

The evolution of the European Earth Observation Ecosystem and related Technology needs

Keynote speech to EDHPC Conference

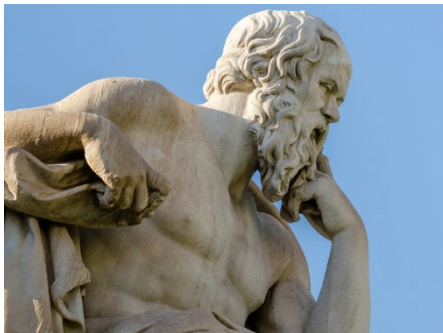
Josep.Rosello@esa.int

EO Technology Coordination, EOP-FMT
EO Future Missions and Architecture Department, EOP-F
Elx, ES, 13 October 2025

ESA UNCLASSIFIED – For ESA Official Use Only



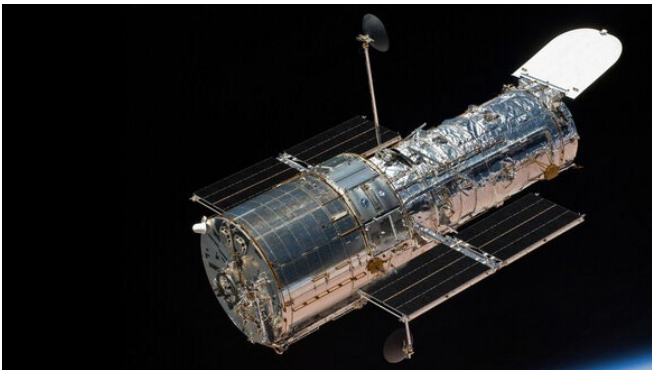
Human hunger for KNOWLEDGE



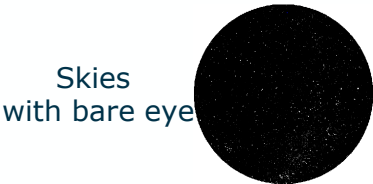
Socrates – *I only know that I **know nothing***



Galileo & enabling **technology**



Hubble – Space Telescope



KNOWLEDGE – same coin, two faces

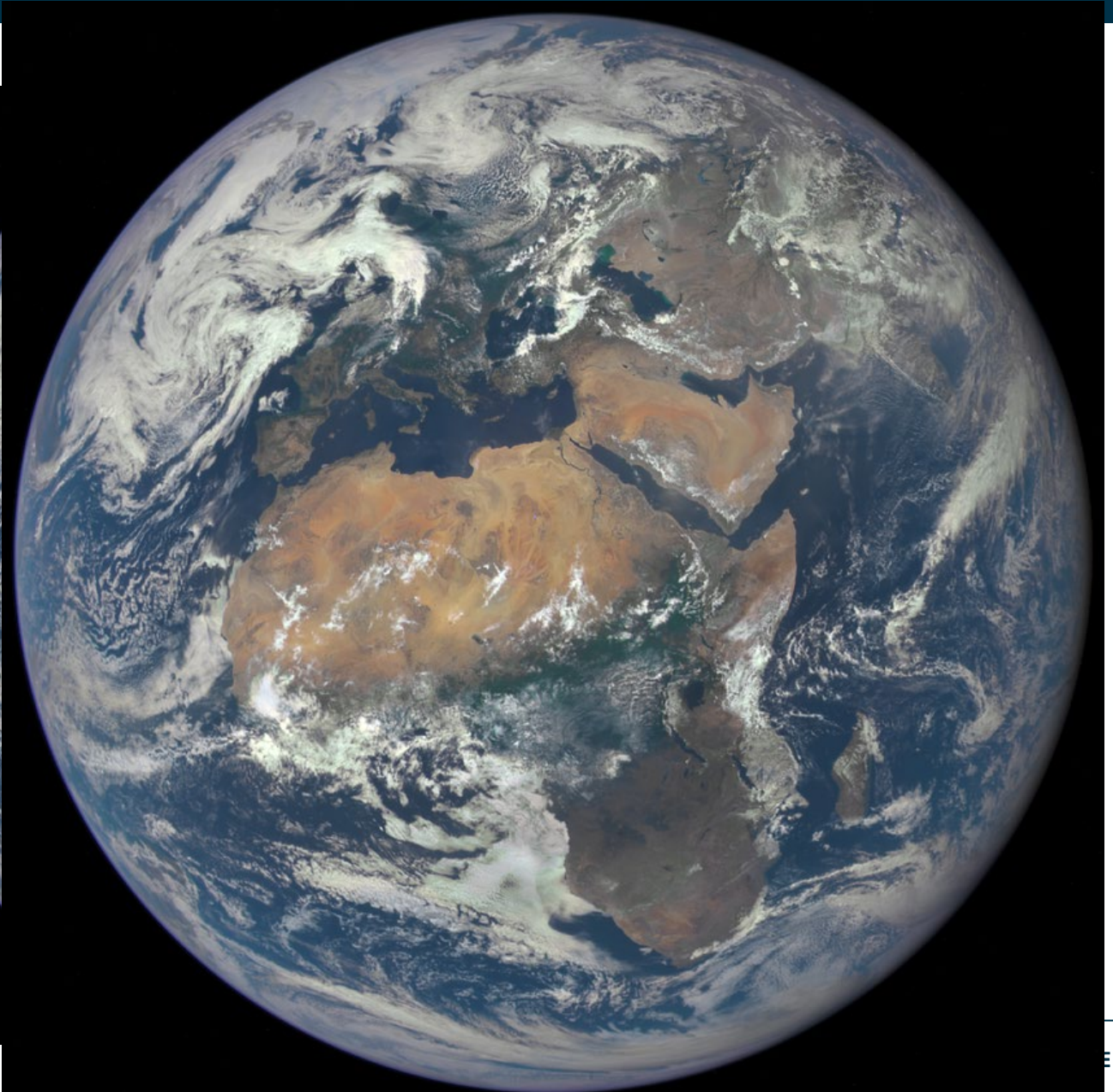
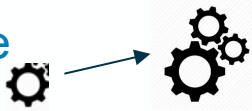
- | | | | | |
|--|----------------------|---|--------------------|--------------------------------|
| | 1) Science | – | the driver | – the “what” to know |
| | 2) Technology | – | the enabler | – the “savoir-faire” to answer |

STEM :
S = Science
T = Technology
E = Engineering

Our focus : our unique Planet

→ more technology needed

More knowledge



ESA & Earth Observation

- **EO Missions**
- EO Technology
- Programmatics & CMIN25
- System of Systems
- M-IND & ADHA - APA

Devising Earth Observation Missions



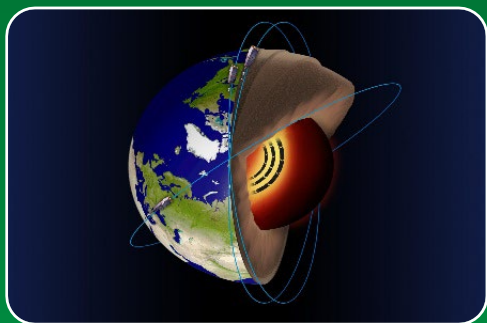
Living Planet Program

Research Missions

Member States

Earth Explorers & Scouts

Ideas from science partners
in MS (Open Calls)



Also **Mission of Opportunity**
with non-ESA MS (NGGM)

+

Stepping Stones Constellations

Earth Watch Missions



Copernicus



ERS & EOGS



Meteorology



InCubed



Member States

Other

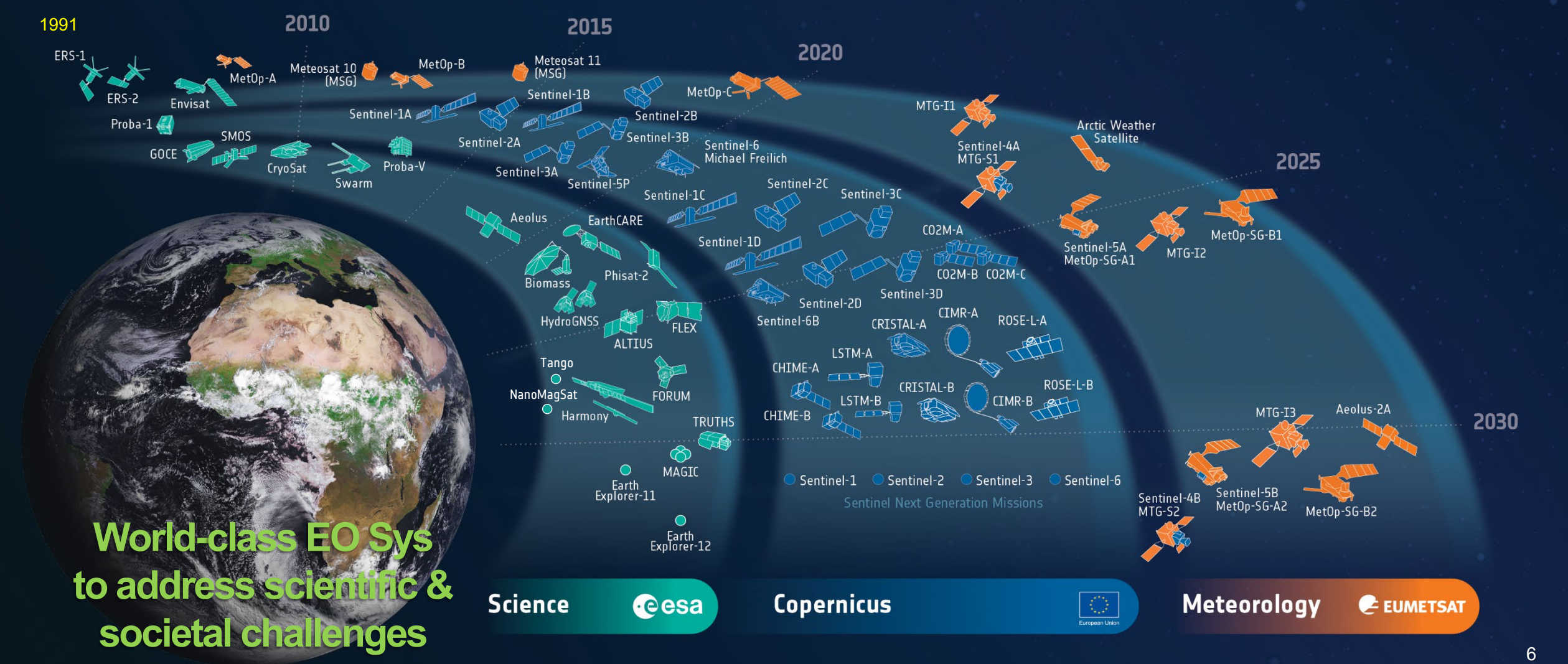
Altius
TRUTHS
Artic Weather Sat - STERNA
PNRR
- IRIDE (IT)
- Atl.Const (ES)
- Camila (PL)
- Constellation (GR)

ERS Clusters

- User needs from institutional partners & industry

ESA's Earth Observation Missions

Satellites: Heritage 08 / Operational 16 / Developing 40 / Preparing 22 / Total 86



Evolution = more technology



Living Planet Framework



Earth Science Strategy



1977

1991

1995

1997

1998

2025



Earthnet: European access to non-ESA missions

User

Meteosat
M-1, 2, 3



Operational
M-4, 5, 6

Transition
M-7

Meteosat(s)
Metop(s)



Meteo

Research Missions
Earth Explorer(s)
Scout(s)



Science

1991
ERS 1, 2



1995

Envisat

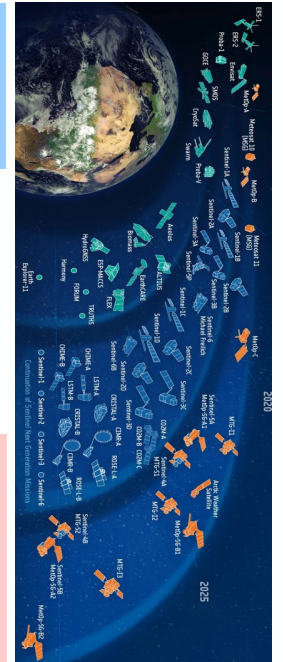


Earth Watch

Copernicus
(in cooperation )

