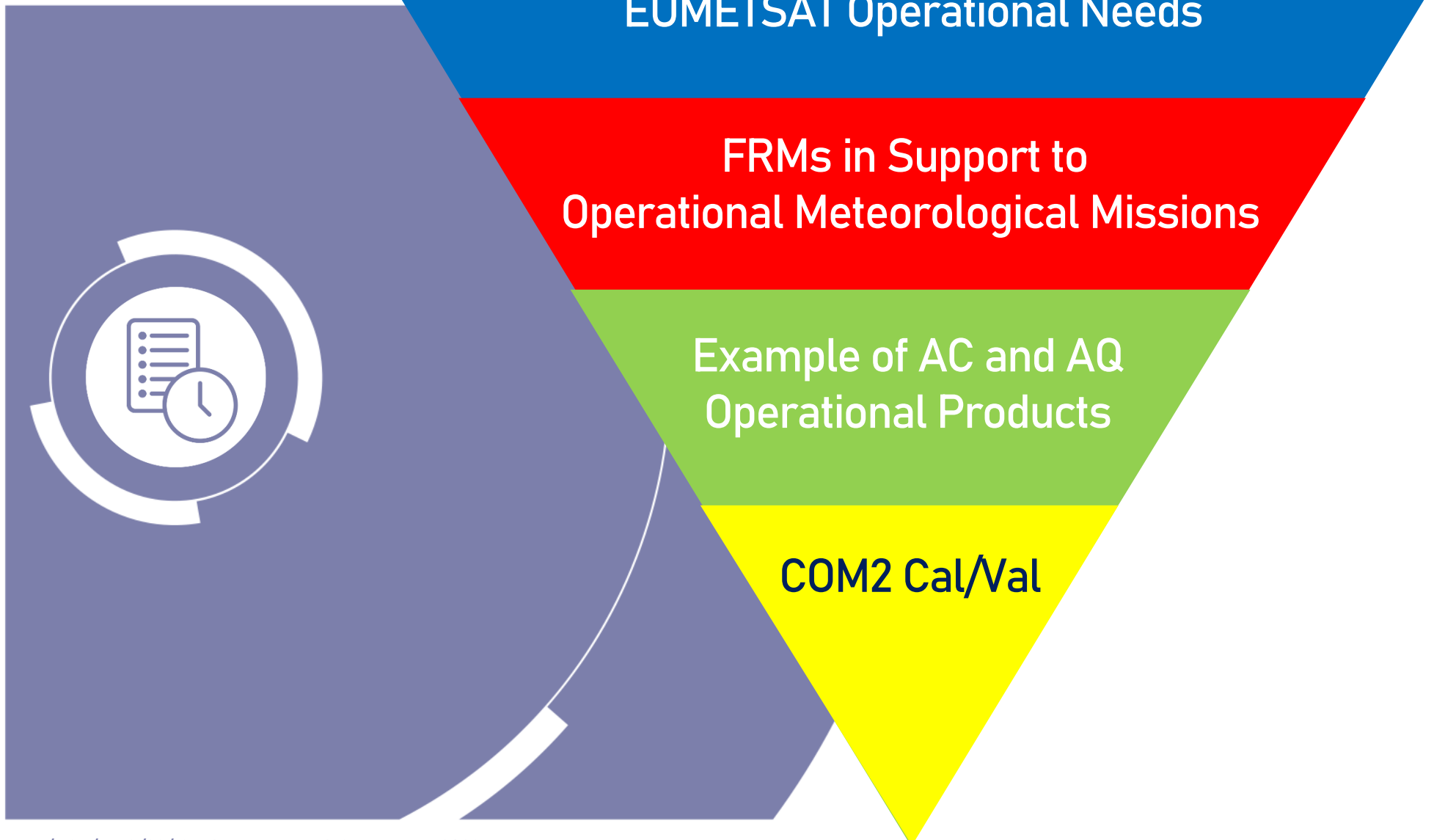


EUMETSAT's Cal/Val Support Strategy

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*CEOS-CGMS Greenhouse Gas Task Team Workshop
17 October 2023*



