPS-SG BUFR test data is also released in March 2023
  - MWS L1B
  - MWI L1B
  - ICI L1B
  - IASI-NG L1C, L1D and L2
  - SCA 1B
  - METimage L2



https://www.eumetsat.int/mtg-test-data

https://www.eumetsat.int/first-version-eps-sg-test-data-bufr-format

https://www.eumetsat.int/eps-sg-user-test-data

IRS L1b Full Disc Test Data

- Released Nov 2022 (TD-417)
- 1 Full disc
  - PCs (IRS-1B-PC)
  - Spectral Radiances (IRS-1B-SSS)
- IRS L1b Product User Guide

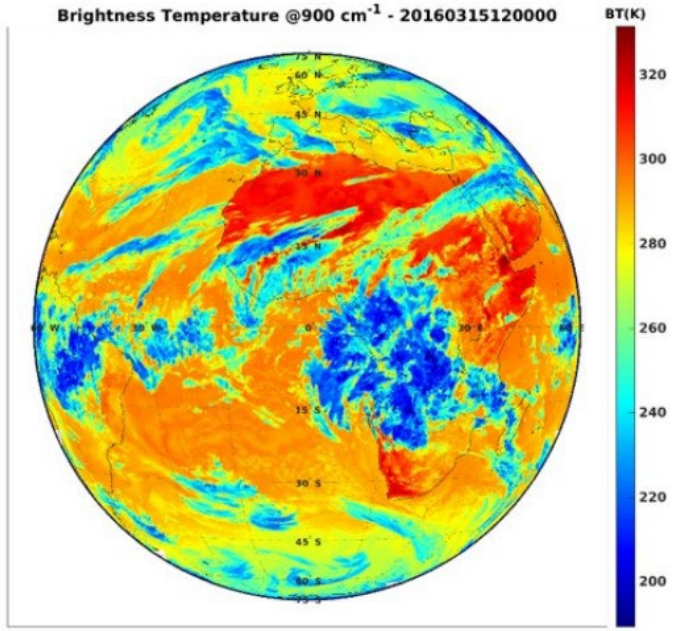


Figure 5: Brightness temperature at 900 cm-1 from the reconstructed radiances, for illustration only; there is no such concept as a "full disc scan" for IRS: as for this Figure, it is possible to assemble all dwells to produce an image of the disc but because of the IRS scan pattern (Fig. 2), the various parts will not have been imaged at the same time nor successively.

