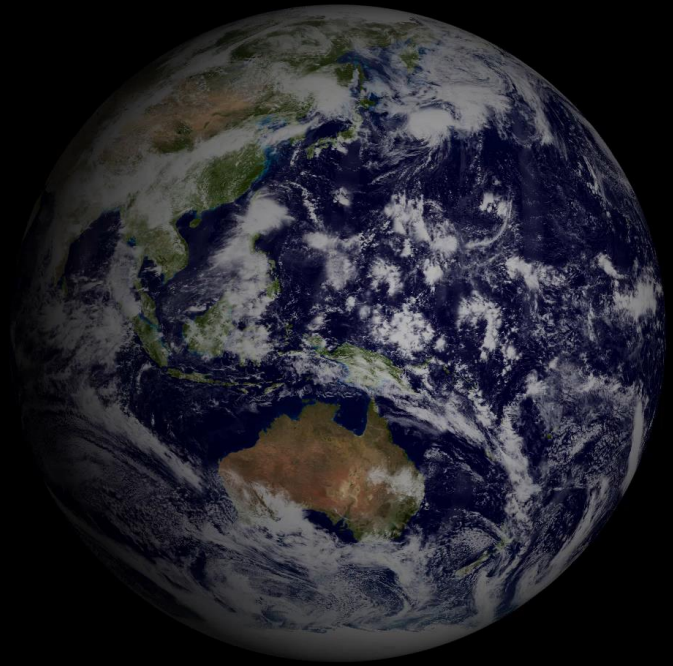
Belgium & ESA EO Programmes

Info Day with Belgian Economic Operators

Brussels, 30 September 2019

Gordon Campbell, Michel Verbauwhede (ESA EOP)

ESA Earth Observation



“Taking the Pulse of our Planet”

A successful Track-Record

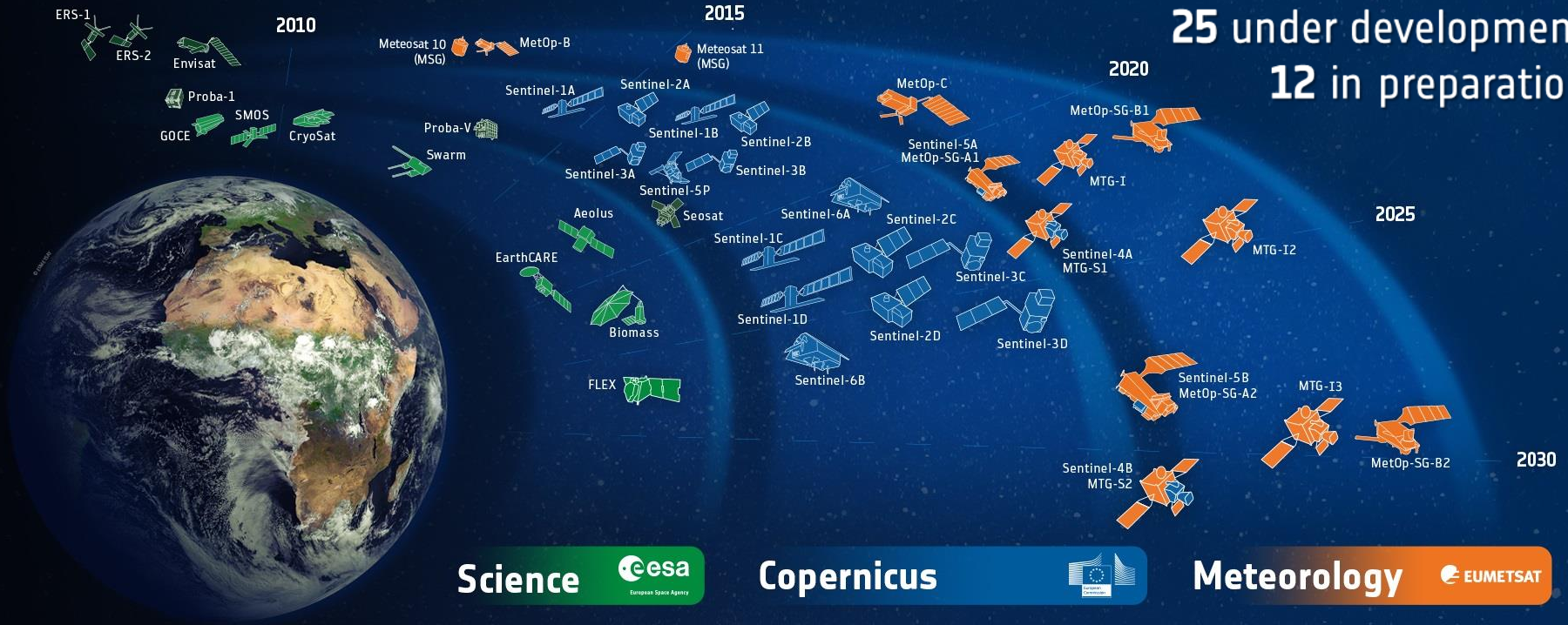
ESA-Developed Earth Observation Missions

Satellites

15 in operation

25 under development

12 in preparation



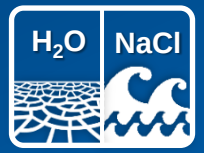
Science **Copernicus** **Meteorology**

Future EO – Continue Successful R&D and Science

Flying Missions

GOCE
2009-2013

SMOS
2009



Cryosat
2010

Swarm
2013

Aeolus
2018

Future Missions

EarthCare
2022

Biomass
2022

FLEX
2023

FORUM
2025

Just selected!

EE-10
2027

3 Cand.

Science & Innovation

4.700+
Reg. Users

300+ Publ. per Year

High Risks for Great Rewards

Copernicus – global European leadership in EO

> 260.000
registered users
= tip of the iceberg

6 operational services

Land | Atmosphere | Ocean | Climate | Disaster | Security

175 TB satellite data distributed per day

full, free & open data policy

7 satellites flying

S1 | S2 | S3 | S4 | S5P | S5 | S6

preparing Copernicus 4.0

Belgium and ESA EO Programmes

BE contributions to ESA EO Programmes

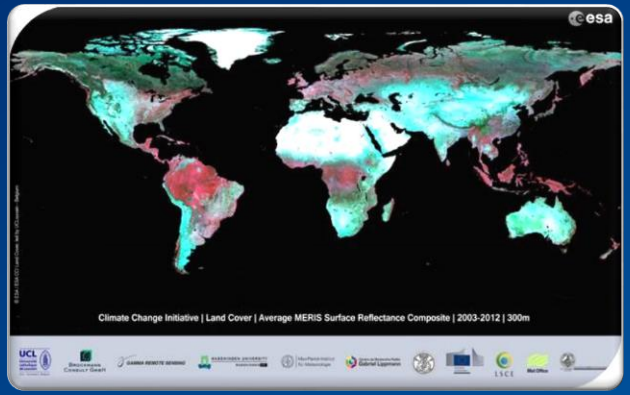
Programme	Economic Conditions	Total Subscribed Envelope (M€)	Belgian Contributions	
			M€	%
EOEP-1/2/3	1997	2,619	55	2.10
EOEP-4/5	2016	2,124	42	2.00
GSC-1/2	2006	1,553	21	1.34
GSC-3	2012	405	3	0.64
MTG	2008	943	24	2.58
METOP SG	2012	809	22	2.66
EW GSE	c.e.c.	135	13	9.61
EW CCI	2009	165	10	5.82
EW PROBA-V	2012	31	31	99.36
EW ALTIUS	2016	98	92	93.62
TOTAL		**8,882**	**312**	