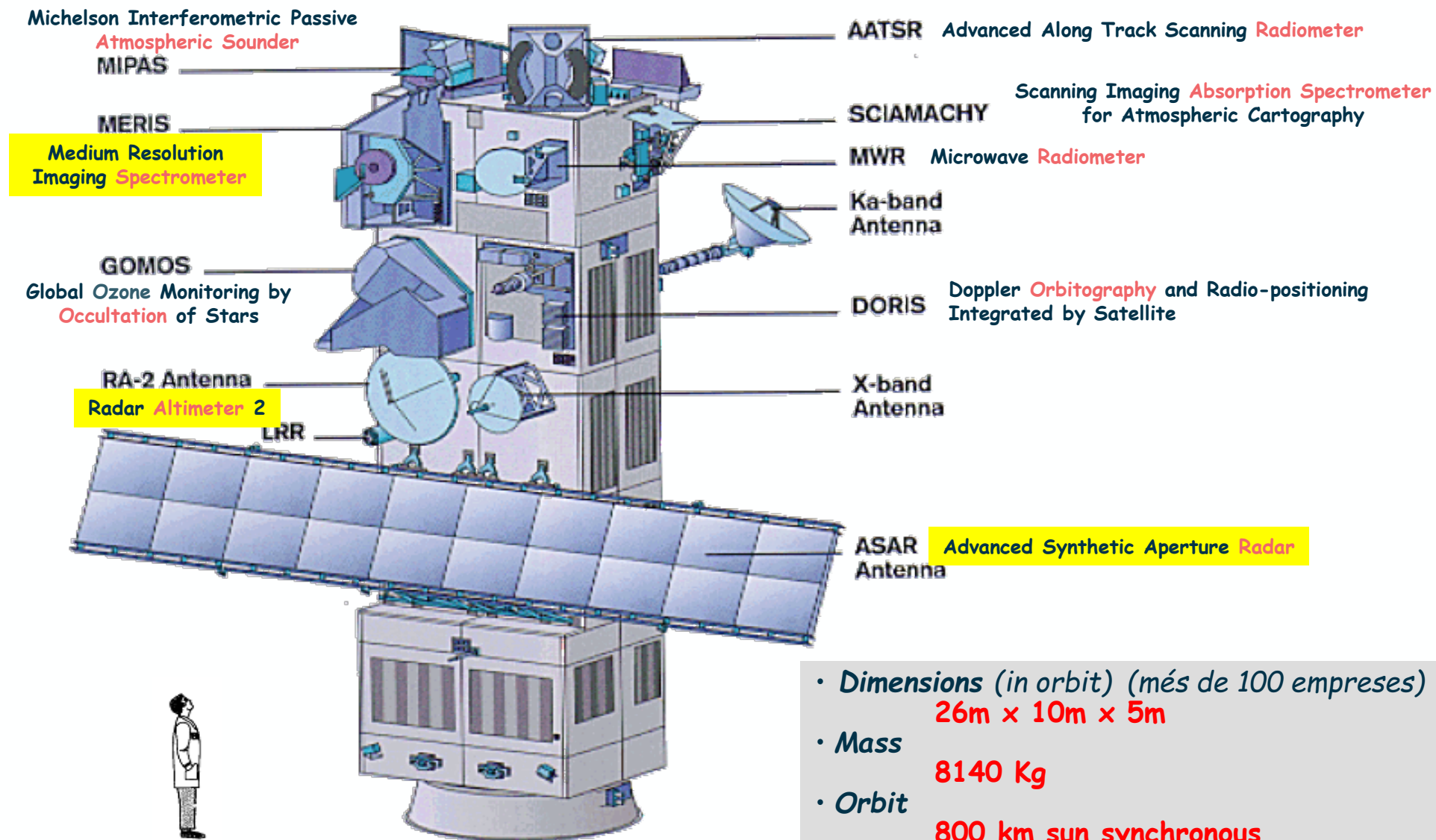
GSTP 
NewSpace
Private
National
Resilience

Applications Services

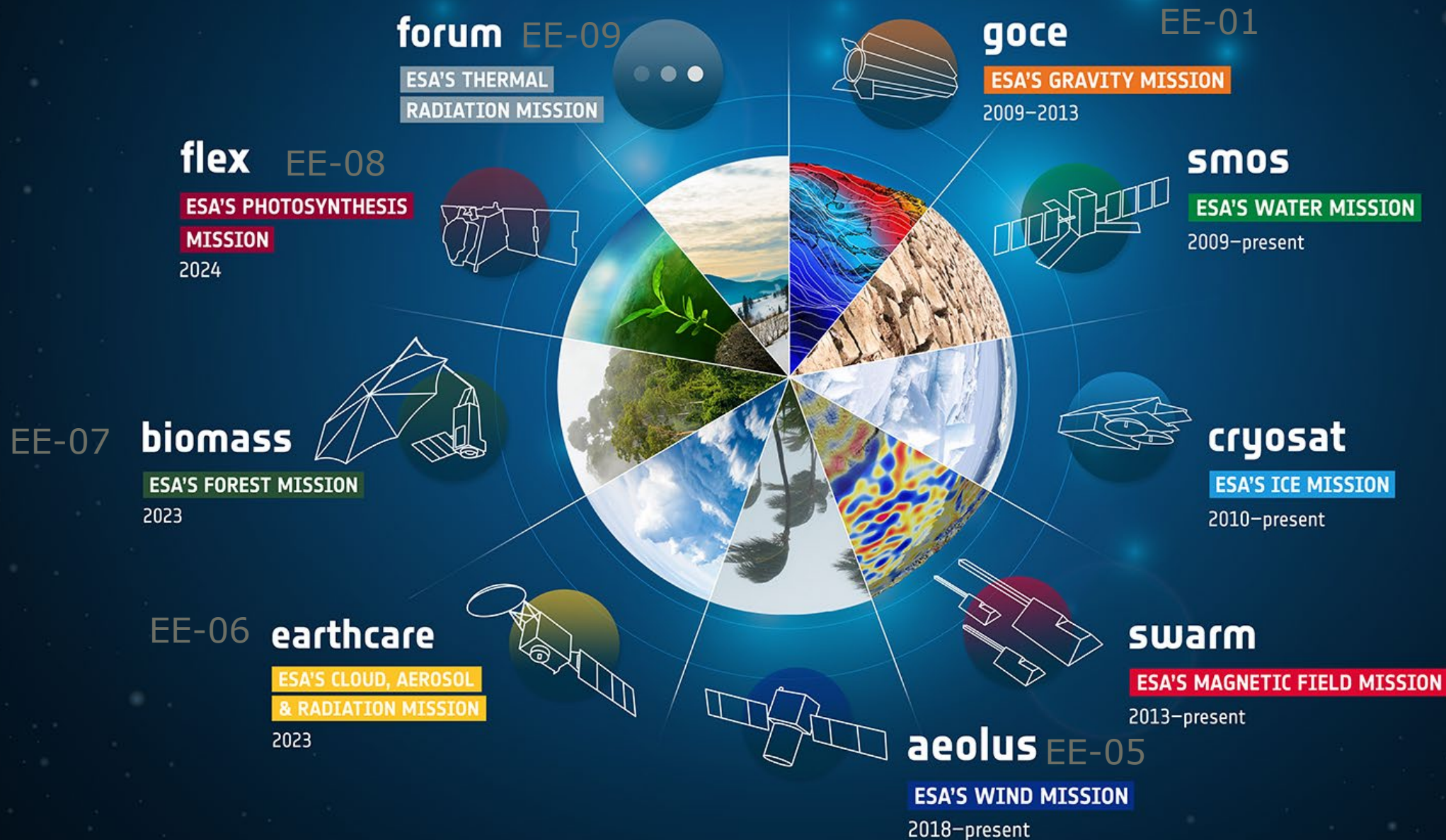


Envisat: 10 instruments

(launched 2002 - until 2012)

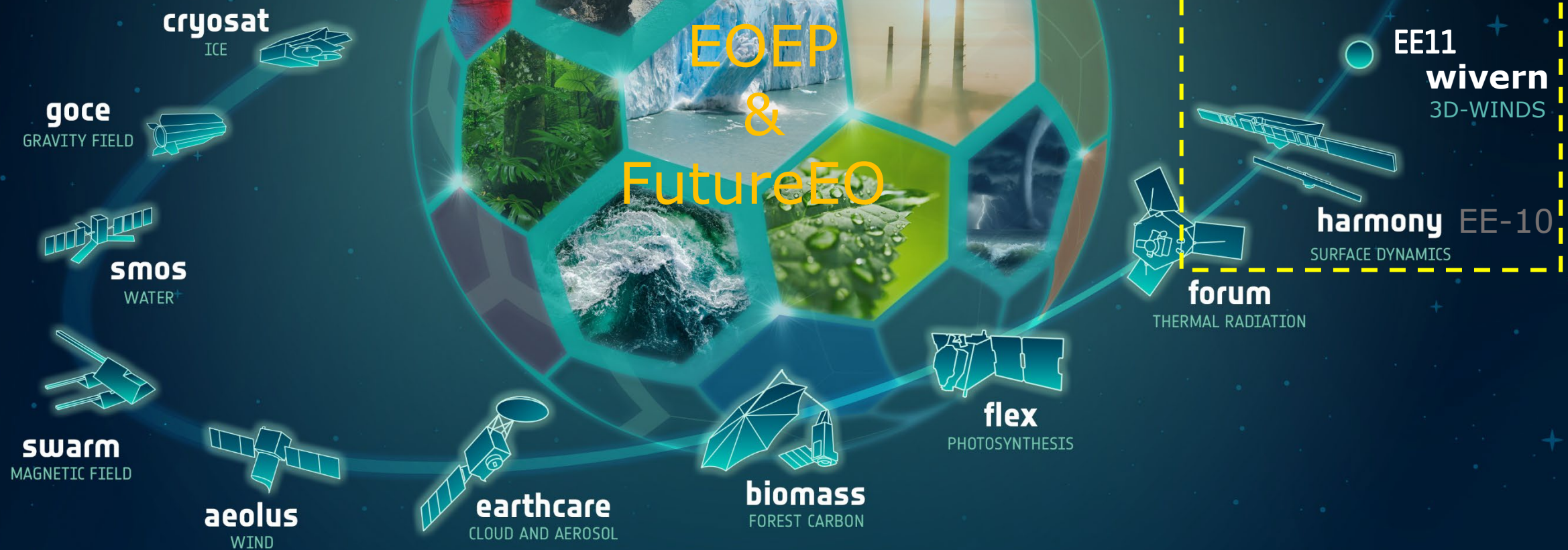


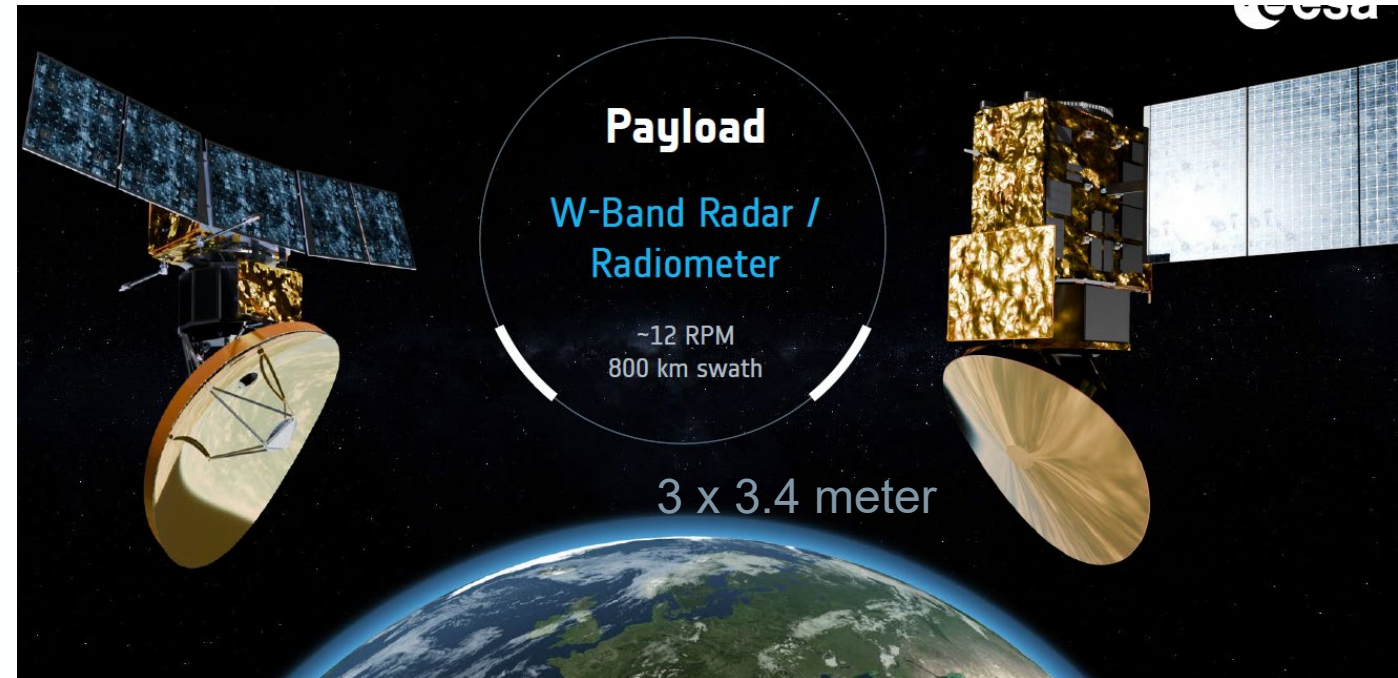
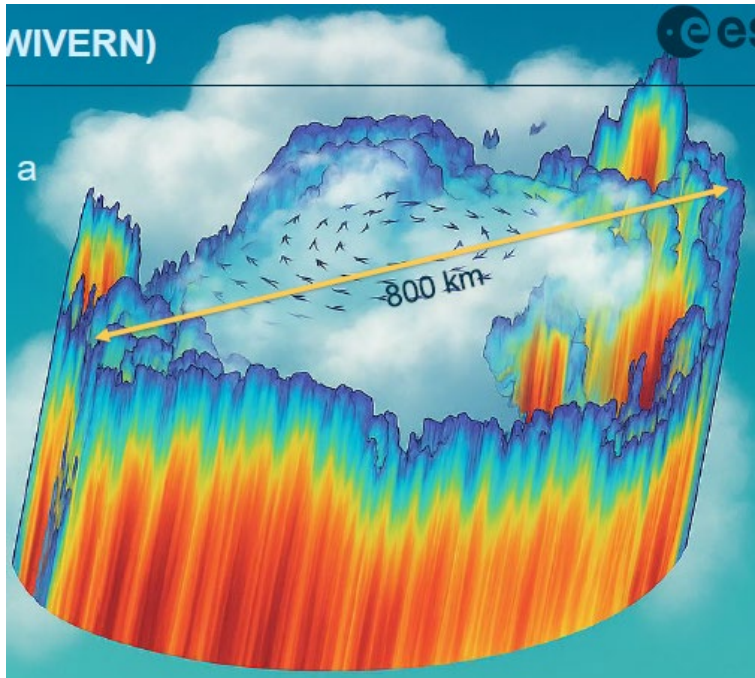
Science: Earth Explorers