EUMETSAT Current and Future

Operational Missions



PROGRAMME OF THE EUROPEAN UNION



EUMETSAT

co-funded with

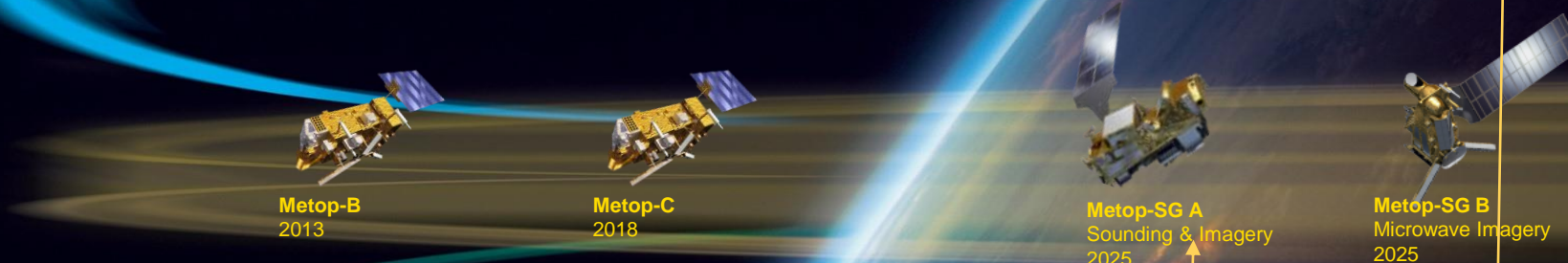


Geostationary Programmes

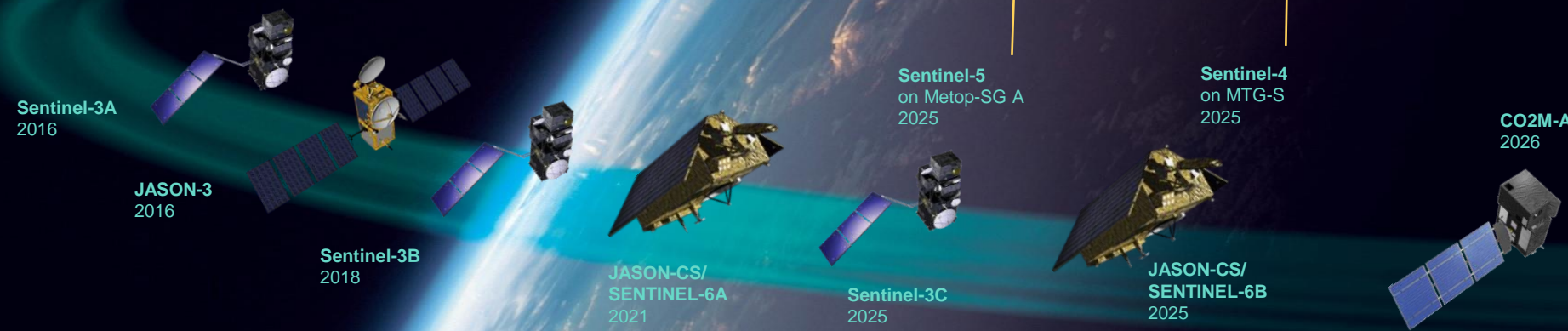


Mandatory Programmes

Polar Programmes



Optional and Third Party Programmes (incl. Copernicus)





The calibration and validation (Cal/Val) activities are a key component of EO missions with two major objectives:

1. Provide data products with associated documented and traceable uncertainty estimates tied to the mission's EURD and Cal/Val plans;
2. Gain understanding of the sensor performances and the algorithm characteristics in order to improve their quality and reliability.

EUMETSAT has additional constrain due to the operational needs:

- Reliability : more than 99% - 24/7
- Timeliness (Near Real Time dissemination from sensing time):
 - 100 to 180 min for LEO
 - 20min for GEO
- Quality control
- Continuity over the mission lifetime : maintenance of timeliness, quality standards, etc.
- Consistency between the different systems