Belgium's Contributions for Mandatory Activities 2018-2020: 2.72%

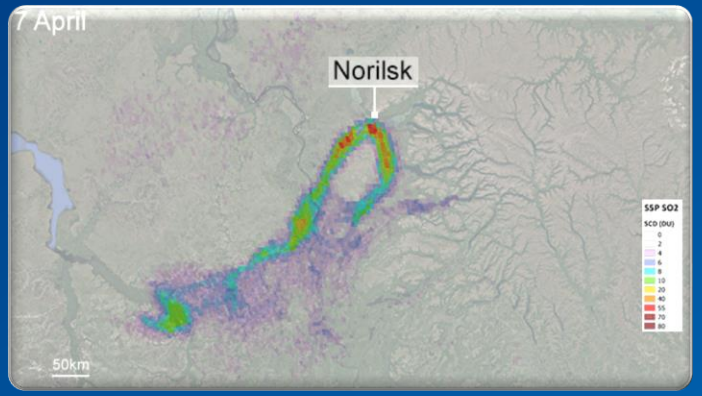
Belgian thematic strengths

Contributions to:

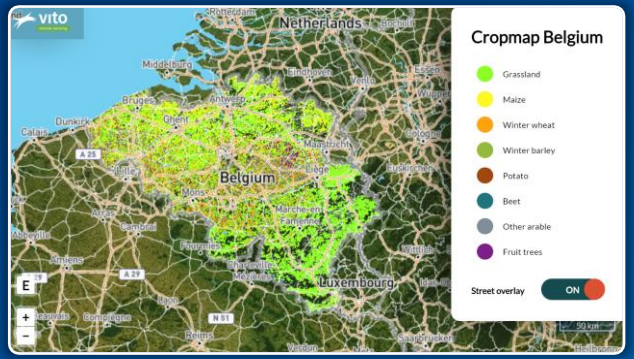
- Air Pollution Monitoring
- Weather & Climate
- Water Management
- Agriculture
- Land Management
- Earth Science
- …



CCI – Land Cover
MERIS 2003-2012
© UCL



SO_2 by Sentinel-5P
April 2018
© BISA

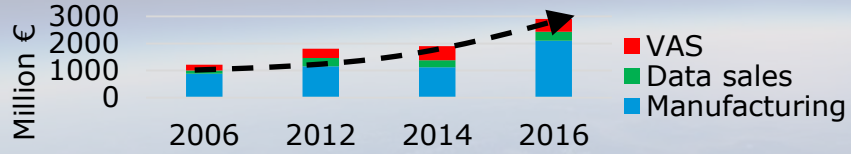


Agricultural landscape
in Belgium
Sentinel-1 & Sentinel-2 Data
1 Jan. – 15 June 2018
© VITO

EO Strategy & Elements at Space19+

Europe's place in the global EO market

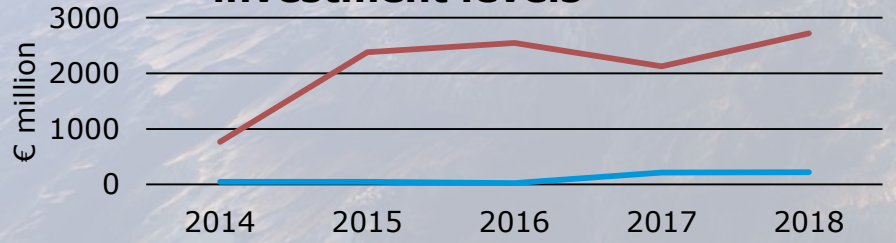
→ The EO market in Europe has seen a substantial growth throughout the decade, driven by public sales.



→ Each € invested in EOEP/FutureEO leads to **3.8€** created in Europe in GDP, technology and knowledge spillovers and **55000** job years created.

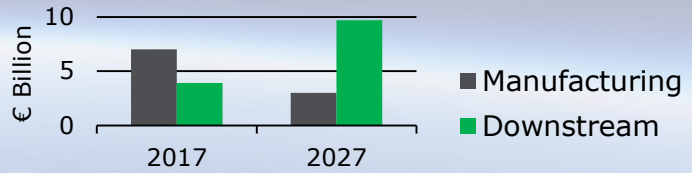
PWC, 2019

European vs Global private investment levels

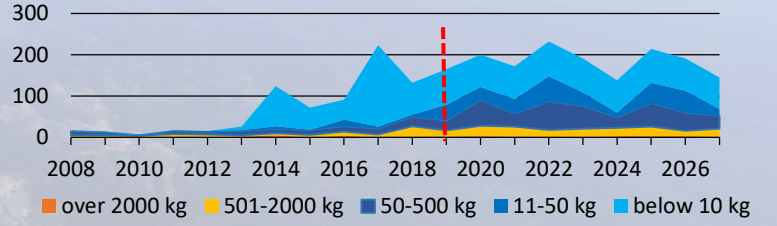


Bryce 2019, ESPI 2019

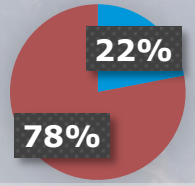
EO market decade projections



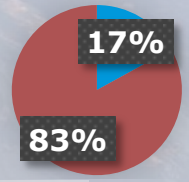
Launched EO satellites (non-meteo) worldwide



Satellite manufacturing segment (2018-2027)



Downstream segment (2018-2027)

