Prepared by ESA
CGMS-53-ESA-WP-06
Information Document

STATUS OF THE CURRENT AND FUTURE ESA EARTH OBSERVATION MISSIONS AND PROGRAMMES

CGMS is informed of the status of the European Space Agency's **Earth Observation missions currently in-orbit**. Three of them – MSG, MTG and MetOp – are in co-operation with EUMETSAT, as are the future Aeolus-2 and EPS-Sterna programmes.

Meteosat Third Generation Imager 1 (MTG-I1) was launched successfully in December 2022, and this marked the advent of a new generation of meteorological satellites that will provide better monitoring and forecasting of severe weather events. Data from two instruments onboard MTG-I1 – the Flexible Combined Imager (FCI) and the Lightning Imager (LI) – were successfully combined for the first time in September 2023, highlighting their synergistic power potential impact.

Copernicus represents the major continuing initiative of European efforts in Earth Observation. The first Copernicus dedicated satellite ("Sentinel-1A") was launched on 3 April 2014, followed by series of satellites until Sentinel-6 Michael Freilich in November 2020. Others will follow in the coming years from the next generation of Sentinels and from the expansion missions.

Sentinel missions are developed, launched, and operated in partnership with the European Union and EUMETSAT. The Sentinel-4 and 5 instruments developed by ESA will fly respectively on the MTG-S and Metop-SG missions also developed by ESA, in cooperation with EUMETSAT.

The Earth Explorer missions – SMOS, CryoSat-2, Swarm and EarthCARE – currently in orbit are performing extremely well and the related data exploitation is based on continuous data of excellent quality. The four missions all feature strong elements of international collaboration and a growing synergy between them. End-Of-Life Activities were conducted from 3 April to 5 July 2023, and Aeolus was successfully deorbited on 23 July 2023. Aeolus was the first satellite mission to successfully acquire wind profiles at a global scale and a follow-on Aeolus-2 mission is in the planning, in collaboration with EUMETSAT.

The Proba-V Cubesat Companion (PV-CC) was launched on 9 October 2023 as part of the Small Satellites Mission Service (SSMS) rideshare mission, on board Vega flight VV23. The PV-CC successfully concluded its LEOP activities less than 24 hours after launch and its commissioning activities began straight afterwards.

CGMS is further informed of the status of the European Space Agency's **Earth Observation future missions**. While ESA has a wealth of experience under its belt in observing Earth from space, the sector is changing rapidly – becoming increasingly competitive, but also offering new opportunities as concepts like New Space evolve and the digital revolution gathers pace. Through its Future Earth Observation programme (FutureEO), ESA is committed to remaining ahead of the game.

Progress in the preparation of the forthcoming Explorer missions – Biomass, FLEX, FORUM and Harmony – is described in this report.

In November 2023 two candidates for the next and 11th Earth Explorer (EE11) research mission were selected to proceed to Phase A feasibility - CAIRT and WIVERN.

A call for ideas was issued for Earth Explorer 12 (EE12) proposals in February 2023, and 4 mission ideas were selected in March 2024 to proceed to Phase A assessment – CyroRad, ECO, Hyrdoterra+ and Keystone. Notably, each of the four EE12 recommended mission ideas were variants/improvements of previously submitted Earth Explorer proposals.

Activities related to Aeolus-2, Arctic Weather Satellite (AWS) in cooperation with EUMETSAT, TRUTHS, SCOUTs and ALTIUS are ongoing. Each of these missions are planned to contribute routine, operational monitoring data to improve our understanding of the Earth system and climate change.

Six Copernicus Expansion Missions – CHIME, CIMR, CO2M, CRISTAL, LSTM, and ROSE-L – are being studied to address EU policy and gaps in Copernicus user needs, and to expand the current capabilities of the Copernicus space component. The System Requirements Reviews for all 6 missions have been completed.

CGMS is also informed of the status of the Earth Watch Programme element, Global Monitoring of Essential Climate Variables (also known as the 'ESA Climate Change Initiative' or CCI). The CCI focuses on the exploitation of data records primarily, but not exclusively, from past ESA satellite missions, for the benefit of climate monitoring and climate research. Specifically, the CCI supports the study and monitoring of 23 essential climate variables (ECV) derived from satellite data, thereby helping to fulfil the objectives of the WMO Global Climate Observing System (GCOS).

Table of Contents

STATUS OF THE CURRENT AND FUTURE ESA EARTH OBSERVATION MISSIONS AND PROGRAMMES

1. INTRODUCTION

This paper provides information on the status of the current and future European Space Agency Earth Observation missions as of April 2025. ESA's EO Programme comprises a science and research element, which includes the Earth Explorer missions, and an Earth Watch element, which is designed to facilitate the delivery of Earth observation data for use in operational services. Earth Watch includes the well-established meteorological missions developed in coordination with the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). These missions (MSG, MTG, MetOp and MetOp-SG) are not dealt within this report.

