Latest developments of the Copernicus program

Francesco Affaitati

Space Meetings Veneto 2023

Venezia

17/05/2023

ESA UNCLASSIFIED – For ESA Official Use Only

We Are ESA

EUROPE'S GATEWAY TO SPACE

WHAT	22 Member States, 5000 employees
WHY	Exploration and use of space for exclusively peaceful purposes
WHERE	HQ in Paris, 7 sites across Europe and a spaceport in French Guiana
HOW MUCH	€6.68 billion = €12 per European per year

What Does ESA Do?

ALL OF THIS IS POSSIBLE THANKS TO THE COLLABORATION OF MEMBER STATES

ESA is active across **every area** of the **space sector**

World leader in **science** and **technology**

Over 80 satellites developed, tested, and operated **since 1975**

More than 220 launches from Europe's Spaceport in Kourou

1975 Signing of ESA Convention

10

MEMBER STATES

Today - 2023

22

MEMBER STATES

ESA Establishments *(1)*

Headquarters
Located in Paris, home to the main programme directorates that steer and formulate ESA policy.

ESRIN
ESA's centre for Earth observation activities, near Rome, Italy, also develops information systems and hosts the Vega launcher project.

ESTEC
The European Space Research and Technology Centre, Noordwijk, the Netherlands, is the largest site and the technical heart of ESA.

ESOC
The European Space Operations Centre, Darmstadt, Germany, tracks and controls European spacecraft.

EAC
The European Astronaut Centre, Cologne, Germany, trains astronauts for missions to the International Space Station and beyond.

ESA Establishments *(2)*

ESAC
The European Space Astronomy Centre, near Madrid, Spain, hosts the science operation centres and archives for ESA's astronomy and planetary missions.

Harwell (ECSAT)
Harwell Centre, in Oxfordshire, UK, is focusing on commercialisation and partnerships in space activities.

Redu
Redu Centre in Belgium is part of ESA's ground station network and is also home to ESA's Space Weather Data Centre.

Guiana Space Centre
ESA's launchers lift off from Europe's Spaceport in Kourou, French Guiana. It is jointly operated by the French space agency (CNES) and Arianespace with the support of European industry.

ESOC
The European Space Operation Centre

ENABLING & SUPPORT

Operations

Where Missions come alive

- **ESOC**

ESOC Main Control Room

- **MCR**

ESOC in numbers

- ESOC
- Facts sheet

Mission Operations

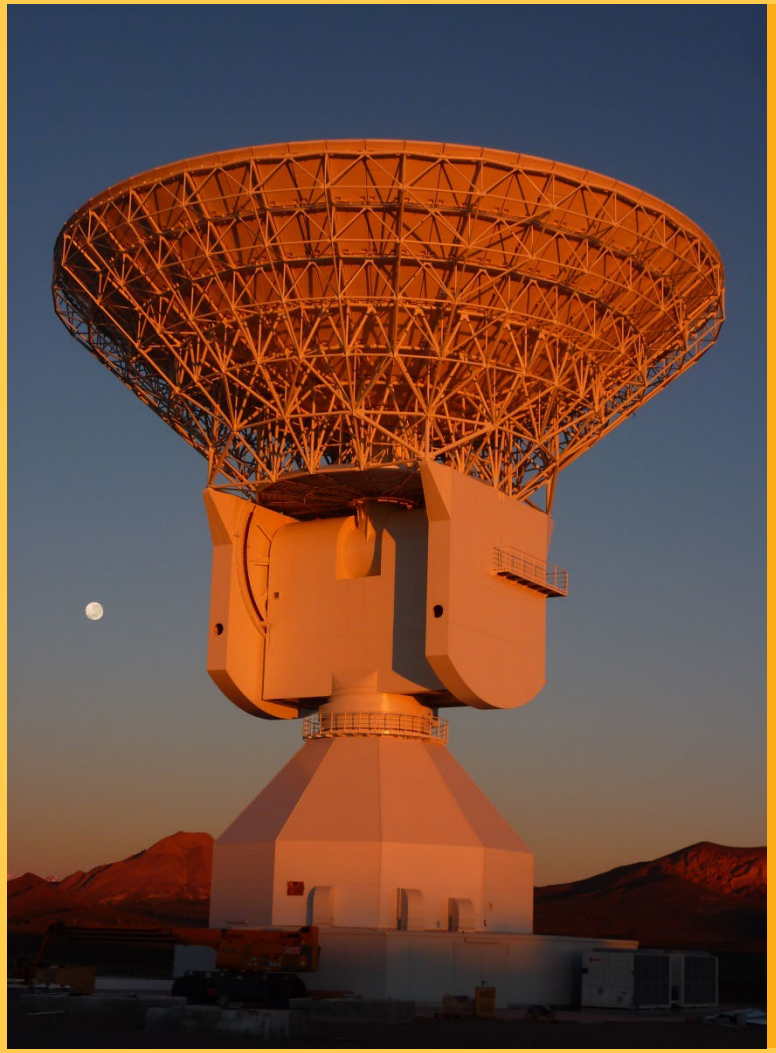
ESOC, the European Space Operations Centre (Darmstadt, Germany), is ESA's centre for mission operations and ground systems engineering, where we:

- Study and develop mission concepts and technologies;
- Specify required ground facilities and functionality;
- Simulate mission scenarios and train multi-disciplinary mission teams;
- Perform end-to-end mission readiness testing;
- Plan and execute spacecraft and ground facilities operations during all mission phases.

Ground Segment Engineering

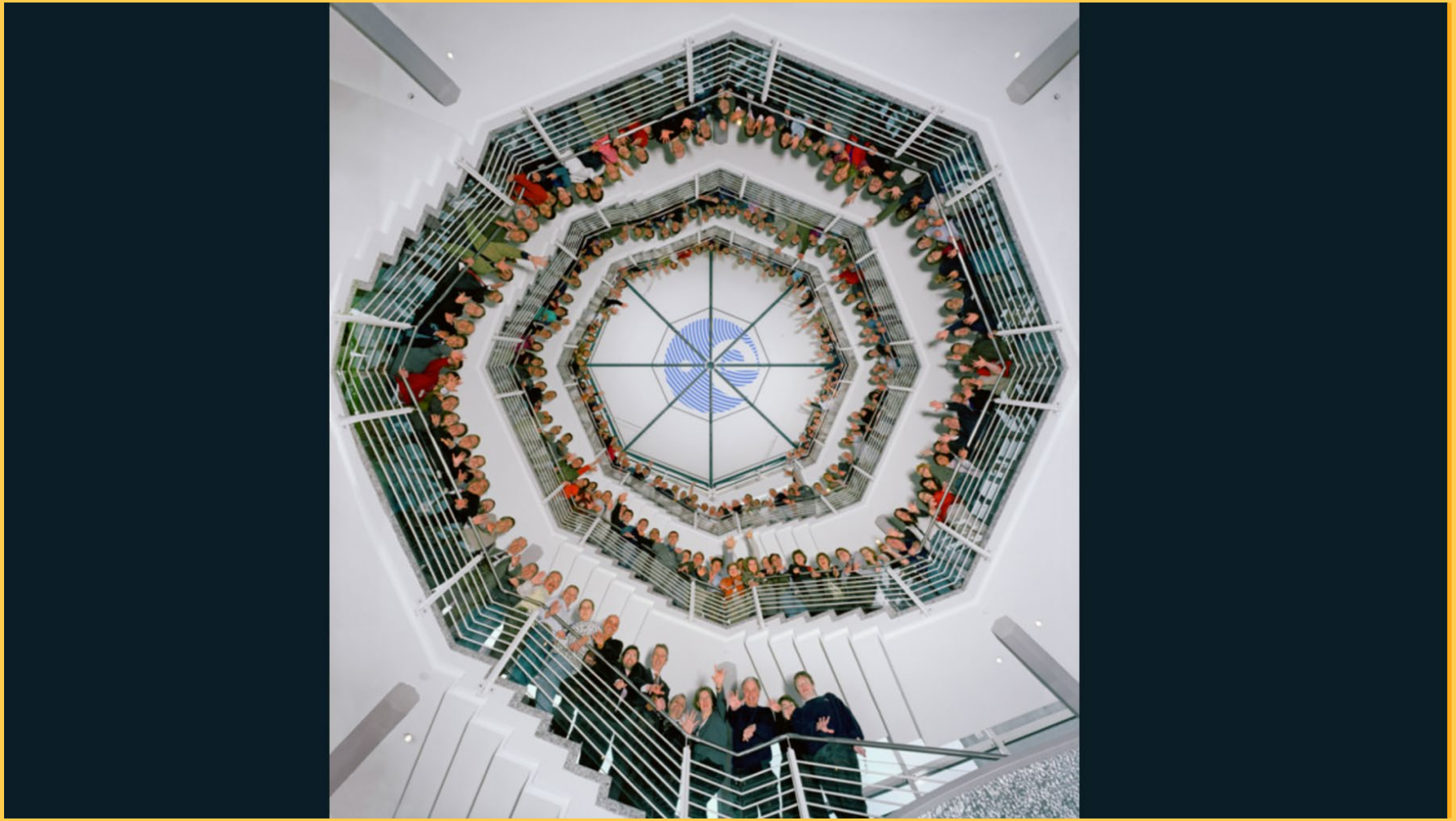
ESOC's **ground systems engineering teams**:

- Develop multi-mission infrastructure for mission control systems, ground stations, high-fidelity simulators, operational communication and computer systems and tailor them for specific missions;
- Perform studies, mission analysis, flight dynamics, high-precision navigation, space-debris monitoring and avoidance and CleanSpace studies;
- Develop new technologies and standards to support future missions.
- Track spacecraft in the deepest reaches of space via our tracking station network (**ESTRACK**)