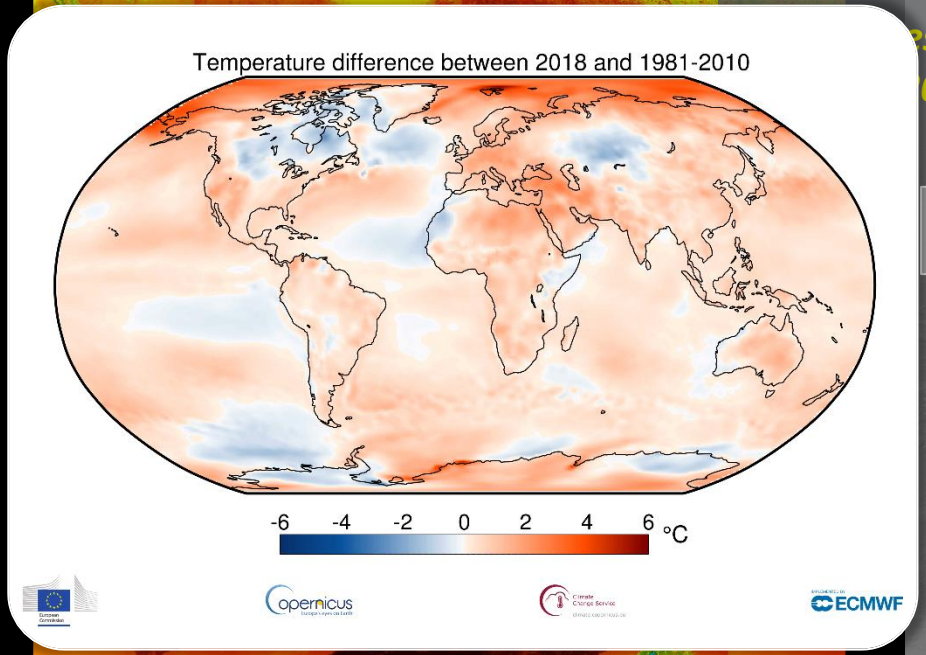


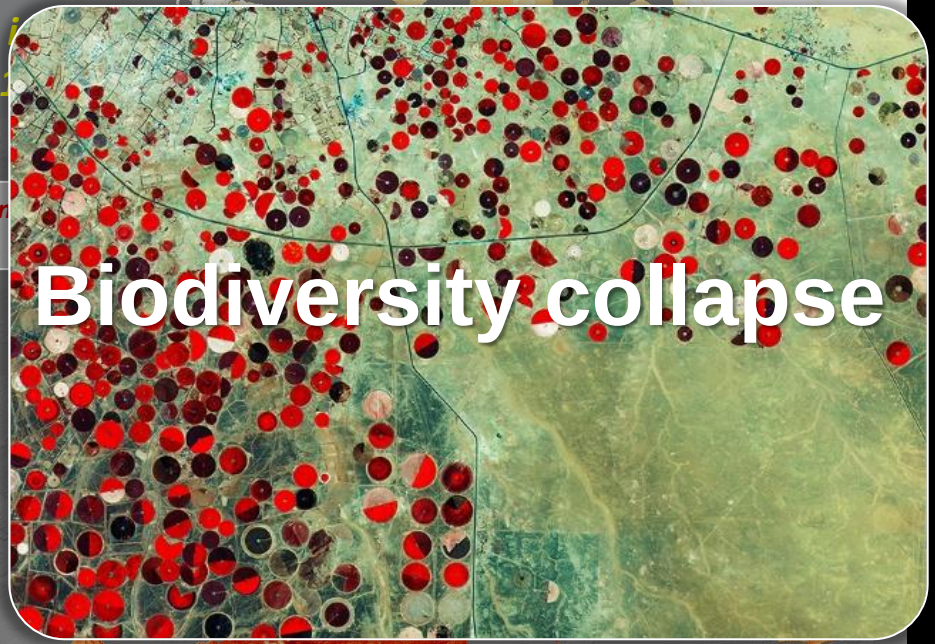
Europe
Rest of the World

Euroconsult, satellite based EO 2018

Sentinel-3 SLSTR
Daytime Land Surface Temperature

EO is relevant to the greatest challenges of the 21st century:



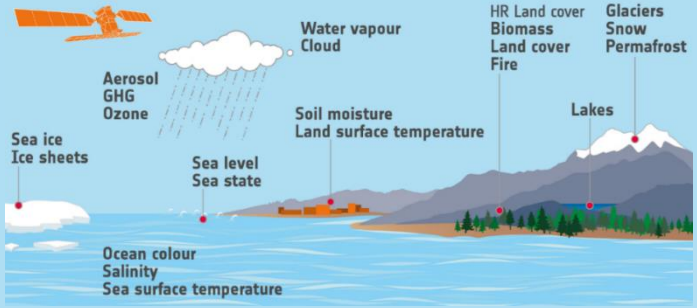


EO provides answers to the World otherwise impossible to discover.

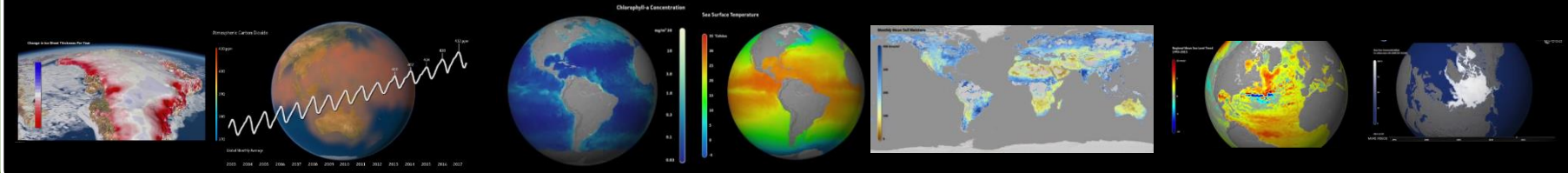
International community engagement

GCOS
GLOBAL CLIMATE OBSERVING SYSTEM

Essential Climate Variables



"Tackling climate change is the main challenge facing us in the 21st century. Out of the 50 essential climate variables (ECVs) defined by the Global Climate Observing System (GCOS), 26 can only be measured from space." Jean Yves Le Gall



Industry voice

→ **70%** of the EOEP contractors interviewed and surveyed by PWC deem that Earth Explorer data, technology and free ESA software have contributed to **climate change scientific advancements** in a significant to crucial manner.

"We are the last generation that has the luxury of making a choice.

Let's make the choice of sustainable innovation to enable our children to live their lives."

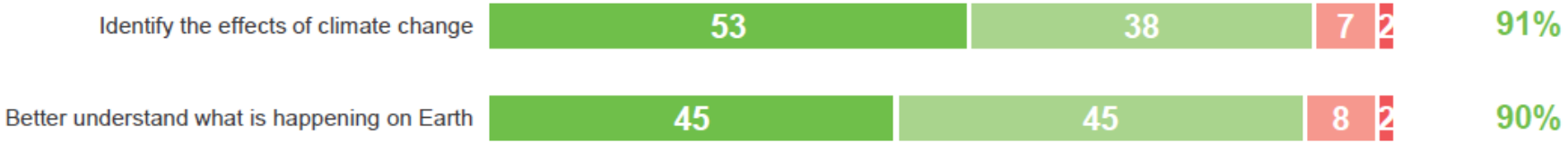
Ilham Kadri, CEO of Solvay, March 2019

Citizens voice

- In your opinion, do space activities today allow us to…?

Harris study, 2019

- In the future, do you believe that priority should be given or not to space activities that allow us to...?