Current in-flight missions include R&D satellites missions from the Earth Explorer series, small satellites of the Proba series, and Sentinel satellites. The Sentinels specifically respond to the needs of Copernicus, which is the Earth Observation component of the European Union's space programme. The status of these missions is presented, as well as the progress in the development of the ESA Climate Change Initiative (CCI).

Although the past ESA ERS-1, ERS-2, Envisat and GOCE missions are no longer operating, thousands of users still access the large ESA on-line archives to get products generated from their respective instrument complements.

Important note: The status provided in this document reflects the situation as of April 2025. Dates for launches and all other activities in the future are indicative at the time of writing.

2. ESA COUNCIL MEETING AT MINISTERIAL LEVEL – 2025 (CM25)

ESA's Ministerial Councils bring together ESA's Member States and observers every three years to decide on new proposals and funding for ESA's next years of work. The last such an ESA Council meeting at Ministerial level was held in Paris from 22-23 November 2022.

The next ESA Council at Ministerial level will be held from 26-27 November 2025. Government ministers representing ESA's Member States, Associate States and Cooperating States will resolve together to strengthen Europe's space ambitions, ensuring a continuous concerted effort to serve European citizens.

3. CURRENT ESA SATELLITE SYSTEMS

Satellites	Equator Crossing Time /Altitude	Launch date	Access to data or products	Instruments	Status, Applications, and other information
Aeolus	97° 320 km	22/08/2018	Earthnet on line	ALADIN instrument (Atmospheric Laser Doppler Instrument)	Global observations of wind profiles from space to improve the quality of weather forecasts, and to advance our understanding of atmospheric dynamics and climate processes. (EOL 23/07/2024)
PROBA-1	7:30 (D) 615 km	22/10/2001	Earthnet on line	CHRIS, SREM	The orbit is drifting from the original 10:30 desc. ECT.
SMOS (with CNES and CDTI)	06:00 (A) 755 km	02/11/2009	SMOS data centres	MIRAS (Microwave Imaging Radiometer using Aperture Synthesis), GPS, STA	L-band radiometer for salinity & soil moisture observation
PROBA-2	06:00 (A) 730 km	02/11/2009	Earthnet on line	SWAP, LYRA, TPMU, DSLP	2nd flight unit of the PROBA programme. Main mission: space weather
CryoSat-2	717 km (92° incl.)	08/04/2010	Earthnet on line	SIRAL (SAR Interferometric Radar Altimeter), DORIS, LRR	Polar ice monitoring
EarthCARE (with JAXA)	14:00 (D) 393 km	29/05/2024	Earthnet on line	Cloud Profiling Radar, Atmospheric Lidar, Multispectral Imager, Broadband Radiometer	3D structure of cloud and aerosols
Swarm A & C (with CNES and CSA)	87.35° 460 km	22/11/2013	Earthnet on line	ACC, SM, EFI (SWARM), GPS (ESA), LRR (DLR), STR (SWARM), VFM	Earth magnetic field
Swarm B	87.75° 530 km	22/11/2013	Earthnet on line		
Sentinel-1A (with EC)	06:00 (D) 693 km	03/04/2014	Copernicus Space component data access	SAR-C	Radar imagery
Sentinel-1C (with EC)	06:00 (D) 693 km	05/12/2024	Copernicus Space component data access	SAR-C	Radar imagery
Sentinel-2A (with EC)	10:30 (D) 786 km	22/06/2015	Payload Data Ground Segment (PDGS) and at appointed X-band stations.	MSI (Multispectral imager)	Land and vegetation observation
Sentinel-2B (with EC)	10:30 (D) 786 km	06/03/2017	Payload Data Ground Segment (PDGS) and at appointed X-band stations.	MSI (Multispectral imager)	Land and vegetation observation
Sentinel-2C (with EC)	10:30 (D) 786 km	05/09/2024	Payload Data Ground Segment (PDGS) and at appointed X-band stations.	MSI (Multispectral imager)	Land and vegetation observation
Sentinel-3A (with EC)	10:00 (D) 814.5 km	16/02/2016	Payload Data Ground Segment (PDGS) and at appointed X-band stations.	DORIS, GPS, LRR, MWR, OLCI, SLSTR, SRAL	Primary mission: ocean observation. Secondary mission: atmosphere and land applications
Sentinel-3B (with EC)	10:00 (D) 814.5 km	25/04/2018	Payload Data Ground Segment (PDGS) and at appointed X-band stations.	DORIS, GPS, LRR, MWR, OLCI, SLSTR, SRAL	Primary mission: ocean observation. Secondary mission: atmosphere and land applications
Sentinel-5P (with EC and NSO)	13:30 (D) 824 km	13/10/2017	Payload Data Ground Segment (PDGS) and at appointed X-band stations.	TROPOMI	Atmospheric composition and air quality monitoring.
Sentinel-6 Michael Freilich	non-Sun- synchronous orbit 1336 km	21/11/2020	Payload Data Ground Segment (PDGS) and at appointed X-band stations.	AMR-C, DORIS-NG, GNSS POD Receiver, GNSS-RO Receiver, LRA (Sentinel-6), Poseidon-4 Altimeter	Continuity of the reference, high-precision ocean topography service after Jason-3