Earth Explorers

Pioneering Scientific and Technical Excellence





It measures:

- **3-D winds within clouds** at a global scale - for the first time
- **cloud** and **precipitation** properties **simultaneously**

Geometry:

- **across swath:** 800 km
- **horizontal resolution:** 1 km



2031

EO Delivers together with European Industry



5 Satellites (4 Launches) in 2024



29 May *EarthCARE*



4 September
Sentinel-2C

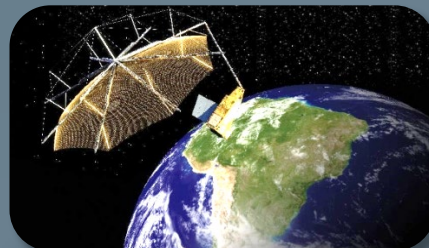


16 August
Arctic Weather Satellite
+ *Øsat-2*



5 December
Sentinel-1C

11 Satellites (9 Launches) in 2025



April: *Biomass*



Q4: *Sentinel 6B*



July: *MTG-S1 & S4*



Q4: *MetOp-SG A1 & S5*

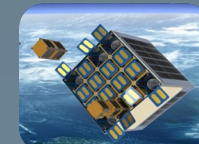


Q3-Q4: *Sentinel 1D*

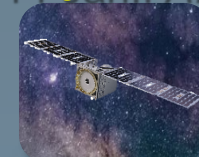


Q4: *HydroGNSS*

InCubed (5)



14 Jan.: *AIX*



14 Jan.: *Hive*



14 Jan.: *Forest-3*



'25: *UKKO*

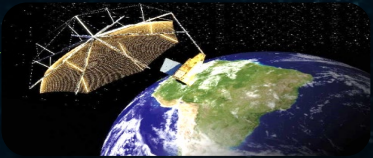


'25:
Hyperfield



11 Satellites to be Launched in 2025 + National

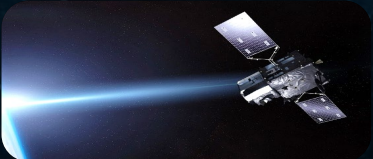
Launched
successfully



Apr.: Biomass



Nov.: Sentinel 6B



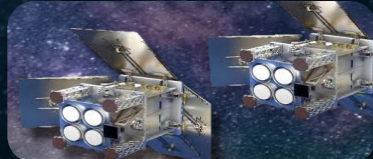
Jul.: MTG-S1 & S4



Aug.: MetOp-SG A1 & S5

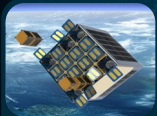


Nov: Sentinel 1D

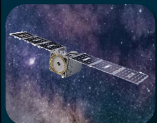


Nov.: HydroGNSS

ESA
InCubed



Jan.: AIX



Jan.: Hive



Jan.: Forest-3



'25: UKKO



'25: Hyperfield

National Constellations

Italian constellation - Iride

Jan. & Jun.: Argotec HEO satellites

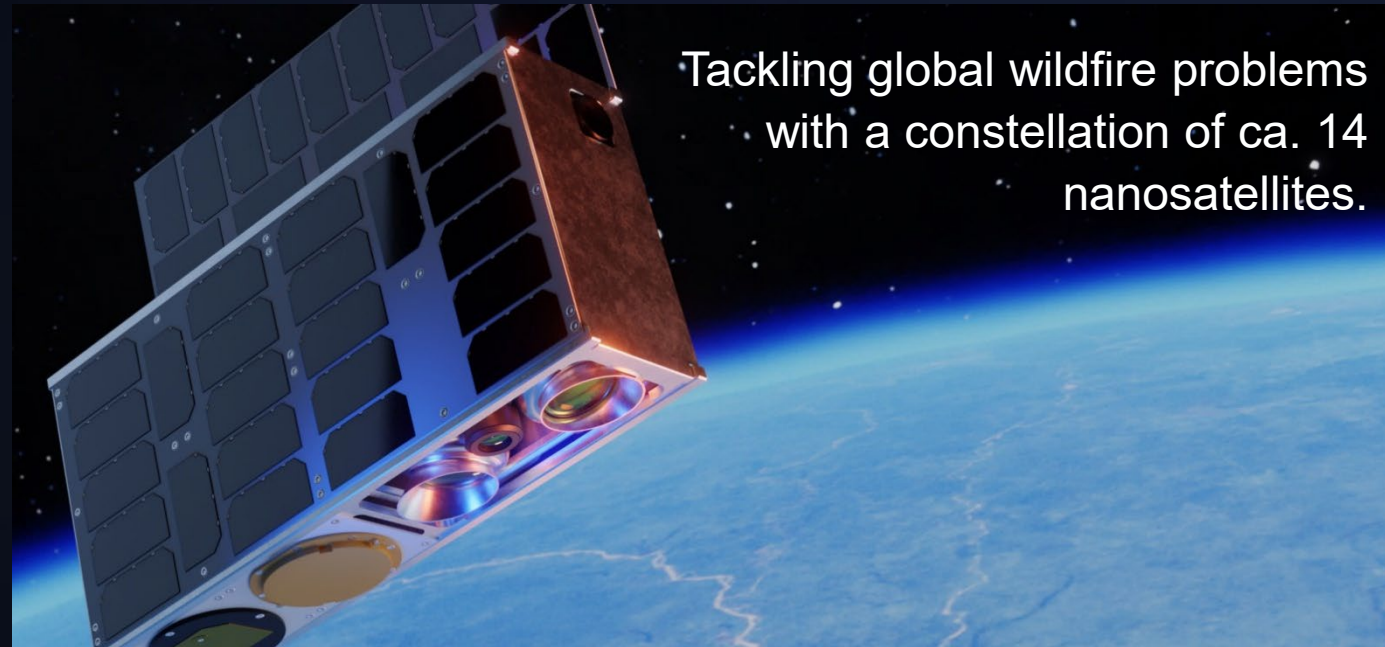
Nov: OHB-I Eaglet-II satellites

Greek constellation

Nov.: Iceye satellites

Q4: Ororatech satellites

InCubed Supported OroraTech's Thermal IR CubeSat



Tackling global wildfire problems
with a constellation of ca. 14
nanosatellites.

OroraTech Technology to be used in
Greece's National Wildfire System

Scout Missions



Scout HydroGNSS

Measure key hydrological
climate variables

Launch Oct. 2025

Tango

Implementation initiated in 2025

Measure methane, carbon
dioxide and nitrogen dioxide

NanoMagSat

Implementation initiated in 2025

Measure Earth's magnetic
field and ionosphere

Characteristics

- Operational missions designed to deliver science in orbit
 - Service contract - Sat. now owned by ESA
- Strict cost and schedule boundaries
 - 3 years from Kick-Off to launch
 - Maximum 35M EUR industrial cost, incl. Launch
 - ➔ Based on SmallSat/CubeSat format
 - ➔ Application of NewSpace standard

4 Scouts in 2nd Cycle

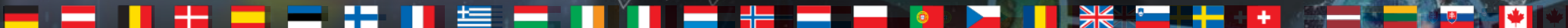
HiBiDiS
NAIAD
SIRIUS
SOVA-S

Sitael
SSTL
TAS-ES
OHBCZ & Berlin Space Techno

Feasibility initiated in 2025

4 Scouts in 3rd Cycle

ITT for feasibility in 2027



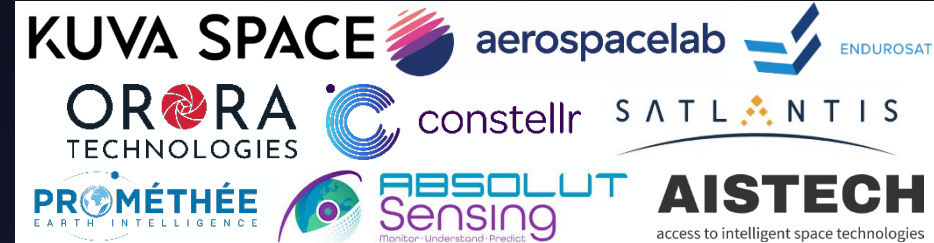
19 New Signatures for Copernicus Contributing Missions



EC funding through ESA



9 European emerging data suppliers



6 European established data suppliers



4 non-European data suppliers



Sentinels 1st Gen.

supporting 6 operational services



land atmosphere climate ocean disaster security

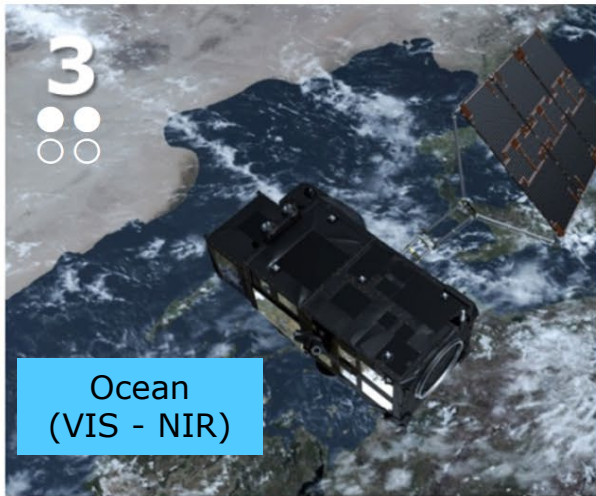
1



Radar Vision
(C-band)

2014 / 2016 / 2024

3

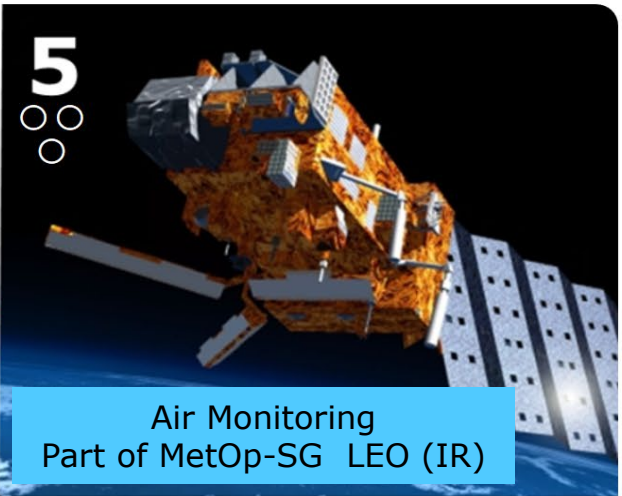


Ocean
(VIS - NIR)