Citizen climate protests around the World

Space19+ and Earth Observation

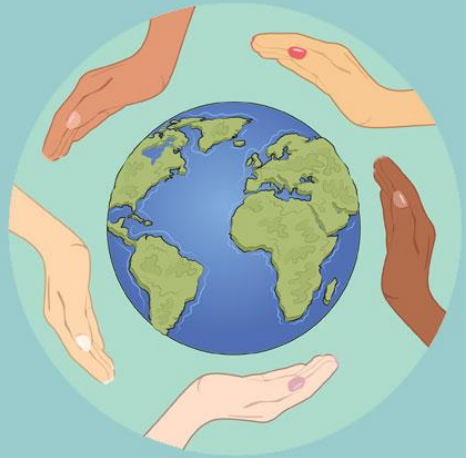
Inspiration

Understand the Earth
Enable new science
Address challenges

Competitiveness

Boost European tech.
Innovative Industry
Jobs and growth

Responsibility

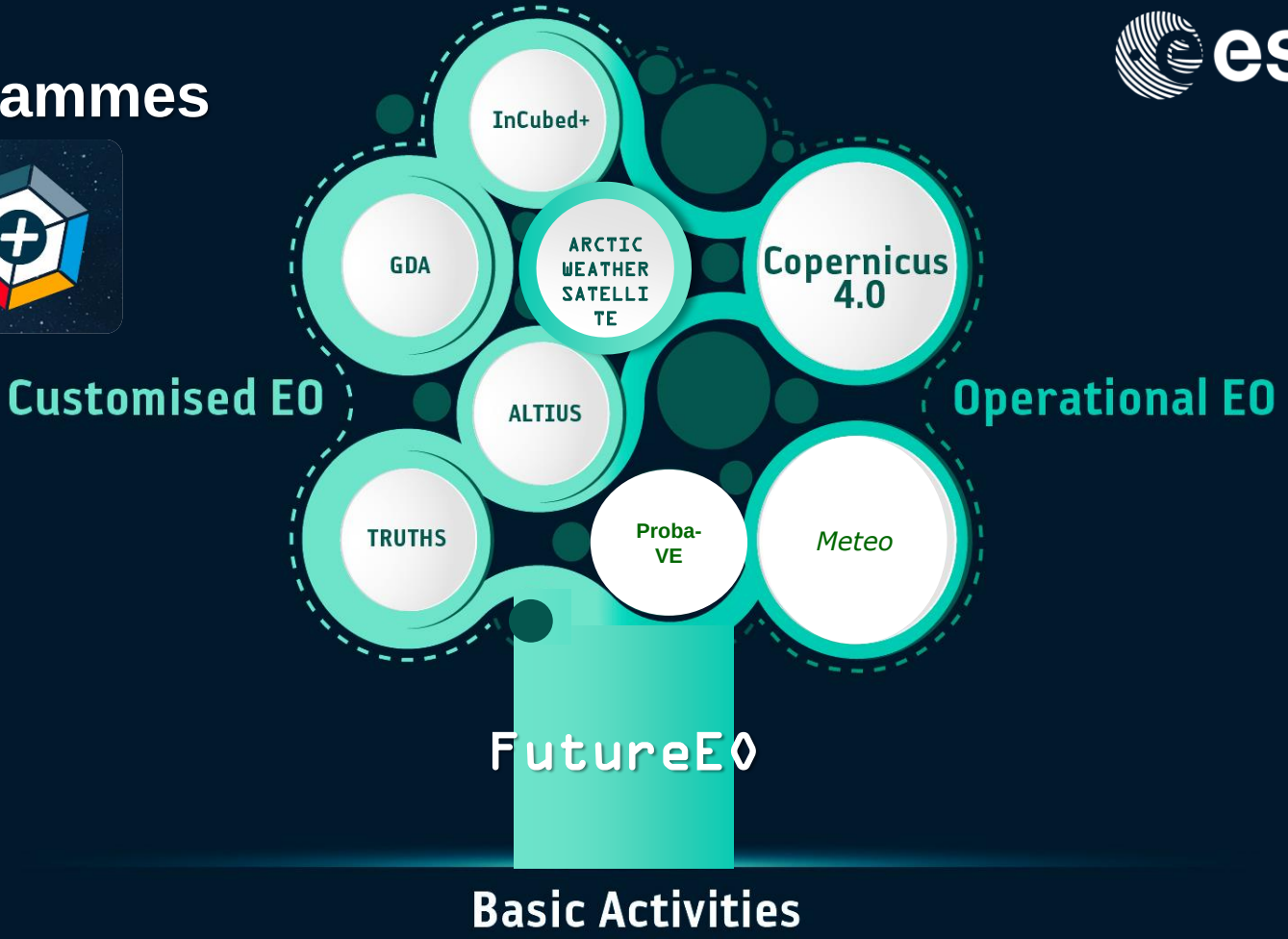


Climate change
Biodiversity
Resilience

EO Programmes at Space19+

ESA EO Programmes

Space19+

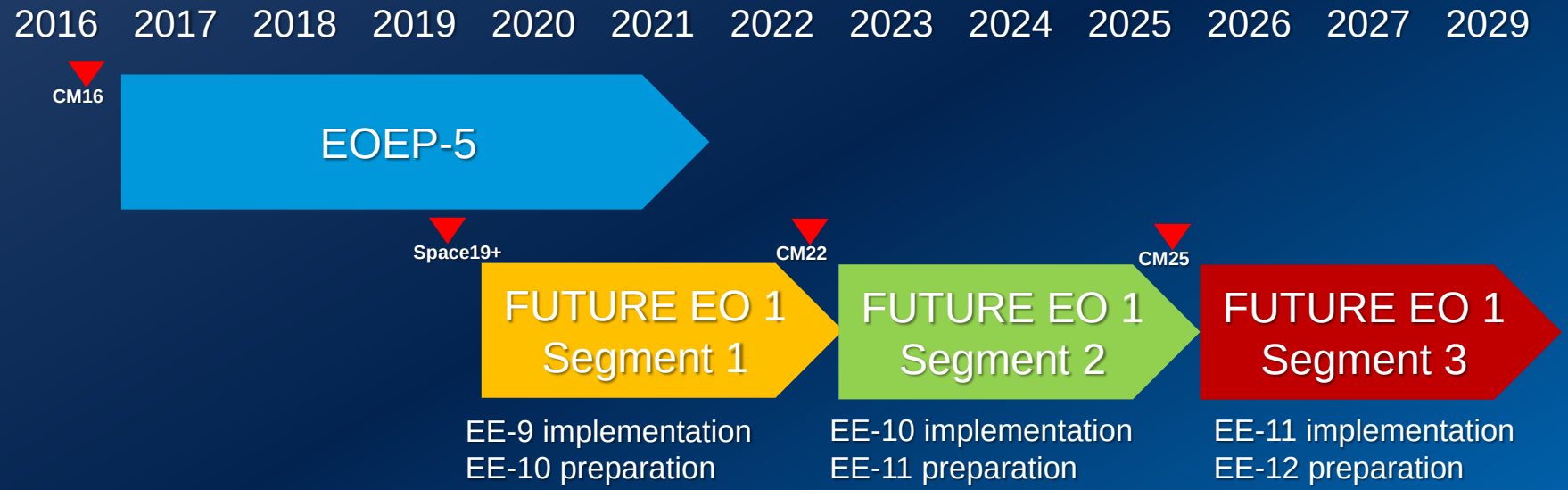


Future-EO-1

Smart evolution of EOEP

Synchronisation of EO programmes with the Ministerial Council cycle:

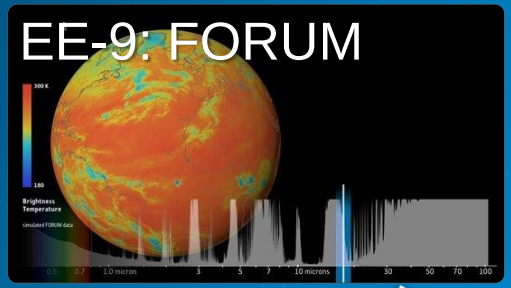
3-year segments FutureEO-1



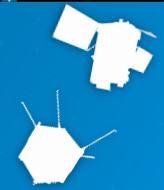
FutureEO – new Elements of Innovation

Hardware & Technology

EE-9: FORUM



Scouts & Φ-Sats



HAPS

Operations

Increased Data Diversity & Volumes

BIG DATA

EO AFRICA

Safety & Civil Security

EO contribution to ESA-wide pillar

Science & Applications

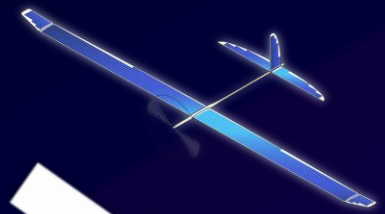
Machine Learning

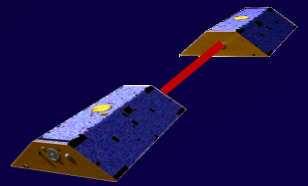
AI for Space and EO

Cloud Computing

Block 1 – Foundations, Concepts and Technology

E2E preparation of EO missions – incl. techno and science activities (raise TRL/SRL and mitigate risks)