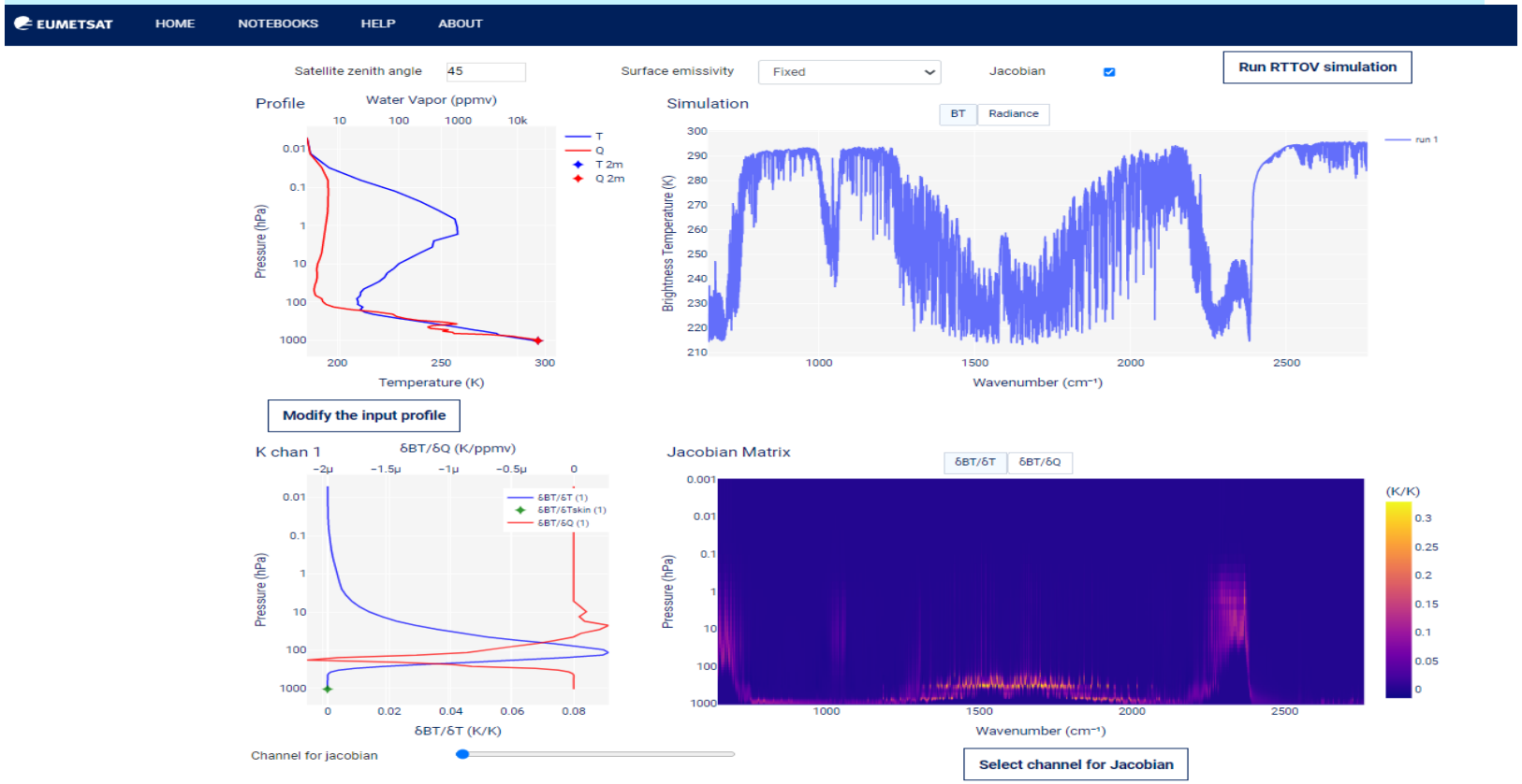
```
# Read input datasets:
EVFile = "CM  PCA-USER MTS1+IRS 20190321090000 static.nc"

PCSFile = "W XX-EUMETSAT-Darmstadt,SND+SAT,MTS1+IRS-1B-PC--Qx--CHK-
BODY--DIS-
NC4E C EUMT 20160315120000 IDPFS DEV 20160315120800 20160315120817
 N  C 0048 0049.nc"

band = "lwir"
quantisation = 0.5
n = 150     # No. global PCs
n local = 5 # No. local PCs.

E = h5read(EVFile, "/$(band)/eigenvectors")
mean = h5read(EVFile, "/$(band)/mean spectrum")
N = h5read(EVFile, "/$(band)/noise normalisation")
R = N * E
P = quantisation .* h5read(PCSFile,
        "/data/$(band)/compressed/global_pc_scores")
p_local = quantisation .* h5read(PCSFile,
        "/data/$(band)/compressed/local_pc_scores")
R local = h5read(PCSFile,
        "/data/$(band)/compressed/local pcr operator")

# Reconstruction from matrix multiplication of global PCs and
# elementwise addition to the mean spectrum
reconstructed[i,j,:] = mean[:] .+ R[:,:] · p[i,j,:]
```

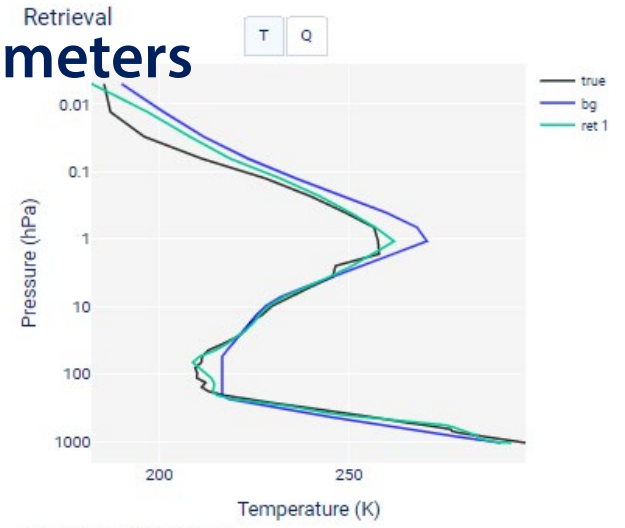
```
# To include the local PC contribution then also
# apply the following matrix multiplication and elementwise
# addition of local elements to the global reconstruction
reconstructed[i,j,:] = reconstructed[i,j,:]
                        .+ R_local[:,:] · p_local[i,j,:]
```