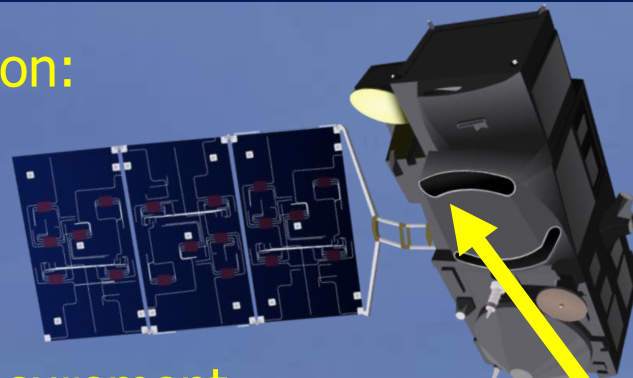
- EUMETSAT is maintaining a FRM Roadmap which describes the needs and propose a way forward to cover for future needs and related possible support to FRMs for the next five to ten years.
- In order to avoid duplication of activities and to minimise costs, the roadmap also monitor and provides an overview of cooperative activities on FRM with:
 - Established “in-situ” networks,
 - Working groups and organisations,
 - Member States,
 - Other Space agencies.
- The goal is to centralise the FRMs needs and therefore highlight commonalities and synergies between the instruments (i.e. product-wise gap analysis);
- The gaps analysis will cover:
 - Gaps in **parameters**;
 - Gaps in **timeliness**;
 - Gaps in **location of station**;
 - Gaps in **auxiliary data**;
 - Gaps in **algorithms for ground based remote sensing measurements** (e.g. accurate RT model).



Metrology Standards and/or **Community Recognised Best Practices**

FRM for the atmospheric column are depending on:

- their vertical distribution
- acquisition geometries
- absorption cross sections
- microphysics assumption for the retrieval
- ingested into modelisation to correct the measurement (e.g. so called air mass factors)
- Traceability of uncertainties is difficult
- **Community recognised best practices**



Gases

Clouds

Aerosols

Vegetation

SST, OC

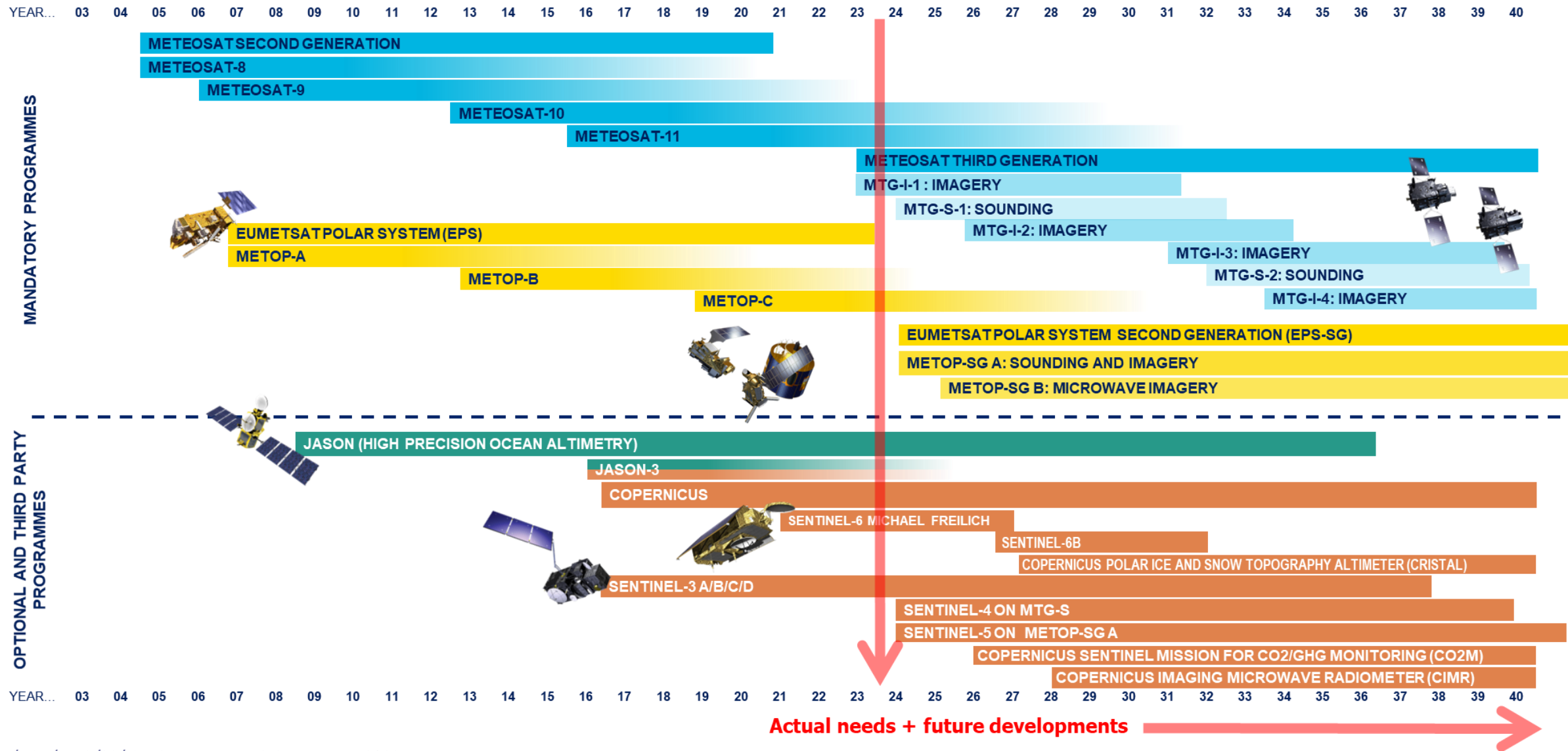
FRM for surface products can be estimated from on-ground measurements