- Call for Innovative Early (Mission) Concepts
- Early phases/campaigns/IPD for:
  - EE-11
  - Sentinel-1/2/3-topo/6 NG,
  - future Meteo Missions,
  - Mission of Opportunity (e.g. NGGM)
- Other Instrument Pre-developments
- Cross-cutting technology pre-developments, e.g. for small instrument concepts, platforms

Block 2 – Research Missions

Earth Explorer-9 FORUM

By measuring radiation emitted by Earth into space, FORUM will provide new insight into the planet's radiation budget and how it is controlled

Scouts

- Valuable smallsat science for ~30 M€
- Challenge issued in early 2019
- Up to 2 missions selected after Space19+,=
- Development & launch within 3 years

Preparing Future Missions

- Earth Explorer-10 phase B1
- Timely development activities for a mission of Opportunity (e.g. NGGM)
- Timely development activities for future operational 3D-wind measurement mission

Block 3 – Mission Management

smos | cryosat | swarm | aeolus | earthcare | biomass | flex + EE-9 + EE-10

Mission Operations

- Phase E2 of Earth Explorer missions (Phase F if relevant)
- Extension before PBEO in 2022 and part of 2023

Generic Fiducial Reference Measurements

Payload Data Ground Segment

Generic elements and Services for data accessibility, archiving, network, etc.

Geophysical Products

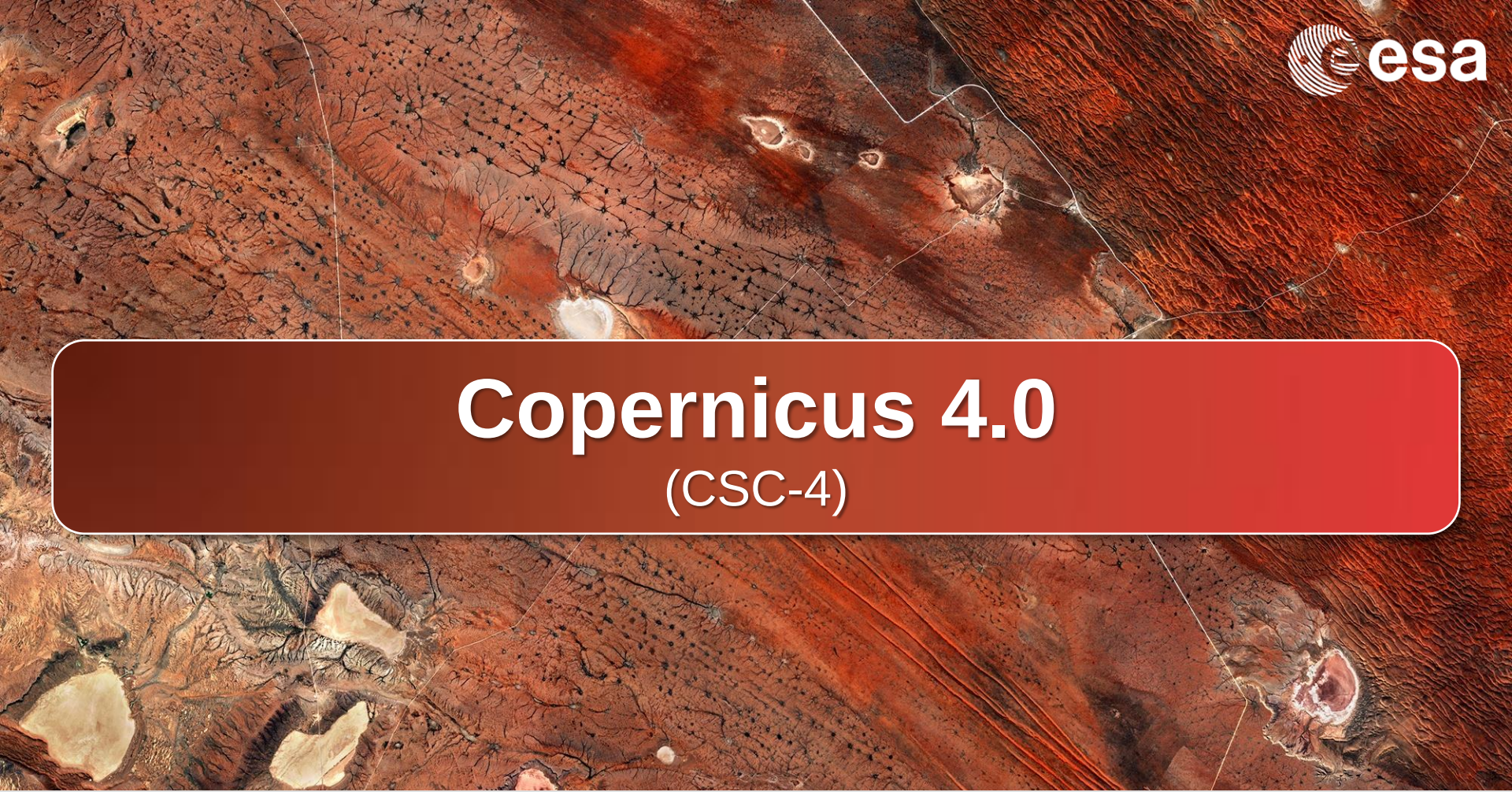
- Development & maintainance of ‘Level 2’ products
- For missions in Phases B/C/D/E (9), including cal/val campaigns

Block 4 – Earth Science for Society

- Grand Science Challenges (with EC/RTD)
- Resilient Society (Environmental Threats)
- Regional Initiatives (Applications and Platforms)
- Pioneer Artificial Intelligence for EO (Big Data)
- HAPS
- EO Africa
- Civilian Security Applications
- 10% of budget via Open Call to foster innovative projects

FutureEO potential for Belgian Industry

- Aspirations to develop cheaper systems (e.g. Aerospacelab) and full-instrument expertise (e.g. AMOS) ➔ both possible in Future-EO-1 (and InCubed+)
- Belgium has leadership in new Sentinel developments for Terrestrial Ecosystems Grand Challenges and is strongly involved in the Agriculture-Water-Carbon Grand Challenge and in the Atmosphere science challenges.
- In Resilience and SDGs, BE also has strong capabilities in coastal habitat management, land habitats, urban development and natural resource management applications.
- Proposals through the Science for Society (permanent) Open Call: funded topics include machine learning, cubesat data analysis, applying AI to Earth Observation. Ongoing projects: Φ-Sat-1, Citizen Science Lab.