4. STATUS OF CURRENT EARTH EXPLORER SATELLITES

Four ESA Earth Explorer missions are currently in operation, namely SMOS (launched in 2009), CryoSat-2 (launched in 2010), the Swarm constellation of 3 satellites (launched in 2013) and EarthCARE (launched in 2024). All four missions, as well as Aeolus (which was deorbited in July 2023) and GOCE (which was retired in 2013), have provided outstanding results of interest to the meteorological and climate research communities at large. The overall performance of the SMOS, CryoSat, Swarm and EarthCARE missions remains excellent.

4.1. SMOS

Launched on 2 November 2009, ESA's Soil Moisture and Ocean Salinity (SMOS) mission is the second Earth Explorer Opportunity Mission to be developed as part of ESA's Living Planet Programme. SMOS carries a novel microwave sensor to capture images of brightness temperature, from which information on soil moisture and ocean salinity can be derived. By consistently mapping these two important components in the water cycle, SMOS is advancing our understanding of the exchange processes between Earth's surface and atmosphere and is helping to improve weather and climate models.

Since the last reporting period:

- The overall performance of the SMOS mission of with an availability of 99.9% was excellent.
- FRM4SM (Fiducial Reference Measurements for Soil Moisture) has been extended for the period 2025-2027.
- The RFI situation in Russia/Ukraine and Myanmar remains critical.
- Key papers on soil moisture forecast and on global terrestrial carbon stock changes using SMOS data have been published in Nature and Science.

4.2. CryoSat-2

ESA's Earth Explorer CryoSat-2 mission, launched on 8 April 2010, is dedicated to the precise monitoring of the changes in the thickness of marine ice floating in the polar oceans and variations in the thickness of the vast ice sheets that overlie Greenland and Antarctica.

Since the last reporting period:

- The overall performance of the mission (98.74%) has been outstanding and remains well above the design specifications. Since the start of the exploitation phase, the overall system availability has been 99.22%.

- There have been no further indications of leakage following the reconfiguration of the propulsion system in November 2023. Considering fuel and battery status, the estimated lifetime is projected to be between spring 2029 and spring 2032.
- A special operation to verify the checksum of the onboard EEPROM memory banks was performed. This is crucial to prevent future memory leakage, which would send the satellite to safe mode.
- All ground segment activities are progressing according to plan.
- A key paper, published on Nature by the GlaMBIE team, shows, for the first time, global glacier mass changes from 2000 to 2023, confirming that glaciers are one of the most important contributors to sea-level rise.

4.3. SWARM

Swarm is the fourth Earth Explorer Opportunity Mission of ESA's Earth Observation Envelope Programme. This constellation of three satellites is designed to measure the magnetic signals that stem from Earth's core, mantle, crust, oceans, ionosphere, and magnetosphere.

Since the last reporting period:

- The overall mission performance is nominal.
- Two Swarm products are included in the multi-agency Community Coordinated Modelling Center (CCMC). SWIPE was included in October 2024, and the IBP model in January 2025.
- Since 19 February 2025 the second FAST L2 product type - Total Electron Content (TEC) - is available on the Swarm dissemination server.
- The Swarm mission team has started the preparation of the third Level 1B full reprocessing campaign and, once completed, will start the generation of all products (planned to be completed in Q2-Q3/2025).
- The processing of CryoSat-2 magnetic data is now operational. At the beginning of every month, all data of the previous month are automatically processed, and daily CDF files in Swarm like format are produced and distributed. This is a major milestone as it is the first time that AOCS magnetometer data from an ESA satellite have been processed on an operational basis.
- Full CSES mission HPM magnetic data has been reprocessed and shared with the Swarm community through the Swarm dissemination server.