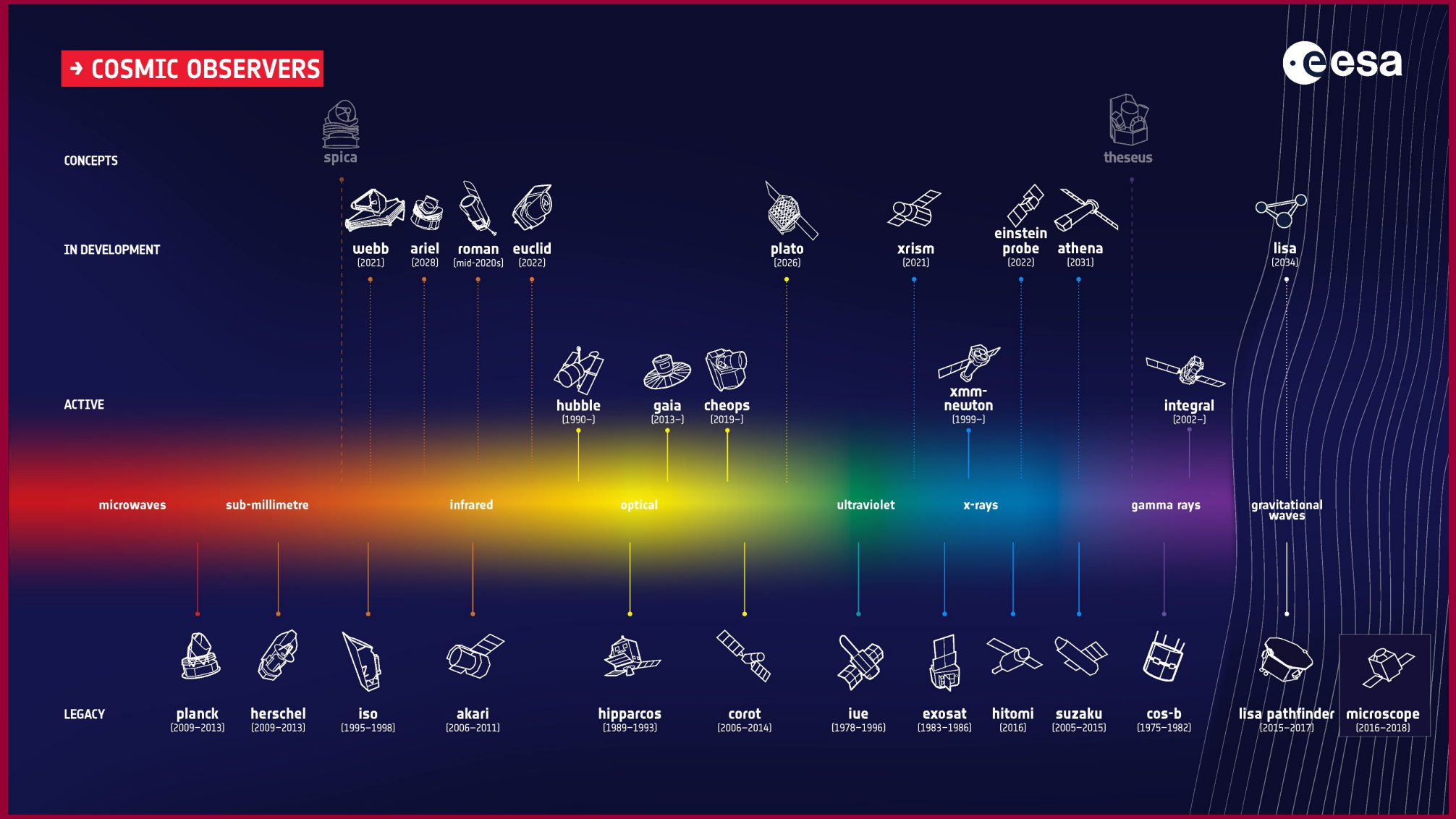
Launch and Early Operations Phase Operations

- **LEOP Operations Team**



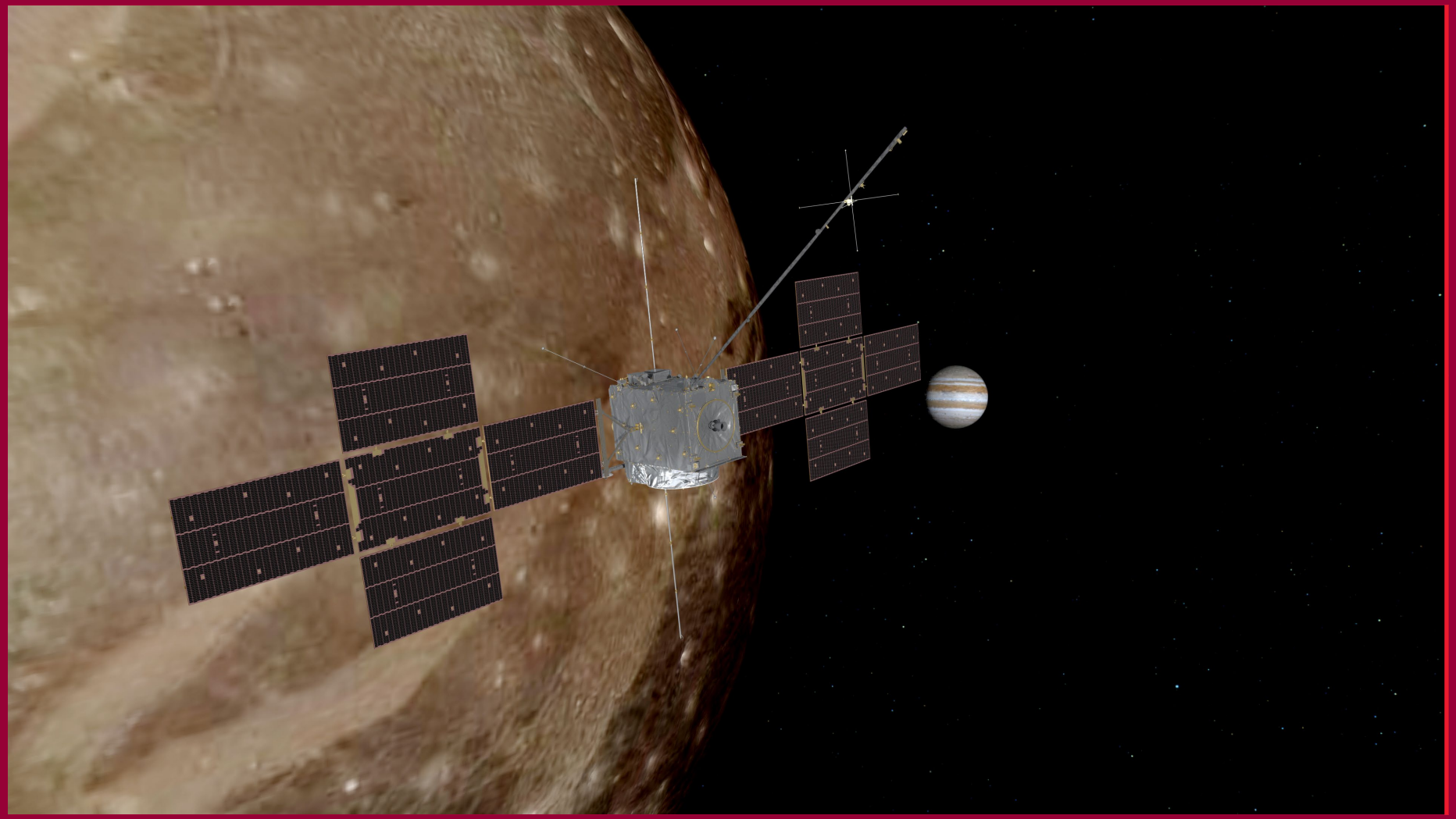
SCIENCE & EXPLORATION

Some of Today and Tomorrow's Science Missions



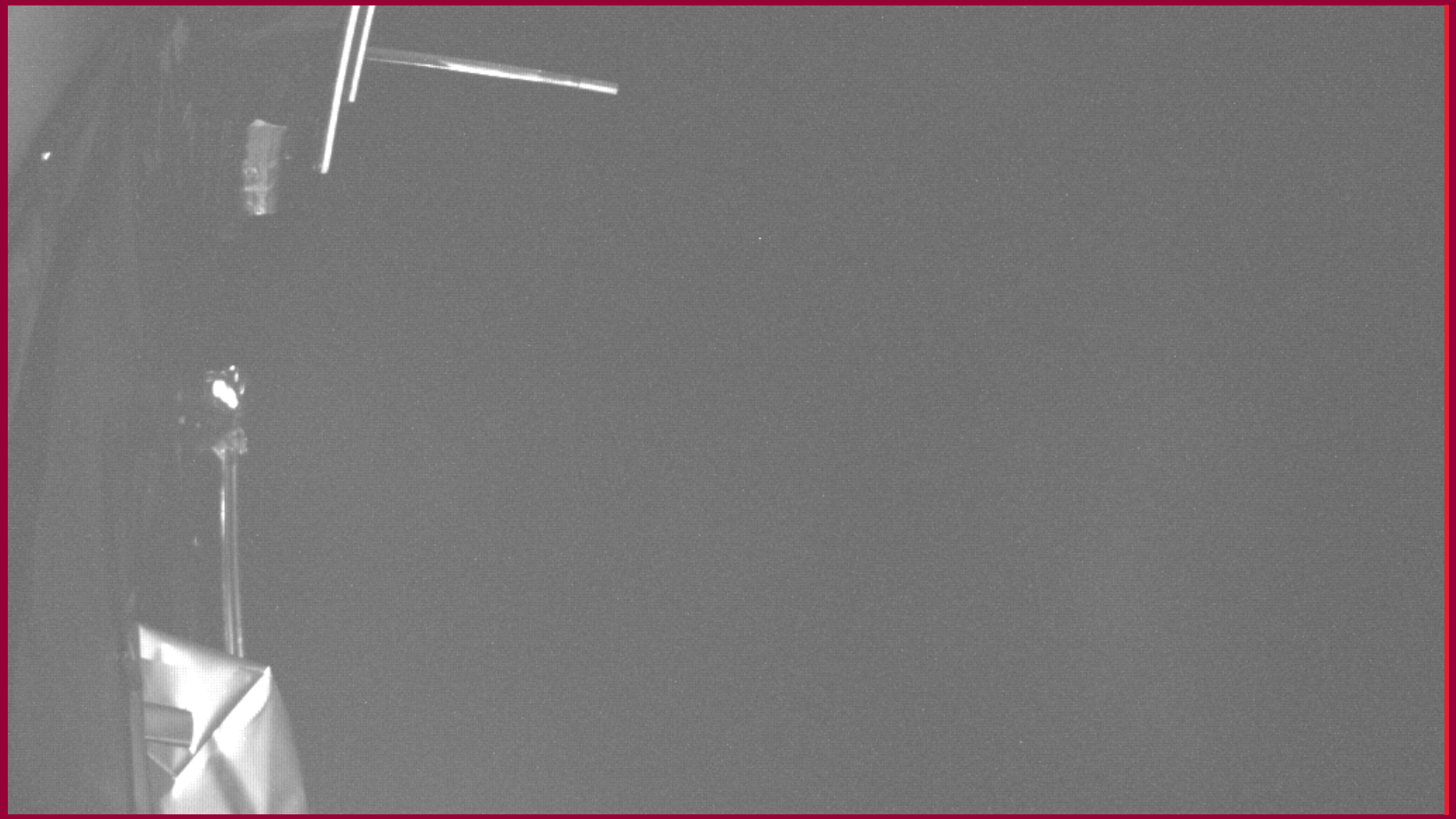
Juice will make detailed observations of Jupiter and its moons – Ganymede, Callisto and Europa