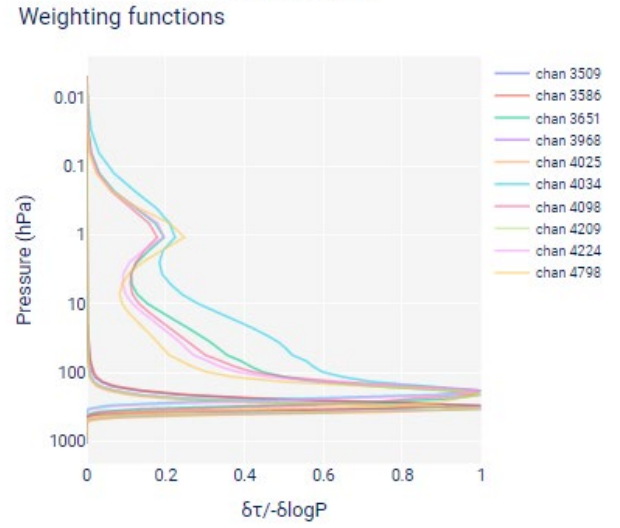
Prototype Web-based Satellite Sounding Training Application

- **A web interface to RTTOV and 1Dvar**
  - **Simulate radiances and jacobians from satellite sounders**
  - **Perform retrievals of temperature, humidity and other parameters**

https://sounding.trainhub.eumetsat.int/







- Online webinars on MTG and EPS-SG observation missions and key applications
- Overview of measurement principles, L1 and L2 product generation, data formats and dissemination

Observation Mission	Dates	Participants	Countries	Q&A
IRS and IASI-NG	13-14 Oct 2020	153	32	38
LI	16-17 Feb 2021	217	49	64
SCA	20-21 May 2021	144	40	31
FCI and METimage	8-10 Jun 2021	174	33	103
3MI	14-15 Jun 2021	130	33	46
MWI/ICI/MWS	12-13 Oct 2021	122	30	45
RO	27-28 Oct 2021	70	26	38
UVN/UVNS	3-4 Nov 2022	61	22	34

- **A baseline of information for guiding users**

Recordings, presentations, Q&A available online:

MTG resources | https://www.eumetsat.int/mtg-resources
EPS-SG resources | https://www.eumetsat.int/eps-sg-resources

User Days 2022 on MTG and EPS-SG

- Checked user readiness for MTG-I1 data;
- Discussed R&D needed to fully exploit the innovation potential in MTG and EPS-SG data:

- Engaged users from Member State NMHSs and academia, SAFs, R&D bodies in Europe, and partners (ESA, NOAA, CNES, DLR, CAMS, WMO)

R&D Synthesis of EUMETSAT User Days 2022

2022 MTG AND EPS-SG USER DAYS

KEY ITEMS REQUIRING R&D SUPPORT

01 New developments to enhance user uptake of satellite-based products

- **Develop (integrated) nowcasting tools** using uncertainty information.
- More research on handling of **spatial and temporal errors**.
- Explore the value of providing model-based O-B analyses to forecasters.
- Analyse fire-related operational forecasting and risk management chains and assess **added value of fire products**.
- **Visualise complex new products** e.g., 4D weather cube, lightning, 3MI - based.
- Provide online monitoring tools of the instruments.
- Systematic assessment of **EUMETSAT/SAF climate data record portfolio**.
- **Develop cloud infrastructure (European Weather Cloud) to improve data accessibility**, enable a multi-sensor approach, facilitate prototyping, and generate documentation.

