ESA Council at Ministerial Level (CM22) Earth Observation programme package

Belgian info Day, 30/09/2022, Antwerpen

Michel Verbauwhede, ESA EO Directorate

ESA "Raison d' Etre"

22+ Member States
Doing together what none can do alone

Promoting cooperation among European States in space research, technology and applications, for exclusively peaceful purposes

Council at Minister Level meets every 3 years to define and subscribe to the future ESA programmes

We need a successful CM22 to face the Global challenges for 2023-2026 and beyond and ensure European strategic autonomy

AN EO PROGRAMME PACKAGE THAT IS:

- ESSENTIAL
- EO-ENABLED
- COHERENT
- URGENT
- COLLABORATIVE
- LONG TERM

An ESA Programme is:

A legal container = materialization of a collective will (by Interested Member States) to perform an activity

WHAT (activities/ deliverables)	HOW MUCH (it costs)	HOW LONG (it lasts)	HOW MUCH I CONTRIBUTE (subscription at CM22)

1 programme ≠1 satellite. *Can be (part of) a satellite (and its ground segment and its operations), several satellites, other types of activities (i.e. applications), a combination thereof*

- Incentive for Member States: scientific return, industrial competitiveness, geo-return, **societal relevance**
- 95% of ESA EO activities correspond to optional programmes.
- Most of our programmes are spanning several CM cycles

22 + Member States doing together what none can do alone

Sovereignty
Climate change
Green transition
Knowledge, science, jobs

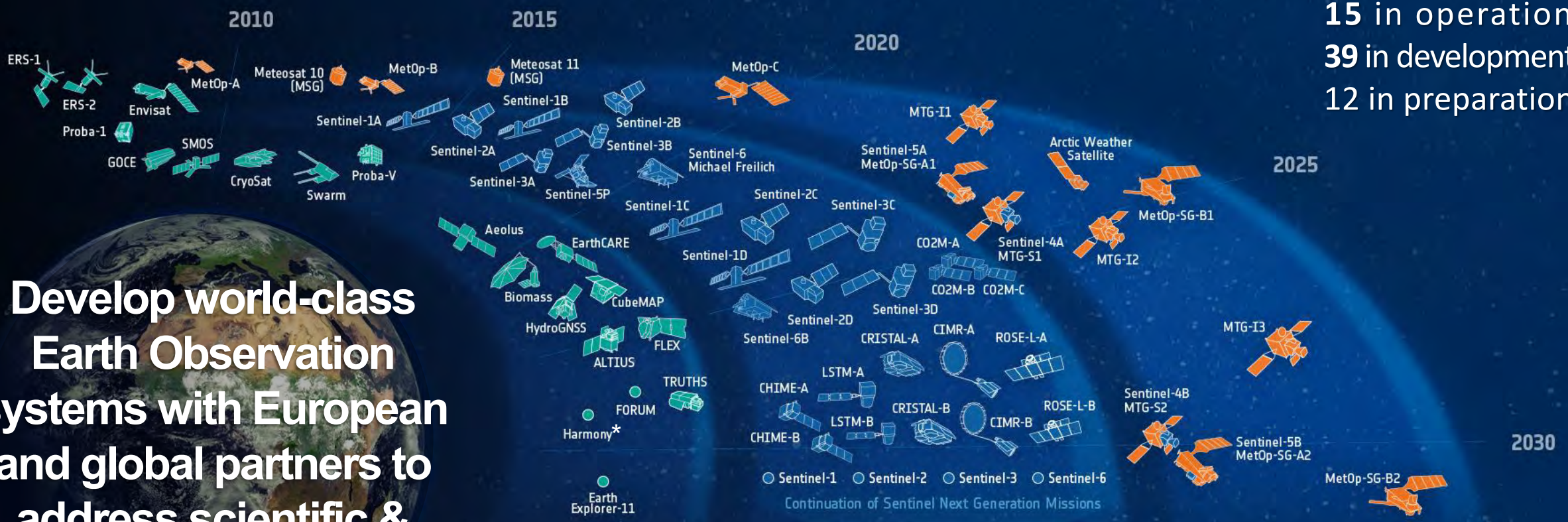
What happens in Arctic doesn't stay in Arctic

ESA's Earth Observation Mission

esa

Missions

15 in operation
39 in development
12 in preparation



Develop world-class Earth Observation systems with European and global partners to address scientific & societal challenges

Science esa | Copernicus | Meteorology EUMETSAT

*Pending final mission selection

Without EO there is no evidence-based information to measure, monitor and guide global and local initiatives…

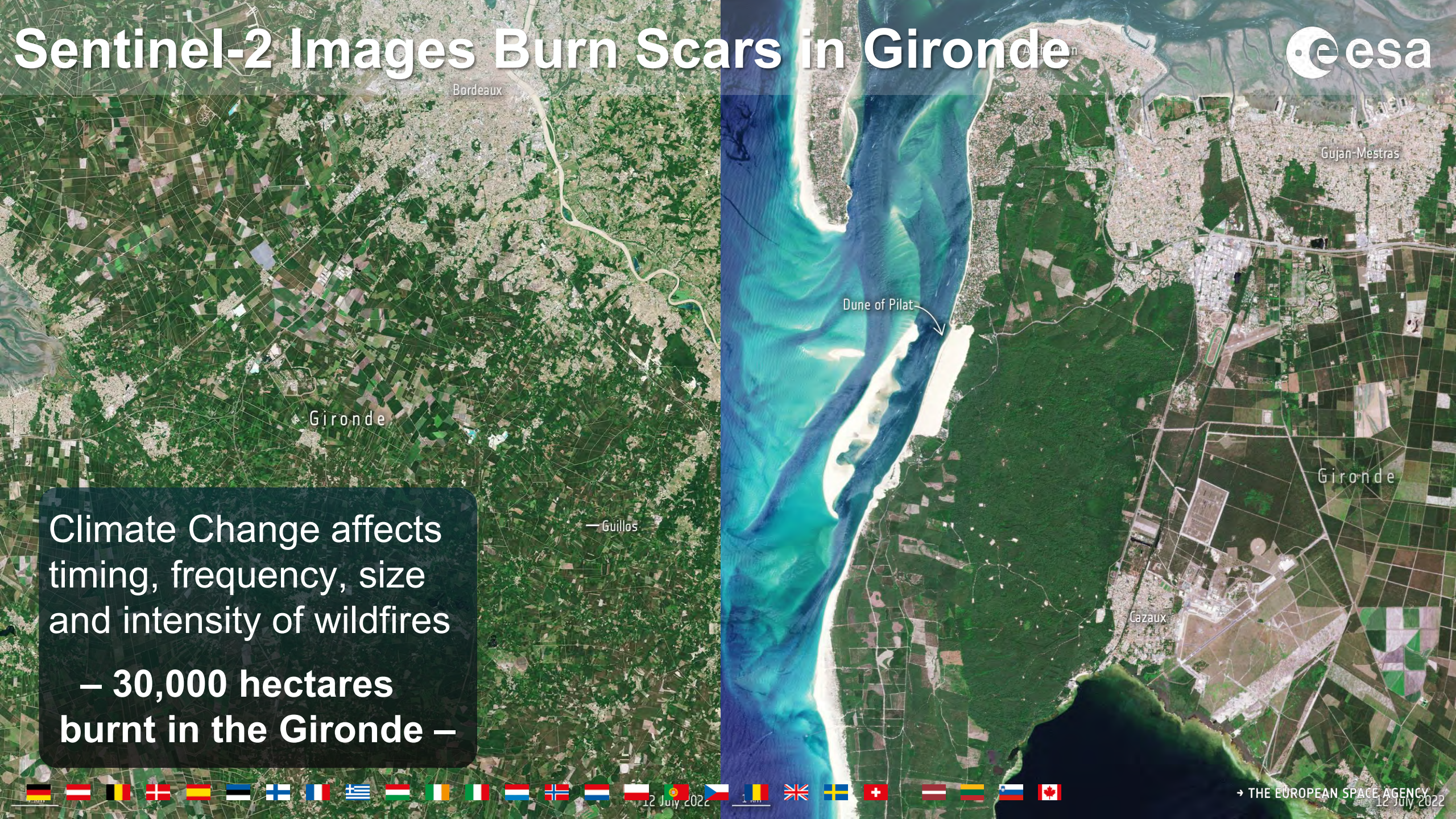
We can only manage
What we can measure…

With EO we can measure
With EO we can manage

Cryosat manages first sea ice observations over summer

Sentinel-2 Images Burn Scars in Gironde

esa



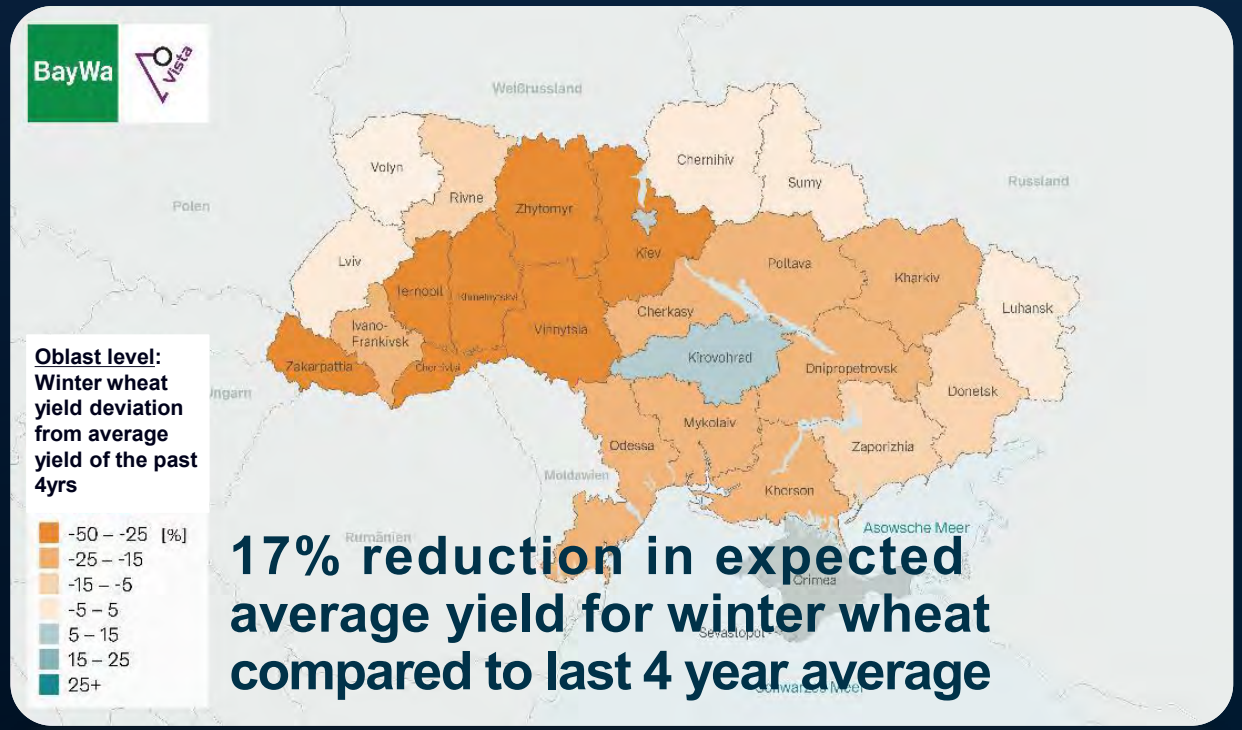
Climate Change affects timing, frequency, size and intensity of wildfires