- Juice



Juice Breaking News

The Radar for Icy Moons Exploration (RIME) antenna is now free



APPLICATIONS

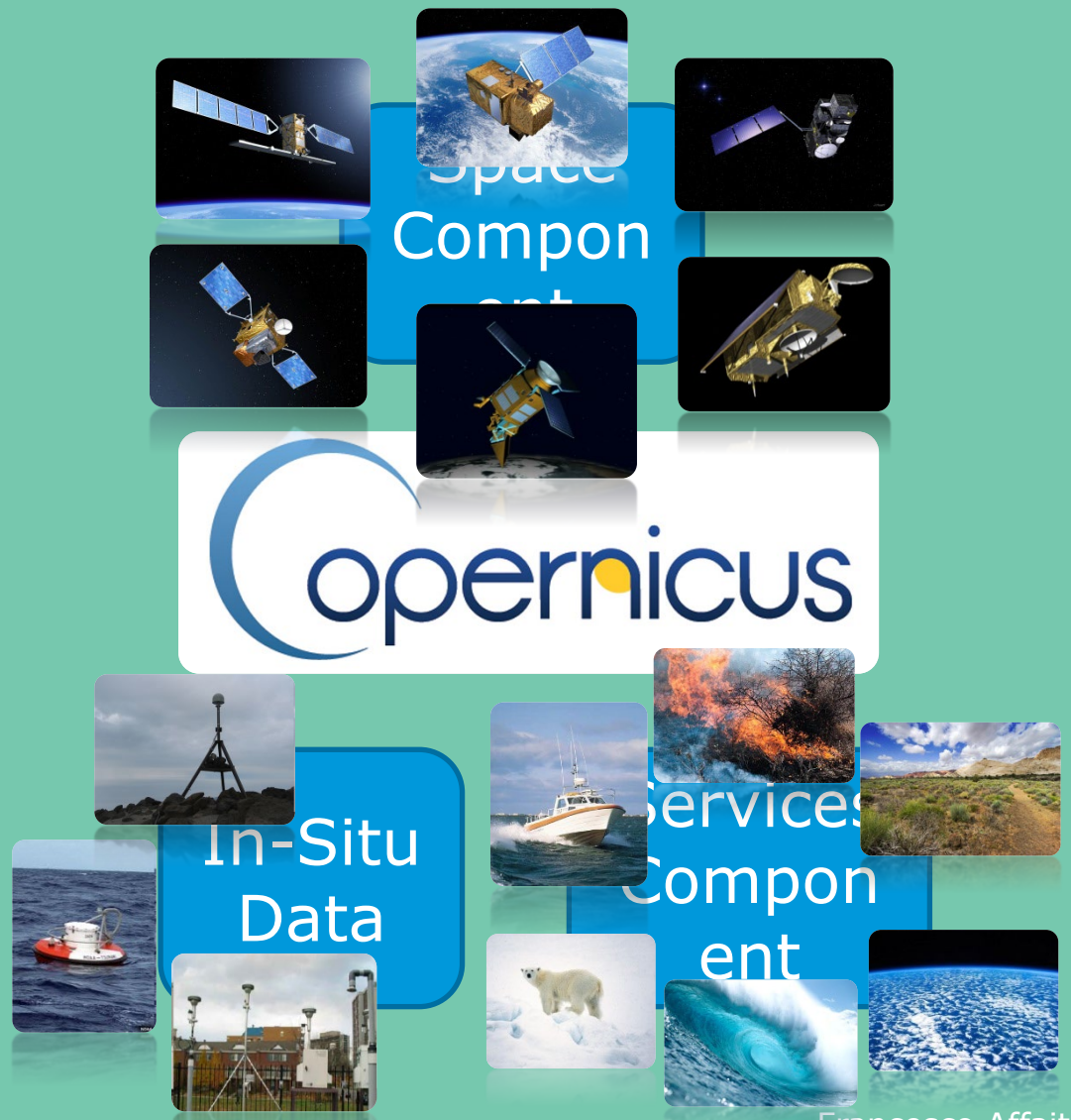
Earth Observation
The Copernicus Programme

ESA for Earth Observation

What is Copernicus?

European response to global needs:

- to manage the environment,
- to mitigate the effects of climate change and
- to ensure civil security



Baveno 20 anniversary

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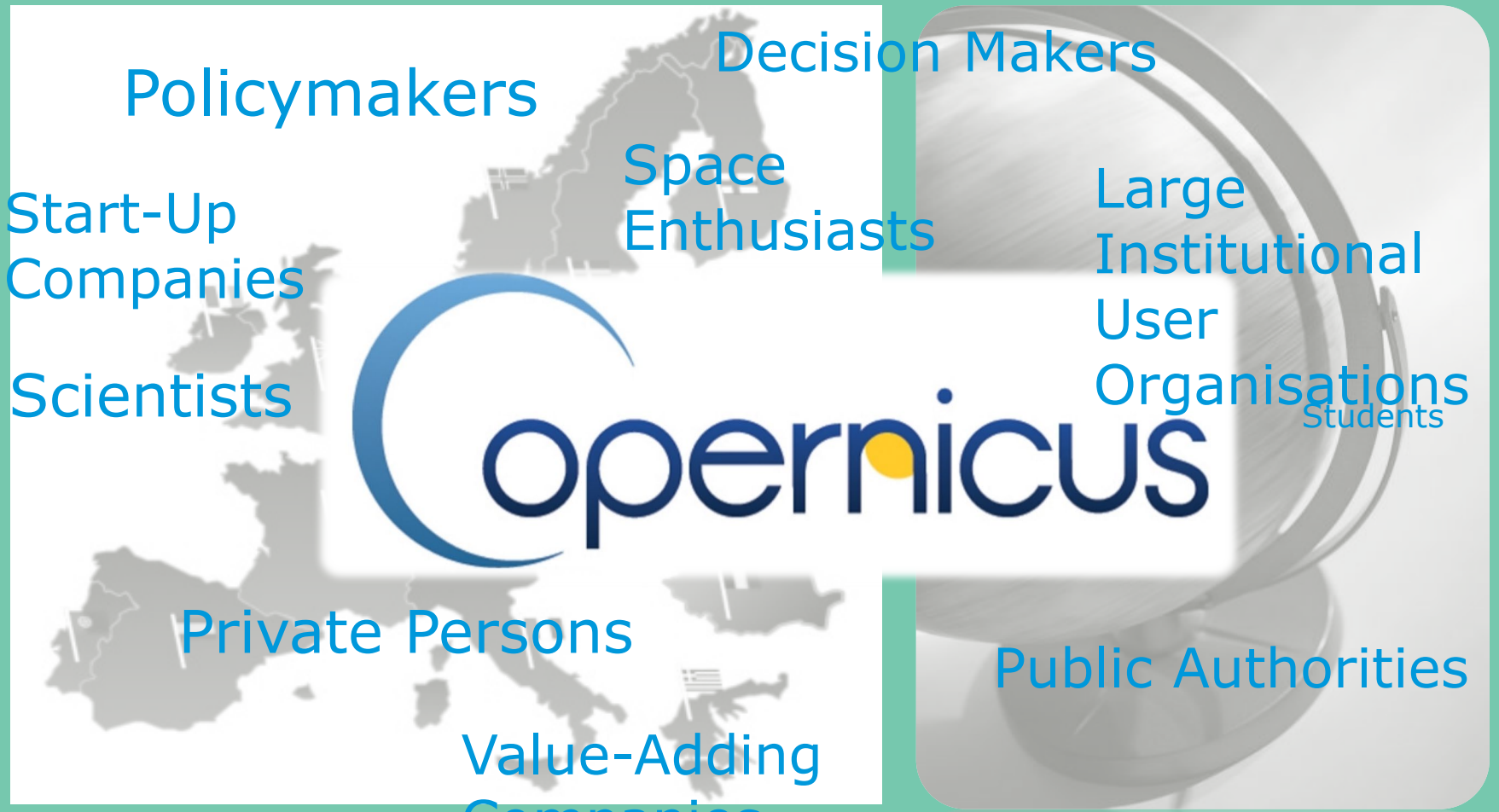
Copernicus Users



Copernicus Facts & Figures

PROGRAMME OF THE EUROPEAN UNION

copernicus Europe's eyes on Earth

esa

1543
Niccolò Copernicus publishes his theory of a heliocentric system

6
service domains covered

€ 10
of public return for every € 1 spent by the European tax payer on Copernicus

€ 7 B
invested by ESA and EU till this day

2014
start of Copernicus operational phase

14+
new satellites & instruments specifically developed for the operational needs of Copernicus

€ 0
to pay for access to Sentinel data

83000
jobs generated by Copernicus by 2030

Components & Competences

PROGRAMME OF THE EUROPEAN UNION

Coordinators:

Partners:

European Commission

Overall Programme coordination

Space Component

Industries

Private companies

National Space Agencies

Eumetsat

Services Component

EMCWF

EMSA snd FRONTEX

M ercator Ocean

Service operators

EUSC

EEA

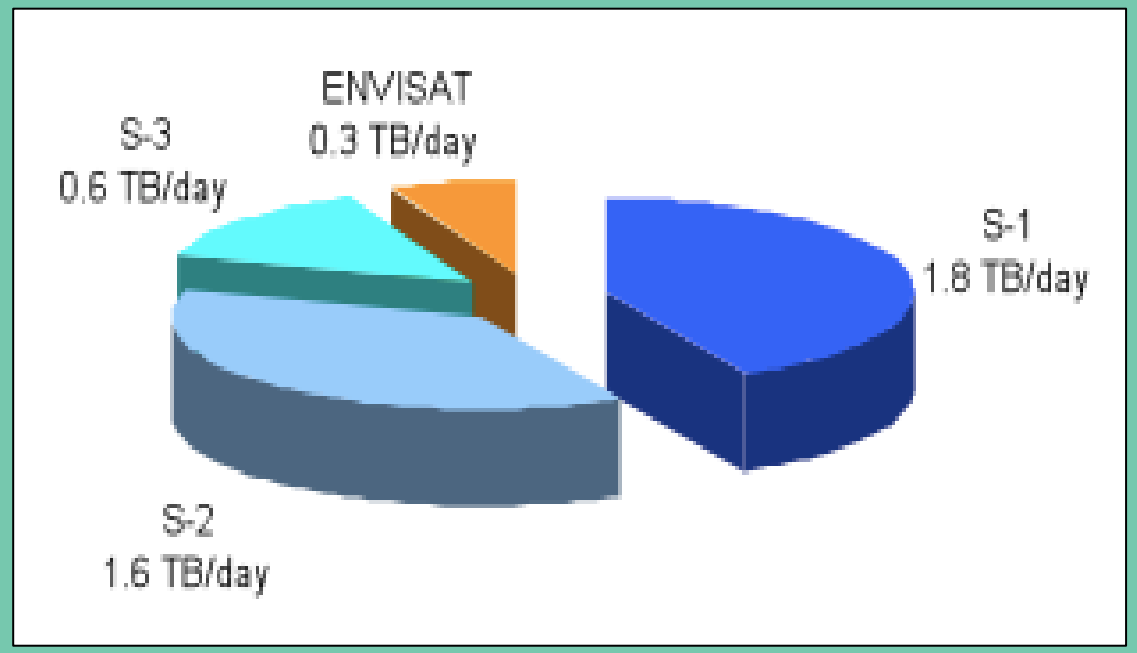
JRC

In-situ data are supporting the Space and Services Components

Systematic Earth Monitoring

Sentinel-1, Sentinel-2, Sentinel-3 acquire data

- continuously,
- over much wider swaths,
- at improved resolutions,
- in more spectral bands than any of their 'predecessors'



Sentinels-1/-2/-3 (A+B) generate, together, more than **13 times the volume of data** generated by the 10 instruments on board Envisat, the largest EO satellite ever.

Copernicus is the 3° world data provider.

Copernicus Space Component

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S1A/B: Radar Mission — 3 April 2014 / 22 April 2016

S2A/B: High Resolution Optical Mission — 23 June 2015/ 7 Mar 2017

S3A/B: Medium Res. Imaging and Altimetry — 16 Feb 2016 / 25 Apr2018

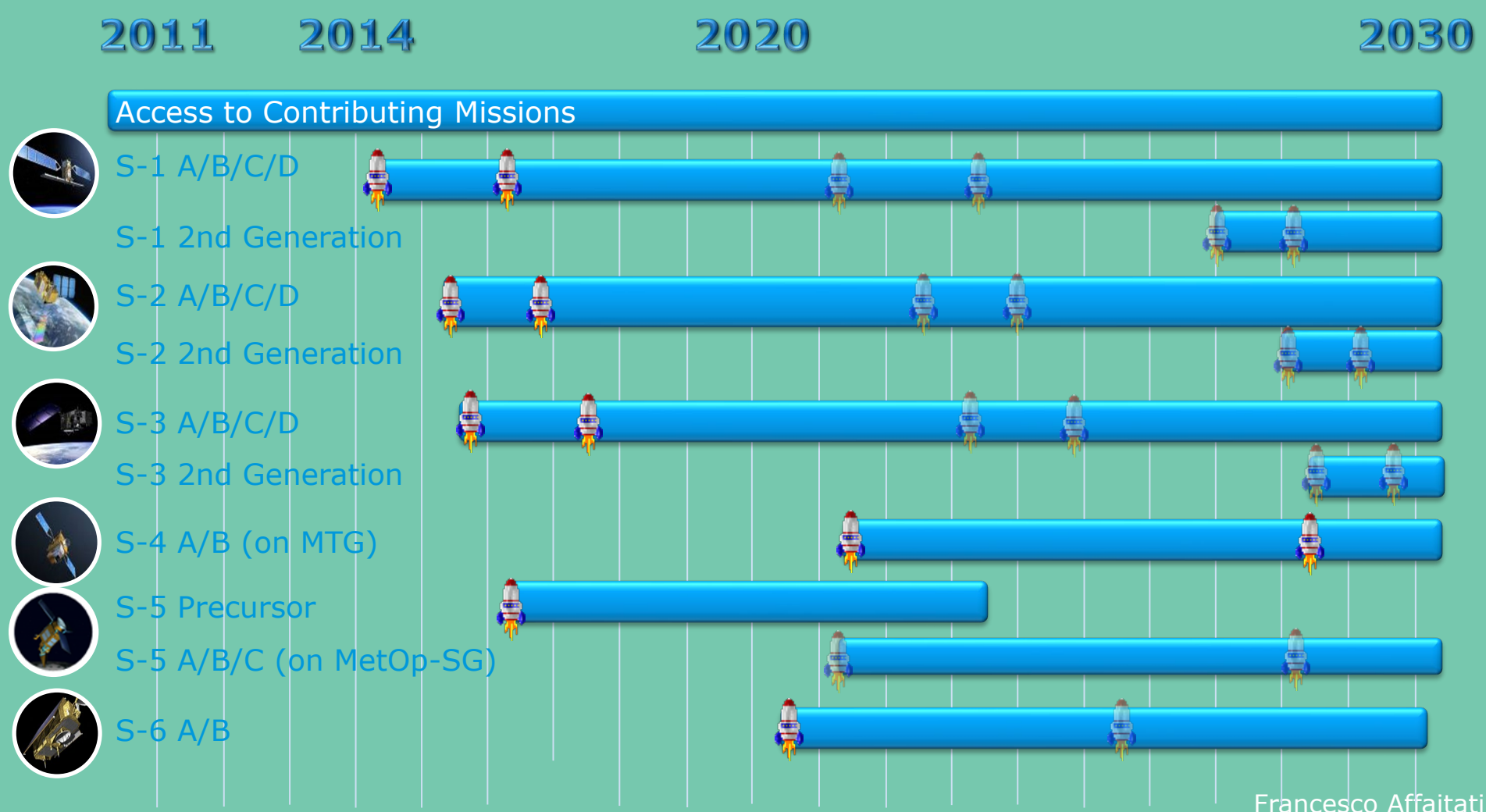
S4A/B: Geostationary Atmospheric Chemistry Mission — 13 Dec 2022/2027