5P

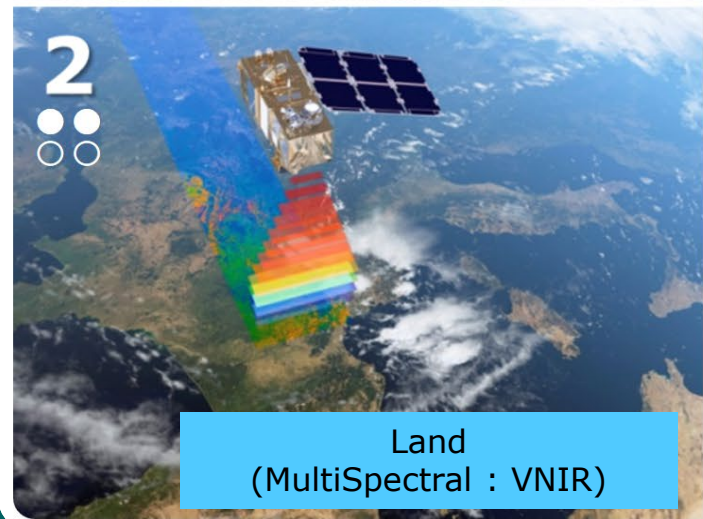


5



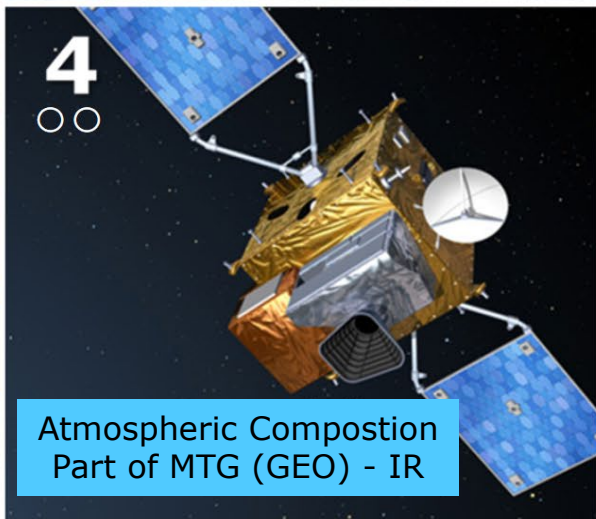
Air Monitoring
Part of MetOp-SG LEO (IR)

2



Land
(MultiSpectral : VNIR)

4



Atmospheric Composition
Part of MTG (GEO) - IR

6



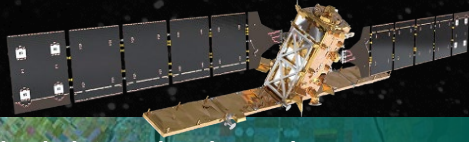
Altimetry - Sea Level
(Ku-band)



The Copernicus Space Component | Sentinels



Sentinel-1



All-weather, day-and-night radar imaging mission for land and ocean services

2014 / 2016 / 2024 ●●●○

Sentinel-2



Multispectral high-resolution imaging mission for land monitoring

2015 / 2014 / 2024 ●●●○

Sentinel-3



Multi-instrument mission for sea-surface topography, sea/land-surface temp. and ocean/land colour

2014 / 2018 ●●○○

The largest producer of EO data in the world with full, **free & open data policy***

> 360.000
Registered Users

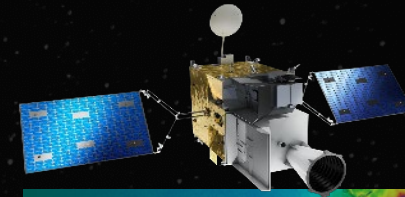
20 TB
of daily data production

800+ PB
of products disseminated for services to society

supporting 6 operational services



land atmosphere climate ocean disaster security



Sentinel-4

Geostationary atmospheric monitoring

●○ 2025

Sentinel-5/5p

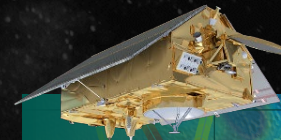


●○○ 2025

Polar orbit atmospheric monitoring

● 2017

Sentinel-6



Altimeter for global sea-surface height

●○ 2020 / 2025/

● operational
● inactive
○ To be launched

*Esa Sentinel Data Policy (Sep 2013) and EU Delegates Act on Copernicus Data and Information Policy (Dec 2013)



→ THE EUROPEAN SPACE AGENCY

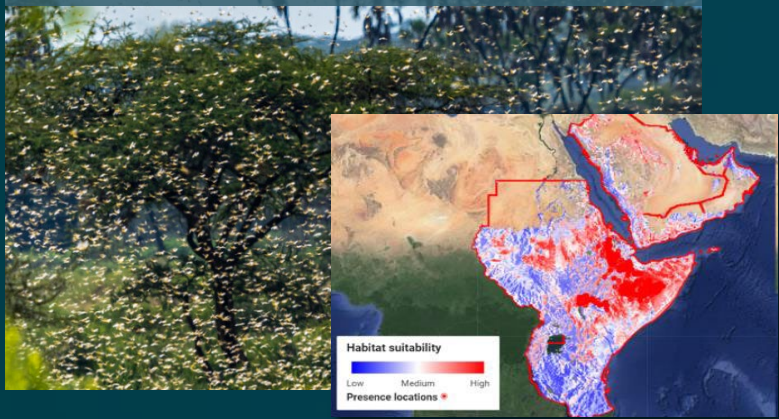


From space, the evidence for climate change is compelling



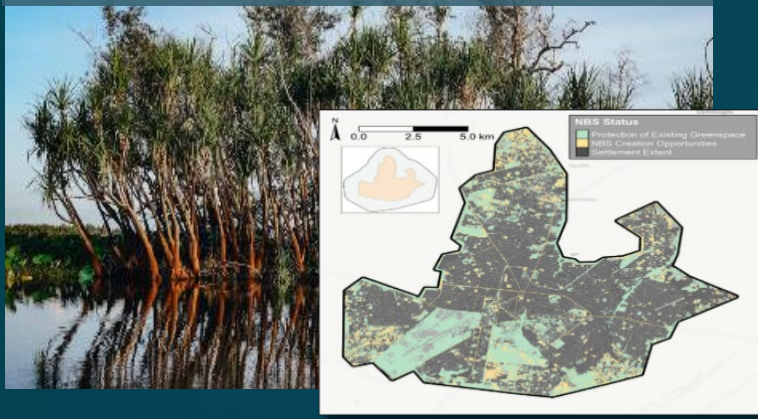
EO bridging the gap from science to action for developing country governments

Agriculture and Fragility



Desert Locust monitoring service to support early warning actions as well as impact assessment of damaged crop areas.

Disaster Resilience



Nature-Based Solutions (NBS) Opportunity Scan for assessing the most impactful EO integration supporting NBS related investments

Climate Resilience



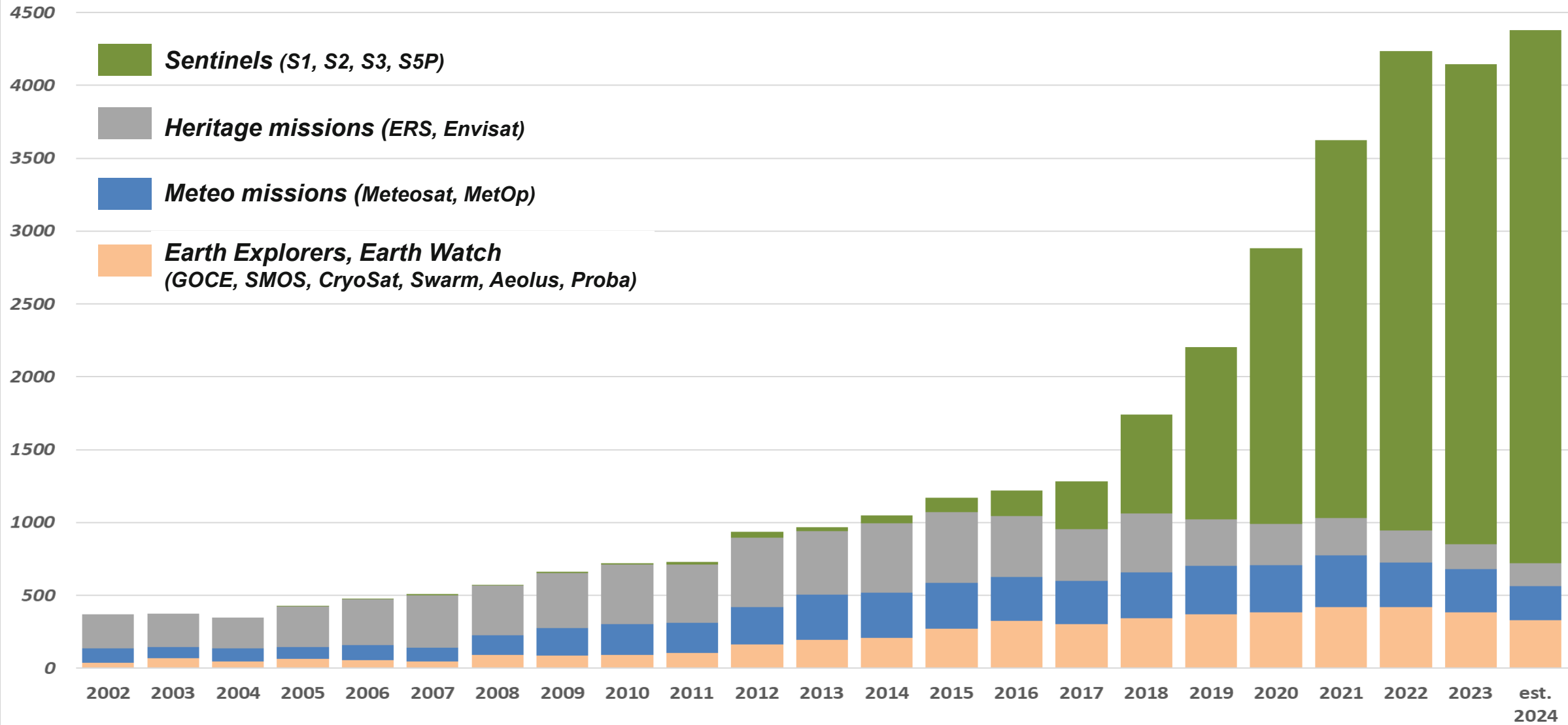
Enhancing climate-smart water resources management in South Sudan by providing flood management data products.



Scientific Impact of ESA EO Missions



Number of scientific publications



Copernicus Space Evolution

(all in Ph. C/D)



PROGRAMME OF THE
EUROPEAN UNION

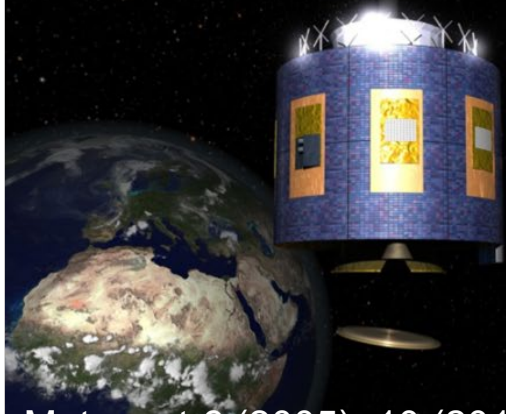
co-funded with



Meteorological Missions

G
E
O

Meteosat SG



Meteosat-9 (2005) -10 (2012) -11 (2015)

Meteosat TG



MTG-I1 (2023) - S1 (2025)

6 MetOp-SG satellites
– 2 decades of service

3 x MetOp-SG **A**

- METImage (DLR)
- IASI-NG (CNES)
- **MWS**
- RO
- Sent.5

3 x MetOp-SG **B**

- SCA
- MWI
- RO
- ICI
- Argos-4 (CNES)

M
E
O

MetOp



Metop-B (2012) -C (2018)

MetOp SG



Metop-SGA1 (2025) -SGB1 (2026)

Arctic Weather Satellite

- reduced **MWS**
- Precursor of STERNA (20 sats)

Higher dynamics:
• temporal revisit
• Techno Innovation

(August 2024)

ESA & Earth Observation

- EO Missions
- **EO Technology**
- Programmatics & CMIN25
- System of Systems
- M-IND & ADHA - APA

Higher performance / cost ratio

Largest part

- New Measurements/ **EO instruments** (enabler)
 - Higher spatial, temporal, radiometric, spectral resolution
 - Full spectrum 
 - Disruptive: e.g. "Quantum Sensing" 



Generic
e.g. via BA, GSTP

- Lower recurring **development cost / faster adoption**
 - Platform Standardisation & multi source suppliers
 - Spin-in techno: e.g. COTS
 - Lifetime & flexibility (FPGAs)
 - Digitalisation (e.g. MBSE, others)