02 R&D on improving existing or developing new satellite-based products

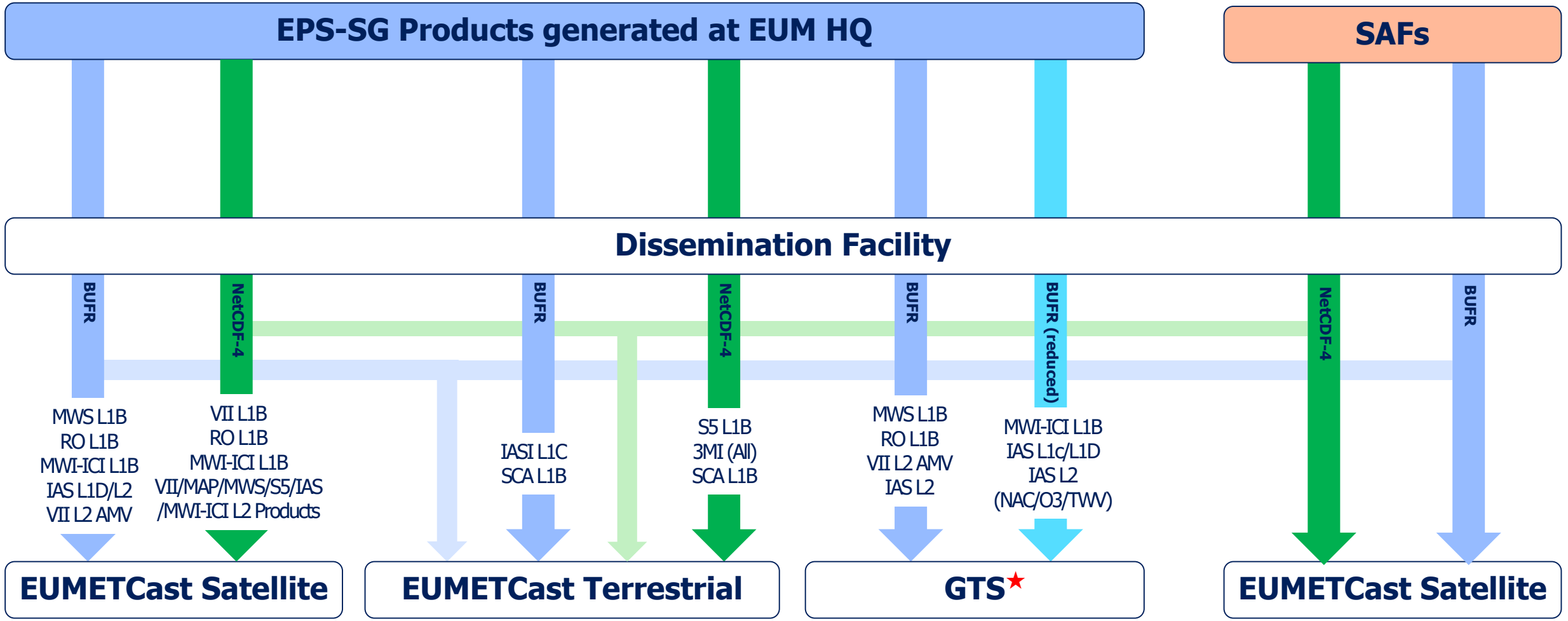
- Develop **merged, multi-sensor, multi-mission (synergy) NRT products**.
- Research into consistent and unbiased multi-mission **climate data records** (L1, L2).
- Develop **all-weather global** products over land, sea ice, and snow cover.
- Additional research to understand **cloud microphysics and phase in severe storms**.
- Research into **merging of precipitation products** (rain rate, accumulated rainfall).
- More research on **fire-related emission estimates** based on satellite products and complementary data.
- More research on **inferring cloud vertical information** to meet demanding aviation requirements.
- More research needed on **cloud microphysics dynamics** during convection using rapid scan imagery and new channels sensitive to thin cirrus clouds and cloud phase.
- Improve **night-time tracking of aerosols and cloud microphysics**, incl. using ML-based techniques.
- Research into developing a prototype peroxyacetyl nitrate (PAN) concentration product derived from TIR.
- Make available a **"sandbox" for flexible product prototyping, testing and feedback**.