Copernicus 4.0

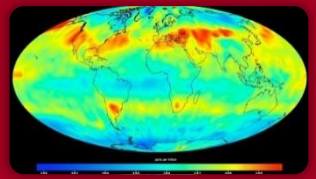
(CSC-4)

CSC-4 Programmatics

- **New segment of existing programme:** implemented in three phases with only first phase (2020-2029) presented at Space19+
- **Phase 1 to support:**
  - Phase B2/C/D/E1 of the six High Priority Candidate Missions
  - Ground Segment Development & Collaborative G/S activities
- **Topped up by EC contribution** (recurrent models, launch, operations)
- **For each HPCM:** single procurement action under ESA procurement and project management for both prototype satellite (funded by ESA) and recurrent satellites (funded by EU)
- **Programmatic review at the end of ph B2** (before end of 2021)

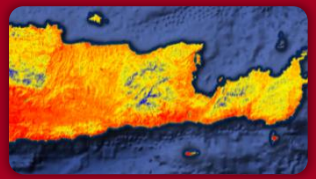
Copernicus new Missions

CO2M - Anthropogenic CO_2 Monitoring



Causes of
Climate Change

LST – Land Surface Temperature Mission

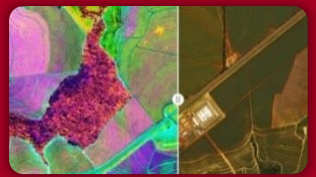


Agriculture & Water
Productivity

CRISTAL – Polar Ice & Snow Topography

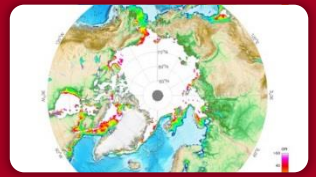
Effects of
Climate Change

CHIME – Hyperspectral Imaging Mission



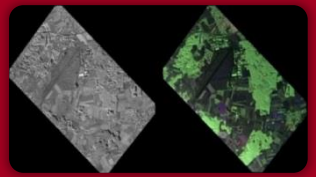
Food Security, Soil,
Minerals, Biodiversity

CIMR – Passive Microwave Radiometer



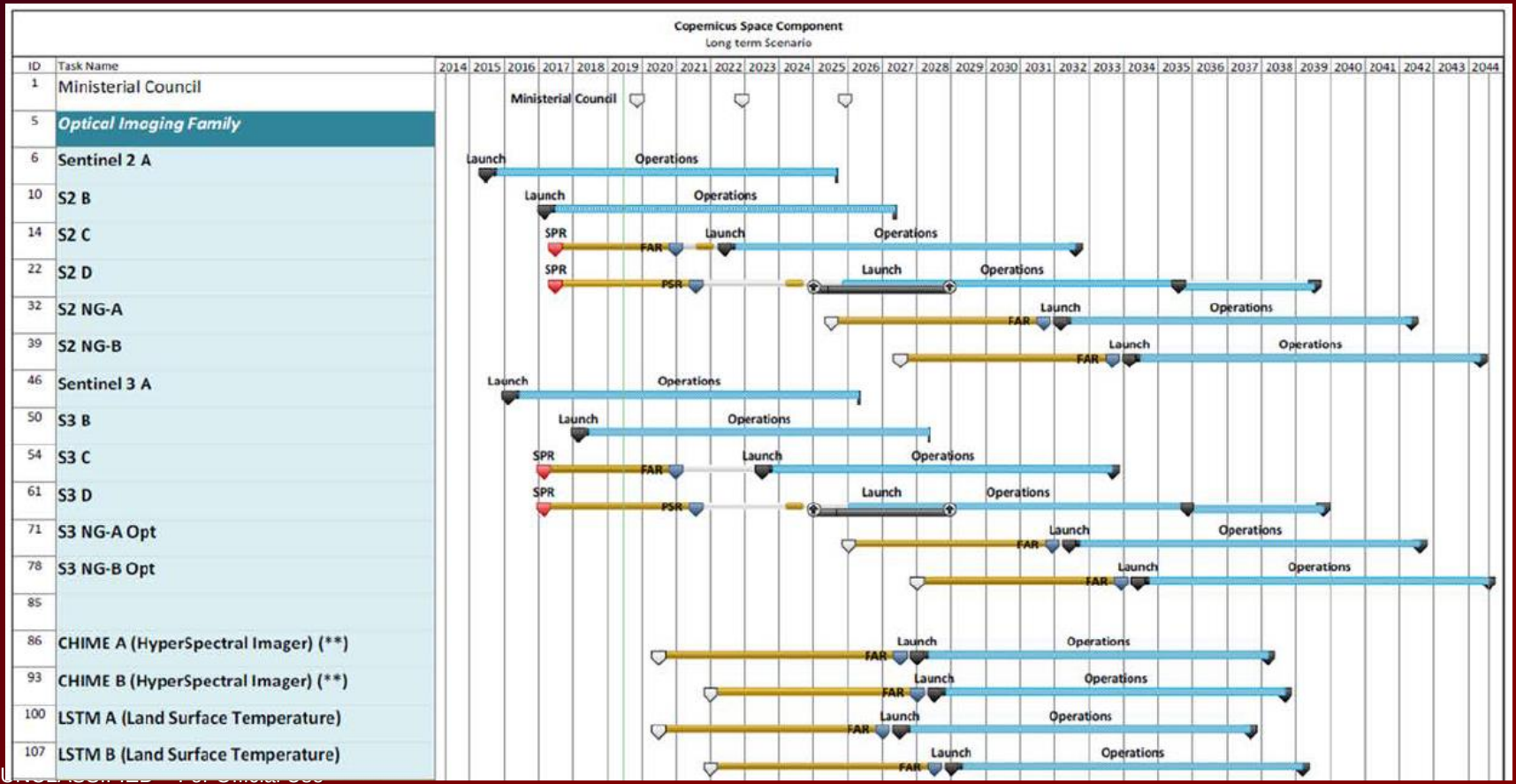
Sea: Surface Temp.
& Ice Concentration

Rose-L – L-band SAR Mission



Vegetation & Ground
Motion & Moisture

A boat you cannot miss



Copernicus new Missions

MISSION	RFP publication Planned	- Actual	Status
CHIME (Hyperspectral)	end July 2019	24 July 2019	**Issued (closing 16 Dec)**
LSTM	end July 2019	24 July 2019	**Issued (closing 16 Dec)**
CO2M	begin Oct. 2019	(27 Sept. 2019) best forecast	In preparation Pre-MEB 10 Sept
CRISTAL	begin Oct 2019		In preparation Pre-MEB 20 Sept
CIMR	end Oct 2019		In preparation Pre-MEB 4 Oct
ROSE-L	mid Nov 2019		In preparation Pre-MEB 15 Oct

CSC-4 Projected Potential Industrial Return for BE

Potential important roles in the instruments of CHIME and LSTM. Also SAR expertise and atmospheric chemistry expertise.

