European perspectives (ESA EDAP, TPM, CCM)

Leonardo De Laurentiis (ESA)
(Leonardo.De.Laurentiis@esa.int)
14/Apr/2025


2010
2015
2020
2025
ERS-1
ERS-2
Envisat
MetOp-A
Meteosat 10 (MSG)
MetOp-B
Meteosat 11 (MSG)
MetOp-C
Proba-1
SMOS
GOCE
CryoSat
Swarm
Proba-V
Sentinel-1A
Sentinel-1B
Sentinel-2A
Sentinel-2B
Sentinel-3A
Sentinel-3B
Sentinel-5P
Sentinel-6 Michael Freilich
Sentinel-1C
Sentinel-2C
Sentinel-3C
Sentinel-1D
Sentinel-2D
Sentinel-3D
Sentinel-6B
MTG-I1
Sentinel-5A MetOp-SG-A1
Arctic Weather Satellite
MetOp-SG-B1
CO2M-A
Sentinel-4A MTG-S1
MTG-I2
CO2M-B
Aeolus
Biomass
EarthCARE
ALTIUS
FLEX
Scout-1
FORUM
TRUTHS
Earth Explorer-10
Earth Explorer-11
CIMR-A
ROSE-L-A
CRISTAL-A
LSTM-A
CHIME-A
CRISTAL-B
ROSE-L-B
LSTM-B
CIMR-B
CHIME-B
Sentinel-1
Sentinel-2
Sentinel-3
Sentinel-6
Next Generation
ESA acts as a customer, `a partner or an enabler
Commercial EO
National missions
2030
Very High Resolution
synergy
Science
Copernicus
Meteorology
EUMETSAT
ESA commercialisation roles
→ `customer, partner, enabler
"Traditional" ESA procurement role
THE EUROPEAN SPACE AGENCY

ESA buys EO data for its own purpose or on behalf of other institutions
→ *ESA Third Party Missions and Copernicus Contributing Missions*

esa **Basic Activities**

Earthnet Third Party Missions

EO data for R&D and science needs

Initial data assessment
(mainly for commercial EO data)

→ *includes some coordination with NASA*

copernicus Europe's eyes on Earth

esa

Copernicus Contributing Missions

EO data (and associated delivery services) for operational public needs

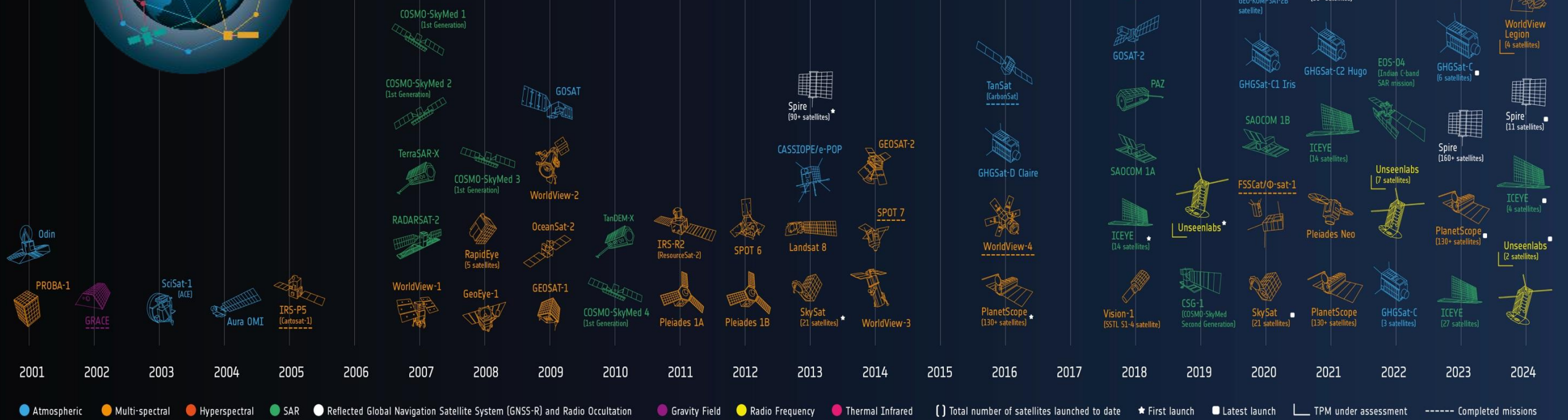
Operational data delivery:
- from established data suppliers
- from **emerging data suppliers**

THIRD PARTY MISSIONS
TIMELINE

SAR, Multispectral, Atmospheric missions approved as ESA Third Party Missions (for scientific use)

- EOS-4 (Indian ISRO C-band SAR added as ESA TPM in 2024)
- Missions under assessment in emerging data domains (Hyperspectral, thermal infrared, atmospheric composition)

- *ESA-JAXA cooperation on using SAR satellites in Earth Science and Applications*
- *ESA-NASA cooperation on assessment of EO commercial data*



THIRD PARTY MISSIONS
TIMELINE

SAR, Optical, Atmospheric missions approved as ESA Third Party Missions (for scientific use)