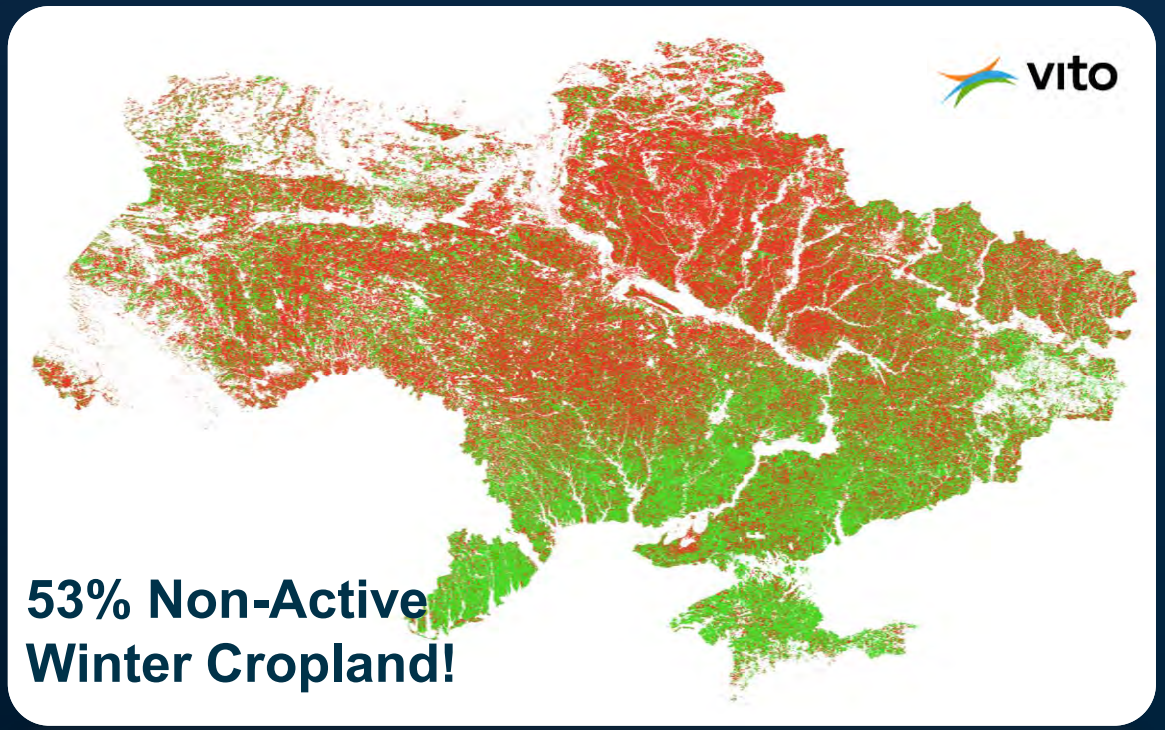
– 30,000 hectares burnt in the Gironde –

Sentinel-1 & 2 Support Food Security

Ukraine Harvest Progress

Yield Forecast



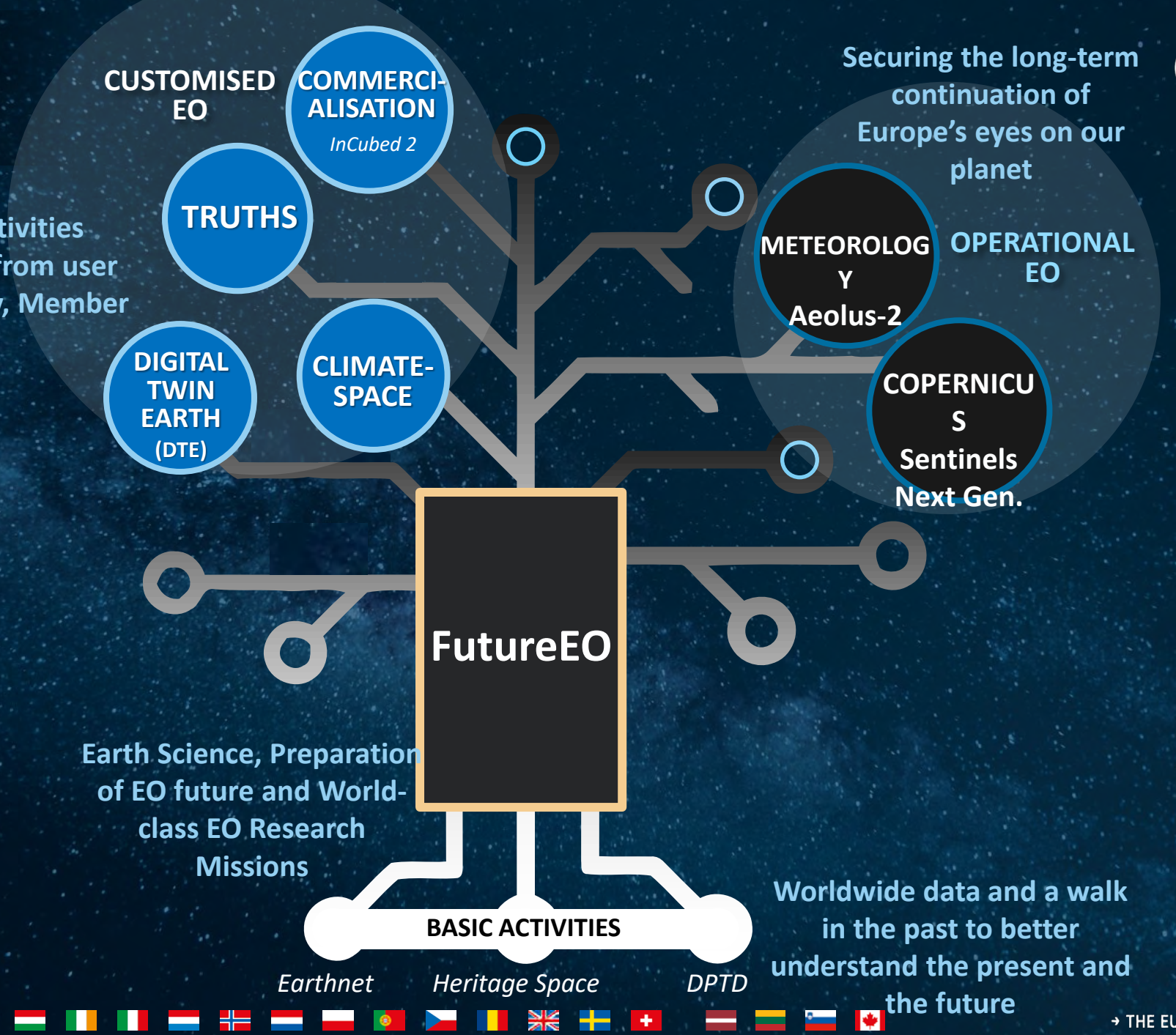


- Mostly due to **drought** that is affecting al of Europe
- Potentially **less use of fertiliser** due to price increase

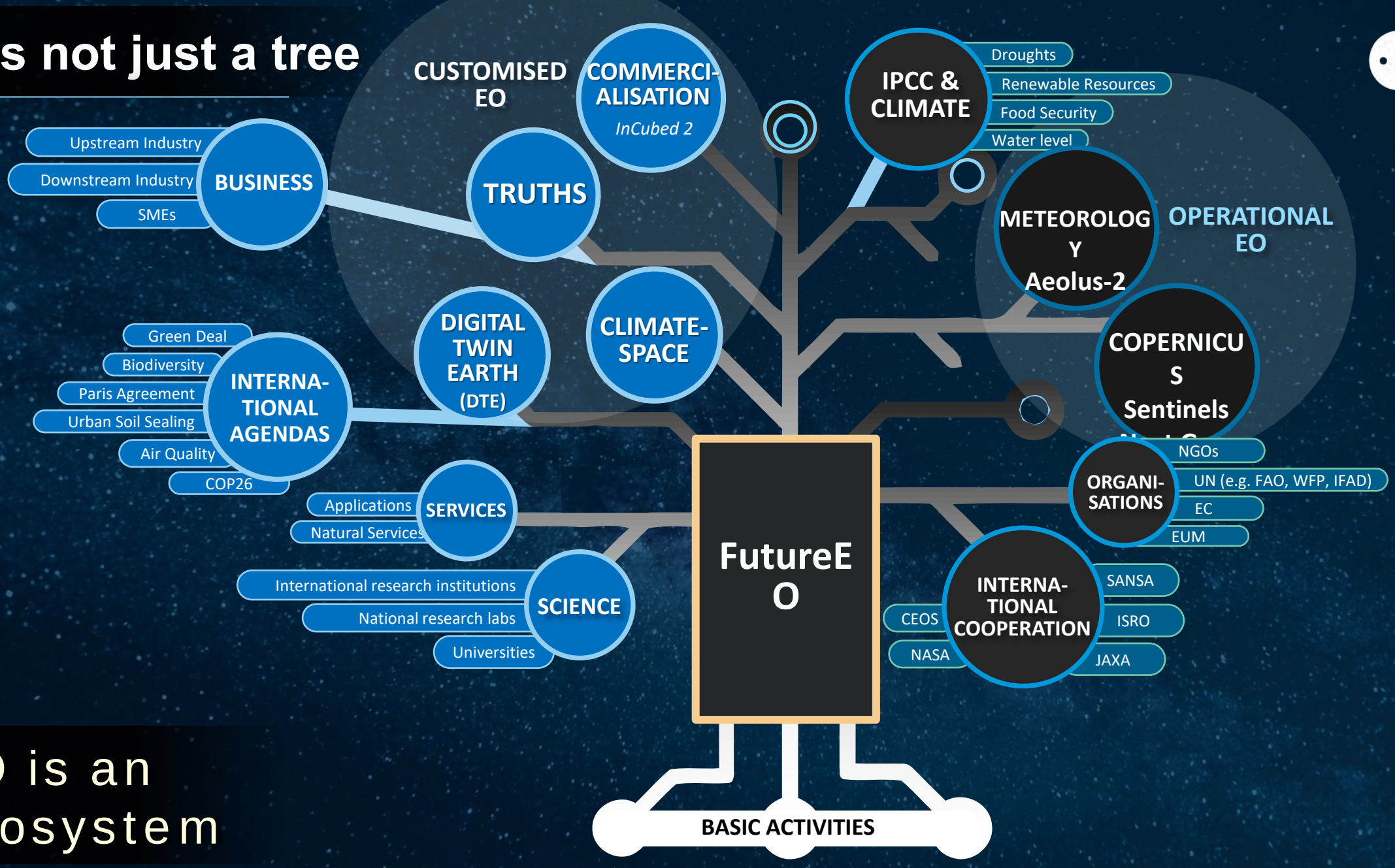
Except we are not here to build satellites, but ultimately to observe our shared Home

EO Programme Package for CM22

Pre-operational activities answering demands from user communities, industry, Member States



EO is not just a tree



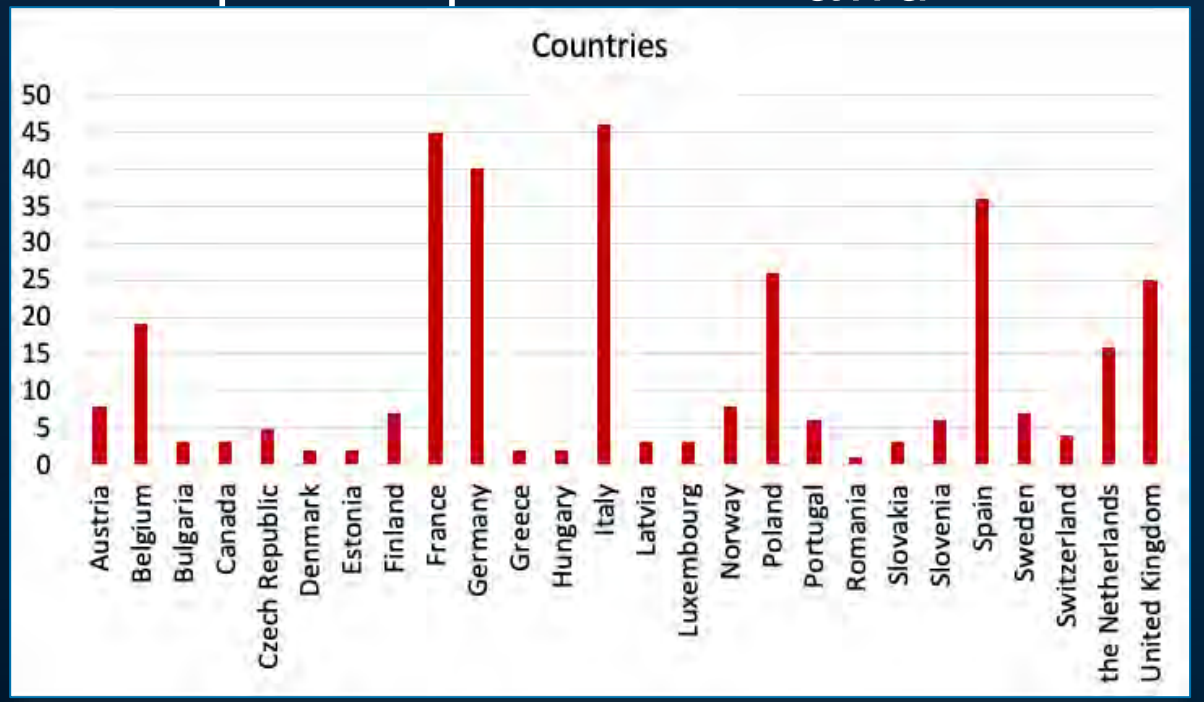
EO is an Ecosystem

Eurospace-led ESA-industry dialogue ahead of CM22

- Assess the attractiveness of ESA CM22 EO programmes
- Understand the size, dynamism and resilience of the European EO "ecosystem"
- Understand where industry would like to be at horizon 2030+
- Identify new ways to co-work with Industry