Customised EO

InCubed+

Continuation of InCubed PPP scheme with IPR for bidders

150 M€

Global Development Assistance

Bring operational EO solutions in ODA

50 M€ ESA + 135 M$

PROBA-V phE Extension

Extension and companion satellites

13M €

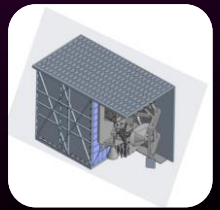
Altius (PhE)

Operational O_3 Monitoring

Launch + 3 years OPS

55 M€

Arctic Weather Satellite



Demo for operational microwave meteorology

42 M€

TRUTHS (PhA/B1)

Calibration to support Climate Forecasting

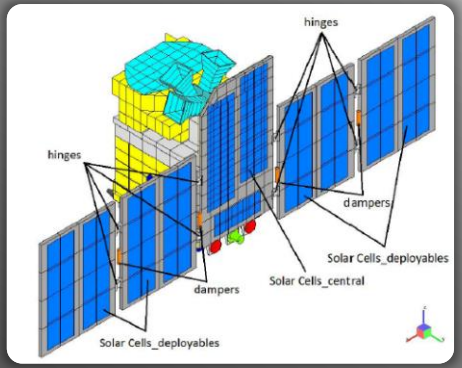
32 M€

Proba-V extension

- Extension of current operations until April 2020 (nominal mode), then until 2024 (reduced experimental mode)
- Proba-V operations augmented with the ph E of two Proba-V companions satellites: Optical (as from Q2 2020) and Thermal (as from Q2 2021)
- 13 M€

Altius Phase E

- Ozone monitoring mission + limb sounding atmospheric chemistry ‘science’ (NO_2, BrO, CH_4, OClO, NO_3, …)
- Proposed phase = Extension current Altius phB2CD to include launch & 3 years of operations = 55 M€
- Participating States to fund phE1/E2 ‘pro-rata’



Status

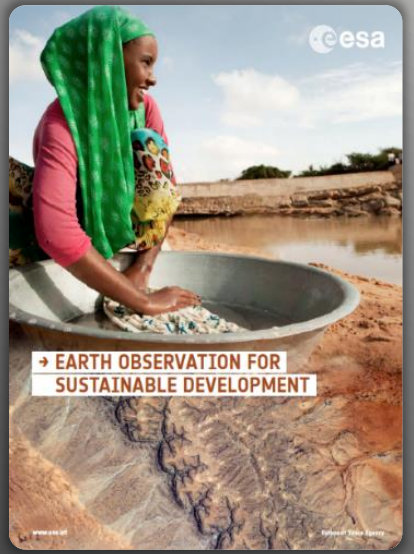
- Space segment consolidation: completed
- Detector procurement: UV and VIS ok; SWIR not yet
- Instrument pre-development; G/S pre-development: on-going
- RfQ for phB2CD (consortium offer): received in summer; still under analysis (baseline versus alternative configurations)

Earth Watch - InCubed+

- Continuation of InCubed until 2024: help industry open new commercial markets
- 150 M€ + co-funding from industry
- Open call – initiative remains with industry/acedemia
- Time-to-contract within 8 weeks
- Considering 4-week ‘fast track’ for smaller proposals lasting under a year
- ESA Executive will assist with introductions to other sources of funding, e.g. VCs and banks
- IP rules ensure commercial bidders retain all IPR
- No Belgian involvement so far but large potential !

Earth Watch - Global Development Assistance

- Size & duration: 150–200 M€, 2020-2024
- Financing composed of:
  - New ESA EO EW element: 50 M€ (conventional ESA financing, will support mainly Knowledge Development activities with the European EO downstream service sector)
  - WB+ADB Trust Fund element: 100–150 M€ (ODA financing from mainly European Aid Agencies/Ministries, will support mainly Capacity Building and Skills Transfer activities in developing countries)
- Joint governance IFI and ESA for the Trust Funds
- For geographic regions in 3 continents: South/Central America, Africa, Asia



Global Development Assistance: ODA in Belgium

Key Players

- **Political**: Directorate-General for Development Cooperation (DGD)
- **Implementation:** Belgian Technical Cooperation (BTC), Belgian Investment Company for Developing Countries (BIO), NGOs, Universities, Community-based organisations and Multi-lateral organisations

Priorities (Thematic/Geographic)

- **National Policy Priorities:** Agriculture & Food Security, protect environment and natural resources, fight to climate change, desertification and deforestation, reduce environmental risks (pollution, biodiversity loss, habitat degradation)
- **Key regions**: Sub-Saharan Africa, Central Africa,18 partner countries with multiannual Indicative Cooperation Programmes (ICPs)

Example Activities (EO-relevant)

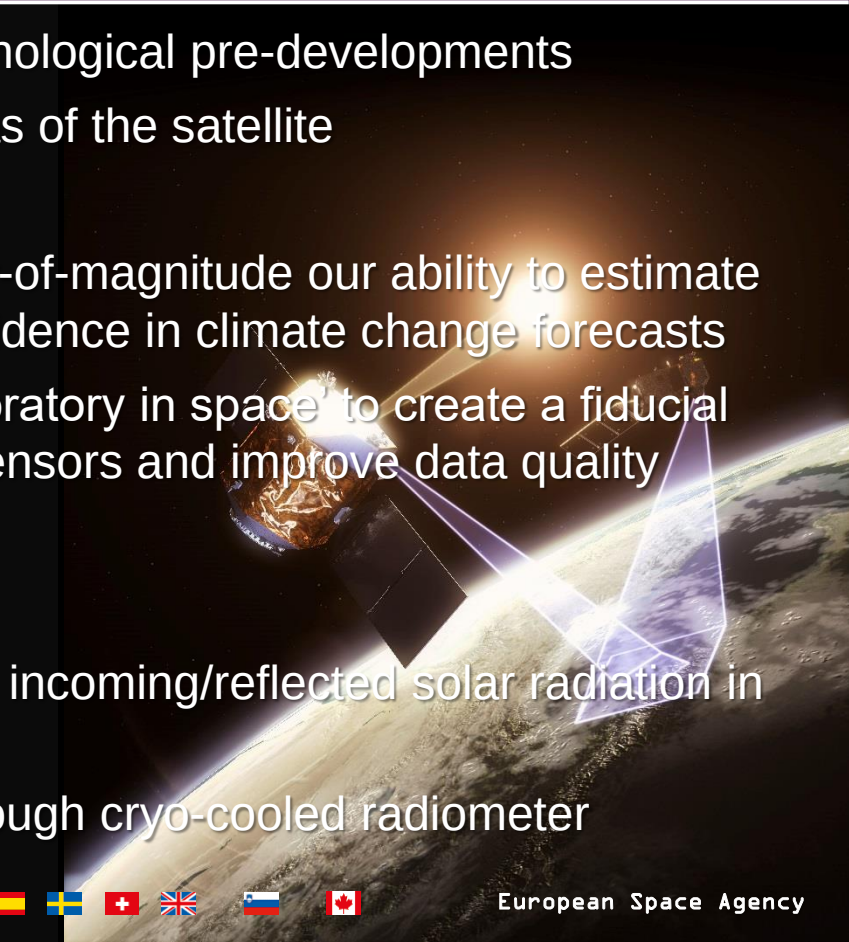
- Forestry management (Rwanda), natural resources, biodiversity and environmental services (Peru), Belgian Agricultural Research Consultation Platform.