→ Documented SI traceability



Timeline of Activities

The timeline of FRM activities follow the one dictated by the EUMETSAT and EUMETSAT operated Copernicus missions



- Actual missions are covered by Metop (GOME-2, IASI) and Sentinel-3 Platform.
- The upcoming Copernicus Sentinel-4, Sentinel-5, CO2M missions completed with the Metop-SG and MTG-S platform will be the European backbone of operational monitoring of air quality and atmospheric composition from space for the coming decades.
- For the first time, we will get space borne observations of both the global distribution as well as the diurnal cycle **of several key pollutants**.
- The MTG and EPS-SG payload will offer synergies (spatial and spectral) which will fully exploit the potential of the missions.
 - The gap analysis is performed product wise (further supported by similar product performance following recommendation (ECMWF-CAMS, WMO))



Example of AC and AQ Operational Products (ii)

Satellites Missions	Metop GOME-2	IASI	S3 SLSTR	OLCI	MTG S4	IRS	Metop-SG S5	3MI	IASI-NG	CO2M
GASES										
O ₃ total column										
O ₃ tropospheric column										
O ₃ profile										
NO ₂ total column										
NO ₂ tropospheric column										
NO total column										
HCHO total column										
SO ₂ total column										
SO ₂ layer height										
CHOCHO total column										
CO total/partial column										
CO profile										
CO ₂ total column										
CH ₄ total/partial column										
Water vapour total column										
Water vapour profile										
AEROSOLS										
Aerosol optical depth	(1)									
Aerosol effective radius										
Aerosol layer height										
Aerosol refractive index										
Aerosol single scattering albedo										
Aerosol Model or Type	(1) class									
Aerosol absorbing index								(2)		
Fine mode fraction										
Angstrom coefficient										
CLOUDS										
Cloud detection and fraction										

1. PMAp aerosol product (assimilated by CAMS) combining of Metop instruments GOME2/AVHRR/IASI
2. MAP aerosol product combining Metop-SG instruments 3MI/Metimage/S5/IASI-SG



Complementary Scientific services have been identified:

- **FRM4AER** (Service for FRMs for Copernicus Aerosol Product Cal/Val Activities) started in 2023 to assess the needs of the **S3 NRT L2 processor** e.g. improving AOD Ocean & Land and in general for the south hemisphere and taking into account results from other ongoing studies e.g. **Sentinel-3 OLCI Aerosol Layer Height Prototype**
→ support to the EUMETSAT aerosol products assimilated by **CAMS** and **ICAP**
- Support to the **PGN** (in coordination with ESA) to improve:
 - Network spatial coverage e.g. in Europe and Africa
 - Instrument stability, spectral range with related SW update to support the GHG measurements: **PanAMA & PaNIR** (Pandora NIR) prove of concept
 - Pandora instrument for mobile platform (ongoing discussion with **NILU** to install an instrument on the “Kronprins Haakon” ship for high latitude/ocean coverage)
- Support to **Urban AQ** monitoring to fill the gaps in term of parameters and spatial coverage.
- In general support to improve spatial coverage e.g. Africa with consolidation of **RMI ozone sonde station** (compatible with SHADOZ requirements)