280 Registered participants

48 Panellists and



Eurospace-led ESA-industry dialogue ahead of CM22

General feedback

Good satisfaction level with the event

- Stakeholders note that the ESA-industry dialogue initiative enables to bridge the information gap
- Supply chain believes that more information generates more political support

ESA EO proposal feedback

All programme components receive good ratings on the 4 criteria proposed

Overall Future EO is the best voted programme by all. Probably because of its budget relevance for most players

Trends and conclusions survey

The survey reveals that respondents are well aligned with the conclusions of the Seminar

Strong support of all the statements proposed in the Seminar synthesis

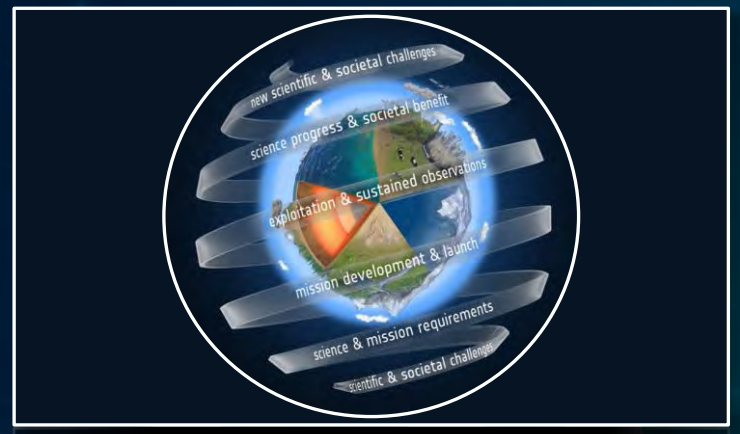
Progress of Preparation

Programme	Readiness
FutureEO-1s2	Entire document package for CM22 is finalised (Programme proposal, Declaration and Implementing Rules)
CSC4-ph2	
Aeolus-2	
EW – TRUTHS	
EW – InCubed	
EW – Climate Space	
EW – Digital Twin Earth	

All proposals received positive internal review

FutureEO - Since 2000: ESA's core Earth Observation research and development programme

Earth Science, Preparation of EO future and World-class EO Research Missions



Foundations and Concepts

Research Missions

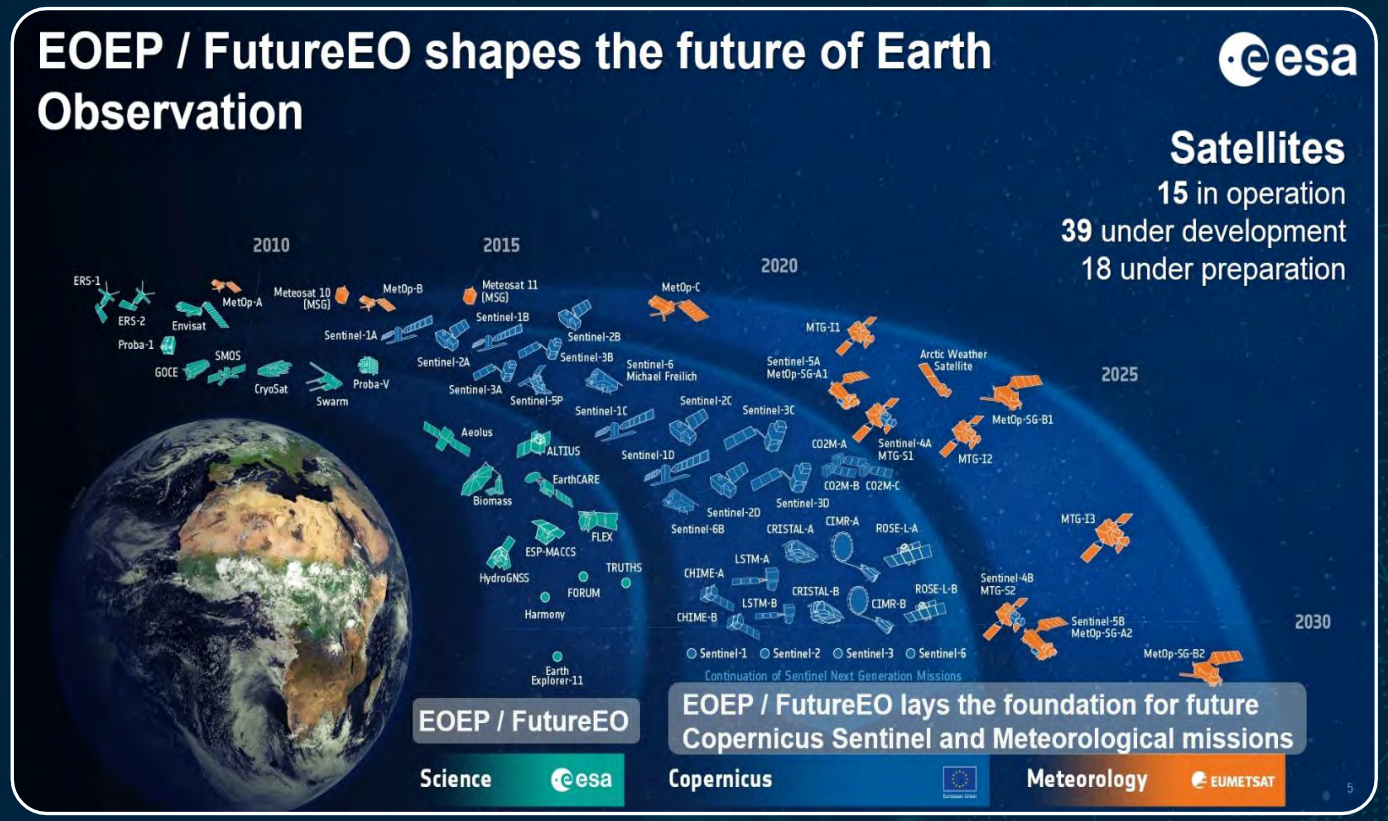
Mission Management

Earth Science for Society

The only ESA (EO) optional programme bringing together all Member States

EOP locomotive at CM22

FutureEO-1 Segment 2 – The rationale behind



The backbone ESA Earth Observation programme for Earth Science – unique selling points

- ✓ **World class Research missions - supporting Earth Explorers entire cycle**
- ✓ **Preparing all desirable EO Future**
- ✓ Bringing together science – technology - application
- ✓ Cooperation with international actors of the sector

FutureEO-1 Segment 2 will keep the essential features of its precursors:

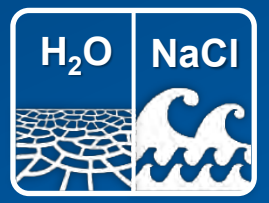
- ✓ Flexibility of an envelope approach
- ✓ Driven by scientific excellence and technological innovation
- ✓ Financing implementation of at least one world-class research mission per 3-year segment
- ✓ Long-term vision with continuity

FutureEO – Earth Explorers

Flying Missions

GOCE
2009-2013

SMOS
2009



Cryosat
2010

Swarm
2013

Aeolus
2018

Future Missions

EarthCARE
2023

Biomass
2023

FLEX
2024

FORUM
2027

Harmony
2029

Science & Innovation

1.200+ Active Users

400+ Publ. per Year

High Risks for Great Rewards

FutureEO-1 Segment 2 – Key highlights

The Research Missions

- Implement BoostFutureEO early phases
- Implement Harmony as Earth Explorer 10
- Prepare candidate missions for Earth Explorer 11 – Wivern, Cairt, SEASTAR, Nitrosat (up to selection prior to CM25)
- Calls for EE 12 & 13 candidate missions
- Implement Next Generation Gravity Mission
- 2nd Scout challenge and implementation (Scout 3 and 4)
- Operate and manage growing amount of EEs in orbit

Paving the way to the future

- Combining Mission Feasibility with enabling Technology & Science and Campaigns
- Prepare the whole EO family of missions
  - The Research Missions (cf above)
  - Copernicus Sentinel Next Generation missions (Sent-2-NG and Sent-3NG Opt)
  - Meteosat Fourth Generation and MetOp Third Generation missions
- Further science, applications and downstream industrial competitiveness

+ Enhanced “Generic Preparation of the Future” and “Instrument Pre-development”

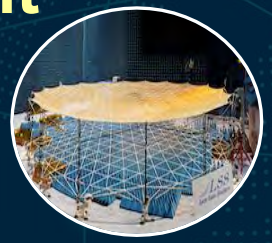
smos
earthcare
cryosat
biomass
swarm
flex
aeolus
hydrognss
cubemap

FutureEO-1 Segment 2 – Foundations and Concepts

Mission Feasibility

EE-12	≤ 5 mission concepts in Phase 0 (+≤ 4 commended missions in maturation pool); ≤ 2 in Ph.A
2nd Scout challenge	≤ 4 mission concepts in Feasibility Phase
Sent-2 and -3 Opt. NG	Phase A/B1

Technology pre-development



Instrument pre-development:

- as part of Mission Feasibility
- support to commended EE-11
- enable new EO concepts (raise TRL)

Standard Platform + Communications:

- Incl. reducing recurring costs / operations

Other Preparatory, e.g. architectural / system studies:

- Incl. synergies with DPTDE / GSTP for EO
- Meteosat 4th Generation
- Frequency Management

Science and EE preparation

BoostFutureEO:

- Step-1: Living Planet Challenges
- Step-2: New EO Mission Ideas (NEOMI)
- Step-3/4: Maturation as part of Mission Feasibility

End-to-End Simulators:

- as part of Mission Feasibility
- also enable new EO concepts (raise SRL)

Campaigns

FutureEO-1 Segment 2 – Research Missions
EE10 Harmony

esa

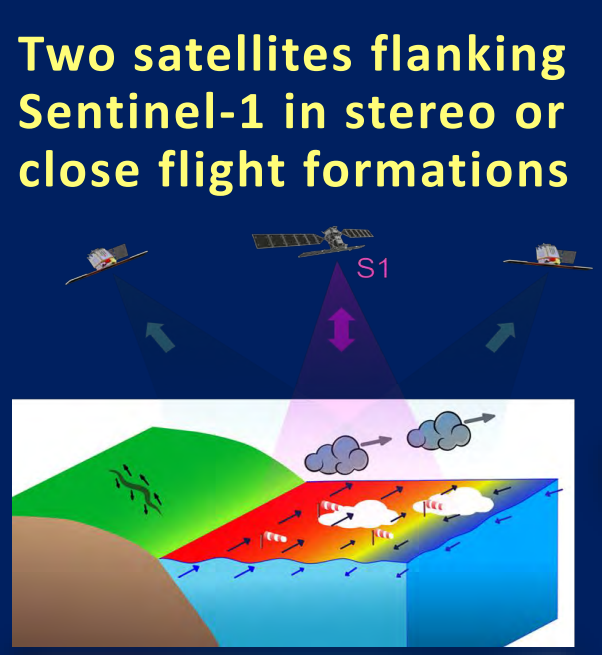
Studying small-scale motion & deformation fields

(Expected launch 2029)

Two passive receiving antenna satellites

Bi-static SAR + TIR instruments, in stereo and close formation with Sentinel-1, demonstrating synergies between ESA's EO research missions and EU Copernicus missions