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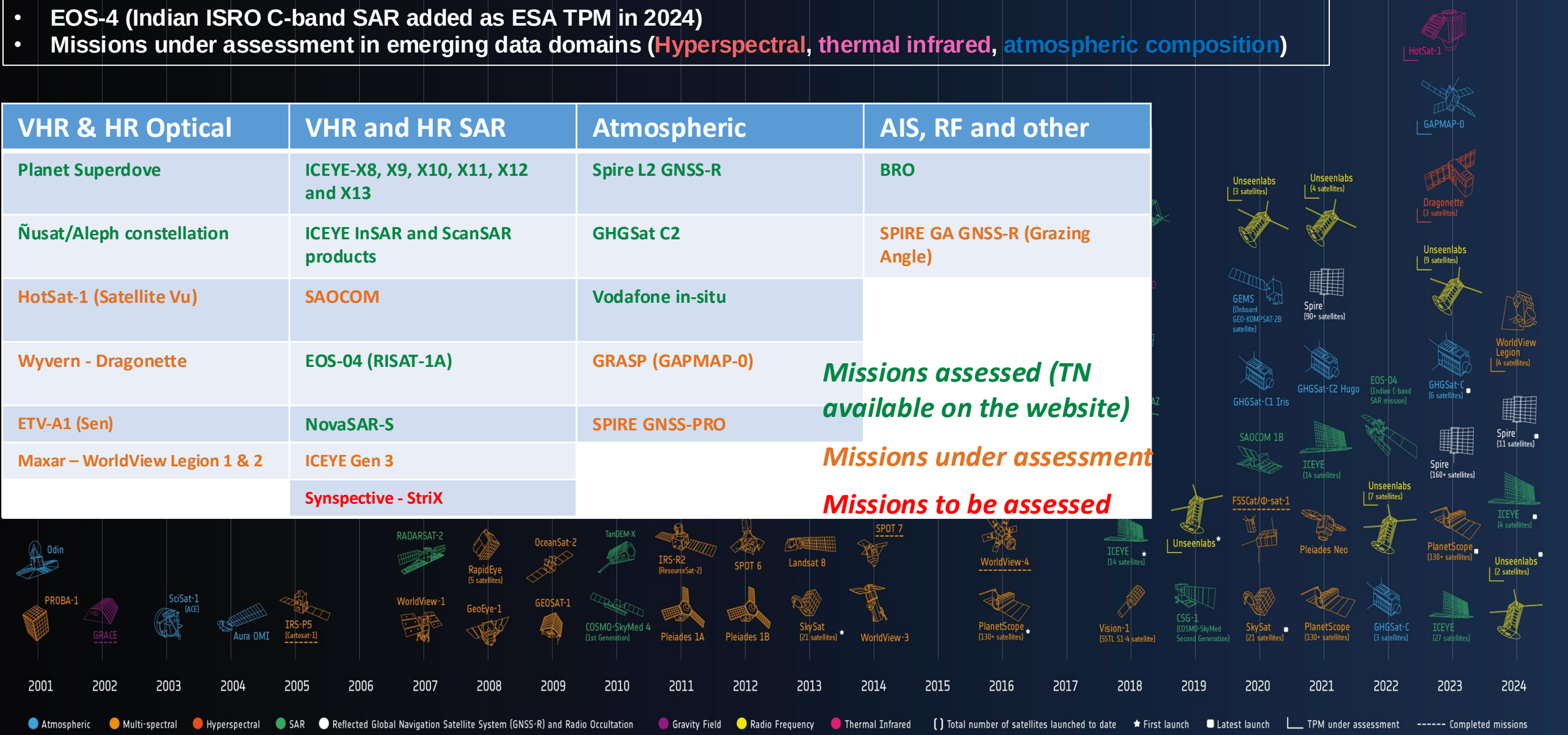
- Missions under assessment in emerging data domains (Hyperspectral, thermal infrared, atmospheric composition)

VHR & HR Optical	VHR and HR SAR	Atmospheric	AIS, RF and other
Planet Superdove	ICEYE-X8, X9, X10, X11, X12 and X13	Spire L2 GNSS-R	BRO
Ñusat/Aleph constellation	ICEYE InSAR and ScanSAR products	GHGSat C2	SPIRE GA GNSS-R (Grazing Angle)
HotSat-1 (Satellite Vu)	SAOCOM	Vodafone in-situ	
Wyvern - Dragonette	EOS-04 (RISAT-1A)	GRASP (GAPMAP-0)	
ETV-A1 (Sen)	NovaSAR-S	SPIRE GNSS-PRO	
Maxar – WorldView Legion 1 & 2	ICEYE Gen 3		
	Synspective - StriX		

Missions assessed (TN available on the website)

Missions under assessment

Missions to be assessed



Missions previously addressed during the first EDAP: 2018 - 2021

Very High and High-Resolution optical sensor:

- Skysat
- PlanetScope Dove
- Maxar HD
- Nemo HD
- Skysat Video
- Landsat 1-7
- Landsat 8
- Proba-1 (CHRIS)
- Dove-R
- HySIS
- Vivid-i
- Blacksky
- Vision-1
- SuperDove
- GRUS-1 (AxelSpace)
- Jilin-1 SP03 (Video)
- GF02A
- GF03B
- GXA
- Jilin-1 KF01
- Jilin-1 GF03A
- Jilin-1 GP01

Low-Resolution optical sensor:

- Oceansat-2
- MOS
- GOMX-4 (HyperScout-1)
- FSSCat (Hyperscout-2)

Very High and High-Resolution SAR sensor:

- SAOCOM 1A
- ICEYE-X2
- ICEYE X4-X7
- SAOCOM 1B
- Capella
- PAZ
- Cosmo / TerraSAR-X / PAZ Intercomparison

Atmospheric mission domain:

- GHGSat-D (Claire)
- GHGSat-C1 (IRIS)
- GOSAT-1
- GOSAT-2
- TANSAT
- GCOM-C
- SPIRE

Technical notes available on the website

→ ***https://earth.esa.int/eogateway/activities/edap***
→ ***https://earth.esa.int***

PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

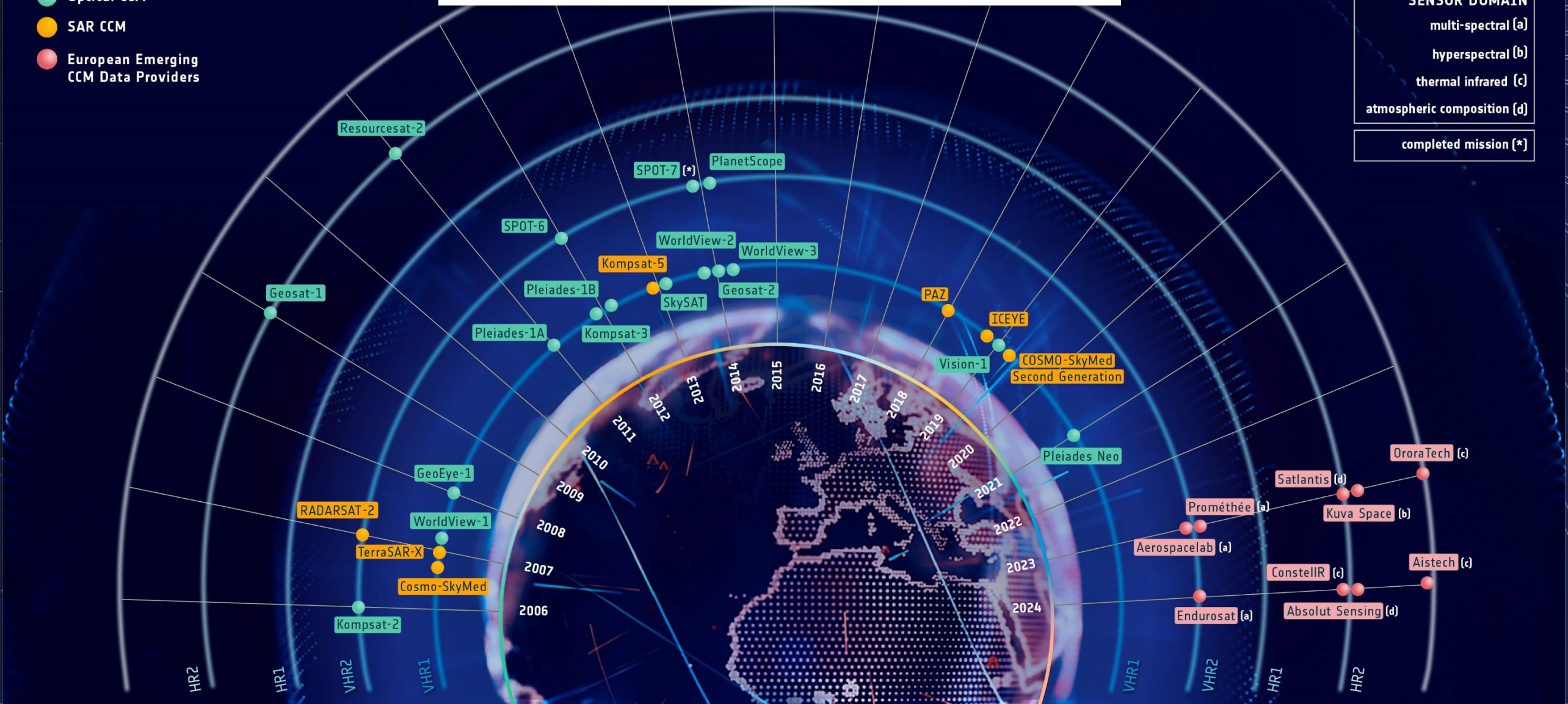
co-funded with esa

Copernicus Contributing Missions (established and emerging data suppliers) – current status

- Optical CCM
- SAR CCM
- European Emerging CCM Data Providers

SENSOR DOMAIN
- multi-spectral (a)
- hyperspectral (b)
- thermal infrared (c)
- atmospheric composition (d)

completed mission (*)



PROGRAMME OF THE EUROPEAN UNION

co-funded with esa

Copernicus Contributing Missions (e
emerging data suppliers) – curr

- Optical CCM
- SAR CCM
- European Emerging CCM Data Providers

SENSOR DOMAIN
- multi-spectral (a)
- hyperspectral (b)
- thermal infrared (c)
- atmospheric composition (d)

completed mission (*)

CCM contractual landscape – April 2025

PROGRAMME OF THE EUROPEAN UNION

opernicus Europe's eyes on Earth

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	(European) Emerging data providers	Established data providers	
	Current Category-1	Current Category-2 (EU)	Current Category-3 (non-EU)
Multispectral - ≤1m		AIRBUS	MAXAR TECHNOLOGIES through EUSI; planet.
Multispectral - ≤4m	ENDUROSAT; aerospacelab; PROMETHEE EARTH INTELLIGENCE	GEOSAT; AIRBUS	planet.
SAR		e-geos; AIRBUS; hisdeSAT; ICEYE	MDA
Atmospheric Composition	ABSOLUT Sensing; SATLANTIS		GHGSAT
Thermal IR	constellr; ORORA TECHNOLOGIES; AISTECH access to intelligent space technologies		
Hyperspectral	KUVA SPACE		
Radio Frequency			

esa 50 1975 2025

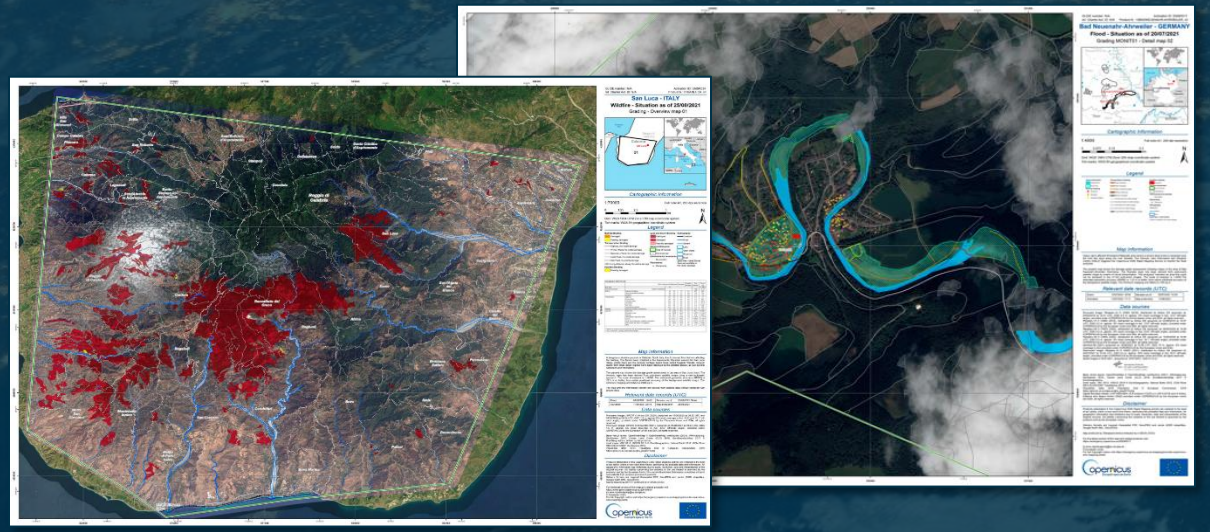
20 contracts so far in different procurement categories

A second competition in CCM Category-1 is ongoing (up to 7 additional contracts with European emerging data providers) will be signed in Q2 2025, to cover different data domains