Often co-funded
GSTP & FutureEO



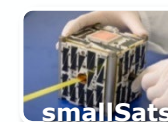
CleanSpace (e.g. demisable, EoL disposal)

- **Big Data & Analytics** ([AI enabler](#)) & Data continuity



Miniaturisation and constellations

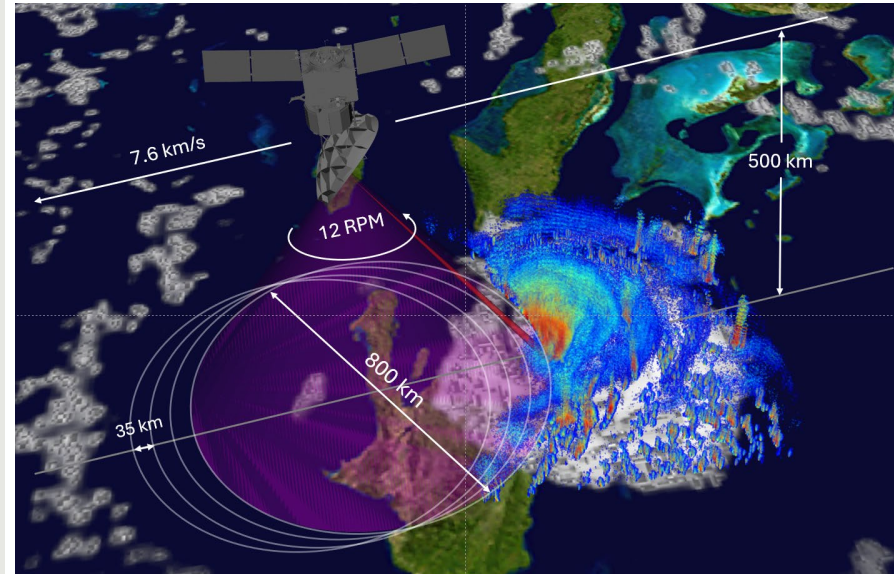
- More **autonomous** platform & operations & synchronisation
- **Distributed** Ground Segment



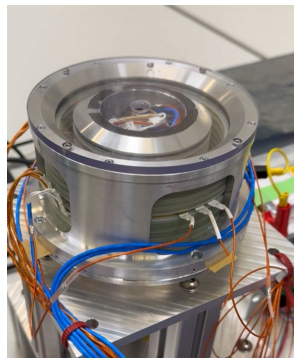
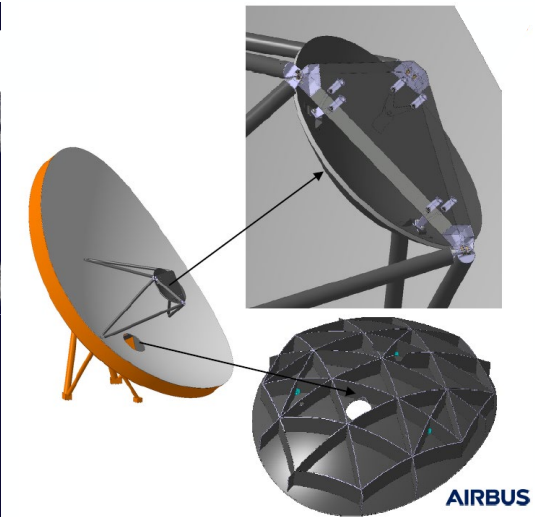
Not limited to **LEO**: also **HEO** & **GEO** orbits relevant for EO

Earth Explorer 11 candidate mission – WIVERN

- Conically scanning **W-band (94 GHz) cloud radar** - in Ph. A
- EE User Consultation → selected on 9-Jul-2025
- Instrument pre-development activities ongoing:
 - Reflector Assembly (ADS-**DE**, TAS-**FR**)
 - Antenna Quasi optics Network (Thomas Keating - **UK**)
 - HPA/EIK (CPI – **CA**)
 - HPA/HV-Power Supply (ASP **DE**, Leonardo **IT**)
 - Backend RF-modules (RAL **UK**, RPG)
 - Scan Mechanism (ADS-**DE**)
 - Ferrite Switches (Harp **FI**, Honeywell **UK**)
 - Heatpipes (EHP **BE**)
 - Coupler & redundancy switch (Flann **UK**)

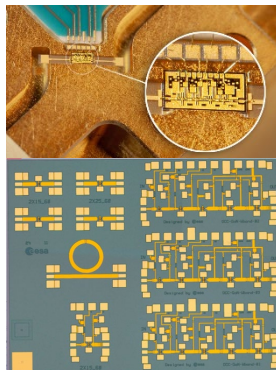


WIVERN conically scanning cloud radar



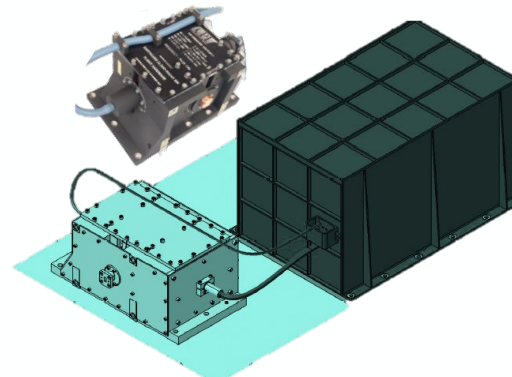
Scan Mechanism

(courtesy **ADS - DE**)

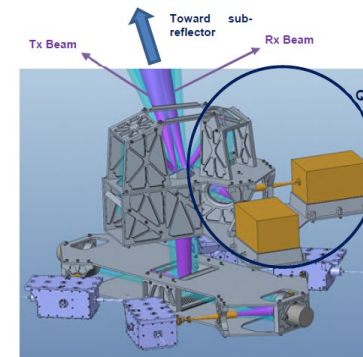


GaAs RF LNA stress test

(courtesy **RPG - DE**)



EIK + HV Power Supply EPC
(courtesy **ACPI – CS + ASP – DE**)

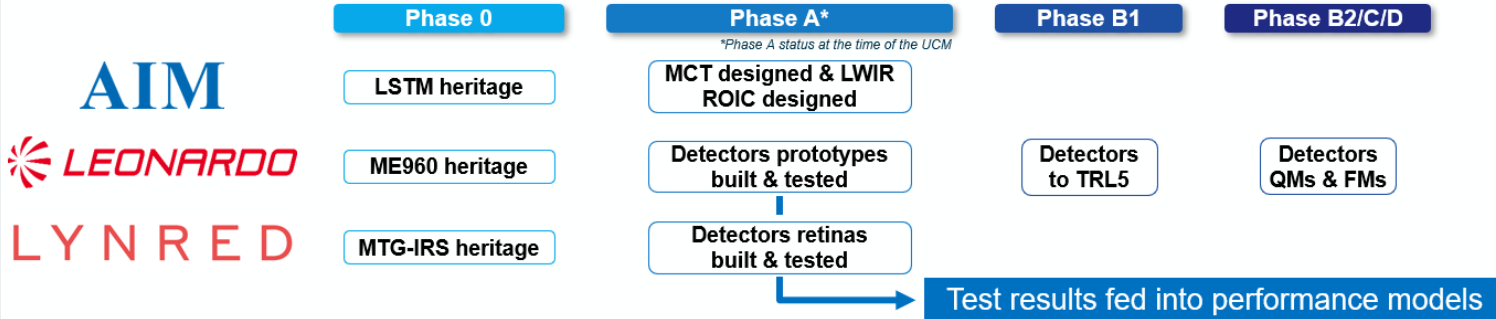


Quasi-Optical Network Breadboard
(courtesy **Thomas Keating Ltd - UK**)

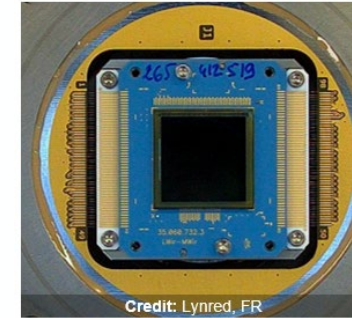


**Main Reflector
Demonstrator Model**
(courtesy **ADS - DE**)

Detectors (LEONARDO, UK) (LYNRED, FR) (AIM, DE)

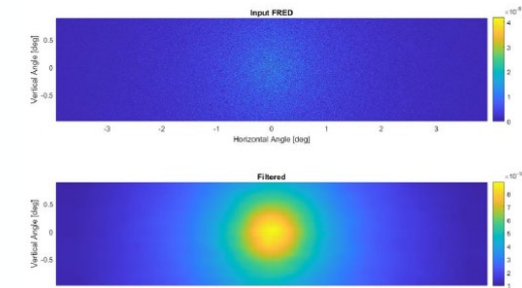
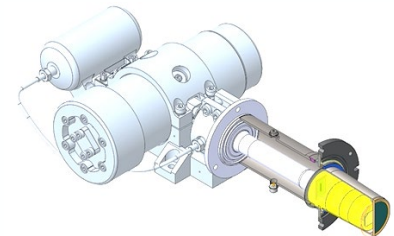
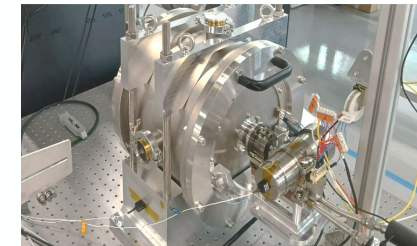
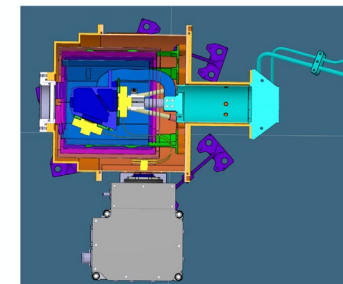
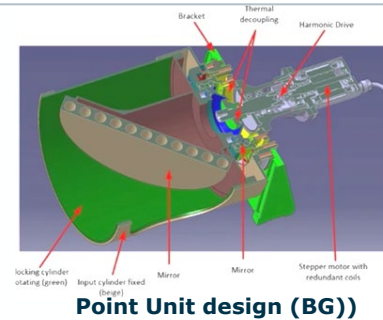


Phase A detectors prototypes



Other CAIRT pre-developments:

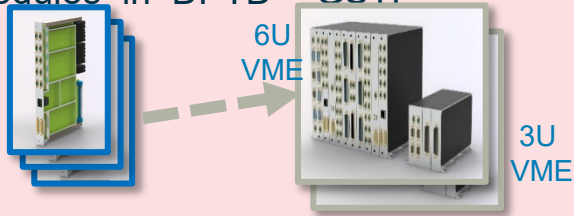
- Compression algorithm (POLITO IT & OHB DE & TAS FR)
- CAIRT Pointing Unit Preliminary Design (SENER ES & Beyond Gravity CH in competition)
- Microvibration de-risking (Leonardo UK and Absolut System FR partnership)
- IDCA development (Leonardo UK)
- Cryostat design (Airbus DE)
- Ghosts & FRED model (MICOS CH)



Std Avionics for Large Sats

Adv. Data Handling Architect. (ADHA)

- Unit /Sys. studies: in FutureEO + DPTD
ADS [DE,FR], BeyGr.[SE], TAS[IT,FR], OHB[DE]
- Modules in DPTD + GSTP



Until 2024: 20+ activities (22 M€)

ADHA extension from P/F to Instruments (ICU, DSP)

Adv. Power Architect. (APA)

- Unit /Sys. studies: in FutureEO + DPTD
OHB [DE] + ADS [FR], TAS[IT,FR], ASP [DE], CRISA [ES], BeyGr.[CH], Terma[DK] up to 10 sub-co
- Modules in DPTD (ITTs in 2025)

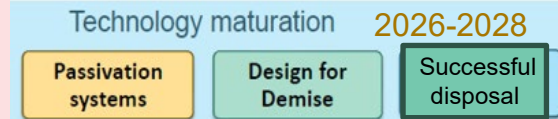
for ALL high-class LEO missions
(+ working on 3U extensions for NewSpace)

Zero Debris Mission End of Life

- End 2023 – New Debris Policy + ESA Debris Mitigation Req.

Large S/C Platform Evolution

- 3 x Sys. studies: in FutureEO + S2P Prog.
ADS [DE], TAS [FR], OHB[DE]
- 2025 : Techno Roadmaps



Small S/C Platform Evolution

- 2 x Sys. studies: in FutureEO + S2P Prog.
Sitael [IT], LuxSpace [LU]
- 2026 : Techno Roadmaps

High EOP coordination with D/TEC, OPS, CSC, STS, ...

- Constellations
 - Resilience / ERS
 - Stepping stones
- European supply chains & Industrialisation
- Clean Space, ...