S5P: Low Earth Orbit Atmospheric Chemistry Mission — 13 Oct 2017

S5A/B/C: Low Earth Orbit Atmospheric Chemistry Mission — 2021/2027

S6A/B: Altimetry Mission — 21 Nov 2020 / 2025

Status of the Copernicus Space Component



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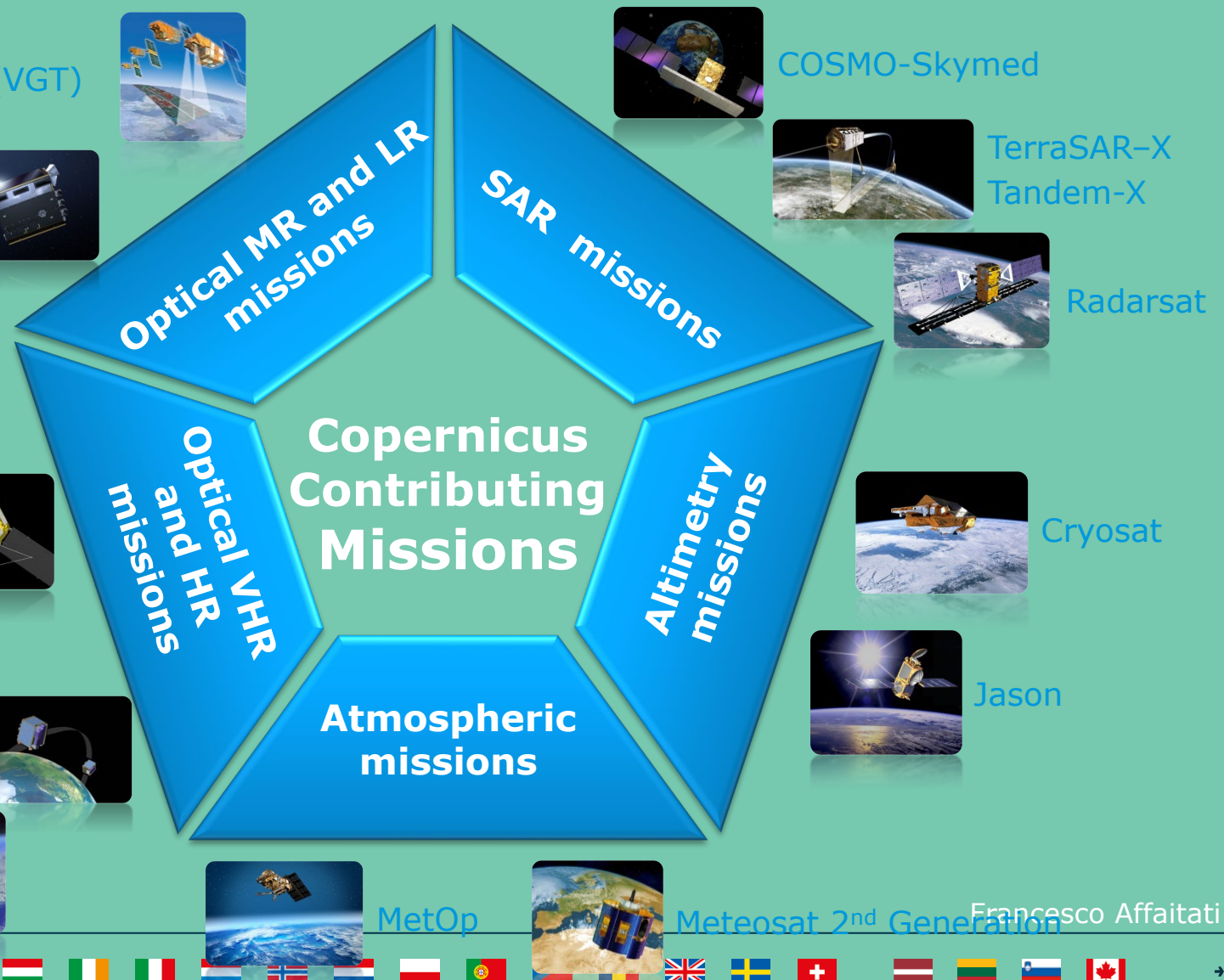
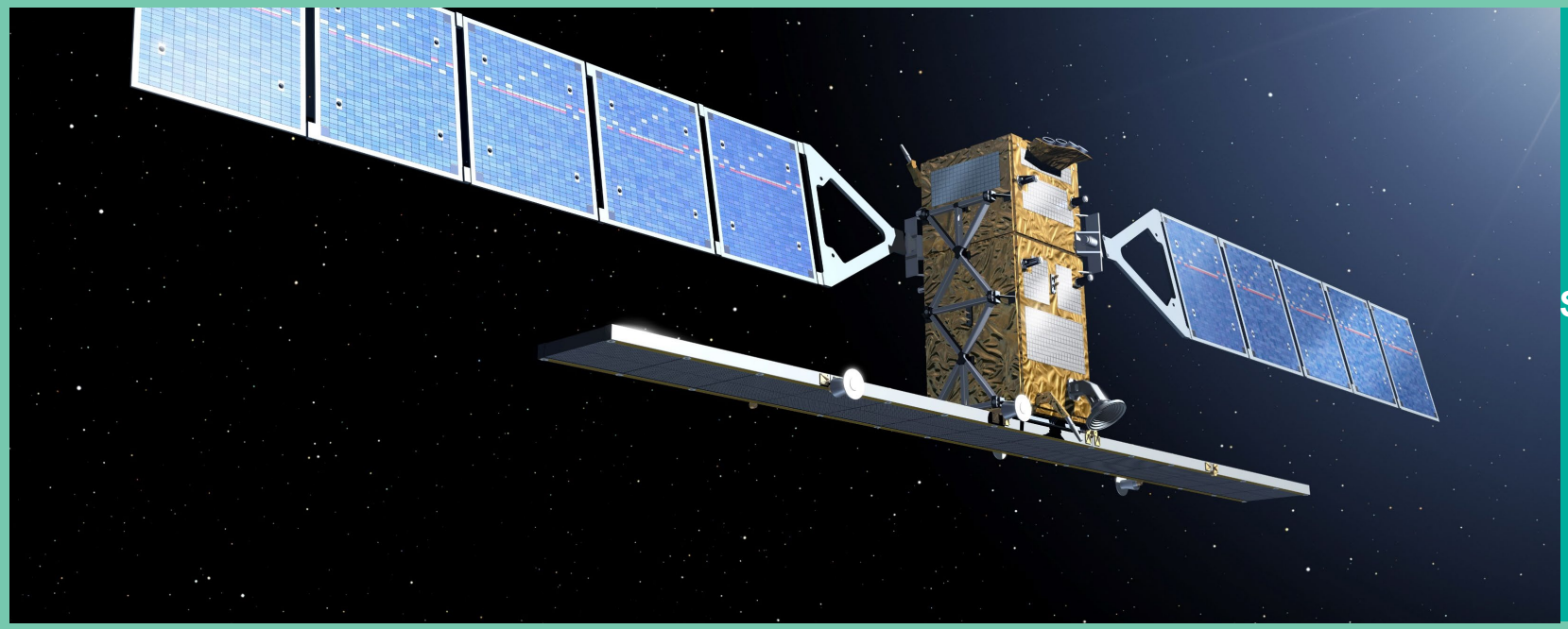
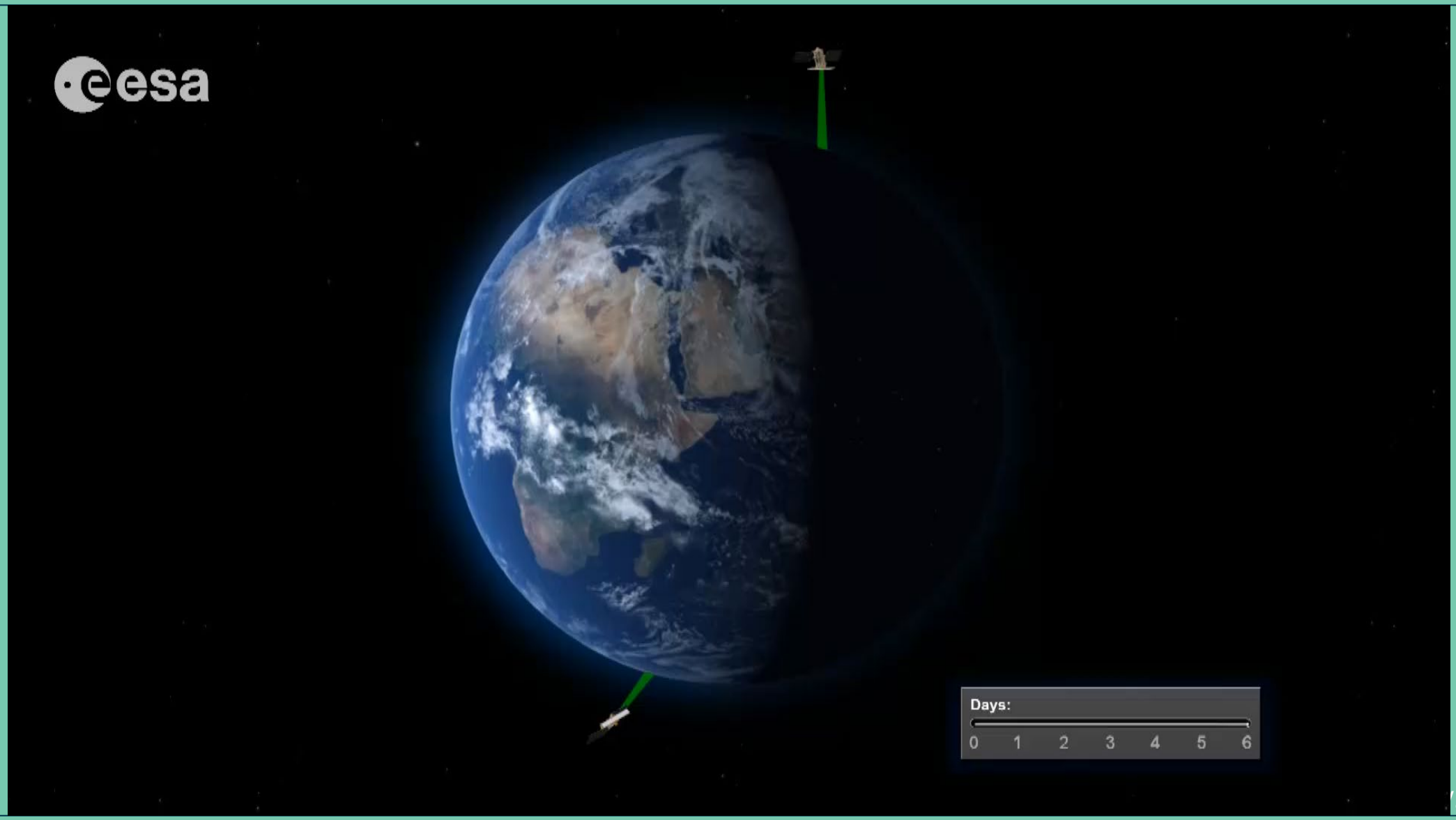
Copernicus Contributing Missions