Targeted effort through interactions with entrusted entities:

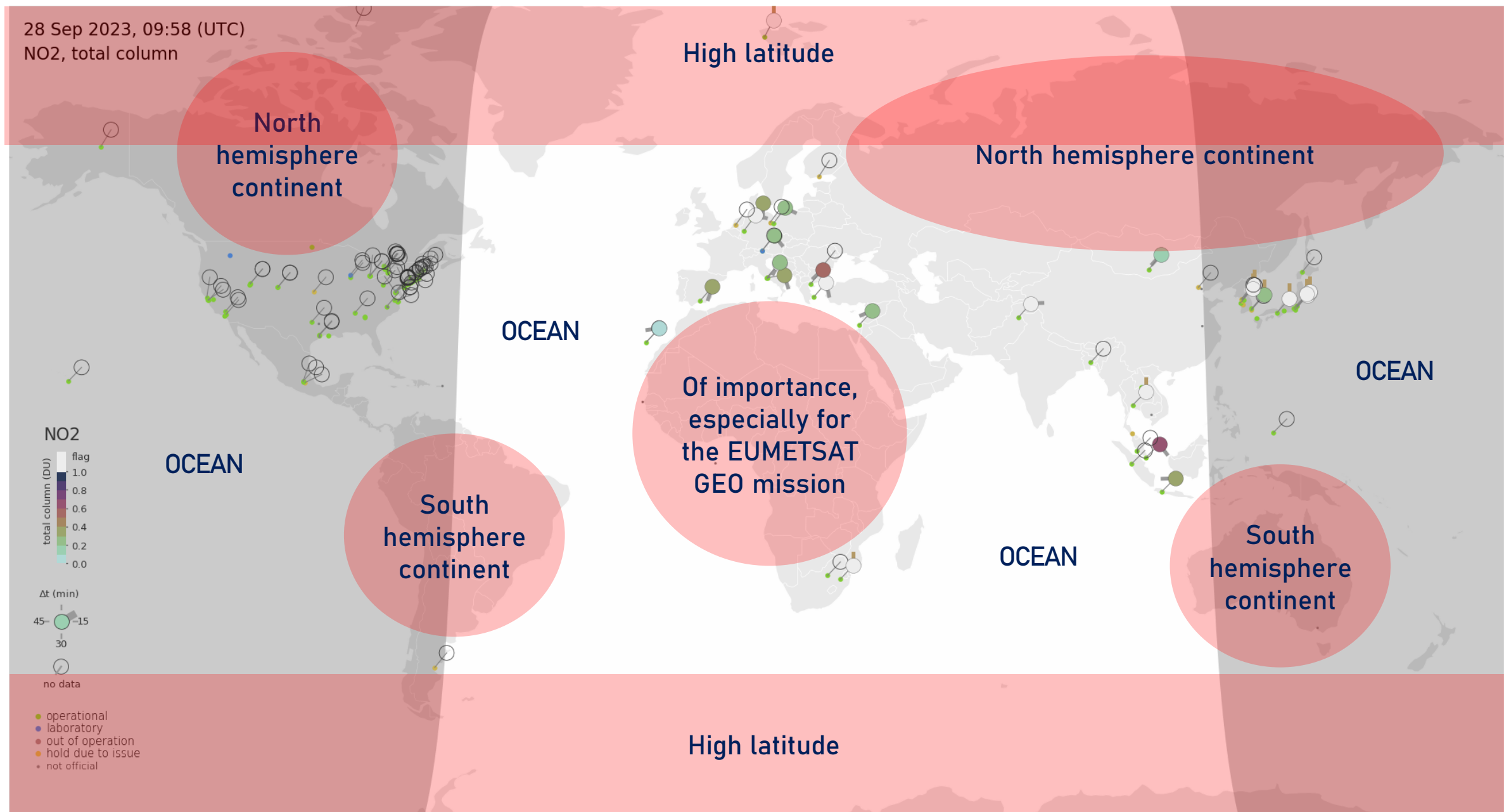
- The EUMETSAT requirements for aerosol/cloud/gas products were presented at the ACTRIS final meeting (held at EUMETSAT premise in April 2019) and propose consolidation of the **ACTRIS operational phase (2025 timeframe)**.
→ EUMETSAT submitted a concept note to **ATMO-ACCESS** to support the TNA (Trans National Access) development and consolidation of aerosol and cloud ground based measurements.
- Supporting **CEOS** discussions/reviews e.g. on the:
 - “**Roadmap towards an Assessment Framework for the FRM**” to which EUMETSAT already proposed to add the timeliness constrain;
 - **GHG Cal/Val Networks** .
- Supporting **WMO** discussions/reviews e.g. on the:
 - **Global Greenhouse Gas Watch (GGGW)**;
 - Development of a **Tiered Observing Network** approach.
- And more with established “in-situ” networks to assess and discuss the possibility to provide FRMs:
 - Ongoing discussion/negotiation with the **global TCCON network**
 - Assessing the use of UAV (e.g. drones) for atmospheric profiling (starting with VW, temperature, pressure)