TRUTHS (Traceable Radiometry Underpinning Terrestrial- and Helio-Studies) Phase A/B1

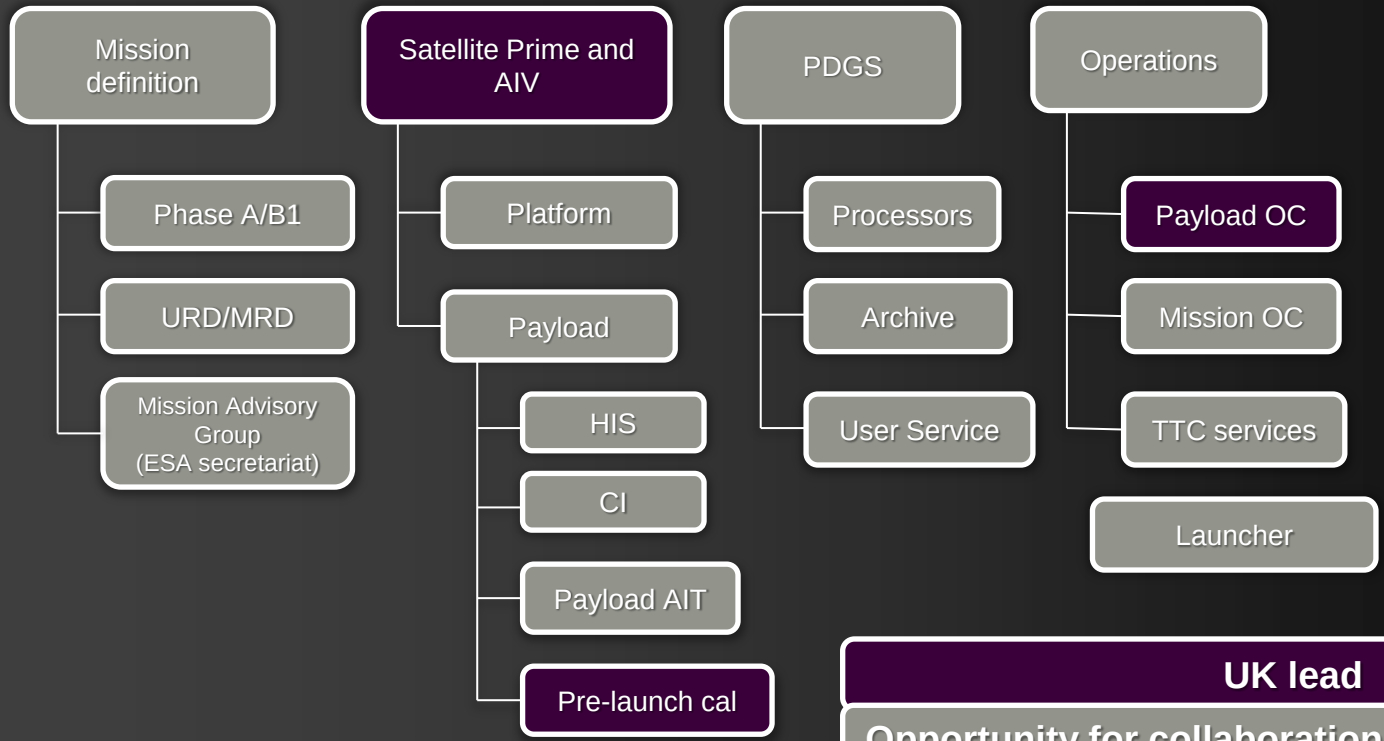
- 32 M€, 30 months: system studies plus technological pre-developments
- Opportunities for cooperation in several areas of the satellite

Mission Objectives

- Climate benchmarking: enhance by an order-of-magnitude our ability to estimate the Earth radiation budget for improved confidence in climate change forecasts
- Satellites cross-calibration: a ‘metrology laboratory in space’ to create a fiducial reference data set to cross-calibrate other sensors and improve data quality
- 1 small / medium size satellite in LEO orbit
- Launch in 2026-2028, for a 5+ years lifetime
- Hyperspectral Imager accurately measuring incoming/reflected solar radiation in the nUV/Visible/NIR/SWIR wavebands
- On-orbit SI-traceable calibration system, through cryo-cooled radiometer



TRUTHS – Development (Phases B/C/D/E1)



UK lead

Opportunity for collaboration with or without UK

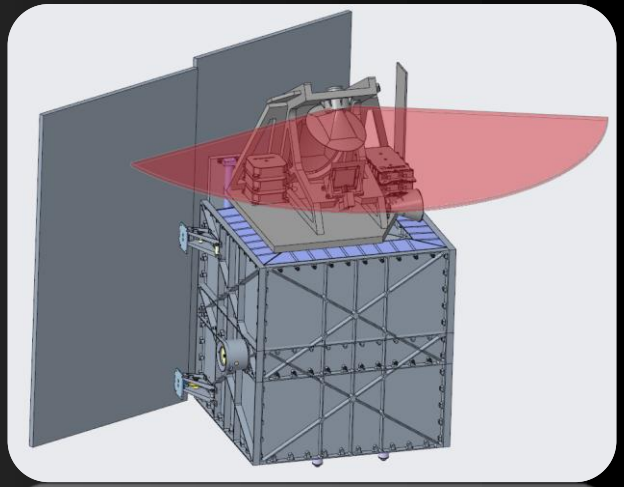
TRUTHS – Development (Phases B/C/D/E1)

EW - Arctic Weather Satellite

- Prototype for future constellation of small polar orbiting satellites for meteo with strong synergies MetOp-SG (Innosat platform)
- Passive microwave sounder (54-664 GHz) for water vapor and temperature profiles
- Arctic and much more
- Based on adaptable Innosat platform, launch ~ end 2023 , 42 M€

Mission Objectives

- Development + launch + 1 year operations
- Confirm impact of increased passive microwave soundings for NWP and nowcasting
- Demonstrate cost-effective approach and finalise technical and programmatic details with EUMETSAT for a possible operational constellation



EW - Arctic Weather Satellite

Industrial Perspectives

Platform:

Structure, Propulsion, Solar Array, Battery, Power Distribution Unit, Star Tracker, Sun Sensor, GNSS Receiver, Reaction Wheels, Gyros, Magnetometer, Magnetorquer, TT&C, Harness, Thermal Hardware.

Payload:

Receiver Front-End elements, Receiver Back-Ends, Calibration Load, Scan Mechanism, Thermal Hardware, Test Facilities.

Ground Segment:

Digital Beam Forming Network Station, Satellite Control Centre, Processing Algorithms, Data Archiving and Dissemination, Data Evaluation.

Attractive EO Missions at Space19+

Earth Explorer 9

FORUM

Far-infrared-Outgoing-Radiation Understanding and Monitoring

Small Missions

2 SCOUTS
and
2-4 Φ-sats

Copernicus

6 ESA-funded Sentinels
(+ 6/7 EU-funded recurrent)

TRUTHS

Phase A/B1

ARCTIC WEATHER SATELLITE

ALTIUS

Phase E

Proba-V

Extension + 2 Smallsat

Prepare future Missions

Phase A/B1 Sentinels NG included in FutureEO
Aeolus follow-on, Earth Explorer-10,
Next Generation Gravity Mission with NASA

Return on European EO Investments

For every

€1 invested

Copernicus

€ 93-191billion (2017-35)

€1 → €10

Meteorology (MetOp-SG)

€ 16-63 billion (2020-40)

up to **€4 return in FutureEO**

Thank you for your attention!

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