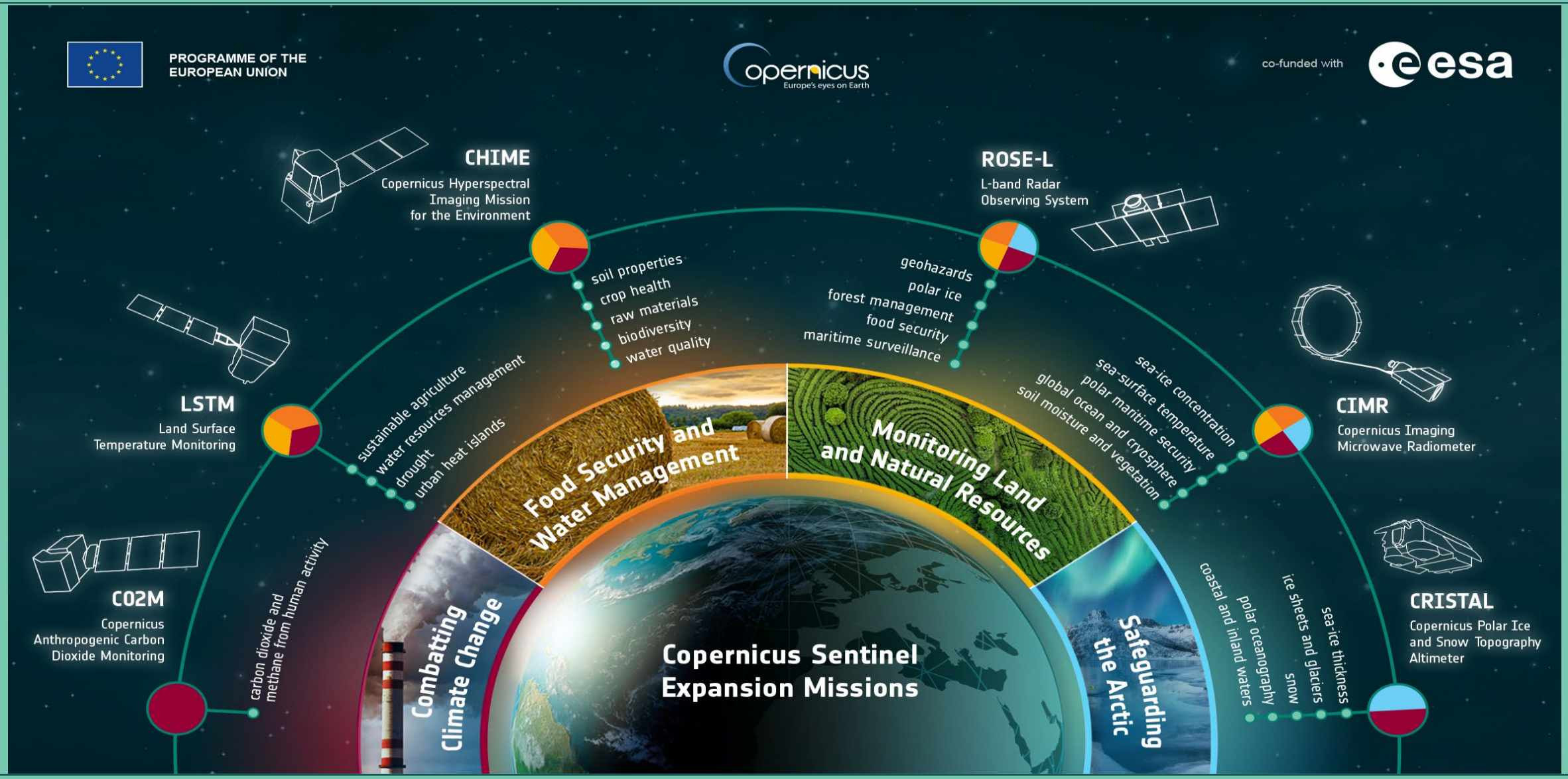
Sentinel-1



Sentinel-1 all’opera



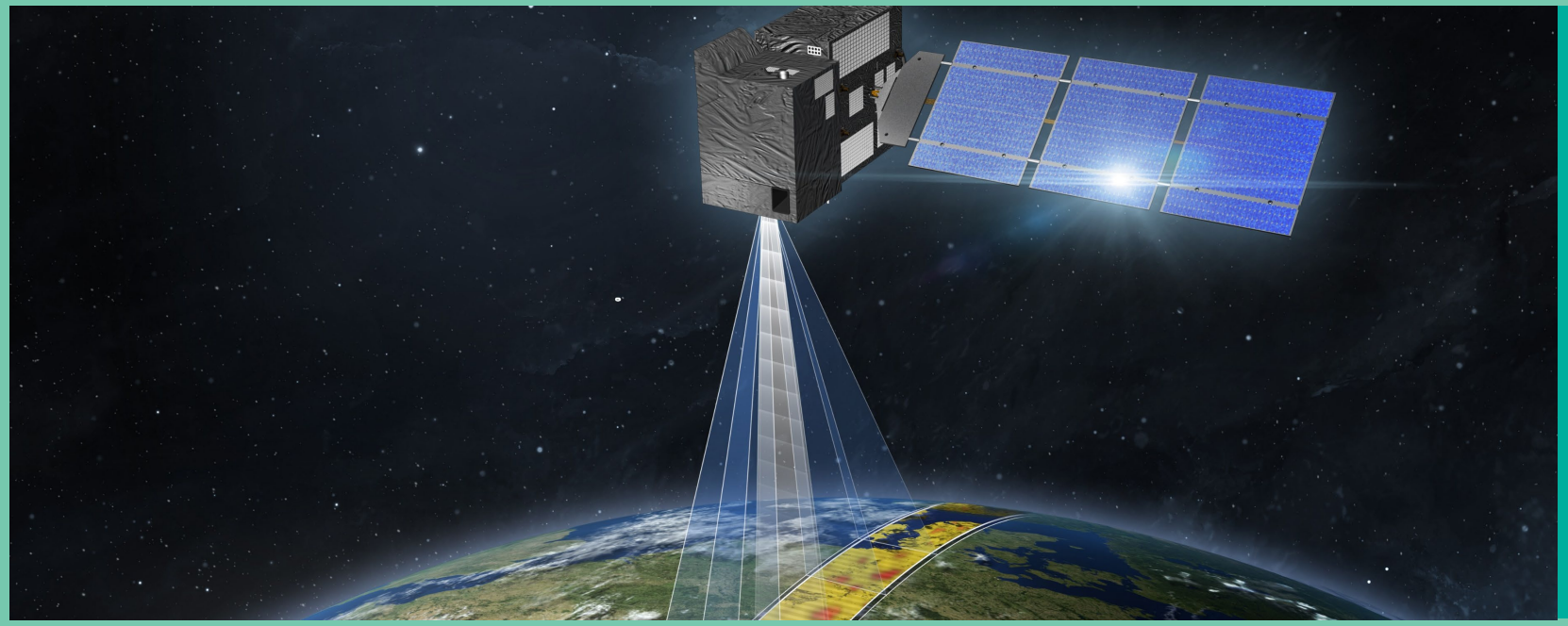
Copernicus expansion



CO2M Copernicus Carbon Dioxide Monitoring Mission

CO2M will be the first to measure how much carbon dioxide is released into the atmosphere specifically through human activity.

The two satellites will carry a near-infrared and shortwave-infrared spectrometer to measure atmospheric carbon dioxide produced by human activity.

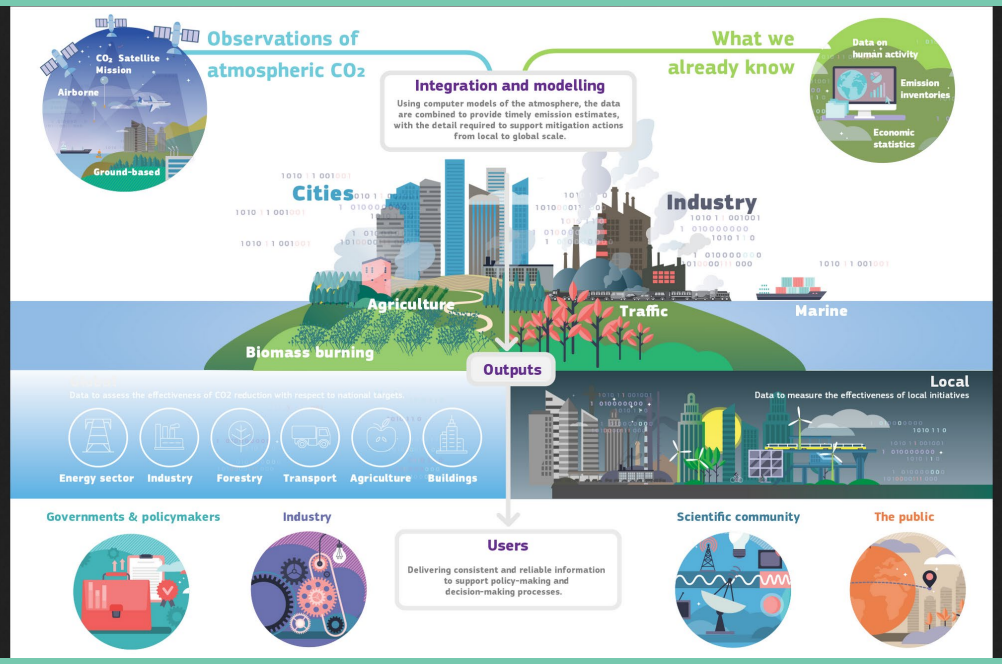


◁ CO2M

CO2M for CAMS Copernicus Atmosphere Monitoring Service

CAMS will be the first to measure how much carbon dioxide is released into the atmosphere specifically through human activity.

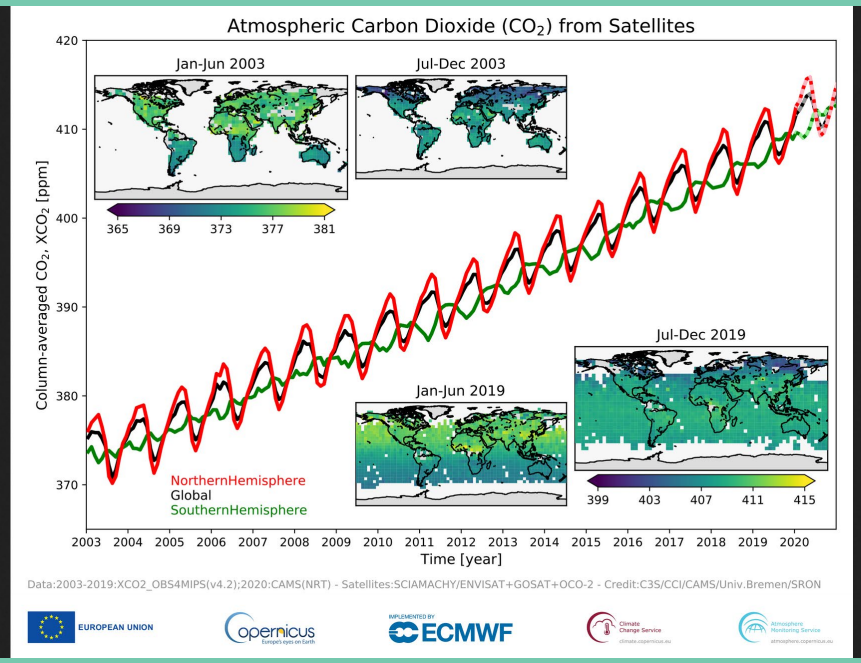
European Union's Copernicus Atmosphere Monitoring Service (CAMS) is working on a tool that will help countries to measure their progress towards meeting their Paris Agreement objectives (COP-21).



◁ CO2M

CO2M for CAMS Copernicus Atmosphere Monitoring Service

CO2M will measure concentrations of carbon dioxide and methane in the atmosphere with an unprecedented combination of coverage, detail, and accuracy.



◁ **CO2M**

LSTM Copernicus Land Surface Temperature Monitoring Mission

LSTM provides observations of land-surface temperature.

The satellites will carry a high spatial-temporal resolution thermal infrared sensor.

It will estimate the vegetation stress to predict, together with Sentinel-1 & 2, the crop yield (“crop per drop”).

◁ LSTM

LSTM Responding to Environmental Policies

- EU Common Agriculture Policy
  - Greening Element e.g. Ecological Focus Areas, Crop diversification
  - Yield predictions at EU and Global scale
- EU Water Framework Directive & Nitrate Directive
  - Water resource management
  - Water pollution
- Sustainable Development Goals
  - Water Efficiency & Water Quality
- UN Convention Combating Desertification & Degradation
- UN Framework Convention of Climate Change