Example of PGN Gap Analysis: Spatial gaps

28 Sep 2023, 09:58 (UTC)
NO2, total column

at.int



28 Sep 2023, 09:58 (UTC)
NO₂, total column

High latitude

North
hemisphere
continent

North hemisphere continent

OCEAN

Of importance,
especially for
the EUMETSAT
GEO mission

EUMETSAT is initiating projects to:

- Improve the instrumentation (e.g. stability, spectral range)
- Improve the L1/L2 retrievals (e.g. GHG)
- Consolidating PGN

OCEAN

South
hemisphere
continent

OCEAN

South
hemisphere
continent

High latitude

NO₂
total column (DU)

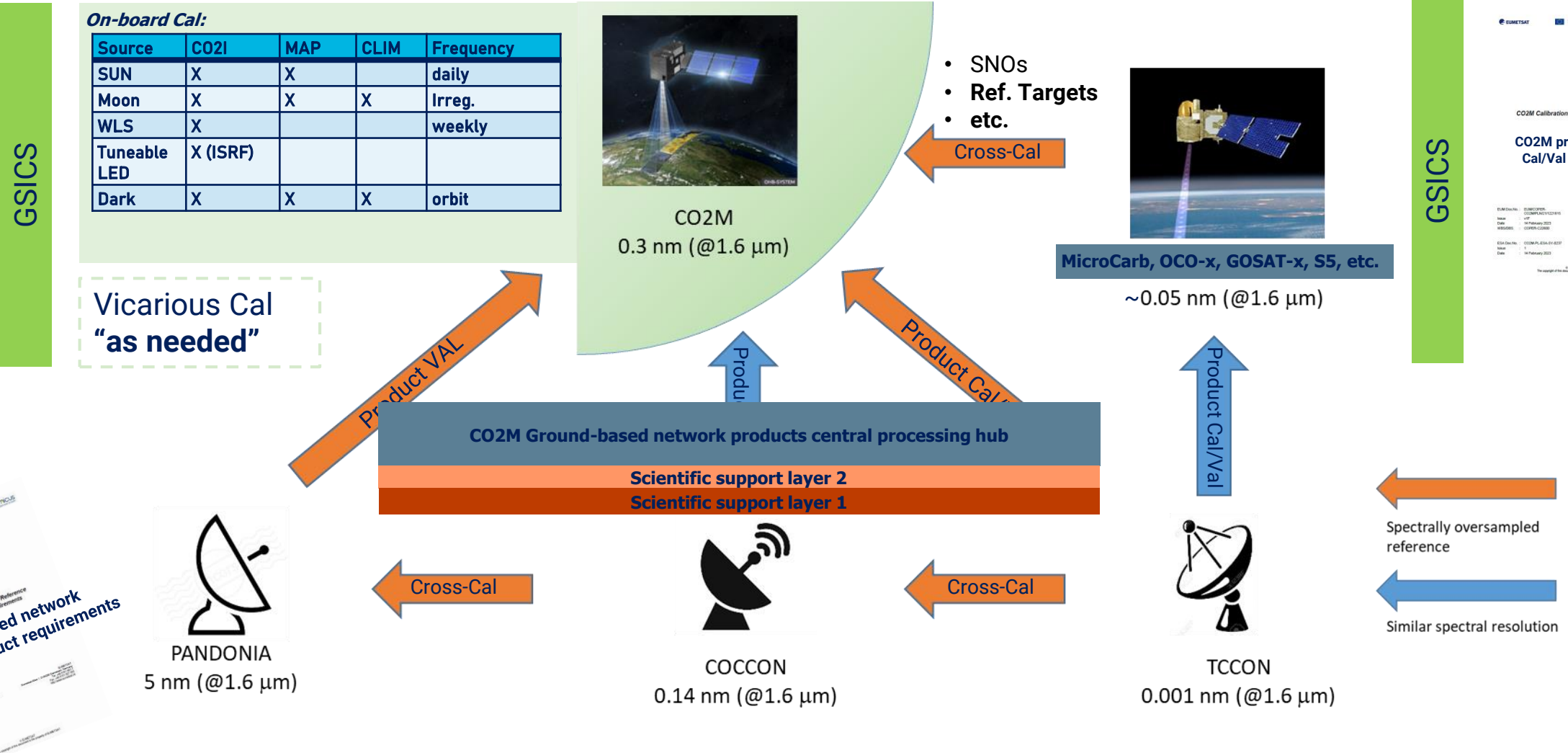
Δt (min)