M-IND

Mid-size sats INDustrialisation

High Revisit → LEO constellations

- Fit purpose: emergency, catastrophes, ...
- Affordable: mid-size sats



COMPETITIVENESS

Develop faster

cost efficiency

Understand drivers in mid-size sats 2025



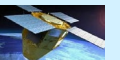
Equipment adaptation 2026-2027

- Mainly in GSTP)
- Multi-source / interoperable
- Industrialisation
- Some new requirements (e.g. I/F to OISL)

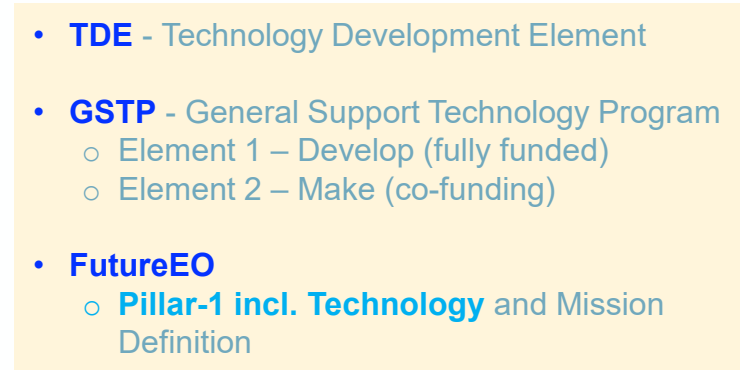


Progressive integration 2028 onwards

Ready for 1st sats in 2028



- **FutureEO: ~25 M€/yr** - varies yearly
- **TDE: ~6.5 M€/yr** - up to TRL 3-4
- **GSTP: ~12 M€/yr** : higher TRLs (product / commercial driven)



ESA & Earth Observation

- EO Missions
- EO Technology - examples
- **Programmatics & CMIN25**
- System of Systems
- M-IND & ADHA - APA



03. Autonomy & Resilience

Obj. 3.1

Develop **state-of-the-art space solutions** ... natural and anthropogenic **disasters** and **emergencies**.

Obj. 3.3

Develop the **next generation technologies** and systems in connectivity, PNT, **EO** and **civil security** ...

04. Competitiveness

Obj. 4.1

Strengthen **industrial capacity** and competitiveness ...

Obj. 4.2

Accelerate **innovation** ... **space technologies**.

Obj. 4.4

... attracting top **STEM** talent.



Increasing focus on resilience and security in and of Europe → including the role of space

- War in Ukraine → Dual use (*Defence and Security*), complementing NATO efforts, ...

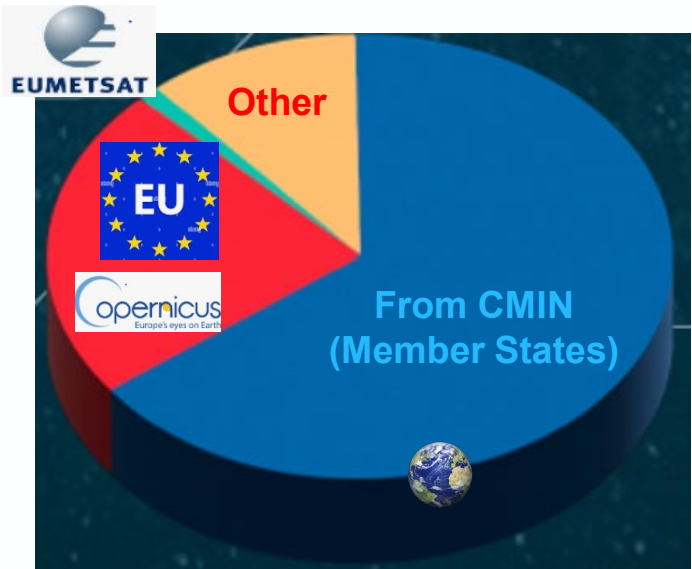
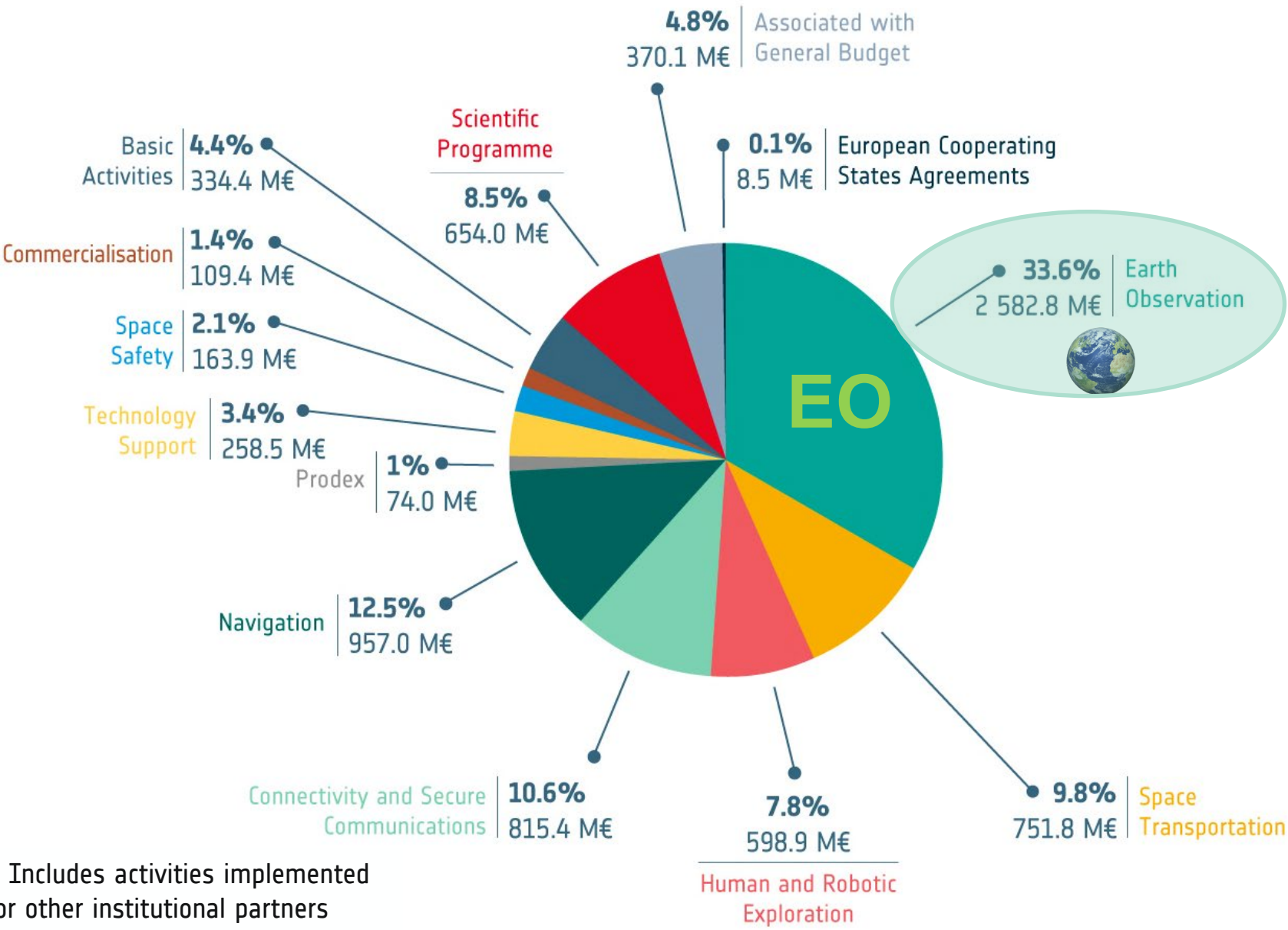
New emphasis on European competitiveness and sovereignty

- New Commission initiatives.

Impacts of new US Administration on International EO Activities

**Opportunity for ESA to solidify our – and Europe's – role
ESA supports actions related to resilience, security, climate and sustainability**

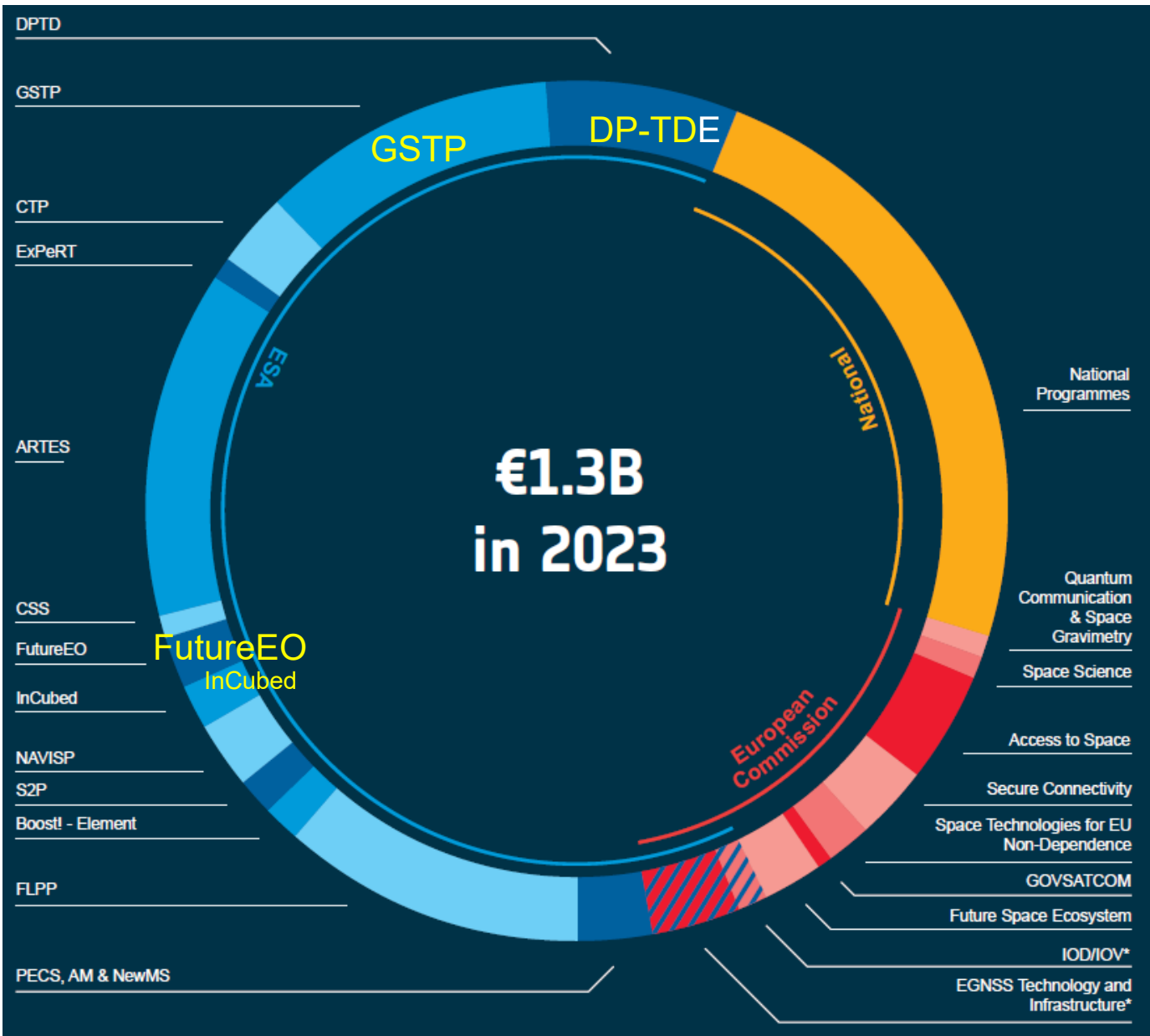
ESA BUDGET BY DOMAIN FOR 2025: 7.68 B€



* Includes activities implemented for other institutional partners

EUROPEAN SPACE TECHNOLOGY BUDGETS (2023)

(Ref. ESTMP 2024)