CHIME Copernicus Hyperspectral Imaging Mission for the Environment

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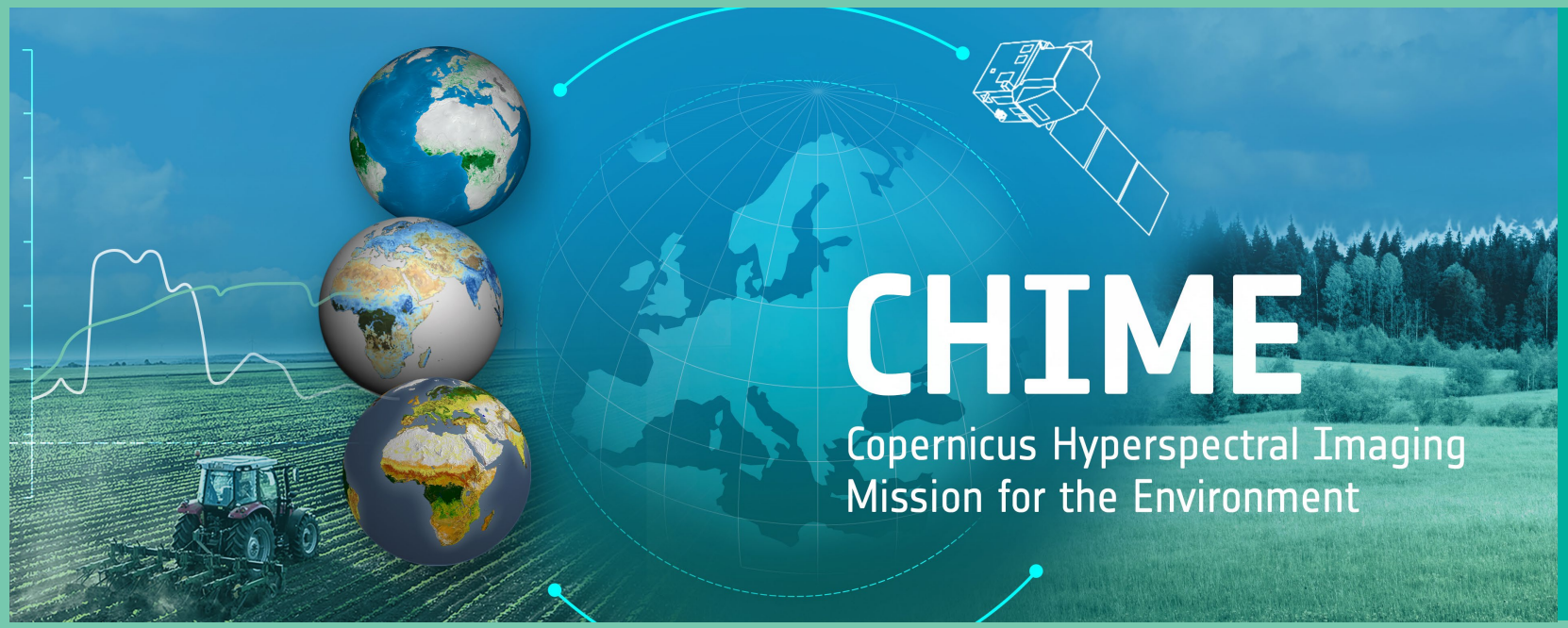
CHIME for sustainable agricultural and biodiversity management, as well as soil property characterisation.

The satellites will carry a unique visible to shortwave infrared spectrometer. The mission will complement Copernicus Sentinel-2 for applications such as land-cover mapping (and Prisma by ASI).



◁ CHIME

CHIME Copernicus Hyperspectral Imaging Mission for the Environment

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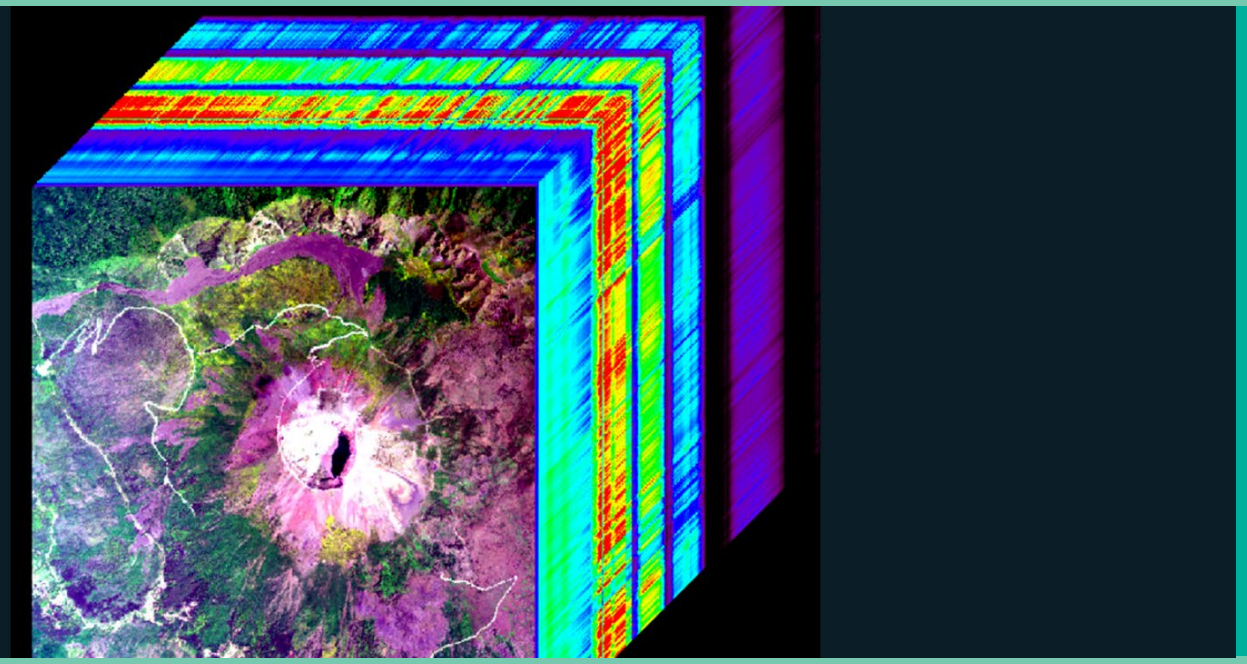
CHIME will measure in the 400-2500 nm spectral range with a continuous spectral sampling ≥10 nm.

Hyperspectral image cube showing Mount Vesuvius, Italy, from AVIRIS, instrument resembles CHIME

The satellites will provide more then 200 bands for the same image (the image cube).

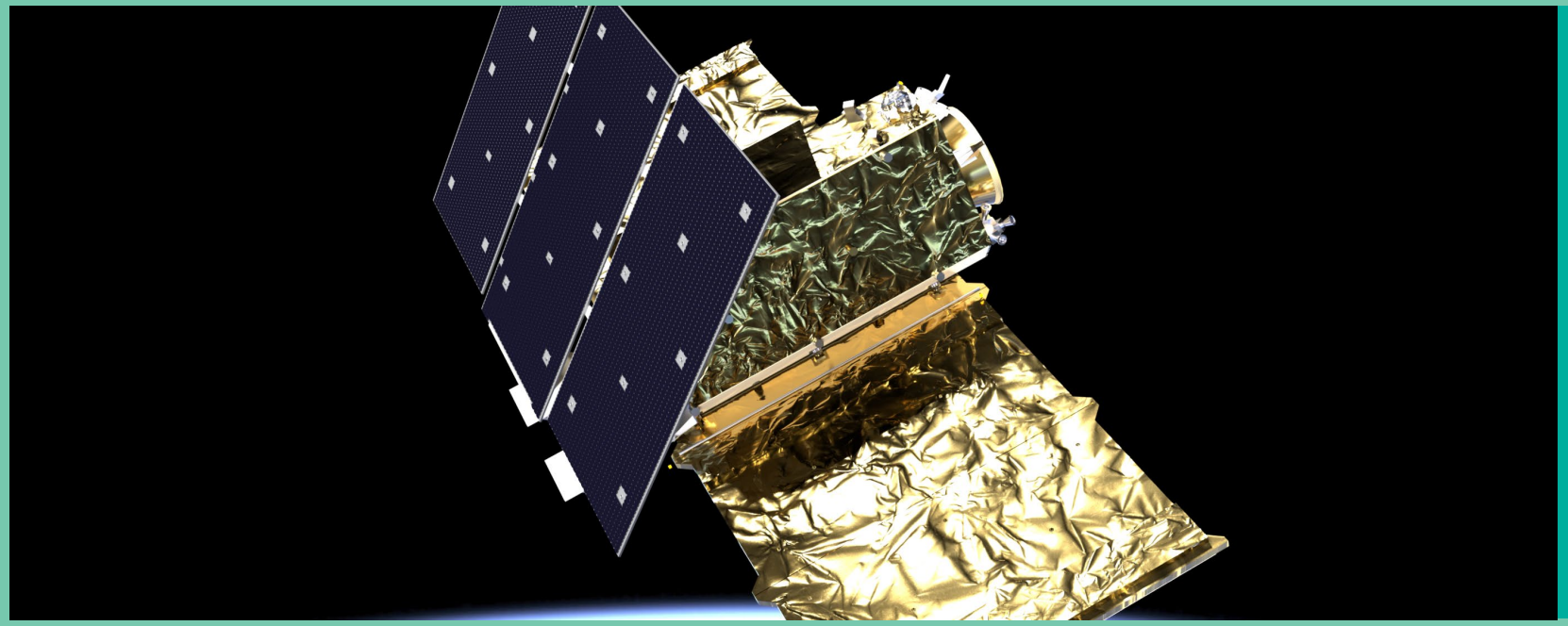


◁ CHIME

ROSE-L Copernicus L-band Synthetic Aperture Radar

ROSE-L for monitoring forest type and cover in support of biomass estimation, as well as soil moisture, vegetation and land ice.

The satellites will carry an L-band synthetic aperture radar. The mission will provide information for monitoring forest type and cover in support of biomass estimation, soil moisture, vegetation and land ice.



ROSE-L

ROSE-L Objectives and Services

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CLMS

C3S

CMEMS

EMS

Security

METEO

Meteorology and Hydrology Services

National and Local Authorities

Geohazards Monitoring

- Deformation
- Landslides
- Urban subsidence
- Flooding

EU-GMS

Land Use, Agriculture and Forestry

- Forest biomass and structure
- Land over and land cover change
- Agriculture

Soil Moisture

- High-resolution soil moisture

METEO

Cryosphere and Arctic

- Sea ice characterization
- Ice sheets and glacier velocity
- Grounding line
- Snow water equivalent
- Permafrost thawing and extent

METEO

Marine Monitoring

- Ocean surface wind vectors
- Swell properties

METEO

Maritime Monitoring

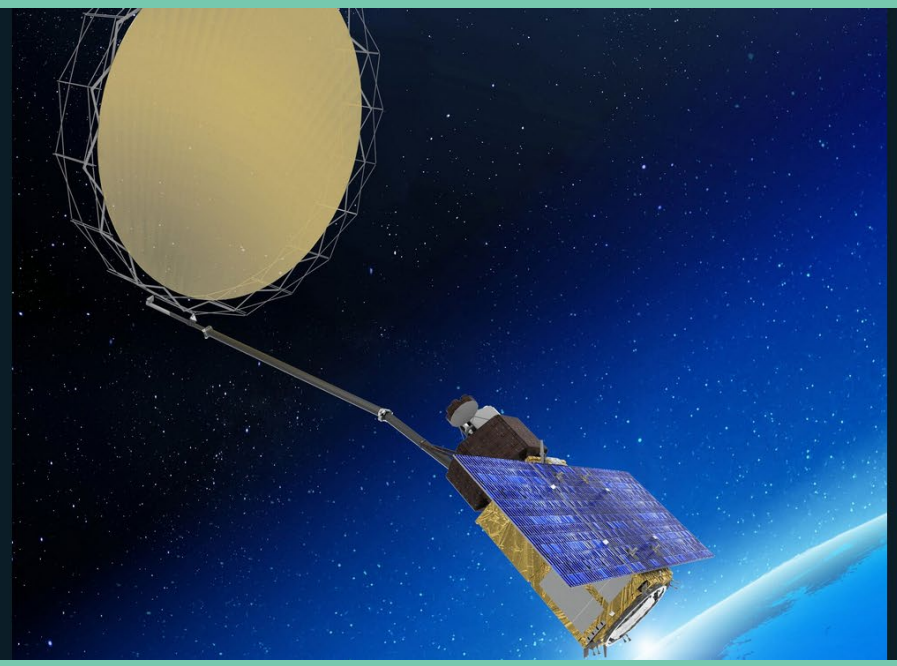
- Iceberg location, size and drift
- Vessel location, size and velocity
- Oil spill location and morphology

EMSA FRONTEX

CIMR Copernicus Imaging Microwave Radiometer

CIMR for measure sea-surface temperature, sea-ice concentration and sea-surface salinity.