no data

- operational
- laboratory
- out of operation
- hold due to issue
- not official



“Four+”-pillar CO2M validation



Vicarious Cal
“as needed”



“Four-pillar” CO2M operational product validation and monitoring space-to-ground and space-to-space approach

+ NDACC/Aeronet for NO2 and AOD



At a workshop organised adjacent to the IWGGMS-19 meeting in Paris, and in dedicated interactions with TCCON and the network PI (Debra Wunch), the status can be summarised as follows:

- ✓ There is a growing awareness of the need for the networks to **move towards a service-based component with a single interface**, addressing the needs of space-based and modelling-based operational system infrastructure.
- ✓ With the current developments for inter- and intra-network(s) “travelling standard”, the missing link to WMO traceability remains the spectroscopy (after full implementation of travelling standards).
- ✓ EUMETSAT preference for the CO2M mission is **the reception of level-1 data using the GGG (TCCON) and ProFast (COCCON) processors** to produce **CO2M mission dedicated level-2 data** in a EUMETSAT ground-based product processing central facility and **for internal mission use only (and no redistribution of data)!**
- ✓ The CO2M mission dedicated level-2 data processing will be done with auxiliary information consistent with what is used in the CO2M operational product processing system. In parallel, **the networks would be provided with all (auxiliary) input data required for their own processing (in case of interest)** - so the PIs can make their own products from such data.
- ✓ To ensure the continuous monitoring and validation of operational CO2M products EUMETSAT plans to establish **a service agreement with the TCCON and COCCON global networks for the timely provision of level-1 data.**



Next to the discussions with TCCON on data provision:

- We started the work with KIT which should make also the central provision of data.
 - This is in coordination with ESA/ESRIN - FRM4GHG (Angelika Dehn) who contribute the investment in instrument development and automation.
- In addition, we invest in the very promising development of Pandonia instruments for GHG (PaNIR).
 - This is a highly automated system successfully used for AQ, and even easier deployable as COCCON and TCCON. However, the required performance (accuracy/precision) for GHG reference measurements has to be proven (expected for 2024).
 - PaNIR has the potential compensating for some of the problems with timely data provision from the current networks and cost of maintenance and operations.



- It is important for EUMETSAT, as an operational agency, to ensure, as far as possible, a gapless provision of data in support of its Cal/Val activities, including for FRM when mission needs change or new needs arise.
- The EUMETSAT FRM roadmap provides a process to monitor such data provisions by centralising the EUMETSAT mission needs which are identified through the mission requirements and Cal/Val plans.
- The resulting gap analysis identified targeted support to the AC and AQ missions operated by EUMETSAT
- In particular the GHG missions, like CO2M, are actively working on Cal/Val solutions through studies and interactions with networks and entrusted entities.



Questions?