R&D activities for space technologies in Europe



- **FutureEO** – Future EO Programme, Development and Exploitation Components



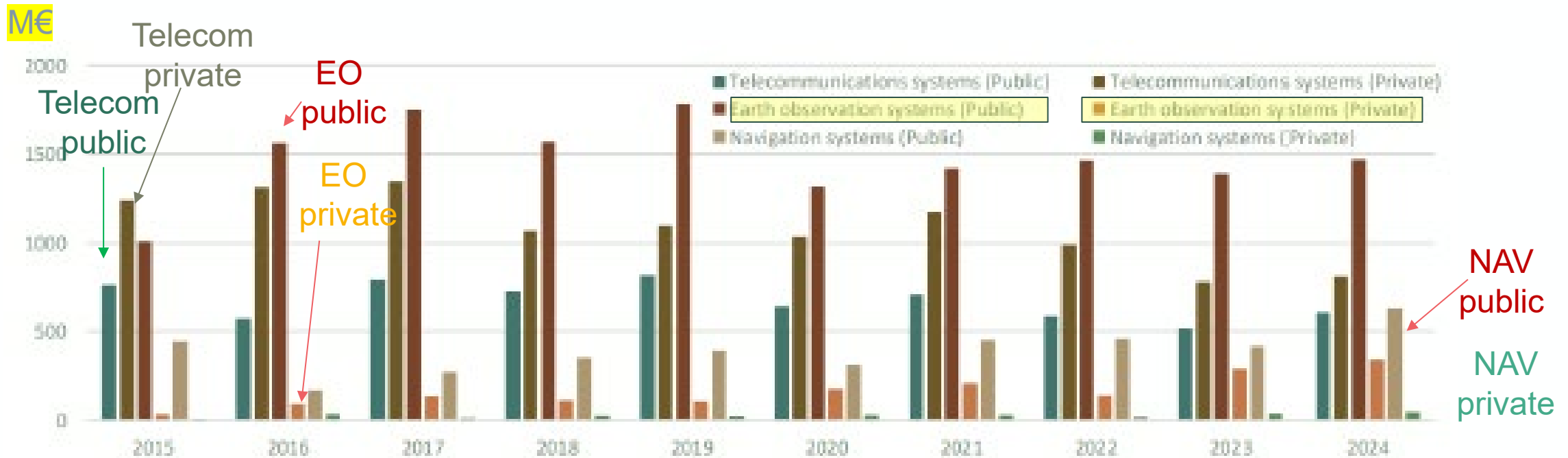
- **InCubed** – Investing in Industrial Innovation

- **TDE** - Technology Development Element
- **GSTP** - General Support Technology Programme

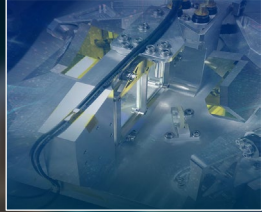
- **CTP** - Science Core Technology Programme
- **ARTES** - Advanced Research in Telecommunications Systems Core Competitiveness
- **SciSpaceE** - Science in Space Environment
- **ExPeRT** - Exploration, Preparation, Research and Technology
- **NAVISP** – Navigation Innovation and Support Programme
- **FLPP** - Future Launchers Preparatory Programme

Credit: Eurospace

- EO dominates the public sales , and growing commercially, but not as fast
- Big question: how much the resilience / constellation needs will change this ?



FutureEO Prog: Three pillars



1) EO Foundations

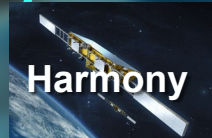
Missions Ph.0/A

Technology

Science



2) EO Missions and Data



Harmony



Earth Explorer
11



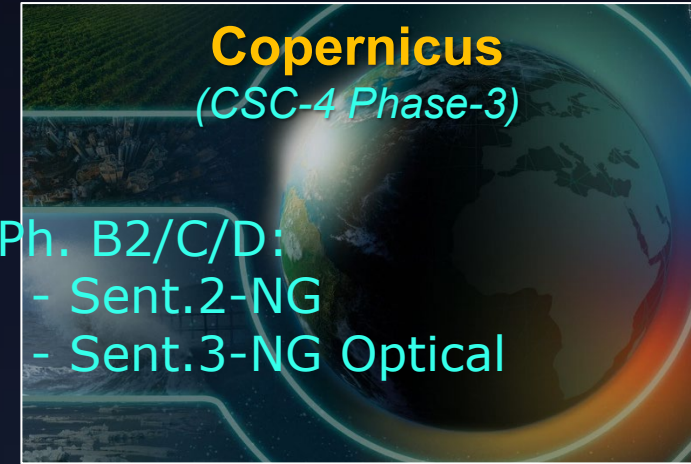
NGGM /
MAGIC



Scouts
5 & 6

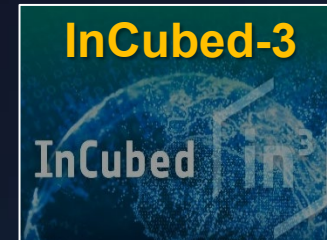


3) Earth Action



Copernicus
(CSC-4 Phase-3)

Ph. B2/C/D:
- Sent.2-NG
- Sent.3-NG Optical



InCubed-3

InCubed
in³



**Digital Twin
Earth**



**European
Resilience
for Space**
ERS-EO part

ESA EO Prog- for all: LSI + Midcap + SMEs



Mission Definition & Feasibility (Ph.0/A)

- **Earth Explorer-13** : 4 mission concepts in **Ph.0** ; ≤ 2 in Ph.A ; Implem. after CM31
- **Earth Explorer-12** : 2 mission concepts in **Ph.A** ; Implem. after CM28
- **Scout-3rd cycle**: ≤ 4 mission concepts in Consolidation Phase; ≤ 2 for Implem. after CM28
- **Stepping Stones** ≤ 4 mission concepts in Definition Phase
- **Sent-6 NG** : **Phase A/B1** (additional freq. for RA + MWR) ; for Implem. after CM28
- **Meteosat 4th Gen.** **Phase 0**
- **Missions of Opportunity** **Phase 0**
- **Phi-Sat-3** **Up to Ph.E1**

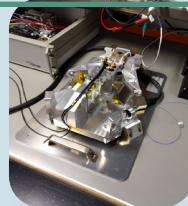
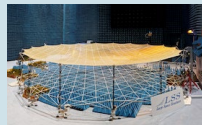
→ Target TRL 5 (end Ph.B1)
SRL 5

Pillar 1

(3 interlinked areas)

Technology Maturation

- Instrument maturation
 - as part of Ph.0/A
 - support to Commended EE-13, future Meteo Missions
 - new low TRL concepts, miniaturisation
- Other Preparatory : e.g. architectural / system studies
 - In synergies with DPTD / GSTP for EO
 - Standard Platform + Communications
 - Frequency Management



Science & Applications (with EOP-S)

- BoostFutureEO in
 - Step-1: EO Science Strategy = update of Living Planet Challenges
 - Step-2: New EO Mission Ideas (NEOMI)
 - Step-3/4: as part of Phase 0/A
- End-to-End Simulation :
 - as part of Ph. 0/A
 - also enable new EO concepts (low SRL)
- Campaigns (in-situ, airborne)



ESA & Earth Observation

- EO Missions
- EO Technology
- Programmatics & CMIN25
- **System of Systems**
- M-IND & ADHA - APA

New Secure Multi-Domain - Governmental services

- **Defence** & Operational constraints
- **Civil Security** (floods, fires, ...)

Observations:

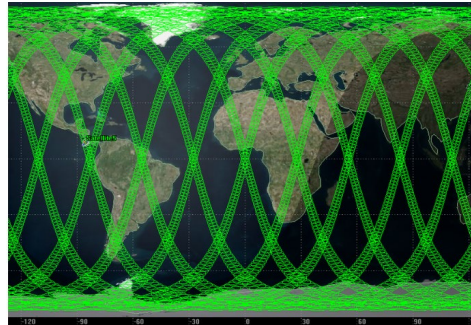
- Cloud free :
- Sub-meter resolution:
- Day & Night (also non-Sun Synch)

SAR
SAR + VIS-NIR
SAR + IR

Timeliness:

- Accessibility : 1 hr → 10s of sat & non-SSO
- Tasking : **near-permanent**
- Downlink : RF direct and via **OISL**
High Security

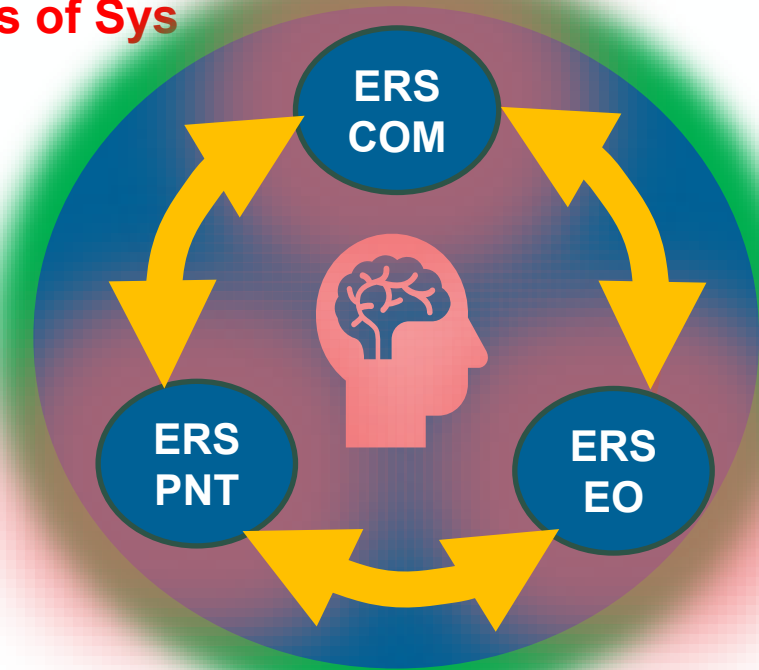
~15 Sun Synch. Orbits / day > 1 day to revisit



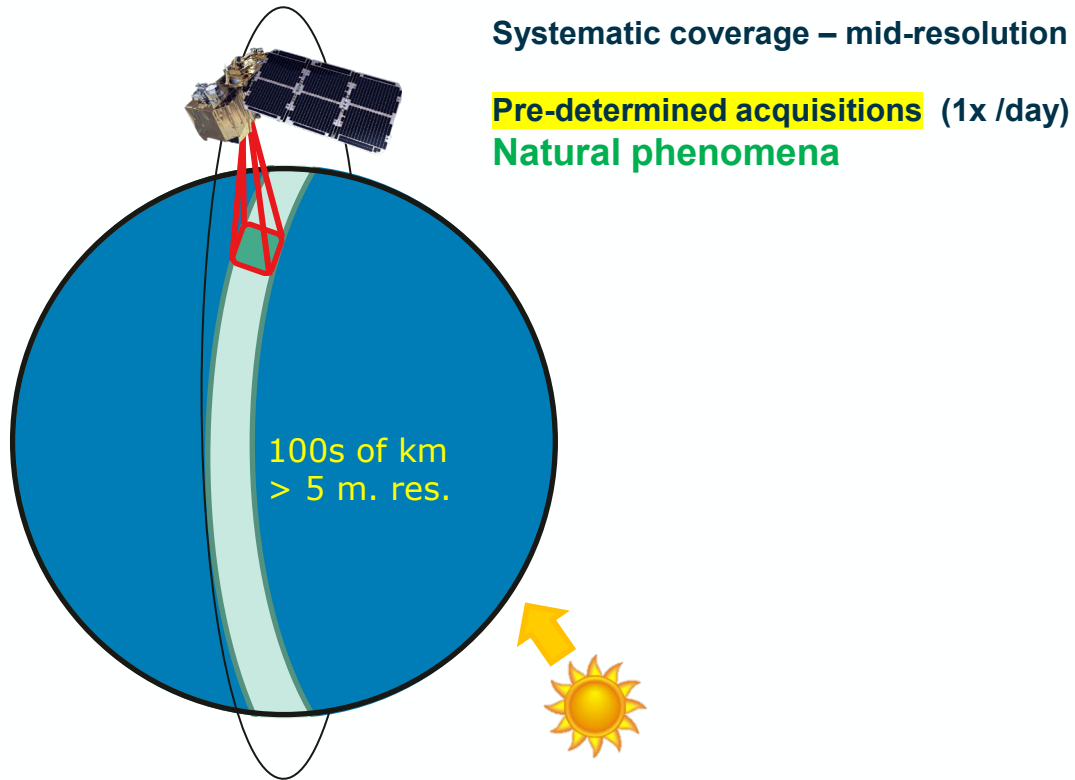
2028: IoD – much more agile planning & adaptability & faster distribution

2031 : ERS-EO Constellation (TBC)