Two satellites flanking Sentinel-1 in stereo or close flight formations



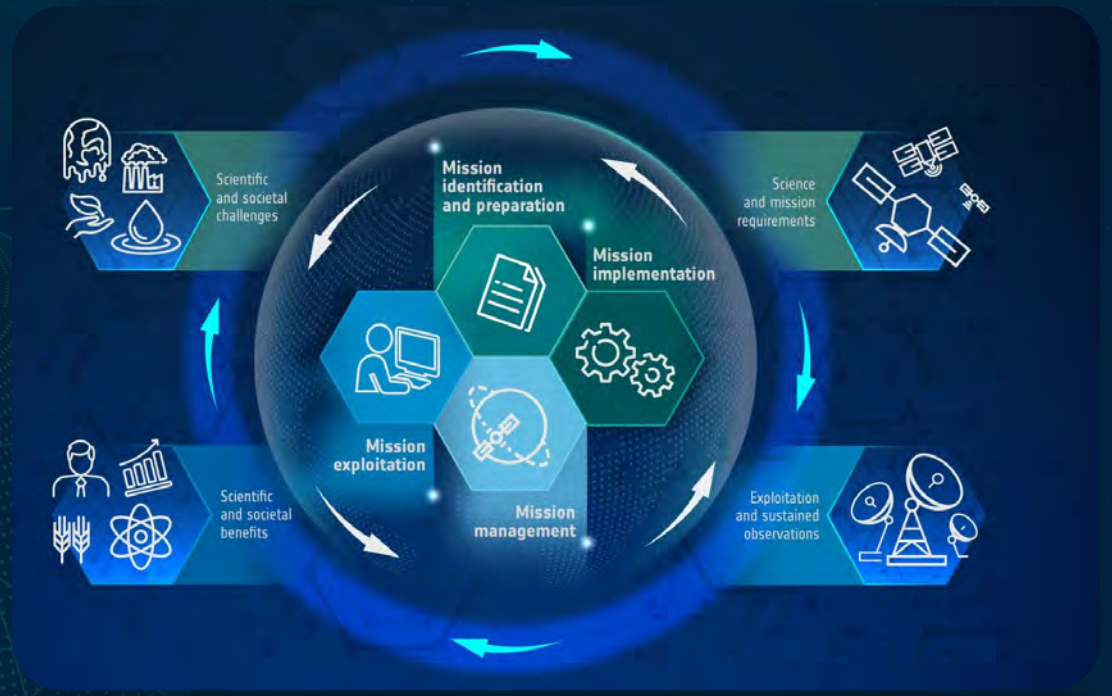
Observing movement in ocean, solid Earth, cryosphere, height-resolved clouds and SST for improved understanding of Ocean circulation patterns, Ice dynamics & mass balance, 3D deformation fields in land topography, Ocean-atmosphere boundary layer

FutureEO-1 Segment 2 – Implementation approach

HOW

- ✓ Incorporating the strength, experiences and synergies between all activities in EOP
- ✓ Working and interacting with National, European and International EO partners

Research Mission	2022	2023	2024	2025	2026	2027	2028	2029
EE10	B1 start		B2/C/D					Launch
EE11 Candidate Missions		Candidate Mission selection for Phase A		Mission selection + implemen-tation of B1				
EE12 Process		Call for EE-12 Mission Ideas (early 2023)	Selection to enter Phase 0 (early 2024)		Candidate Mission selection for Phase A		Mission selection + implemen-tation of B1	
EE-13 Process				Call for EE-13 Mission Ideas	Selection to enter Phase 0		Candidate Mission selection for Phase A	



TIMELINE

+ 2nd Scout Challenge
+ NGGM/MAGIC
+ Many other activities via the D&E Work Plans

FutureEO-1 Segment 2 – Research Missions

MAGIC/NGGM

Credits: SC4GMV

Cooperation framework based on operational coordination and joint data exploitation of 2 satellite pairs developed in parallel with potential exchanges of flight units

Constellation of two pairs of pre-operational nature :

- 1st pair, in polar orbit, driven by enhanced continuity (i.e. fast paced, based on GRACE FO technology) in cooperation between NASA/JPL and DLR/GFZ with potential ESA contribution (e.g. MAGIC accelerometer, possibly adapted)
- 2nd pair with inclined and lower orbit and improved measurement system (MAGIC accelerometer) led by ESA with potential NASA/JPL contribution in the Laser Ranging Instrument
- Joint operations of the 2 pairs to demonstrate the value of a constellation to improve spatial and temporal resolutions of gravity field (mass change) data down to sub-regional level
- Future pairs (e.g. for improved operational system in second half of next decade) based on 2nd pair design

FutureEO-1 Segment 2 – Research Missions Scout

Prove small-budget concepts deliver additional science

Very strict cost/schedule boundaries

- 3 years from KO to launch
- Maximum 30 M€ industrial cost

Innovative implementation to ensure fast response

- High TRL and SRL at proposal level
- Service contracts, use of NewSpace approaches
- ESA role focused on critical risks, higher delegation to industry, institutes and labs
- Extensive dialogue during procurement process needed due to quick system studies (6 months)

Current phase: 2 Scouts under implementation

- CubeMAP, launch Q2 2025

- HydroGNSS, launch Q4 2024

Main lessons learnt

- Learning journey for the industrial, scientific and ESA teams (e.g. lean project review, agile methodology)
- Dialogue phase is essential to secure the implementation
- Maturity level of the system prime to actually take higher responsibility is a key to success

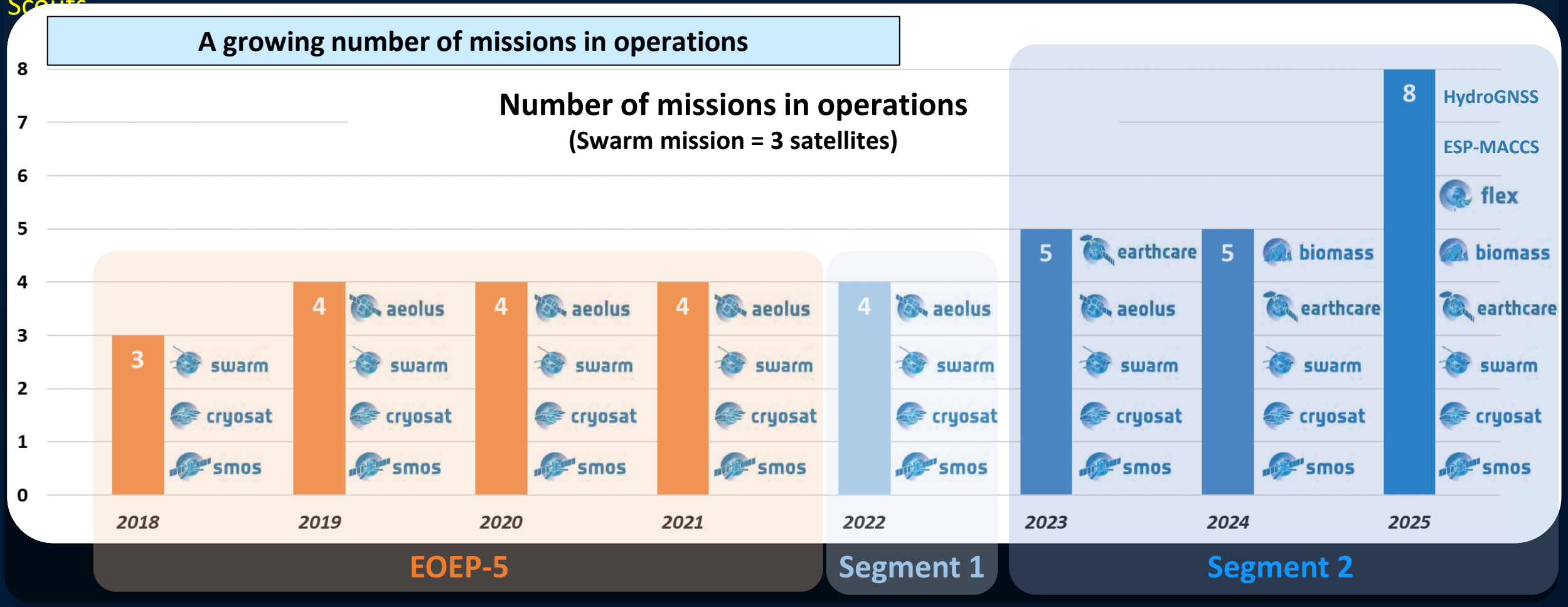
2nd Scout challenge in 2023

- Reuse the same process with slight adaptations
- Put more emphasis on the TRL6 roadmap credibility and SRL raising plan
- Clarify expectations – **Scout is not a technology IOD but a mission delivering science!**

FutureEO-1 Segment 2 – Mission Mgmt. & Ground Segment

Selected future highlights

For the first time the parallel operation of 6 Earth Explorer missions, including various missions much beyond their nominal life time (SMOS, CryoSat, Swarm). Plus additionally two Scouts



The four organisation elements of Block 3

Mission-specific operations elements

- *Mission space & flight (FOS, PLS)*
- *Mission data algorithms & quality (DISC)*
- *Mission data acquisition (acq. stations)*
- *Mission data (first) processing*

Level 2 for Earth Explorers

- *Level 2 for missions in development*
- *Level 2 for missions in operations*

Multi-mission operations elements

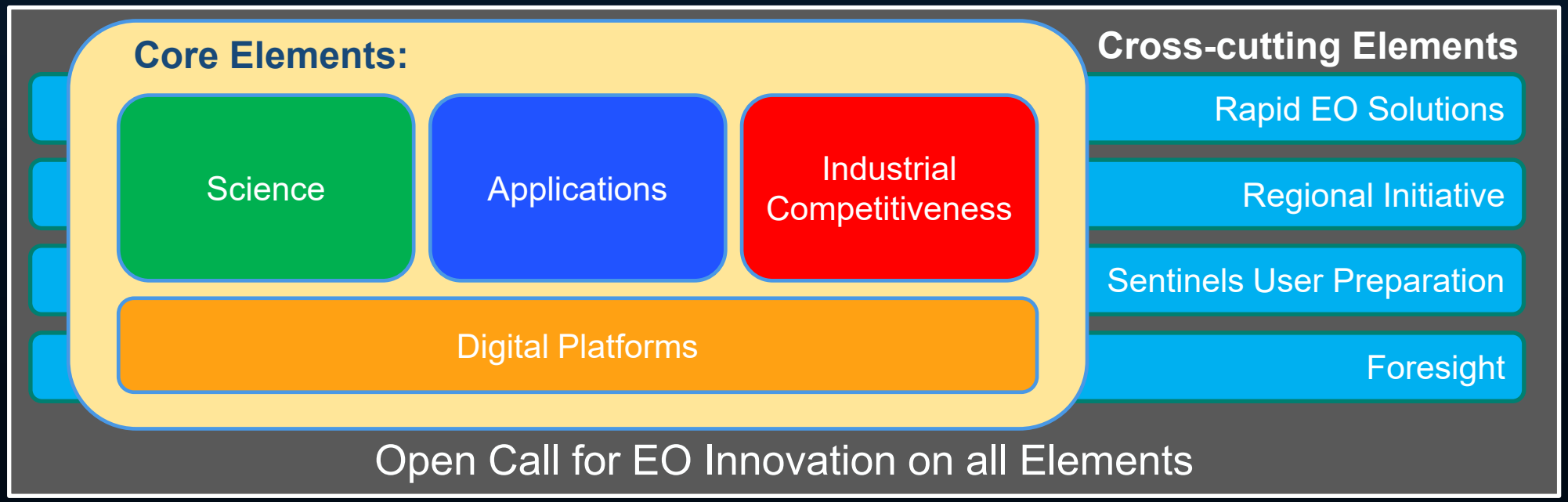
- *Data (re)processing and archiving service*
- *Data access service*
- *Web information service*
- *Cloud & network service*
- *Development of new multi-mission concepts*

R&D for **Fiducial Reference Measurements** for any EO mission

Block 4 - Earth Science for Society

Earth science for society aims at maximising the impact of European EO assets on society and fostering European competitiveness in the exploitation of all EO missions. The programme is articulated through:

- **4 Core Elements** addressing the needs of the scientific community, sectorial policies and European industry, fostering the transition from science to operations by delivering scientific excellence, pioneering novel applications, growing the downstream sector and leveraging on latest digital platforms and ICT solutions.
- **Supported by 4 Cross-cutting elements,** implemented across the development chain, offering dedicated mechanisms to address specific priorities and needs of MSs, exploring the potential of emerging and disruptive technologies and preparing the community for a new era in EO.