Two main groups of CCM data needs

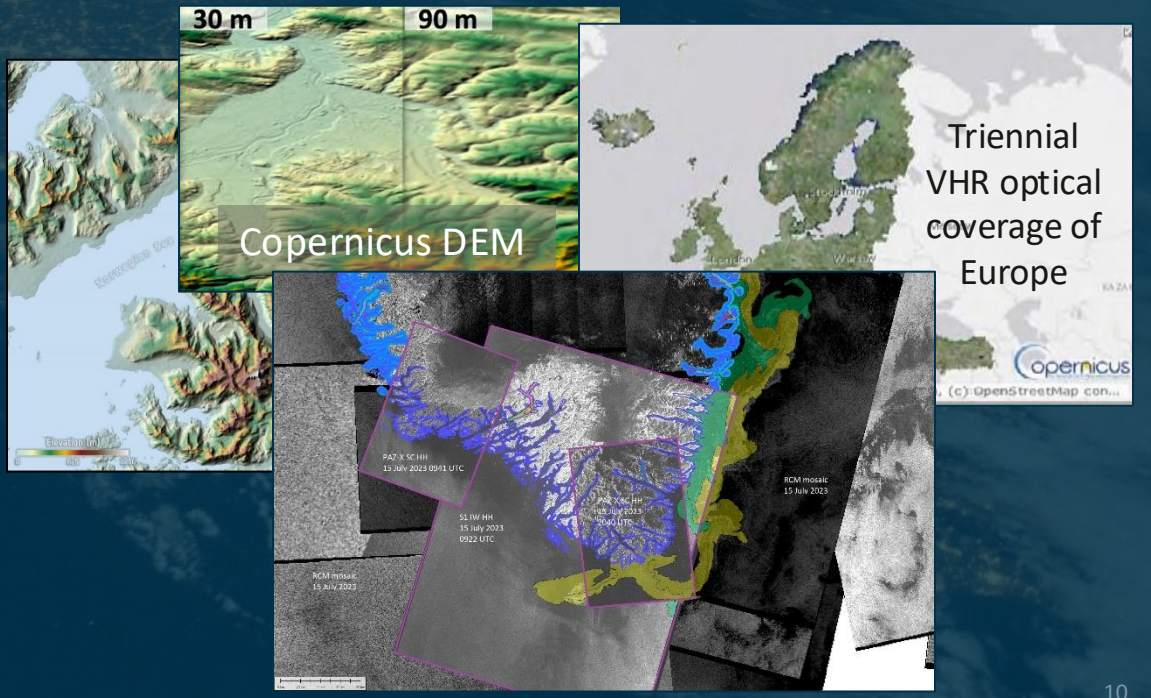
On-Demand data

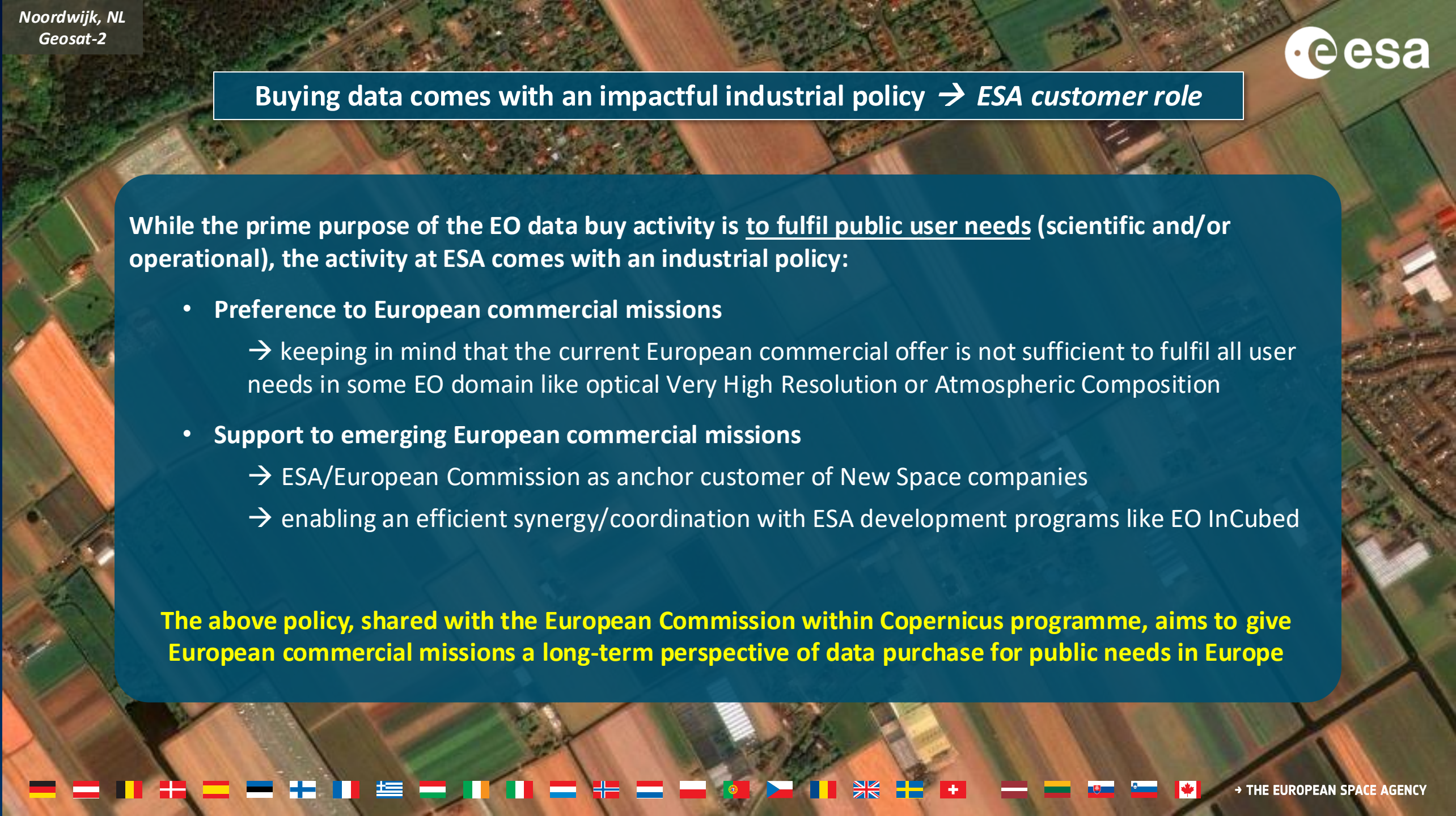
*Acquired mostly in **rush mode** over areas affected by natural and man-made disasters or crisis situations, for the needs of the Copernicus **Emergency** or **Security Services***



Systematic coverage data

CCM predefined seasonal coverages for the needs of the *Copernicus **Land Monitoring or Marine Monitoring Services***





Buying data comes with an impactful industrial policy → *ESA customer role*

While the prime purpose of the EO data buy activity is <u>to fulfil public user needs</u> (scientific and/or operational), the activity at ESA comes with an industrial policy:

- **Preference to European commercial missions**

  → keeping in mind that the current European commercial offer is not sufficient to fulfil all user needs in some EO domain like optical Very High Resolution or Atmospheric Composition

- **Support to emerging European commercial missions**

  → ESA/European Commission as anchor customer of New Space companies

  → enabling an efficient synergy/coordination with ESA development programs like EO InCubed

The above policy, shared with the European Commission within Copernicus programme, aims to give European commercial missions a long-term perspective of data purchase for public needs in Europe

Windsor, UK
Vision-1

Through data buy, ESA assess the quality of commercial EO data
→ *ESA data quality stamp*

Since few years, ESA increased its activity related to the assessment of commercial EO data:

- Earthnet Data Assessment Project (EDAP): early data quality assessment of existing or future missions, with focus on New Space and multi-mission activities.
- A benchmark concept (Product Quality Evaluation Matrix) has been developed and is used to evaluate the quality of commercial mission products
- The role of the Sentinel Mission Performance Clusters (MPC) is expanded to support ESA for the assessment of the CCM data quality (mainly for the emerging data suppliers)
- A yearly forum (VH-RODA) organised by ESA addresses the quality of commercial missions (mainly Very High Resolution)