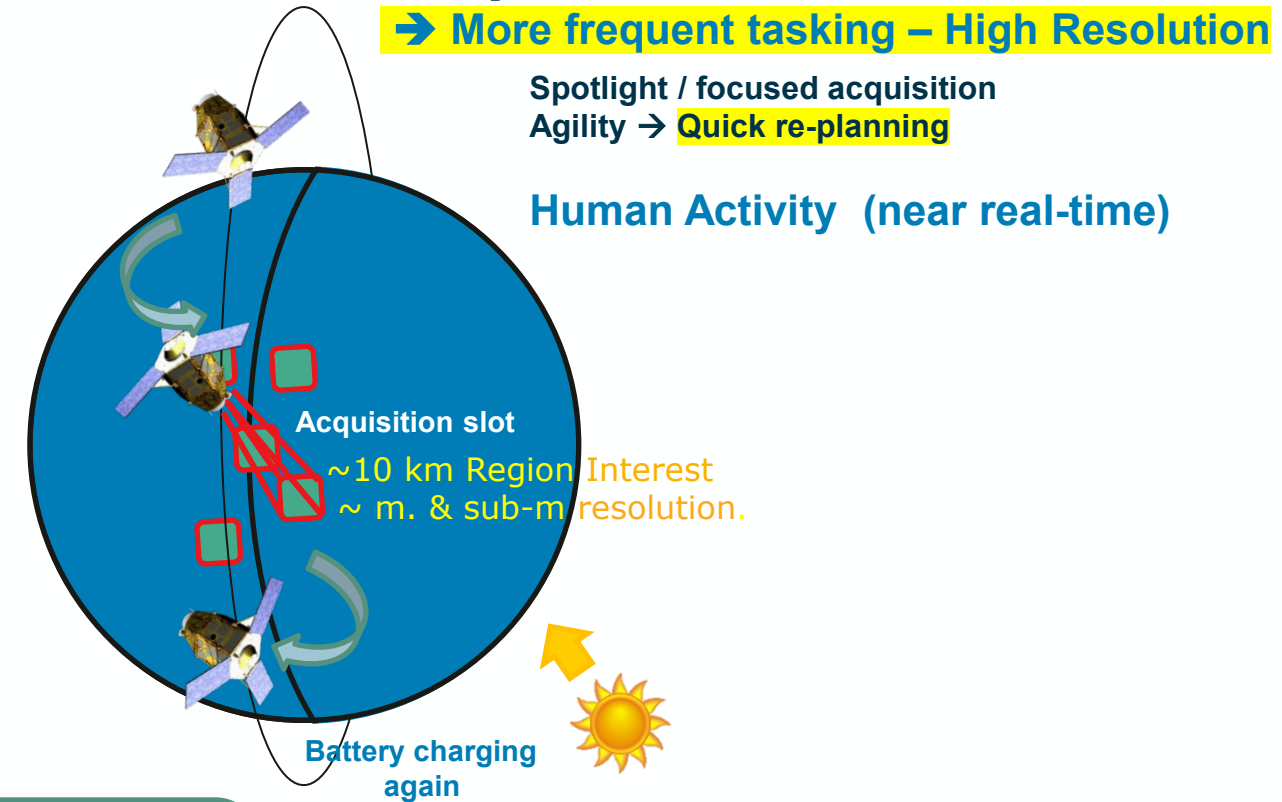
ERS Sys of Sys



Systematic / Carpet mapping



On-demand acquisition with SmallSat



Many New applications combining Traditional & SmallSats

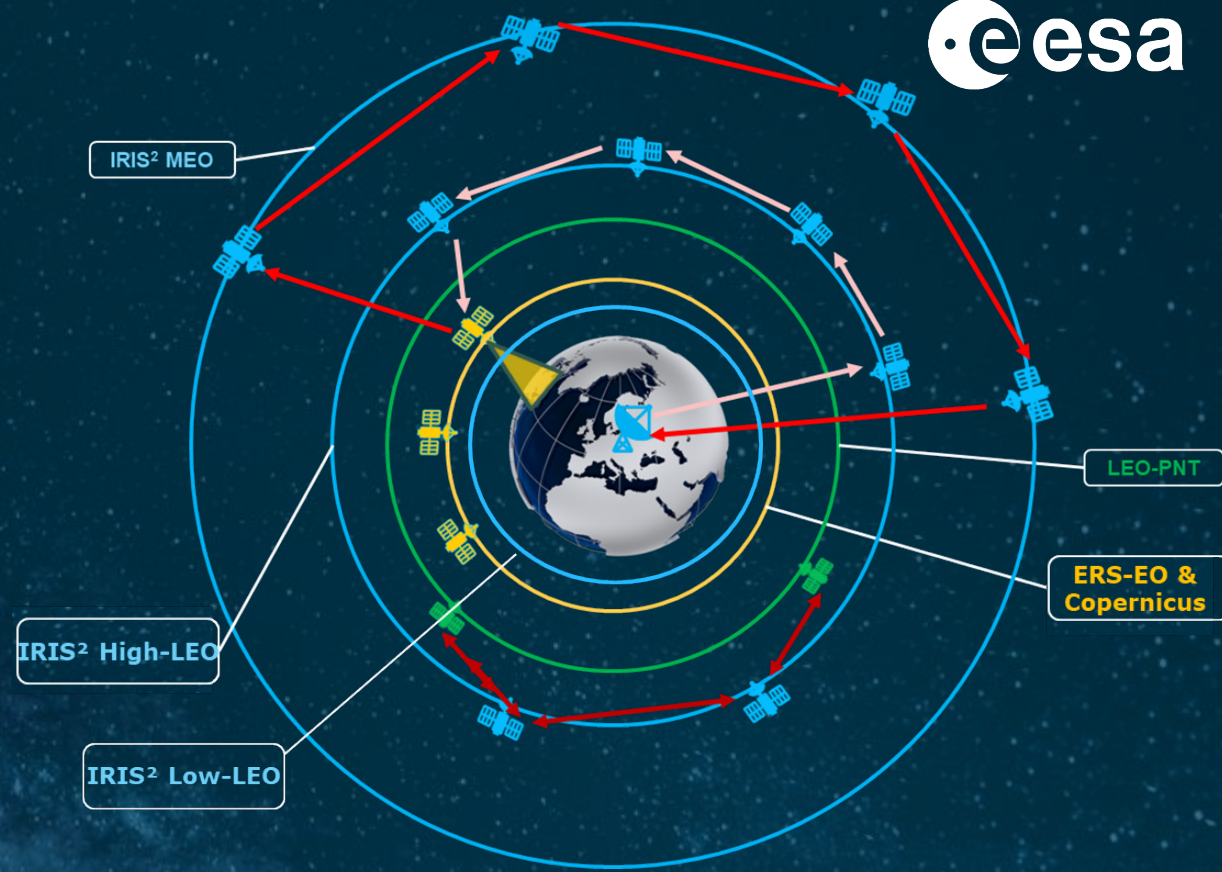
- Agriculture: VHR complement to Sent.2
- GHG (CO₂,CH₄,NO₂): specific plant perpetrator ?
- Event: fire, ships, gas leaks, ...
- Others (e.g. security)

Timeliness → new market(s)
Affordable : keep it simple

System of Systems



- Solutions needed for LEO constellations:
- mid-size sats (affordable & fit-the-purpose)
 - Higher connectivity
 - Industrially resilient (Integrators & supply chain)



GSTP
- Equipment



Application Directorates
Roadmaps
(under elaboration)

ESA & Earth Observation

- EO Missions
- EO Technology
- Programmatics & CMIN25
- System of Systems
- **M-IND & ADHA - APA**

Mid-size Leo Sats: the right time



M-IND Mission Statement

- *Support the European industry for the availability of subsystems (or subsystems' elements) needed to provide European sovereign **mid-size satellite platforms** operating in LEO, by 2028*

Competitiveness of European Industry by 2028

Sovereign technology, when not available in Europe

Volume / Scale-up production → **cost / lead-time** reduction

- Adapt recurring parts → ensure multi-source and interoperability
- Multi-applications: institutional (ESA, EC, National) & commercial

M-IND: Industry-driven recommendations

- **35+** integrators involved in the M-IND initiative
- Survey on platform subsystems pain-points (Feb-25)
- Workshop at **ESTEC 20th March 2025**



5 major M-IND recommendations

(M-IND Report in June-2025)

1. Industrialisation (MRL; support transition highly customised low volume to serial production)
2. Industrial Policy
3. Reduction and communalisation of interfaces
4. Priority platform subsystems (for competitive, modular and sovereign supply to integrators)
5. Constellation deployment and operations

Partially in GSTP Compendium + Roadmaps under preparation together with Programme Directorates

ADHA – APA (in mid-size sat context)

- **Highly vertical integration** (industrial + technical miniaturisation)
- More digital & High Power consumption
- **M-IND Reduced & Common Interfaces:**
 - KO end-Oct.2025 with SpinIn + 3 LSIs
 - Survey Dec Q4-2025 → for all (Integrators + Suppliers) in Europe
 - mini-Workshop (End-Jan. 2026, **TBC**)

Funding schemes (mostly):

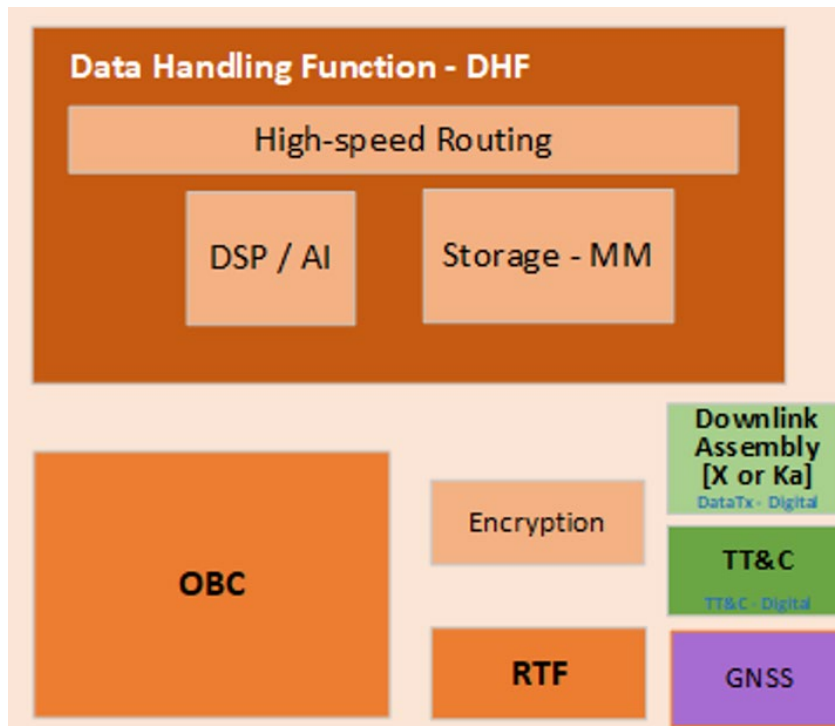
- System enablers : **FutureEO** + DPTD
- Modules: TDE + GSTP

EO Instruments

- Very High-Res
- also Lower-res

PCDU

- Primary Voltage
- Secondary Volt.



Comms (on-board + direct-to-ground + ISL)

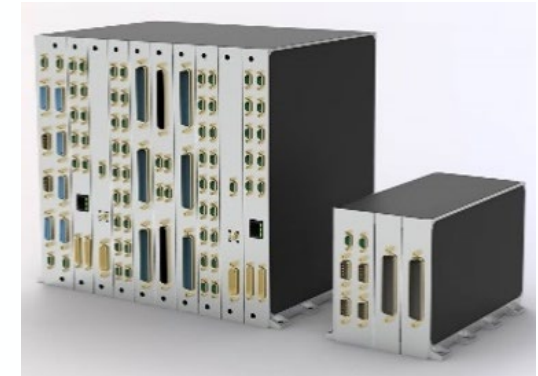
- Low rate (kb/s)
- High rate (Gb/s)

Centralised vs decentralised

- High integration
- Modularity
- SW aspects (AOCS)

Eurocard sizes:

- 6U: 220x233mm,
- 3U: 220x100mm



Take away(s) - very broad EO enabling technologies

EOP Technology needs (incl. European independence)

- New + higher performance (EO instruments) + Higher efficiency (incl. platform / operations)



also demisable

Market pull (User driven: EE, Copernicus, Meteo) + Techno push (enabler for new Mission Calls)

- Driven by **Large Satellites** (institutional), but **Instruments** for **Small Sats** too (Scouts, constellations)



constellations

FutureEO – Pillar 1

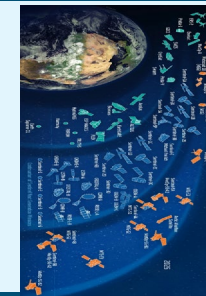
Mission Definition



Technology + Science/Apps

FutureEO Programme

- Unique synergizer to build the whole range of ESA EO missions
- EO technology needs **grows**



FutureEO investing in Technology: substantial increase wrt 1 decade ago → **needs to be sustained in CM25**

- Closely coordinated with **TDE + GSTP** (extremely valued complements)

FutureEO

The ESA Programme to subscribe in
CMIN25 (26-27 Nov)

More about EO Technology:
Josep.Rosello@esa.int



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