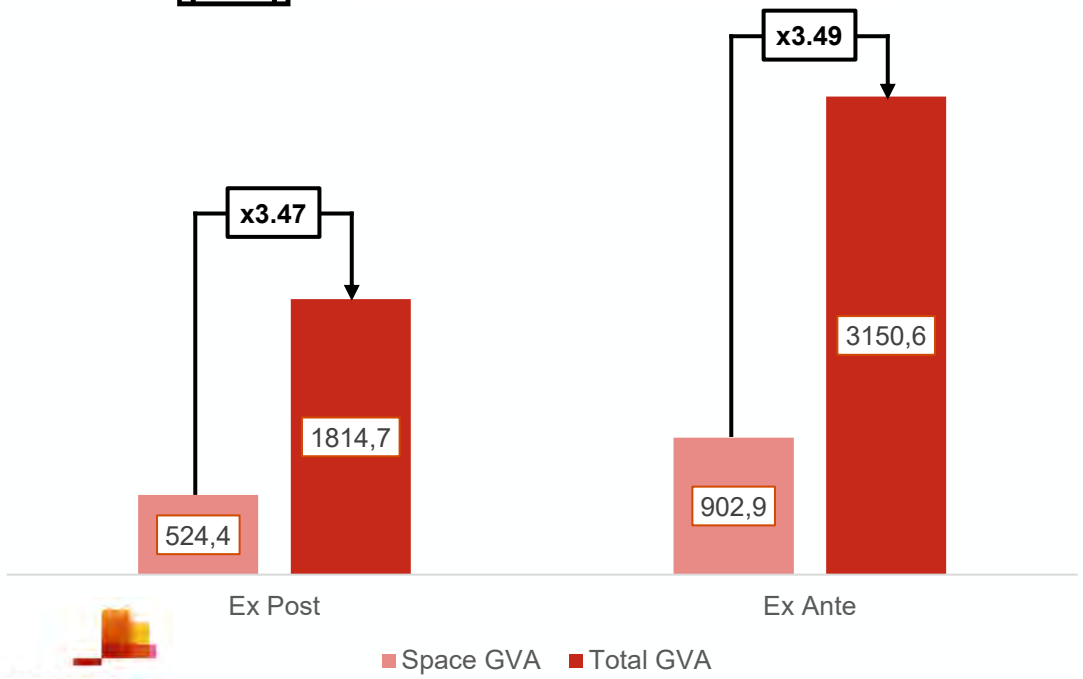


FutureEO - SEIA – Summary of Results

Investment into space leads to cascading benefits through various adjacent sectors of business

GDP Impact Assessment

1€ ⟼ 3.47 € to 3.49 €
Depending on period of assessment



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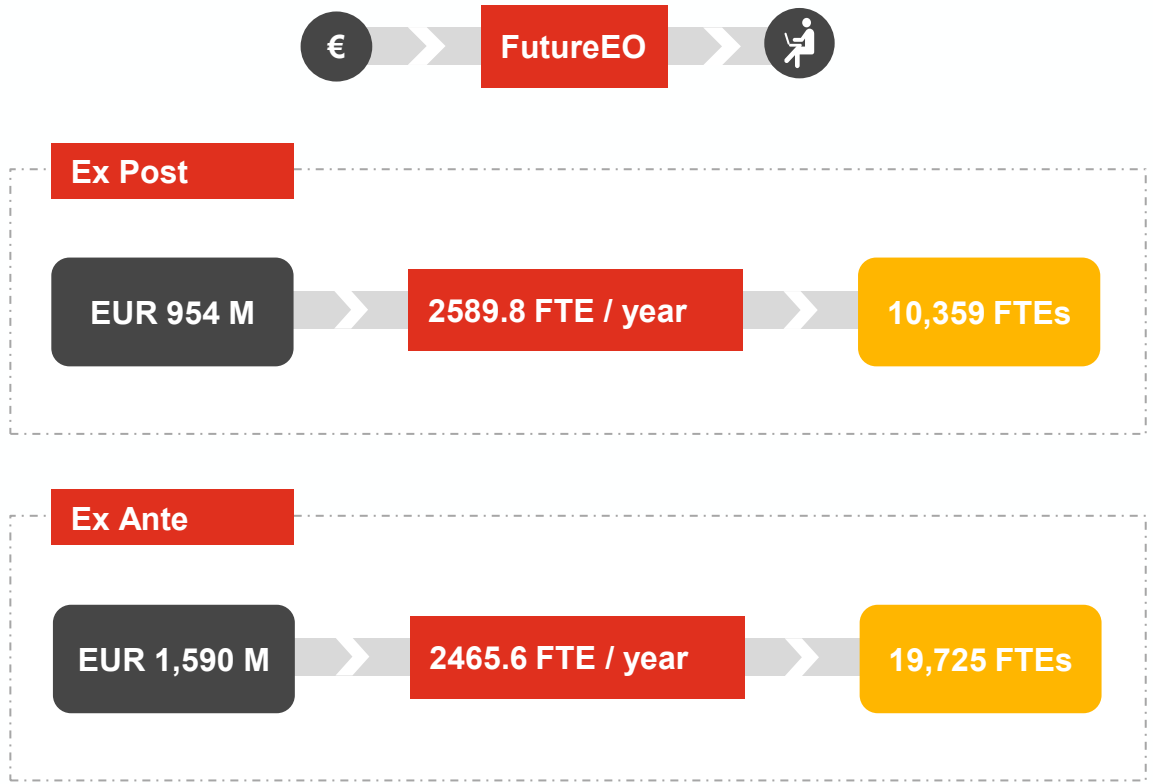
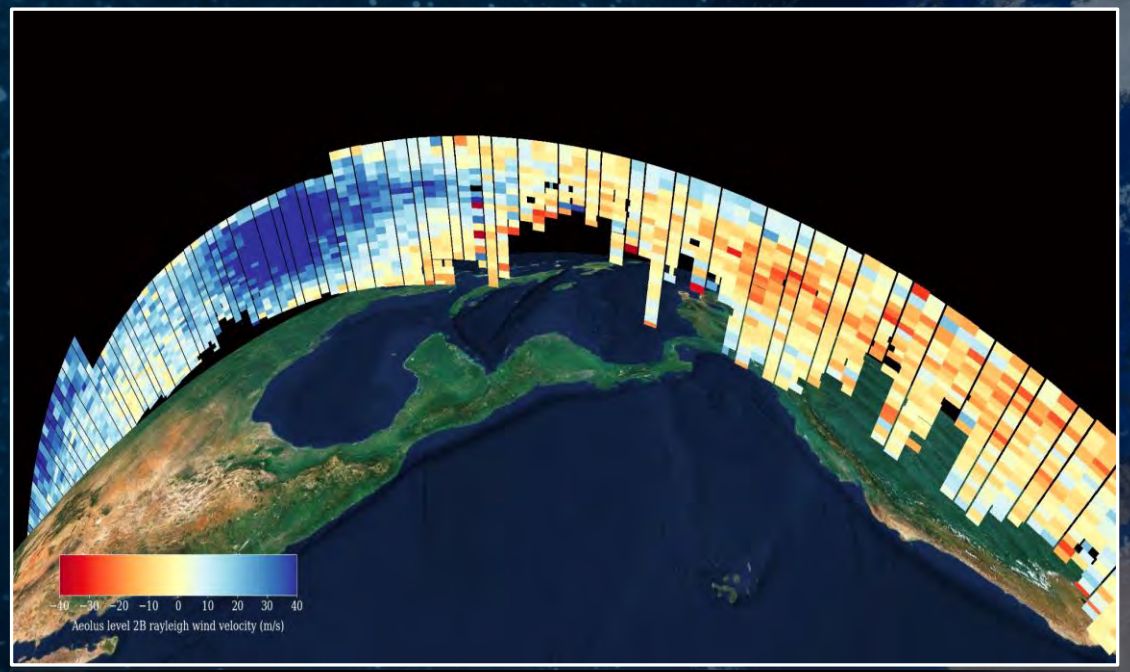
Employment Impact Assessment



Operational EO

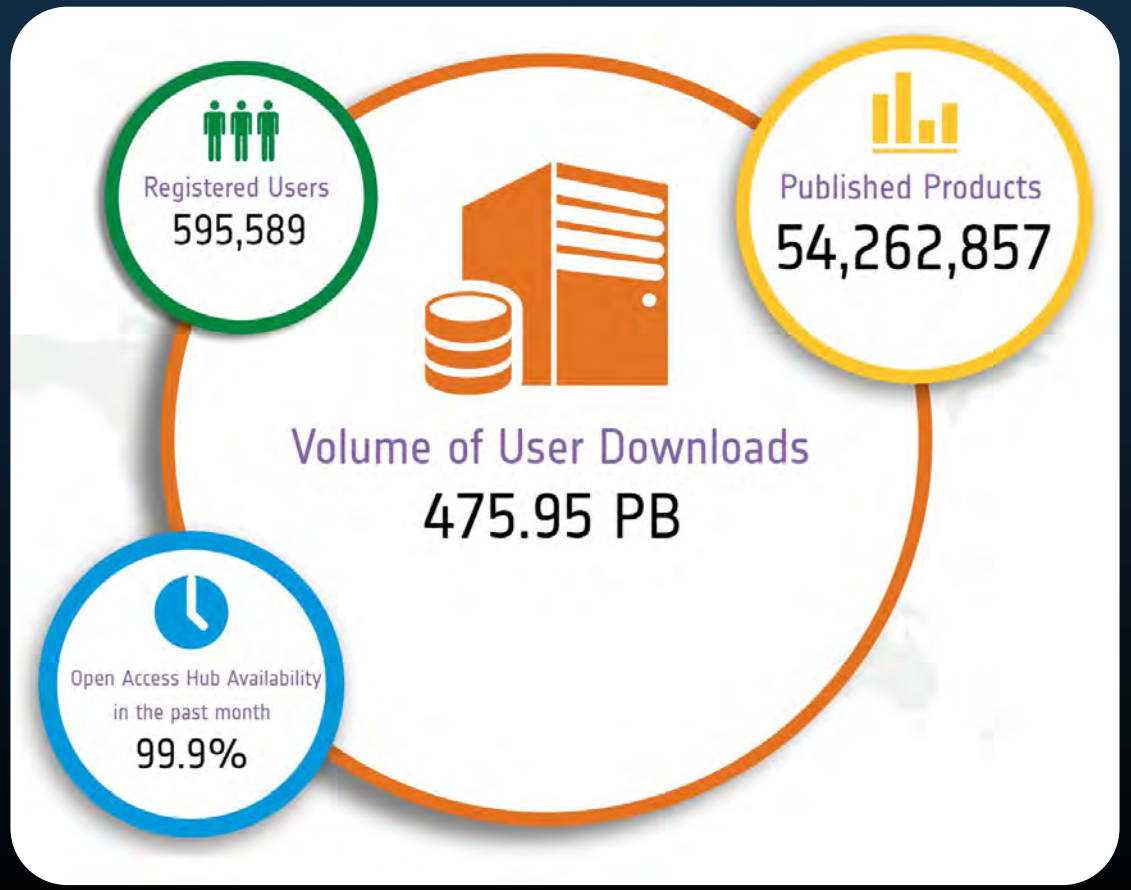
Securing the long-term continuation of Europe's eyes on our planet



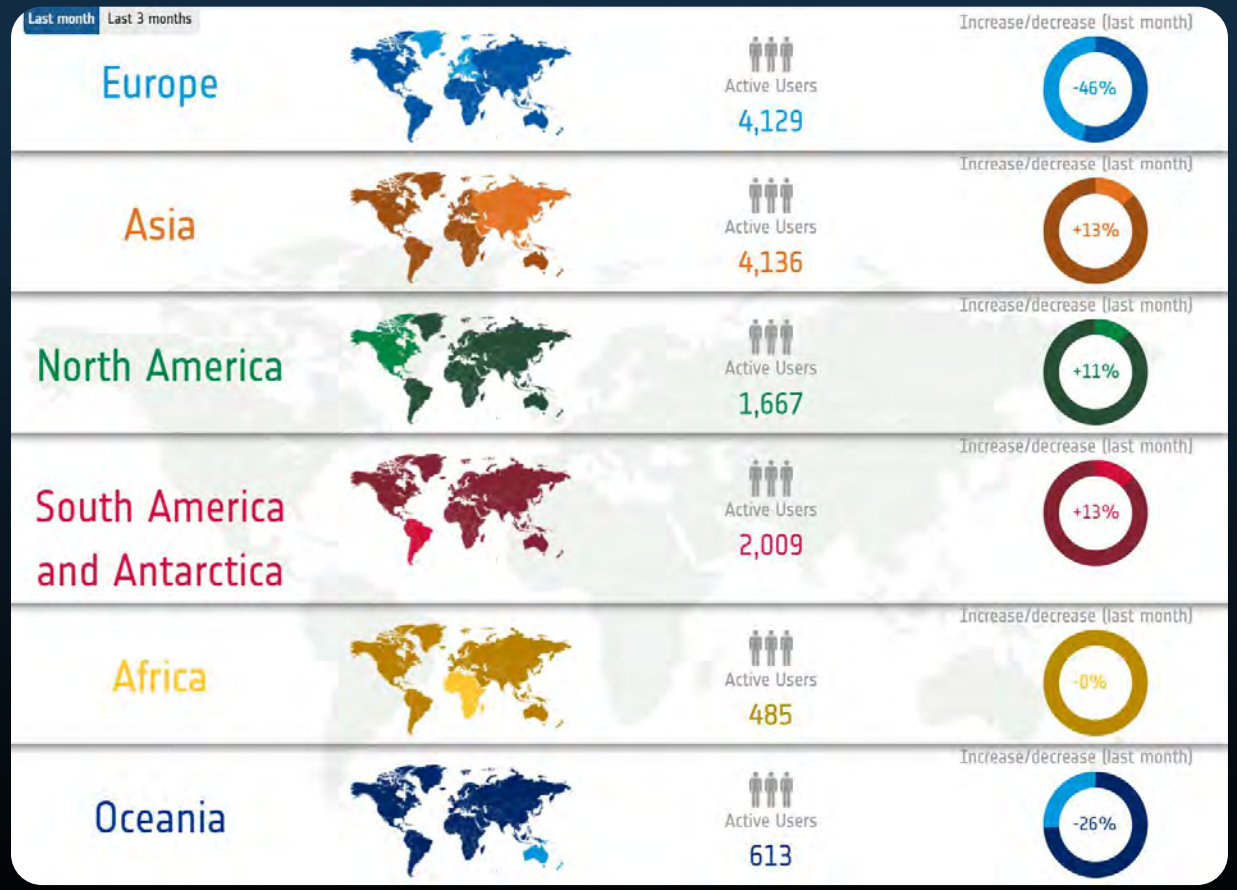
Meteorology - Aeolus-2

Copernicus Sentinels Next Generation

Copernicus - Sentinel Data Dashboard (Status 20 Sep. 2022)