Product Quality Evaluation Matrix

Product Information	Product Generation	Ancillary Information	Uncertainty Characterisation	Validation
Product Details	Sensor Calibration & Characterisation Pre-Flight	Product Flags	Uncertainty Characterisation Method	Reference Data Representativeness
Availability & Accessibility	Sensor Calibration & Characterisation Post-Launch	Ancillary Data	Uncertainty Sources Included	Reference Data Quality
Product Format	Retrieval Algorithm Method		Uncertainty Values Provided	Validation Method
User Documentation 🔒	Retrieval Algorithm Tuning		Geolocation Uncertainty	Validation Results
Metrological Traceability Documentation 🔒	Additional Processing			

Key
Not Assessed
Not Assessable
Basic
Intermediate
Good
Excellent

🔒 Information Not Public

Example with GHGSat-C1 (Iris)

VH-RODA Community

→ this should stimulate the interoperability between CCM and Sentinel missions

EDAP+ Overview

- Service kicked off in July 2022 with 2-year initial duration
- Tasked to perform **early data assessment** on various existing, new and future EO missions
  - Focus on the NewSpace sector
    - The EDAP Assessment on data and documentation quality is one of the **preliminary steps to potential TPM integration**
- Divided into separate instrument domains led by leading European data QC experts
  - Very High Resolution (VHR) & High Resolution (HR) Optical;
  - VHR & HR Synthetic Aperture Radar (SAR);
  - Atmospheric;
  - AIS (RF) & Other
- Additional Tasks focused on
  - QA Framework Best Practice development
  - DEM & Multi-mission Studies
  - Provide scientific, technical and administrative support to ESA for workshops (incl. **VH-RODA**)
  - Maintain and populate the EDAP+ service website

esa

TELESPAZIO a LEONARDO and THALES company

PRIME CONTRACTOR

NPL National Physical Laboratory

serco

aresys

Ilmatieteen laitos Meteorologiska institutet Finnish Meteorological Institute

NORCE

Technical University of Munich

VisioTerra

TELESPAZIO a LEONARDO and THALES company

SUB-CONTRACTORS

2024 Highlights

- Extension of service lifetime
  - 17-month extension to the service taking it to Dec-25
  - 1M€ additional activities

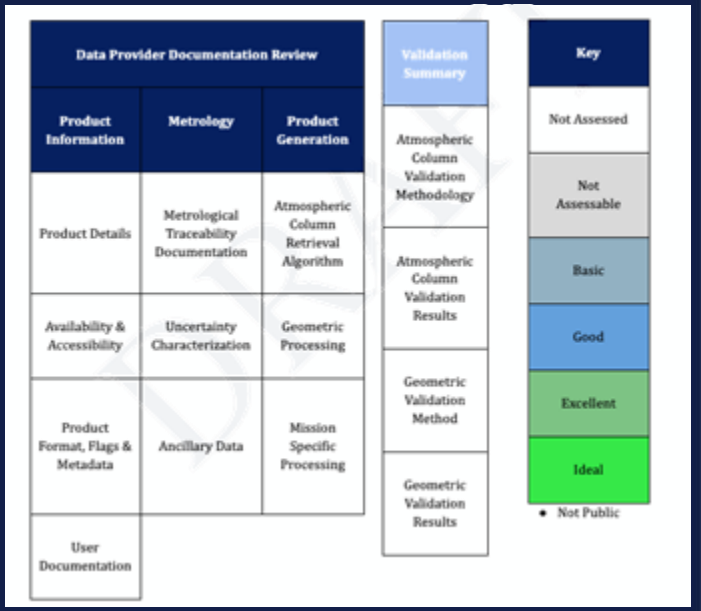
- **ESA-NASA Joint EO Mission QA Framework agreement**
  - Official sign-off of the "ESA-NASA Joint EO Mission Quality Assessment Framework – SAR Guidelines" took place in June 2024

- ESA-NASA Signature of **OPT guidelines** (2025)
- Refinement/development of ATM guidelines (2025)
- Development within **other domains** (e.g., ALT,..) + **Usability** (2025)
- ESA-NASA **Joint assessments**??

NASA's Melissa Yang Martin (Commercial Smallsat Data Acquisition Program Manager) and ESA's Henri Laur (Head of Mission Management and Product Quality Division), at official signature of the ESA-NASA's Joint EO Mission Quality Assessment Framework – SAR Guidelines, in June 2024.
Credits: ESA/NASA

EDAP Guidelines – ATM domain

- **EDAP+ ATM guidelines**
  - ESA-NASA Coordination + CEOS
    - (Common Practice assessing Facility Scale Methane emissions)
  - GHG Atmospheric column Guidelines
    - Total/average column or column enhancement data products (Level 2) from calibrated L1B radiance
  - Emission products Guidelines
    - Emission products (Level 4) derived from atmospheric trace gas column data (Level 2)
  - Guidelines to be used by the ATM-MPC within the CCM framework
    - Currently, 2 Cat.1 CCMs in the ATM domain: Satlantis and Absolut Sensing
    - New Cat.1 CCMs in the ATM domain to be onboarded within Summer 2025



OPT-MPC Overview

The O**ptical Mission Performance Cluster (OPT-MPC)** is part of the Copernicus Sentinel Ground Segment

- Cal/Val component in charge of Mission Performance Assessment through
  - Calibration (CAL)
  - Validation (VAL)
  - Verification (VER)
  - Quality Control (QC)
  - Algorithm Maintenance and Evolution
  - Operational data processors and tools correction and evolution

Focus on **Sentinel** Optical missions, involved with the **CCMs** since June 2023

ACRI ST, France

with sub-contractors

adwäisEO, Luxemburg

Airbus DS, France

Albavalor, Spain

Brockmann Consult, Germany

CS Group, France

Deimos, Spain

DLR, Germany

Earth Insight, Ireland

FMI, Finland

King College of London, UK

Leonardo S.p.A., Italy

RAL Space, UK

Spectral Earth, Germany

Swansea University, UK

SERCO, Italy

Telespazio, France

University of Leicester, UK

University of Southampton, UK

VITO, Belgium

with associate partners

Cat.1 CCMs – Maturity Assessment

The EDAP Maturity Matrices are used to evaluate the data quality

Data Provider Documentation Review		
Product Information	**Metrology**	**Product Generation**
Product Details	Radiometric Calibration & Characterization	Radiometric Calibration Algorithm
Availability & Accessibility	Geometric Calibration & Characterization	Geometric Processing
Product Format, Flags & Metadata	Metrological Traceability Documentation	Retrieval Algorithm
User Documentation	Uncertainty Characterization	Mission-Specific Processing
	Ancillary Data	