03 R&D on underpinning knowledge

- Trigger developments to address **gaps in radiative transfer (RT) models** across the full spectral range and observation conditions.
- Improve **observation operators and surface emissivity models** (over land/sea/sea-ice/snow) to support coupled assimilation, retrievals.
- **Investigate km to sub-km scale processes governing convection** using synergy of MTG 4D Weather Cube.
- Promote and support **long-term investment in fiducial reference measurements** with full uncertainty characterisation over diverse environments.
- Develop OSSE runs for the **assimilation of atmospheric chemistry products** to establish data assimilation approaches.
- Better understand **cloud-aerosol radiative interaction** by creating a collection of cases of poor forecasts due to the presence of dust, and learn from the statistics (focus on Mediterranean area).

Meeting report | https://www.eumetsat.int/media/50569

EPS-SG dissemination baseline



- ✓ The format NetCDF-4 is the baseline for EUMETCast dissemination
- ✓ Archived products will be retrievable in the same formats (NetCDF-4 and/or BUFR), as they were generated and disseminated over EUMETCast

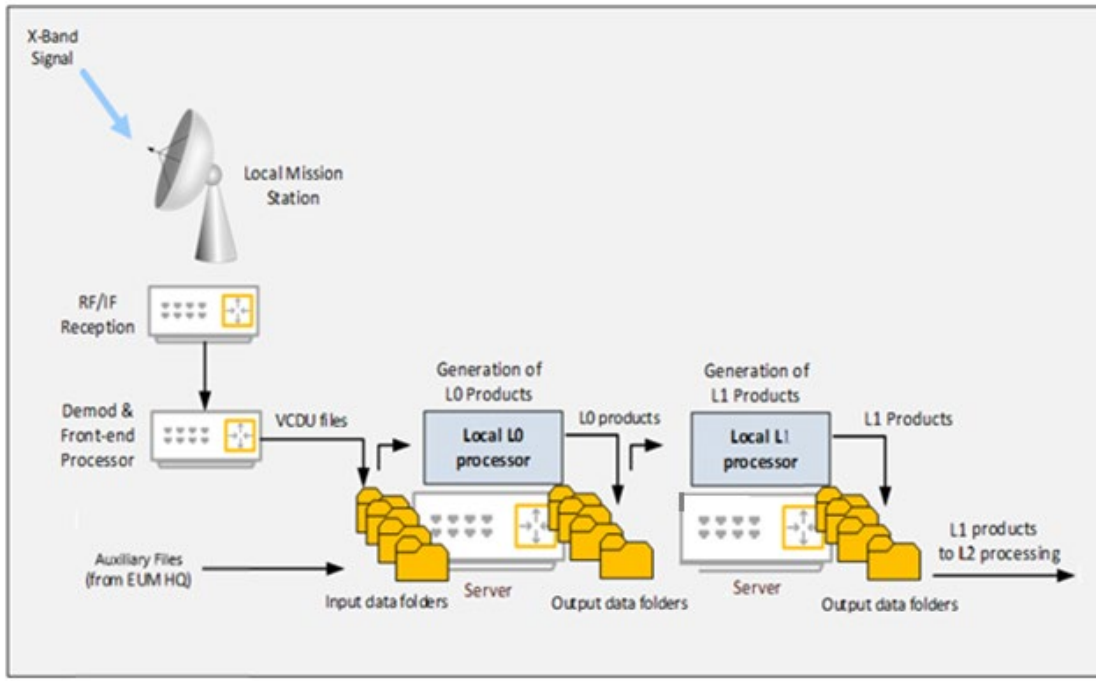
★WIS2

EPS-SG Local Mission overview

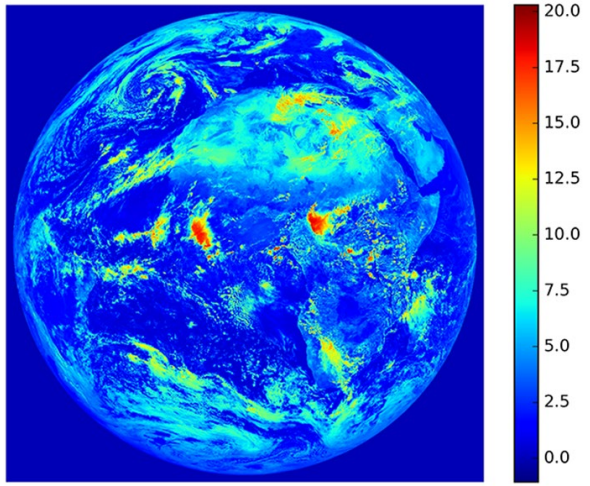
All instruments data will be broadcast in real time by the satellites to receiving stations in visibility of the satellite ("direct broadcast")

- In order to receive and process this data, users will need
  - Receiving stations
    - Receiving antenna: Transmission will be in X-Band and allow reception via a 3-meter antenna
    - Demod and Front End Processor (D-FEP): interfaces directly the Receiving Antenna (RF Signal) and produces as output VCDU Files

    → Metop-SG Direct Data Broadcast (DDB) Space to Ground ICD
  - L0 and L1 processing software procured by EUMETSAT
- NWPSAF provides the Interface between the L0 ,L1 local processors, and local users