Registered Users, total data download and published products since start of operations



Active Users on Copernicus Open Access Hub for the past month: Distribution by continent

CSC4-Phase2 – Overall scope

Declaration on the Copernicus Space Component (CSC) Programme foresees that Segment 4 of the ESA CSC Programme consists of a coherent overall set of activities, carried out in three, partly overlapping, phases.

Phase 1:

- *Phase B2/C/D/E1 of the six High Priority Candidate Missions (HPCMs) (2020-2029)*
- *Ground Segment (G/S) Development & Collaborative G/S*
- *CSC coordination activities*

Phase 2: Open for subscription at the occasion of CM22.

- Phase B2/C/D/E1 of Sentinel-1 NG and Sentinel-3 Topographic NG (2023-2030)
- Ground Segment (G/S) Development
- CSC coordination activities

Phase 3:

- *Phase B2/C/D/E1 of Sentinel-2 / Sentinel-3 Optical NG (2026-2032)*
- *Phase B2/C/D/E1 of Sentinel-6 NG (Sentinel-6 NG funding for the Phase B2/C/D/E1 will be sought at CM25 as part of a revised CSC-4 Phase 3.)*

Aeolus-2 – Programme Proposal Overview

Aeolus-2 is set to succeed and improve upon the highly successful Aeolus Mission, launched in 2018 and demonstrated a significant contribution to the improvement in the accuracy of Numerical Weather Prediction (NWP).

Aeolus-2:

- Collaborative programme with EUMETSAT for a series of two satellites and 10+ years of operations
- Will build on the heritage and experience gained from the Aeolus development/in-orbit operations and an extensive ESA lessons learnt exercise:
  - correction of the observed in-orbit deficiencies
  - an increase of the design lifetime (from 3 years to over 5 years);
  - a (limited) improvement of the observation performances
  - an improvement in the overall robustness and operability
- By EUMETSAT request, Aeolus-2 will also embark a Radio Occultation instrument if feasible.
- First launch planned in 2030

Aeolus-2 – Cooperation Model and Roadmap

Similar ESA-EUMETSAT Cooperation Model for Aeolus-2 as followed on MTG and MetOp-SG:

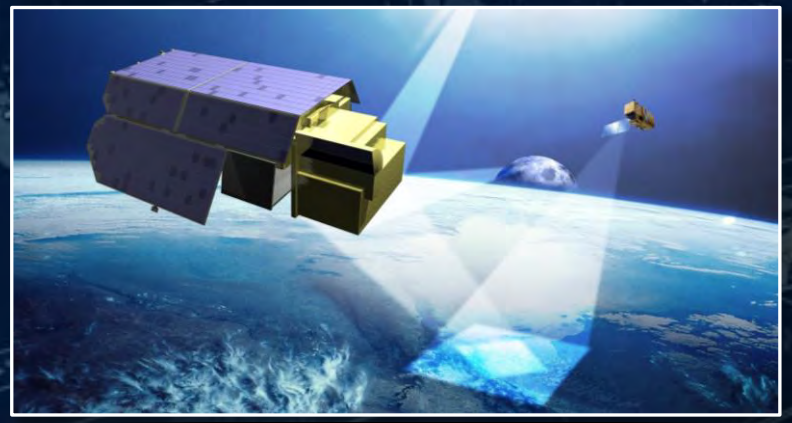
- ESA is responsible for the development of the space segment and, on behalf of EUMETSAT, for the procurement of the recurrent satellite.
- EUMETSAT is responsible for the end user requirements, the overall system, development of the ground segment, operations and procurement of the launch services for all satellites.
- EUMETSAT will provide a fixed financial contribution (30%) to the ESA development programme (for Phase C/D/E1, but not for Phase B2).
- As Aeolus-2 recurrent Satellites are funded by EUMETSAT, Participating States to the ESA Aeolus-2 Programme will automatically benefit from increased industrial return on the recurrent Satellite.

Customised EO

Pre-operational activities answering demands from user communities, industry, Member States

CLIMATE–SPACE

Incubed-2

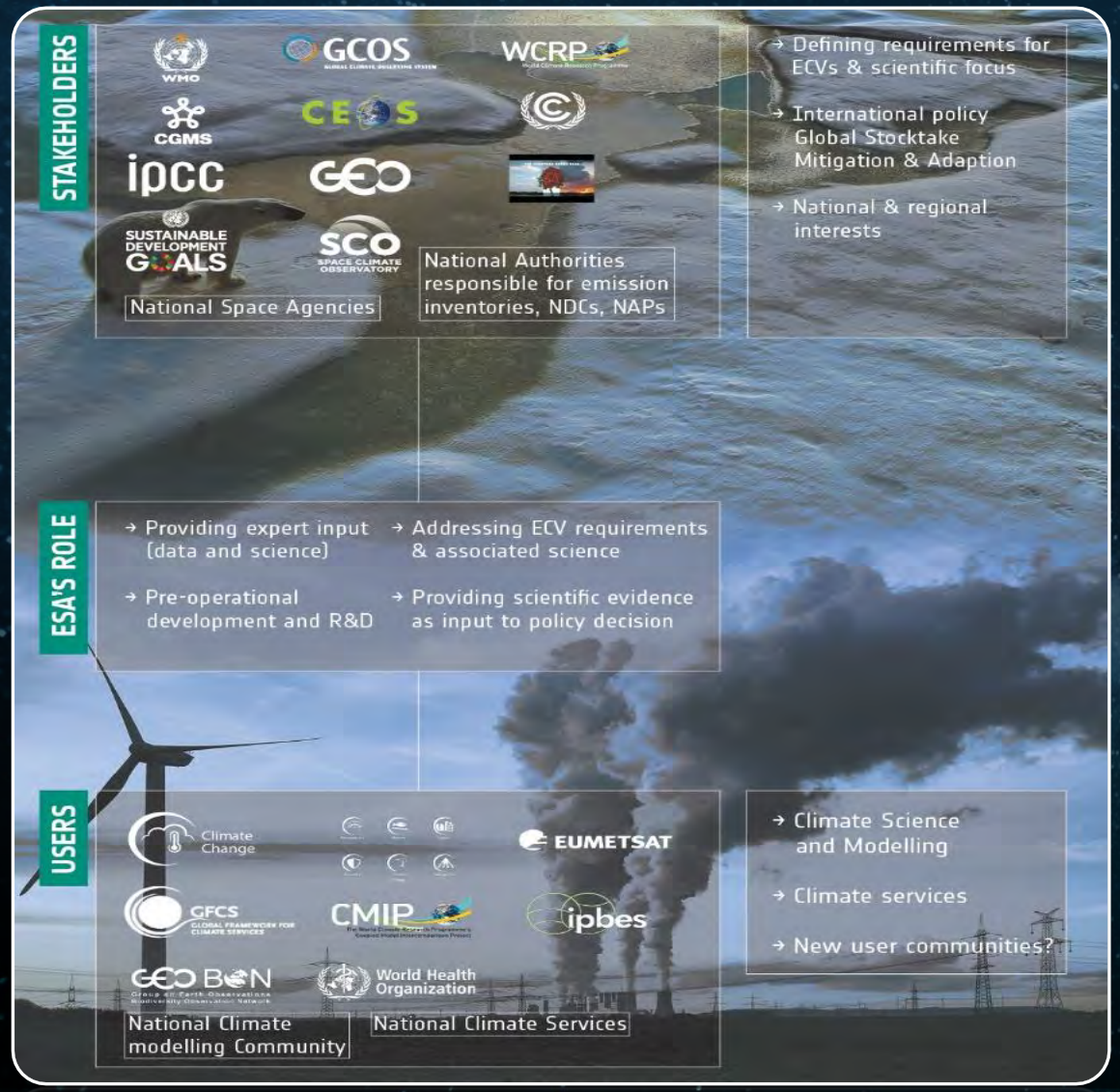


TRUTHS

Digital Twin Earth (DTE)

Climate-Space

Climate Observations and Monitoring for Policy Action Support from Space



THE INTERNATIONAL CLIMATE NETWORK

Policy drivers

- UNFCCC Paris Agreement/ IPCC
- 2030 Agenda for Sustainable Development
- Sendai Framework for Disaster Risk Reduction 2015–2030
- EU's Green Deal
- UN conventions: biodiversity & ecosystems
- Requirements from various stakeholders of the international climate network, in particular GCOS

Focus on collaboration, complementarity and synergy

Climate-Space – ESA's role…

International Climate Network
UNFCCC | IPCC | GCOS | WCRP | Future Earth | CEOS |
CGMS | GEO | EUMETSAT | ECMWF | C3S | SCO | CMIP …

esa

INPUT
Addressing requirements from international climate network and drivers, such as GCOS, WCRP, UNFCCC, IPCC, climate services/C3S, State of the Climate reports.

The excellence base

UNFCCC Paris Agreement

Support to climate modelling

R&D and Services

Scientific evidence base

ECV**s: OCEAN & CRYOSP** (SST, SSS, OC, Sea**, Sea Level, Sea Ic**cier, Ice Sheet)

EC**DRs: ATMOSPHERE (**LL GHG, Ozone, Aer**pre-cursor Aeroso**ne, Water Vapour)

I**CDRs: TERRESTRIAL** MR & HR Land Cove**kes, Soil Moisture,** ass, Permafrost, Fire

High-quality CDRs

OUTPUT
R&D, pre-operational development

Using the excellence base to expand on cross-cutting activities

Support Member States in responding to the requirements of the UNFCCC Paris Agreement	Linking observation and modelling community: CMIP IPO, CMUG, CMIP7+	R&D: cycles, tipping points, trends, cross ECV, R&D and pre-operational development for climate services	State of the Climate, IPCC, WMO etc
			OUTPUT

Delivering Climate Observations to Society
Climate Ambassador

Knowledge Exchange: data access & curation, communication, education and outreach

InCubed 2 – Model and roadmap

‘Investing in Industrial Innovation’ to stimulate and develop European Commercial EO

- The InCubed EW Element comprises InCubed (2016/7), InCubed+ (2019) and now InCubed 2 (2022)
- InCubed is a co-funded programme as it is anticipated that industry will be generating revenue from EO products and/or services developed with InCubed
- The end point is at least a minimum viable product to showcase the EO product or service to potential customers or investors

Activities range:

- End-to-end systems developing more competitive technical solutions for existing markets
- Development of software to exploit new markets using existing data streams
- Spin-in of technologies to address EO needs
- In-orbit technologies that support the unique needs of EO systems
- Flight elements that complement the Copernicus and meteo public infrastructure with a commercial focus
- Experience from the original InCubed and InCubed+ shows that activities costs range in scale from hundreds k€ to many M€, with most activities in the range 0.5-5 M€