Validation Summary
Radiometric Validation Method
Radiometric Validation Results Compliance
Geometric Validation Method
Geometric Validation Results Compliance

Validation Summary	Detailed Validation			
Radiometric Validation Method	Radiometric	Absolute Calibration Method	Signal to Noise Ratio	Temporal Stability Method
Radiometric Validation Results Compliance	Radiometric	Absolute Calibration Results Compliance	Signal to Noise Results Compliance	Temporal Stability Results Compliance
Geometric Validation Method	Geometric	Sensor Spatial Response Method	Absolute Positional Accuracy Method	Band-to-Band Registration Method / Temporal Stability Method
Geometric Validation Results Compliance	Geometric	Sensor Spatial Response Results Compliance	Absolute Positional Accuracy Results Compliance	Band-to-Band Registration Results Compliance / Temporal Stability Method

Key
Not Assessed
Not Assessable
Basic
Good
Excellent
Ideal

Each item is given a grade from “Not Assessable” to “Ideal”

For each item, recommendations are given regarding how to improve

Cat.1 CCMs – Maturity Assessment

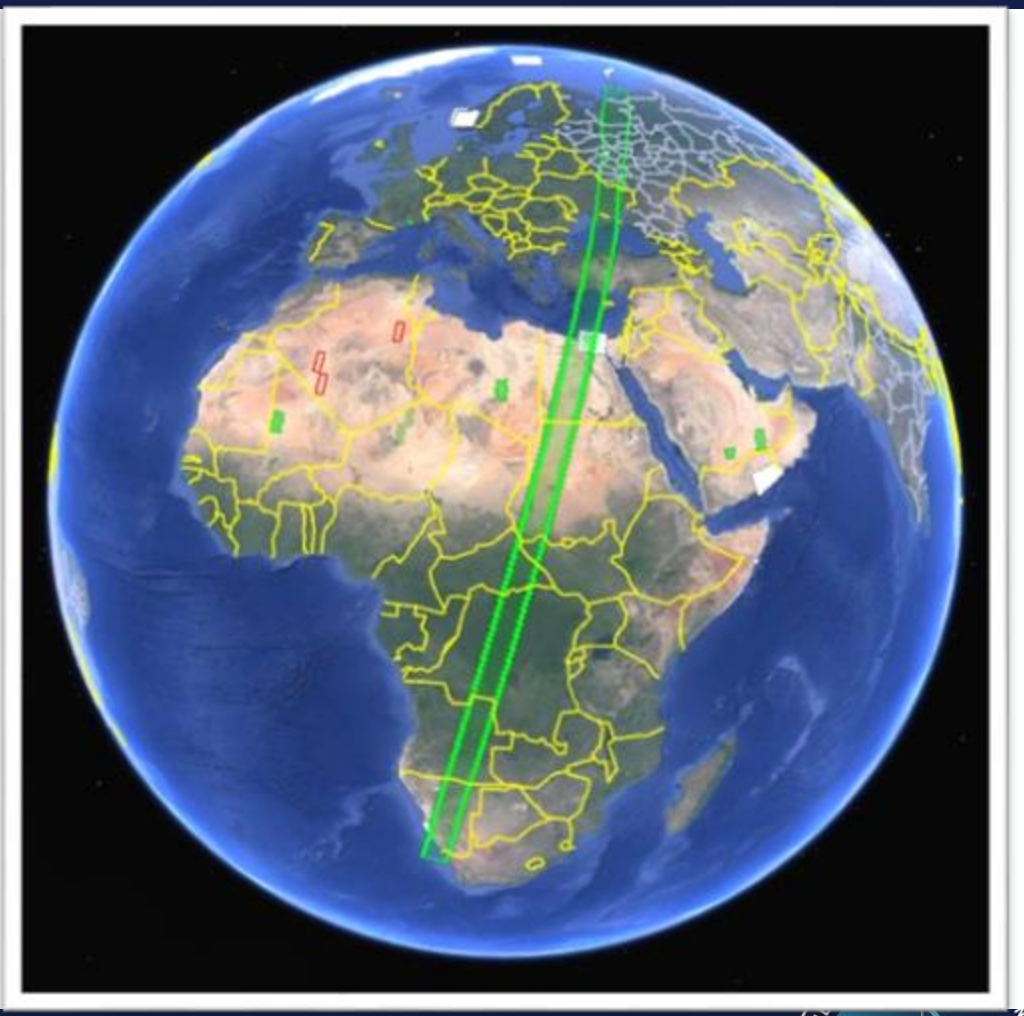
The OPT-MPC is using validation methods and sites employed for the Sentinel Cal/Val or within EDAP

PICS, Radcalnet,...

La Crau, Ankara,…

Effort to harmonize sites and methods across Cat.1 CCMs when possible

New methods must be set-up for “new” domains (hyperspectral, high-resolution TIR)



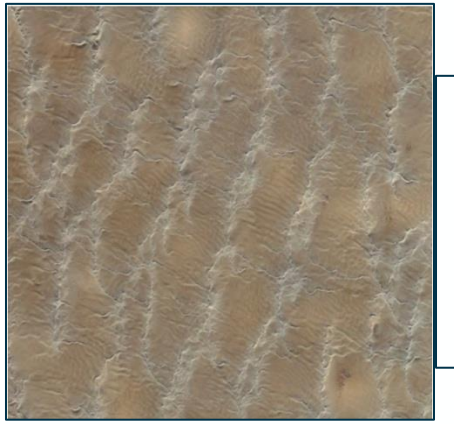
Cat.2 & Cat.3 CCMs – Data Quality Assessment

Analysis of sample data nominally collected by each CCM every 6 months or other contractual periodicity.

Radiometric and geometric assessment performed, plus sharpness level evaluation and basic visual assessment.

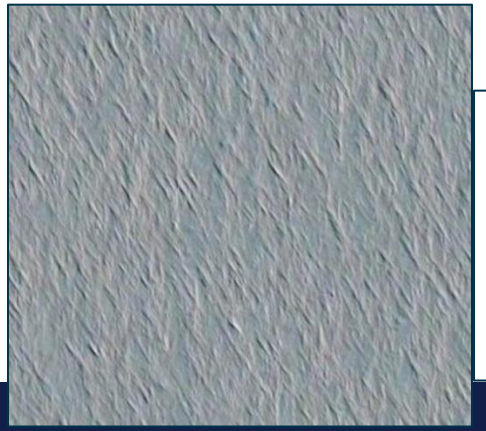
Data are acquired over predefined reference test sites:

- Libya 4 and RadCalNet CEOS test sites for radiometric assessment in the spring/summer period.
- Dome C CEOS test site for radiometric assessment in the winter period.
- La Crau test site for geometric assessment.