The satellites will carry a novel ‘conically-scanning’ multi-frequency microwave radiometer. The mission will also observe a wide range of other sea-ice parameters such as sea-ice thickness and sea-ice drift.



◁ CIMR

CRISTAL Copernicus Polar Ice and Snow Topography Altimeter

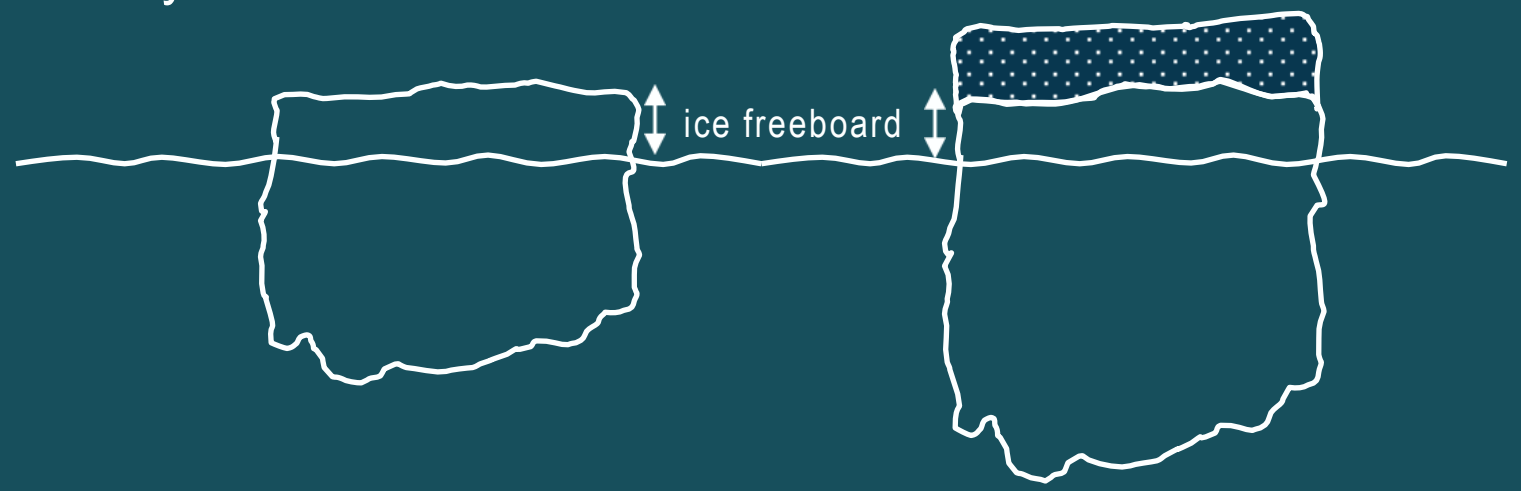
CRISTAL will measure and monitor sea-ice thickness.

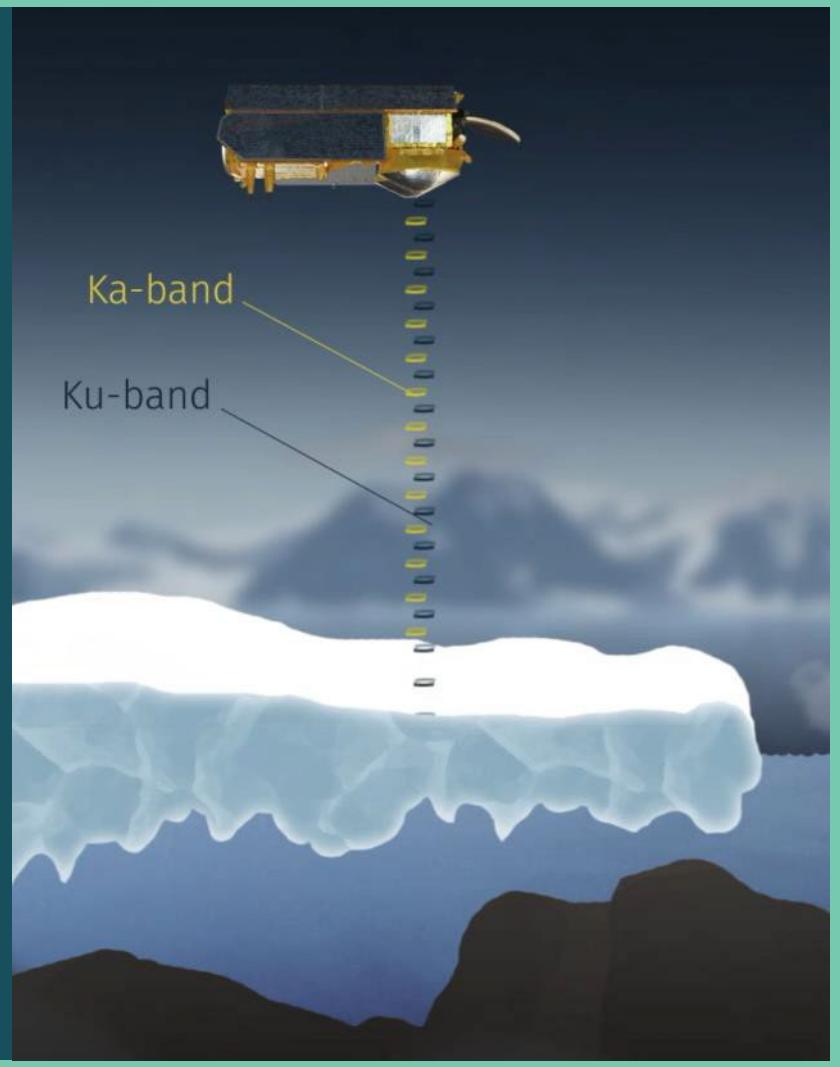
The satellites will carry a dual-frequency radar altimeter, and microwave radiometer. The mission will ill measure and monitor sea-ice thickness, overlying snow depth and ice-sheet elevations.

CRISTAL

CRISTAL will measure snow depth using Ku- & Ka-band

- Snow depth is important in itself - for local and global energy and freshwater budget
- Ku & Ka bands are essential for retrieving sea ice thickness from altimetry





Credits: Isobel Lawrence et al., LPS22

Synergy of the Polar Expansion missions

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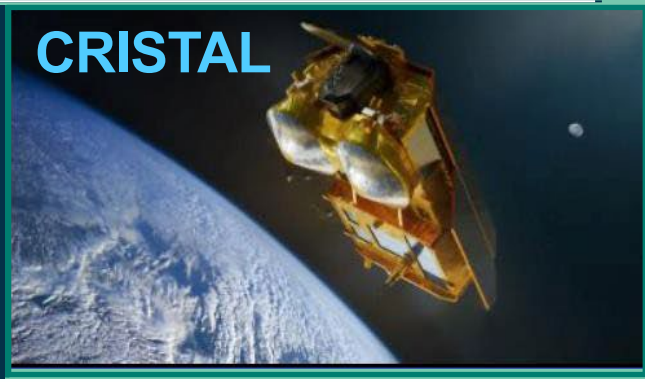

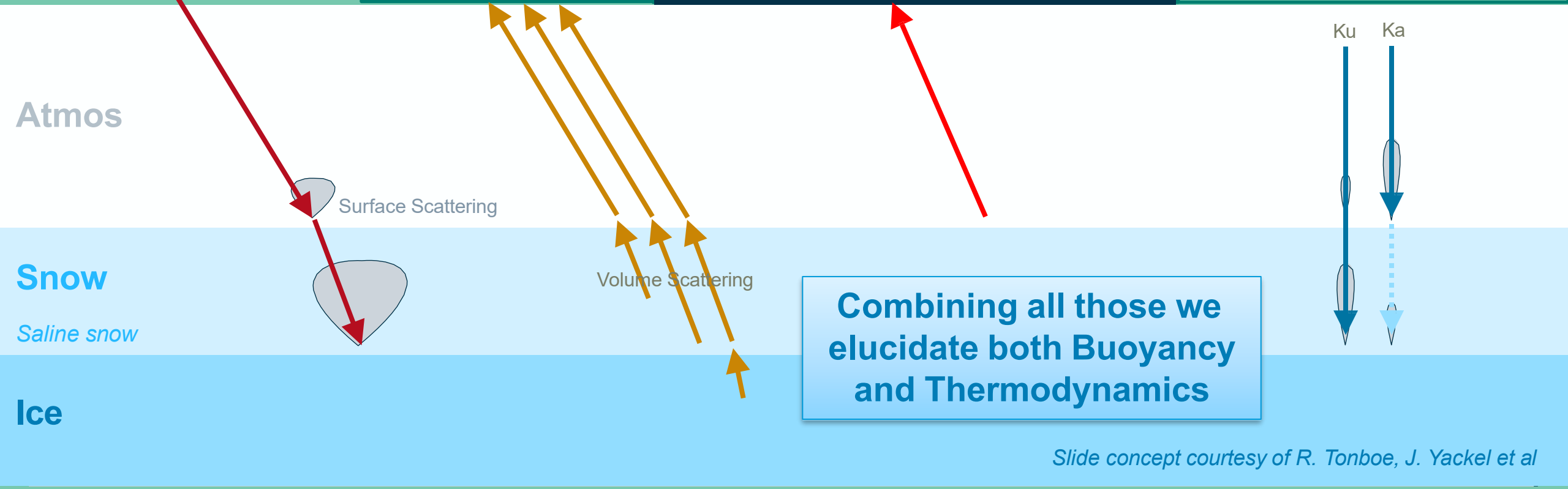

Combining all those we elucidate both Buoyancy and Thermodynamics

Slide concept courtesy of R. Tonboe, J. Yackel et al

Questions?

www.esa.int