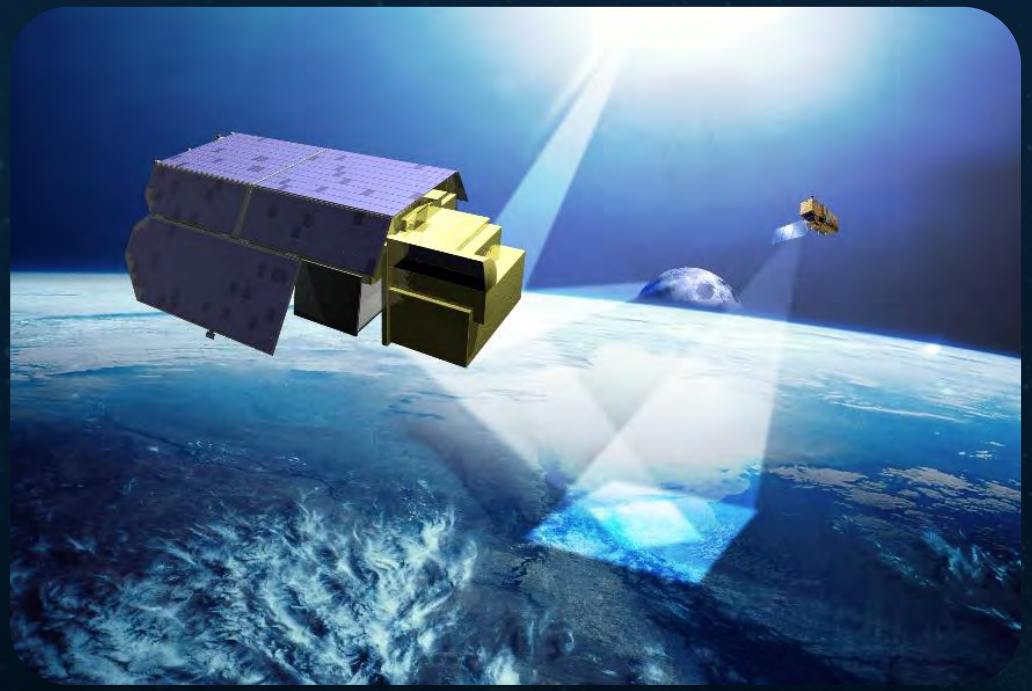
The key InCubed-2 deliverables are:

- A new Open Call for InCubed Proposals and Invest Actions aimed to develop a multi-pillar framework of partnerships and collaborations with external entities capable to strengthen the InCubed offer

Copernicus Contributing Missions (CCM)

- ✓ Under the guidance of the European Commission, ESA has provided a comprehensive CCM Procurement Approach in discussion with the Commission.
- ✓ Within this CCM procurement context, the Commission has requested ESA to follow a Dynamic Purchasing System (DPS) method.
- ✓ ESA is currently implementing a DPS tool within the ESA **'esa-star'** on-line procurement system, along the ESA procurement regulations.
- ✓ The first procurement using the DPS method will start at mid-October 2022 and will be dedicated to European emerging data suppliers (i.e. European New Space companies)

TRUTHS – Mission Objectives



An operational climate mission, providing:

- **Climate benchmarking:** enhance by an order-of-magnitude our ability to estimate the **Earth Radiation Budget** through direct measurements of incoming & outgoing energy,
- **Satellites cross-calibration:** establish a 'metrology laboratory in space' to create a fiducial reference data set to cross-calibrate other sensors and improve the quality of their data (essential for New Space constellations)
- Provide **SI-traceable measurements** of the **solar spectrum** to address direct science questions.

Mission/System Drivers:

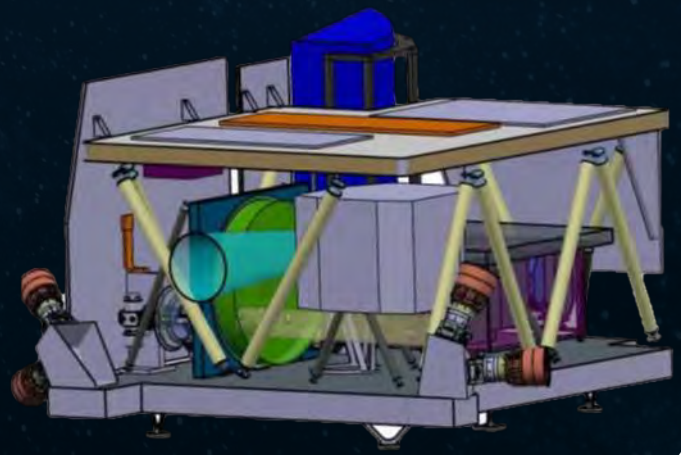
- Climate application drives the stringent Radiometric accuracy (0.3% G÷1% T) ➔ Payload & calibration System design
- Cross-calibration application leads to a non-SSO orbit ➔ Satellite design (CRISTAL P/F recurrent) and dedicated LV (TBC) plus ops.
- Solar/Earth samples in a large spectral range: UV to SWIR (320-2400 nm). SSD 50-100 m , 100 km swath

TRUTHS now and at CM22

- **Platform**, recurrent from CRISTAL, polar non-SSO at 609 km.
- **Satellite**, ~1200kg / 1kW, compatible with Vega-C.
- **Payload,** ~400kg, composed of three elements:
  - ✓ **HIS** (Hyperspectral Imaging Spectrometer) – based on a single passively cooled detector operating from UV to SWIR
  - ✓ **CSAR** (Cryogenic Solar Absolute Radiometer) – operated at 60 K with cryo-cooler, delivering the "absolute radiometric reference"
  - ✓ **OBCS** (On-Board Calibration System) – traceable set of absolute wavelength anchors transferring the CSAR solar absolute measurement to the HIS
- Pre-developments running for all critical items (detector, coating, CSAR, mirror, calibration sources…) with intense interactions with MAG to optimize operational benefit and development risks.
- Phase A completed and phase B1 running at full speed
- At CM22: critical new steps to reach operations in 2030 = Phase B2 + Phase C0 for instrument (engineering model).

TRUTHS satellite

CSAR



Digital Twin Earth (DTE)

Dynamic and interactive representations of processes in the Earth System

Systematically integrating diverse EO data sets

Providing easy access to data, processing & analysis resources and interactive platform functions

Utilising Cloud-, HPC- AI-technologies

Creating new insights through interdisciplinary research based on simulations & predictive modelling

ESA Digital Twins

- DT Polar
- DT Hydrology
- DT Oceans
- DT Carbon
- DT Solid Earth

Derived from DTE precursor activities & defined/developed with the scientific community optimised to utilise ESA EO data assets

DTE Platform Component

Integrating and linking Digital Twins Enabling visualisation/ simulation/modelling functions without coding

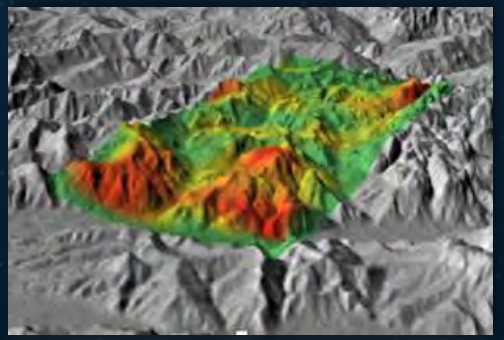
DTE EO Data Space

Full cloudification of ESA Earth Explorer-, Heritage- and relevant TPM-data
Scalable data management for seamless ingestion into Digital Twins Interface
optimisation for integrating other data sets (incl. Copernicus data)

Digital Twin Earth (DTE)

Application Domains:

- Societal Challenges
- Open Science and Innovation
- Integration of national initiatives
- Contribution to European initiatives
- Step towards a unified ESA Space Data



DTE Objectives:

- Provide industrial IT services (i.e. Software as a Service, etc.) for an immersive environment of data exploitation
- Assure scalable system for users to develop: processing-, prototyping-, documentation-, release- workflows
- Commit to the principles of data completeness, timeliness, authenticity, quality, etc. (meet the GAFA challenge)
- Build on a multitude of ESA precursor activities & Member State initiatives
- Serve as basis for possible evolution into DTE&U MDA proposal for 2025
- Feedback into Phase 2 of DestinE

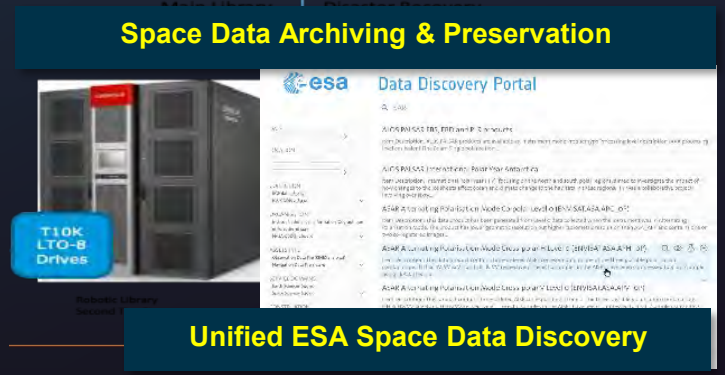
Heritage Space – Overview

- ***ESA-wide coordinated action covering <u>150+</u> heritage missions/campaigns*** from mid 70's including ERS, Envisat, GOCE, Rosetta, Planck *(one of the largest space data archives in the world)*
- Complementing & supporting other ESA programmes by ***ensuring preservation, access, curation and exploitation of ESA heritage space data and information assets*** (continuously growing)
- ***Partners***: EOP, SCI, HRE, OPS, DG Cabinet

Inter-directorate joint activities

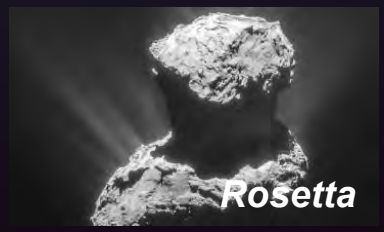
→ ESA-wide *joint innovative concepts & solutions*

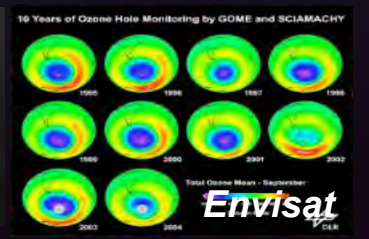
→ Removing barriers and avoiding silos mentality



Directorates specific activities

→ Addressing specific needs and filling gaps wrt common strategy and standards



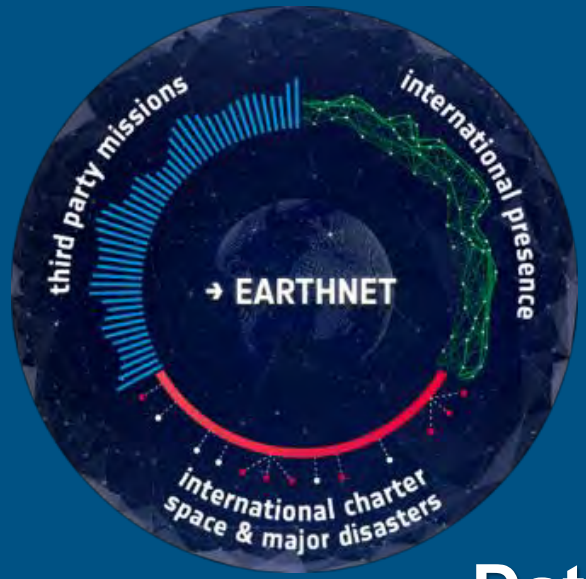


Overarching goal: make ESA heritage data and information more easily accessible to more users, and generate more science and applications out of them

Earthnet – Overview

ESA Earthnet and EU Copernicus Contributing Missions
→ *An excellent synergy*

Earthnet paves the way towards the utilization of commercial data for operational services