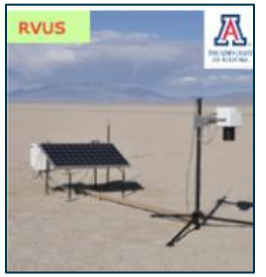
Google Earth Image centered on Libya 4 (Libya) CEOS ROI (28.55N, 23.39E)

La Crau (France) (43.442N, 4.86E)



Google Earth Image centered on DOME C (Antarctica) CEOS ROI (75.1S, 123.39E)

RadCalNet



Cat.2 & Cat.3 CCMs – Data Quality Assessment

Radiometric assessment performed by carrying out three different analyses:

analysis of spectral profiles, to detect any radiometric anomaly present in two (vertical and horizontal) spectral profiles, obtained from two transects casted over the whole image.

inter-comparison with a reference sensor (usually Sentinel-2 and Landsat), comparing the radiometry of the product under analysis with the radiometry of reference products assumed to have a high radiometric accuracy.

inter-comparison with in-situ RadCalNet data, comparing the radiometry of the product under analysis against the in-situ measurements taken over RadCalNet calibration sites.

Geometric accuracy assessment, quantifying the planimetric shift against a reference layer of declared better accuracy covering the same zone, which is an aerial orthophoto downloaded from the national geoportal (https://geoservices.ign.fr) and characterized by a spatial resolution of 0.5 m.

Sharpness level assessment, based on a specific implementation of the well-known Edge Method it exploits an original, semi-automatic and statistically-based approach for identifying all the suitable edges present in the scene that can be used for the analysis, enabling to carry out a repeatable and robust sharpness assessment based on a significant number of selected edges. The results are quantitively expressed by using the Full Width at Half Maximum of the normalized line spread function (FWHM) as reference sharpness metric, which allows to classify the sharpness level of a given product in three categories: aliased, balanced or blurry.

Very High Resolution (VHR) Image 2024 dataset (Analysis and validation)

Analysis and validation of data delivered to the incoming VHR_IMAGE_2024 dataset, providing, in the frame of the Copernicus Programme, a homogenous complete coverage of the EEA-38 regions for the reference year 2024 with multispectral orthorectified satellite data having a resolution in the range of 2 metre up to maximum 4 metre.

A subset of the entire dataset will be checked against the applicable requirements provided by ESA.

The assessment is twofold:

- Check of the coverage -> completeness, acquisition parameters, data product resolution and size.
- Check of product quality ->
  - format and filenaming convention
  - metadata check
  - quicklook analysis
  - image analysis (cloud cover percentage, dynamic range, sharpness level, band to band registration, geometric distortion and accuracy).

ARD within the EDAP guidelines / Cal/Val Maturity Matrix

From the EDAP EO Mission quality assessment framework →

3.1.3 Product Format, Flags and Metadata

An important aspect of EO data products that ensures ease of access to the widest variety of users is their format. Product metadata and flags offer users important extra layers of useful descriptive information, in addition to the measurements themselves, that can be crucial to their analysis.

In the ideal case, the product format would meet the appropriate Committee on Earth Observation Satellites (CEOS) Analysis Ready Data (ARD) metadata guidelines, such as CEOS ARD for Land (CARD4L) [RD-5] requirements in the case of surface reflectance products.

In the case where such a standard does not exist, product format is graded based on the following:

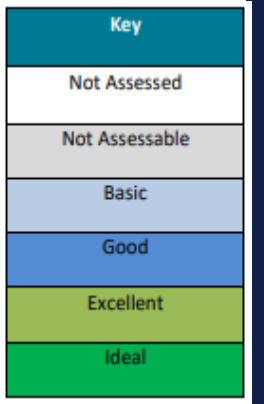
- the extent to which it is documented
- whether a standard file format is used (e.g., NetCDF)

Table 3-3 – Product Information > Product Format, Flags and Metadata – Assessment Criteria

Grade	Criteria
Not Assessed	Assessment outside the scope of study.
Not Assessable	Non-standard, undocumented data format.
Basic	Non-standard or proprietary data format, or poorly documented standard file format. Minimal useful metadata or data flags provided.
Good	Data exist in a documented standard file format. Non-standard naming conventions used. Includes a good set of documented metadata and data flags.
Excellent	Data are organized a well-documented standard file format, meeting community naming convention standards. Comprehensive set of metadata and data flags.
Ideal	Analysis Ready Data standard if applicable, else as *Excellent*.

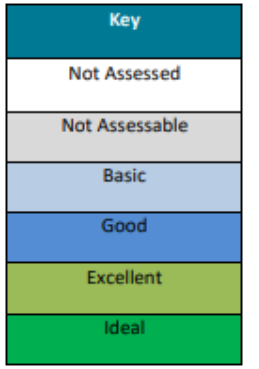
Discussion

- Cal/Val and Data Quality for Commercial Data Providers → **$$**
  - Some CCMs mentioned that they can use the **EDAP results** and table/w grades to internally advocate potential additional support/funding to Cal/Val and Data Quality
  - Concept of “greenlight” for Cat.1 CCMs (**+$$ if Cat.1→Cat.2**)
- For both CCMs and TPMs, the **assessment** is **vs** the **Mission** Stated **Requirements**
- CCMs interoperability (/**complementarity** with Sentinels) is considered at “application-level”
  - Some basic requirements are set upfront (e.g. VHR/HR resolution, domain,..)
- **EDAP TN on ARD** —> The EDAP team proposed a potential extension of the MM with an ARD maturity matrix incl. 4 proposed classes (vs Threshold/Goal)
- Should we embed/implement the ARD Maturity Matrix within the EDAP framework?? Would this mean 2 different assessments anyway for the vendors or can we avoid a double-assessment (i.e., on EDAP and on CEOS peer-review sides)?



Discussion

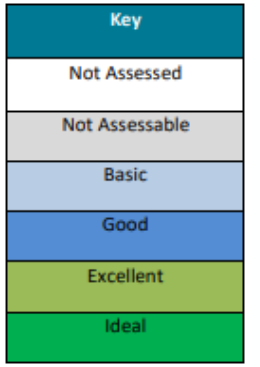
- How do we get **more engagement** from the **Commercial** Domain on the **ARD topic**?
  - How would the ARD generate more **revenues**?? What **value** would it add to the products?
- If we get some more engagement from the more established Commercial data providers, would the newest ones follow? (To basically have interoperability++ (the newest ones would be more willing to adopt ARD as it is “necessary” if they want to be interoperable with others))
- Not even the Institutional missions are getting Goal…
  - If I’m a Commercial Data Provider, Why should I care?