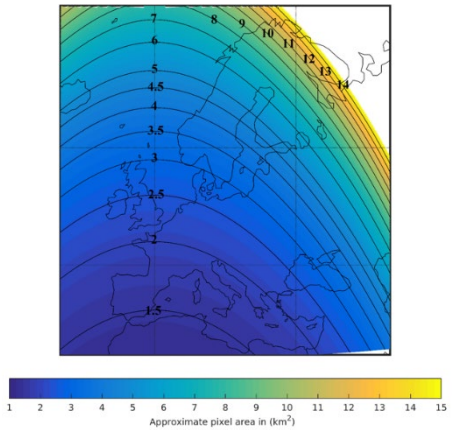


User Preparation Activities



Test data

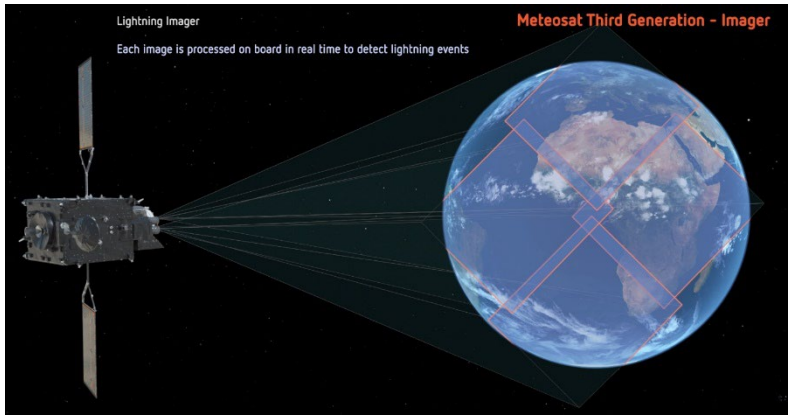
Training testbeds



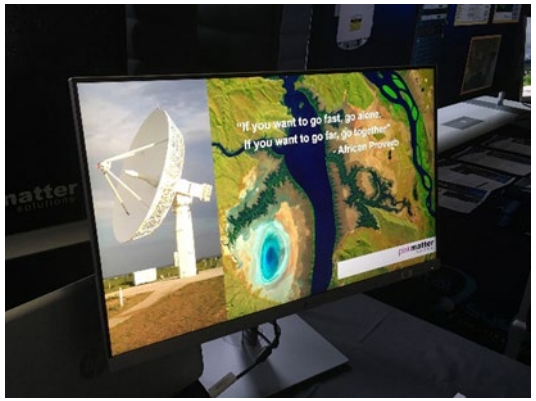
Product guidance

MTGUP User Group
NWP Core User Group

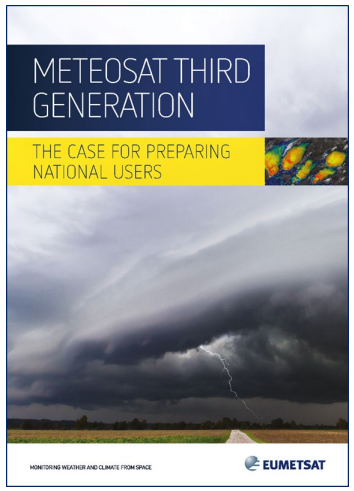
MTG and EPS-SG User Days



Observation mission videos



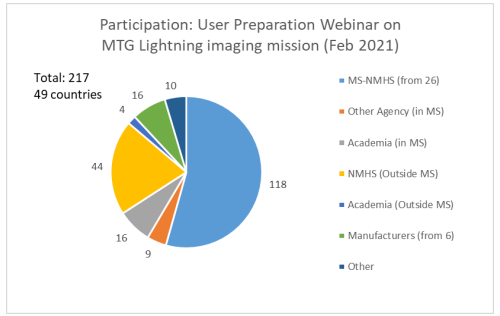
Data access and display



User guidance

FCI L1c NRT user support

Website & future User Portal



Open User Preparation Webinars

Thank you!

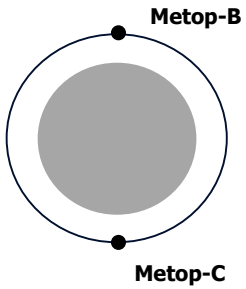
Questions are welcome

https://www.eumetsat.int/meteosat-third-generation

https://www.eumetsat.int/metop-sg .

Metop & Metop-SG Orbit Phasing Proposal (Flight Direction is Counter Clock Wise)

2022

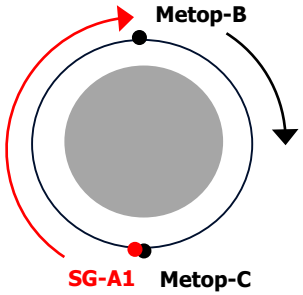


Last Out Of Plane Manoeuvre for Metop-B.

~180 degree Phasing is maintained

(Metop-A already de-orbited)

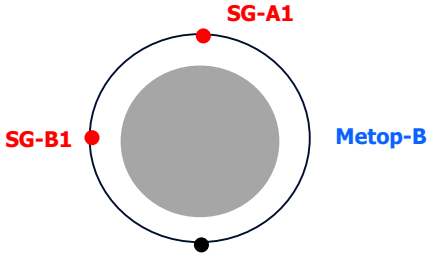
2024



SG-A1 would have a 3-6 months Tandem Flight with Metop-C.

SG-A1 and Metop-C to become primary pair.

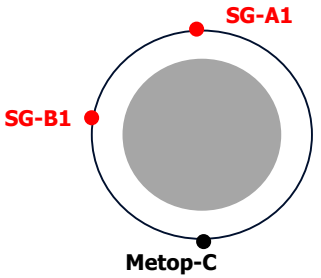
2025



Metop-B LTAN drift is under way (remaining fuel reserved for de-orbiting)

SG-B1 needs no tandem flight, so goes directly to 9 o'clock position.

2027/28



Metop-B will be de-orbited end 2027 or end 2028.

Metop-C phase is maintained, until the slot needs to be freed up for Metop-SG-A2

Commissioning & Cal/Val Timeline

- **Satellite In-Orbit Verification:**
  - L + 3 – verified satellite and instruments functionality, operability and performance against the space segment requirements
- **Commissioning & Cal/Val:**
  - L + 6 – validated L1 products
  - L + 9 – validated IASI-NG L1C, and L1D & L2
  - L + 12 – completion of validation of L2 products
  - L + 12 – validated SAF level 2 and level 3 products

MTG Commissioning planning (overview)

LEOP

System Commissioning — Launch + 12 months

In-Orbit Verification (ESA) — Launch + 9 months

Platform (Satellite")

Instruments

L0 stable

Scientific Validation

L1 Dataset Scientific Validation

L1 stable

Level 2 Product validation

SAF Commissioning

LEOP: Launch and Early Orbit phase, controlling the satellite after it separates from the launch vehicle up to the time when the satellite is safely positioned in its final orbit (10 days).

FCI & LI commissioning are decoupled for MTG-I1: FCI entry into operations is not affected even if LI commissioning tasks would still be ongoing