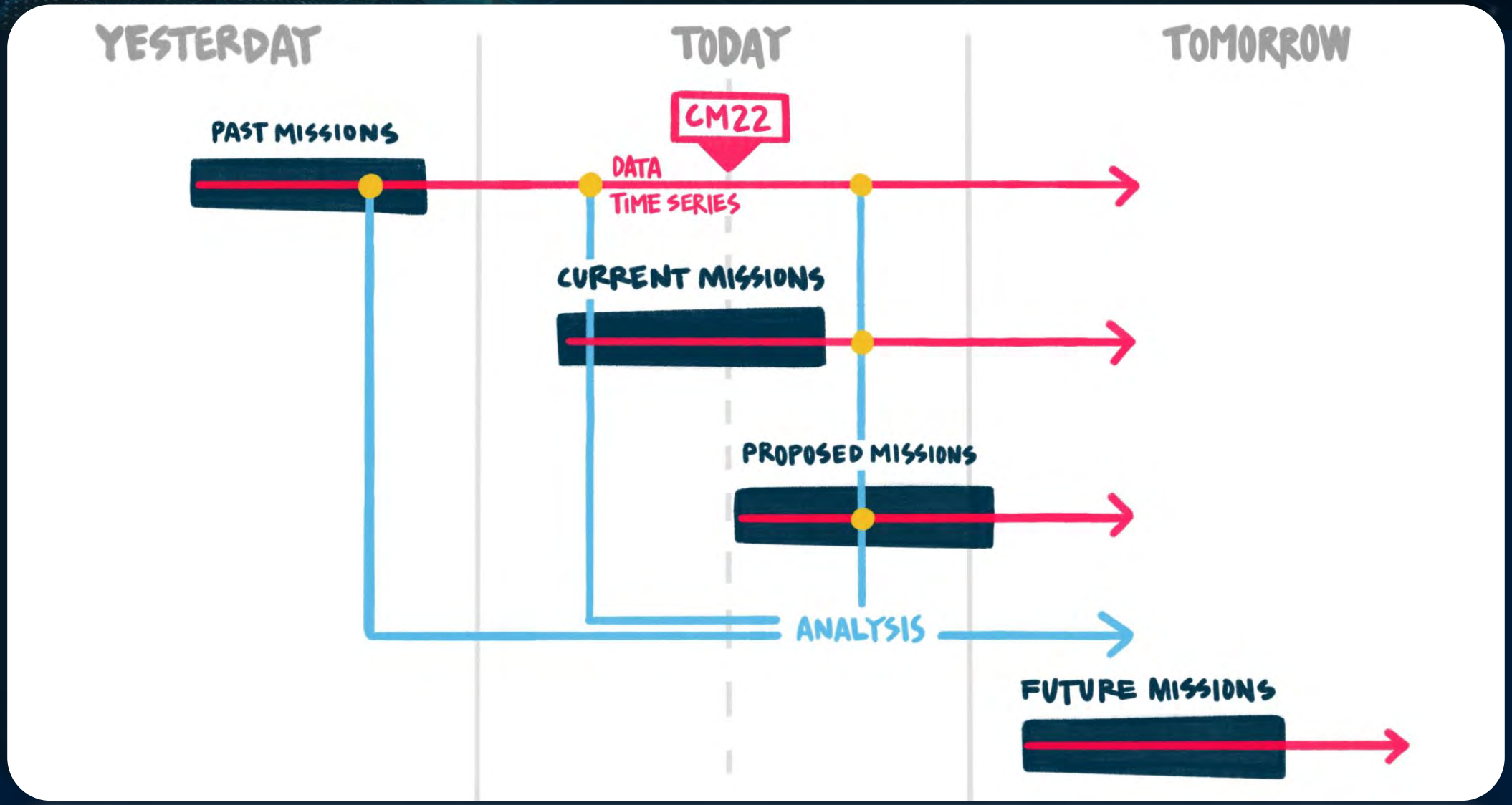
R&D, Sciences → **Operations, Public needs**

Third Party Missions → **Copernicus Contributing Missions**

Data assessment → **Operational delivery**


Long-term view – CM22 is only the next stop
ZWIJNDRECHT
DEURNE
BORGERHOUT
ANTWERPEN
BERCHEM
WIJNEGE
BORSBEE
8 Astrid
15 Regatta
11 Melkmarkt
11 Berchem Station
9 Eksterlaar
1 Zuid
5 10 Wijnegem
Keizerstraat
Roosevelt
Centraal Station
Elisabeth
De Roma
Van Overmeire
Frans Van Dijck
Hof ter Lo
Cogelsplein
Gallifortlei
Lunden
Venneborg
Schotense-stwg.
Ruggeveld
Havik
Ertbrugge
Wijnegem Shopping Center
Schijnbeemden
Fortveld
Melkmarkt
Sint-Katelijne
Sint-Jacob
Jezusstraat
Opera
Astrid
Ommeganck
Antwerpen-Centraal
Ploeg
Diamant
Zegel
Stenenbrug
Lente
Joe English
Plantin
Plantin & Moretus
P+R Melsele
Hof Ter Rijen
Dorp
Van Goey
Verbrandendijk
P+R Linkeroever
Regatta
Sporthal
Halewijn
Van Eeden
Groenplaats
Meirbrug
Meir
Nationale Bank
Museum
Kasteelplein
Van Bree
Lange Leemstraat
Antwerpen-Berchem
Berchem Station
Groenenhoek
Waterbaan
Van Riel
Florent Pauwels
Dassastraat
Apollo
De Preter
Van den Hautelei
Te Boelaarpark
Eksterlaar
Cruyslei
Jozef Verboven
Pacificatie
Bres
Gounod
Harmonie
Montigny
Bestorming
Bolivarplaats
Broedermin
Provinciehuis
De Merode
Markgravelei
Driekoningen
Zuid
Station Zuid
Antwerpen-Zuid
deSingel
Sint-Willibrordus
Koninklijkelaan
R1
Antwerp Expo
Kolonel Silvertop
Volhardingstraat
Jan Moorkens
Kielpark
Olympiade
Pulhof
Fruithoflaan

CM cycle – Deliverables at different timescales



Accelerator-1: Space for a Green Future

+

+

+ Accelerating decarbonisation & sustainability

= Supporting the climate neutrality by 2050 objective

Accelerator-2: Rapid and Resilient Crisis Response

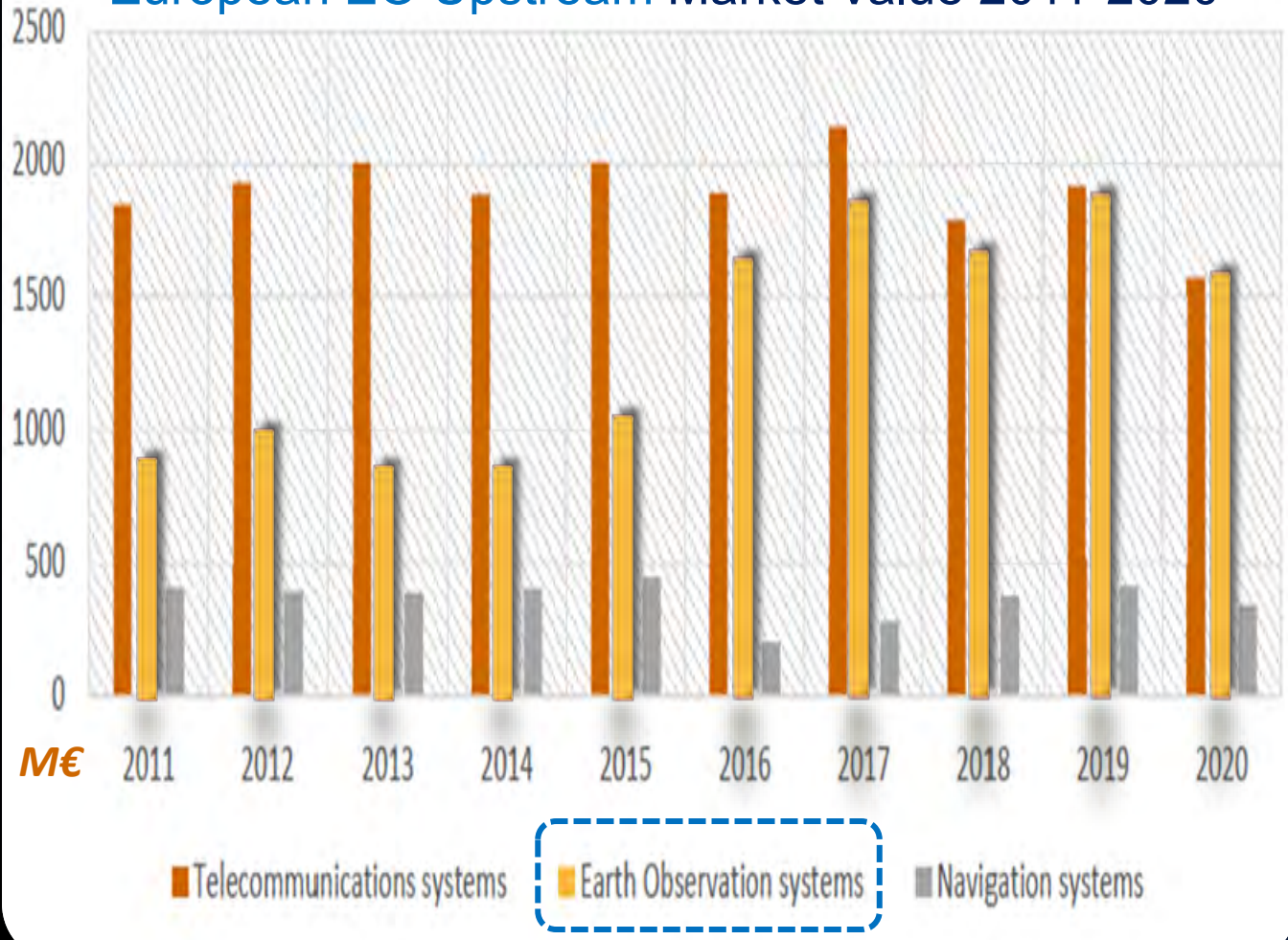
Linking all key information

Earth Observation
HAPS
In-situ

Into one integrated smart network

Growing EO Up- and Downstream Market Value

European EO Upstream Market Value 2011-2020



Source | Eurospace, Facts and Figures, 2021

European EO Up & Downstream Market Value 2021

713 Companies
up from 572 (+24%*)

11,600 Employees
up from 9800 (+17%*)

€1.71b Revenues
up from 1.38b (24%*)

10% CAGR**
sustained

(* Year on year | ** Over 5 years)

Source | **EARSC - European EO Industry (2020 study done 2021)**

TO CONCLUDE

EOP at CM22 = 3 B€

~ 2 euro/year/citizen

- **RoI EO programmes > x4 *(x8…)***
- **CAGR of application sector > 10%**

BE Subscriptions Overview (relative GNP = 2.8%)

Programme	Economic Conditions	Total Subscribed Envelope (M€)	Belgium's Contributions	
			M€	%
EOEP 1-2-3	1997	2,619	55.1	2.10
FUTURE-EO	2012	2,648	59.5	2.25
GSC 1-2	2006	1,553	20.8	1.34
GSC-3	2012	405	2.6	0.64
CSC-4	2019	1,811	48.5	2.68
MTG	2008	1,182	28.7	2.43
METOP SG	2012	809	21.5	2.66
EW GSE	2017	135	13.0	9.61
EW CCI	2009	166	9.6	5.80
EW PROBA-V	2012	43	42.8	99.53
EW INCUBED+	2019	64	5.5	8.52
EW ALTIUS	2016	152	142.1	93.64
EW GDA	2019	28	1.4	4.83
TOTAL		**11,615**	**451.1**	

Actual Geo-Return statistics BE (status 2021-Q4)

Programme	Weighted Amounts (M€)	Return Coefficient (%)	Surplus / Deficit (M€)
EOP DOMAIN prelim. status 2021-Q4	**188.3**	**1.02**	**4.0**
FUTURE-EO	40.2	1.21	7.0
GSC-3 (1)	2.7	0.96	-0.1
CSC-4 (2)	16.3	1.11	1.7
METOP SG	20.4	1.00	-0.1
EW INCUBED+	4.7	1.00	-
EW ALTIUS	75.8	1.00	-
EW GDA	0.2	1.00	-
EOEP 1-2-3	5.9	3.19	4.0
MTG	6.6	0.73	-2.4
EW CCI	1.9	0.62	-1.1
EW PROBA-V	13.6	0.73	-4.9

(1) GSC-3 statistics excluding compensation measures.
(2) CSC-4 current statistics cover only committed Ph.B2-Adv.C/D activities.

What do CM22 EO programmes buy?
8 new satellites (and much more)

Earth Explorer 10

1 HARMONY

2 **MAGIC/NGGM**

Small Missions

3 4 SCOUTS 3-4

Copernicus

5 Sent-1 NG

6 Sent-3 NG

(+ recurrent)

7 **TRUTHS**
Phase B2/C0

8 **Aeolus-2**
(+ recurrent)

Operate
9 Research
missions

Prepare future Missions

Sent-2 NG and 3-opt NG, M4G, EE-11, - 12 and -13, and more (long-term)

Support Commercial EO sector

Deliver activable Earth Science, Essential Climate variables, DTE, …