- **CEOS-ARD** should be regarded as a **community standard**, setting the **reference** for some data quality aspects; it can be **part of the evaluation/assessment** (i.e. verifying that CEOS-ARD requirements are met e.g., for the metadata, product format,..); that’s **already the case in the ESA-NASA guidelines**

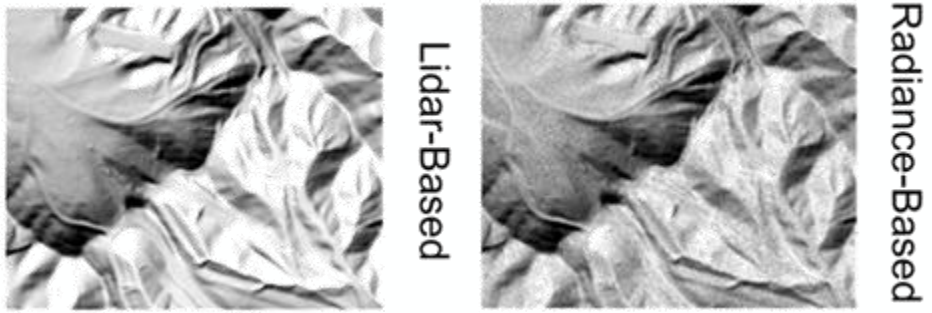
Discussion

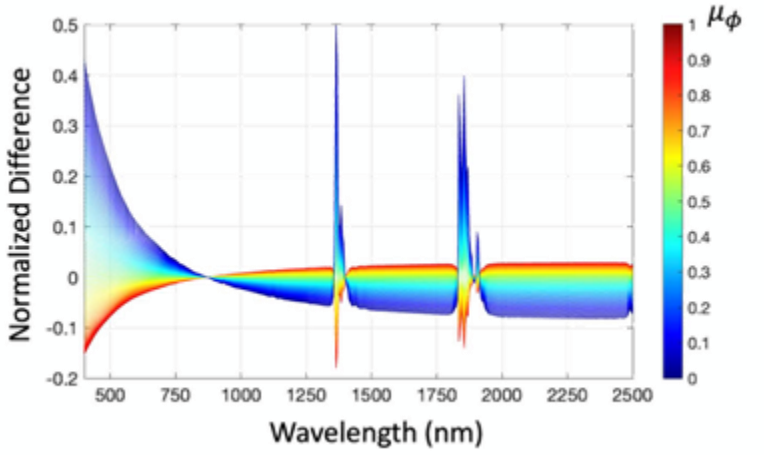
- Is it **fair** to bring Commercial Data Providers into ARD?
  - They just want to serve a **specific application(s),** e.g., fire-detection
  - They'll likely **not care about reaching ARD Treshold/Goal**
- Should **ARD only** focus on **data format interoperability**? (incl. the measurand?)
  - Is Surface Reflectance the right measurand?
  - Within RRD, STAC metadata are required
- Formal **standards** needed **to ensure data interoperability**
  - E.g., all products should be processed using the same DEM, the same ATM-Cor algorithm,…
- **LAND** is **too broad** to represent the whole set of **land applications**; there should be more **application-tailored** requirements, that would lead to a fairer assessment of Commercial missions (that, again, are not designed for a broad LAND target, but more for 2/3 specific applications)
- **Usability guidelines** in development for EDAP; different approaches (literature, simulation/MonteCarlo, user-requirements DBs,..)



Discussion

- Errors in Radiance from assuming flat surface
  - Cannot be corrected ”post-hoc”
  - Existing ”post-hoc” algorithms are “normalizations” **not “correction”**





Credits: N.Carmon,VH-RODA 2024

- Instead of the current **Radiance-Reflectance**, we may consider **single scattering albedo (SSA)** and **Asymmetry Factor (ASY)**
  - **Geometry agnostic!**
  - **Topography** and **BRDF** are coupled and **cannot** (should not) be **“normalized”** post-hoc
  - Current approaches **limit harmonization within the same instrument across time**, and **across instruments**
  - A **physics-informed** solution must be implemented within the radiance inversion algorithm

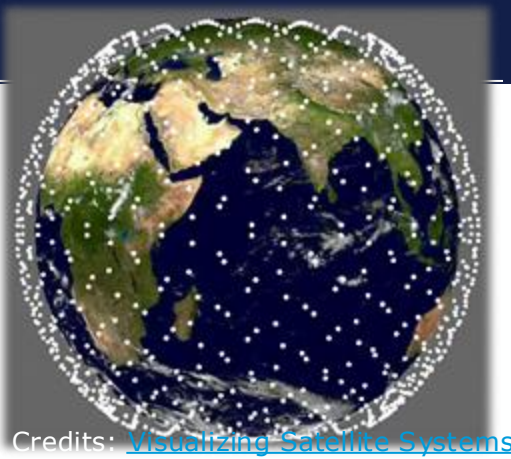
•N.Carmon, Critical Re-Evaluation of Topography and BRDF in VSWIR Atmospheric Correction for Multi-Mission Integration

Discussion

- Development of **Big Constellations** is… HERE!
  - Ensure consistency, automated Cal/Val Procedures (AI?)
- Who'll be the main user of a growing Data-stream?
  - On-the-fly processing (L0 to L2+ → **L0 to ARD on-the-fly!**)
- New data model for full **interoperability**?
- Need to model **uncertainty** for the full-chain
- Topographic **normalization** / illumination correction and

BRDF characterization / correction is **necessary for compliance**

- PSF/MTF missing in CARD4L?
- SNR missing in CARD4L?



Credits: Visualizing Satellite Systems

Credits: https://ororatech.com/resources/newsroom

- Wolfgang Lück, Towards CARD4L Target Compliance for CubeSat and Small-Sat Imagery

VH-RODA Workshop 2025

6th edition: Open forum (new space, commercial and institutional) on status and developments related to the **calibration and validation** of space borne **very high-resolution SAR, OPT and ATM sensors** and data products, focusing the attention on the commercial entities in Cal/Val activities, synergies between optical and SAR communities, presentation of standards and best practices for data quality.

No registration fee!

Expected Dates

17-21 November 2025

ESA–ESRIN | Frascati (Rome), Italy

Workshop topics (for VHR data):

- *Calibration Techniques*
- *Processing and Algorithms (incl. AI for Cal/Val)*
- *Calibration Sites & Fiducial Reference Measurements*
- *Quality Control, Best Practices, Product Validation*
- *Cal/Val and Data quality for Constellations and Big Data*
- *Analysis Ready Data, Digital Elevation Models*
- *Calibration of Future Missions*


THANK YOU!
Leonardo De Laurentiis
(ESA)
Leonardo.De.Laurentiis
@esa.int
THE EUROPEAN SPACE AGENCY
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