- Swarm-related presentations have been made in workshops and conferences and there were more than 15 peer-reviewed articles published. The Swarm Data Quality Workshop (DQW) summary and recommendation report has been consolidated and made available to all.

4.4. Aeolus

Aeolus was launched on 22 August 2018 and was deorbited on 23 July 2023. Aeolus was the first satellite mission to acquire profiles of Earth's wind on a global scale. The primary objective of the Aeolus mission was to demonstrate the Doppler Wind Lidar technique to measure wind profiles from space. The mission set out to provide observations of global wind profiles along the instrument line of sight (LOS) direction over a minimum lifetime of 3 years. The data was assimilated into NWP models, to improve the analyses and forecasting of the 3-D vector wind field. A secondary mission objective was to provide datasets suitable for the evaluation of climate models.

Since the last reporting period:

- Phase F1 started on 1 January 2024. It will focus on the evolution of the processors and on reprocessing of the mission dataset. The main objective is to confirm the impact on Numerical Weather Prediction as well as fostering atmospheric science.
- The Aeolus reprocessing campaign, focusing on Baseline 16 FM-A data, is progressing according to plan.
- Development of B17 baseline is ongoing according to schedule with the plan to release the processor by the end of 2025.
- The Aeolus Re-entry team was selected to receive the International SpaceOps Award for Outstanding Achievement (AOA) for 2025.

4.5. EarthCARE

Launched in May 2025, the Earth Cloud Aerosol and Radiation Explorer (EarthCARE) is a joint ESA/JAXA mission and is equipped with four instruments. JAXA provides the cloud profiling radar, which provides information on the vertical structure and internal dynamics of clouds. The other three instruments are provided by ESA: an atmospheric lidar, delivering cloud-top information and profiles of thin clouds and aerosols; a multispectral imager, offering a wide-scene overview in multiple wavelengths; and a broadband radiometer measuring reflected solar radiation and outgoing infrared radiation. Together these make a range of different measurements that will shed new light on the role that clouds and aerosols play in regulating Earth's climate.

The EarthCARE mission successfully passed the In Obrit and Commissioning Review on 23 January 2025, marking its transition into the operational phase of the mission. This milestone also marked the handover of the mission responsibility to the Ground Segment and Mission Management Department in ESA-ESRIN.

On 14 January 2025, EarthCARE L1 products were released to the public. On 17 March 2025, EarthCARE L2 single sensor and two sensor products were released to the public. The EarthCARE Data Innovation and Science Cluster (DISC) is now fully phased in and has taken over all foreseen responsibilities and tasks during phase E2 of the mission.

5. STATUS OF CURRENT EARTH WATCH SATELLITES

The Earth Watch programme encompasses the development of the series of operational meteorological satellites of EUMETSAT (**not covered in this report**). The satellites in the Earth Watch programme include the Arctic Weather Satellite (AWS) and the Proba series of small satellites for medium-resolution imagery.

5.1. Arctic Weather Satellite (AWS)

Approved at Space19+ (ESA's Council at Ministerial Level), this small satellite (~100 kg) is the prototype for a future constellation of small satellites carrying microwave sounder instruments. The AWS advanced sensors will provide information about humidity, precipitation, and ice clouds in the atmosphere. This data offers meteorological institutes excellent opportunities to improve weather forecasts in Arctic and subarctic areas and helps improve the quality of global forecasts.

EUMETSAT would operate this potential future operational constellation. AWS was launched on 16 August 2024 and this prototype will serve for one year as a demo for the future constellation.

The Satellite was in fully automated operations during the Christmas and New Year period (from 16 December 2024 until 9 January 2025) and everything worked well.

A joint EUMETSAT/ESA AWS Evaluation Workshop was held in March 2025. All the AWS early data evaluators (DMI, DWD, ECMWF, FMI, UK Met Office, Meteo France, MetNO and SMHI) presented their results regarding the quality of the AWS data. The AWS performances were confirmed to be equivalent to the large sounder missions (AMS-A, MHS, ATMS) with no biases or other issues seen in the data. The impact on Numerical Weather Prediction (NWP) is between that of AMSU-A and ATMS for temperature sounding, while AWS is the best for humidity sounding. With the final update of the Satellite Calibration DataBase (SCDB) update performed after the Evaluation Workshop, the observed

scan angle dependency is expected to be removed with the updated sidelobe correction that was implemented after the Evaluation Workshop. The data quality achieved with AWS also confirmed the assumptions that were used to quantify the impact of the future constellation (EPS-Sterna).

ESA is planning to request an extension of AWS operations for 1 more year (from August 2025 to August 2026). EUMETSAT has expressed an interest to continue funding operations thereafter.

5.2. Proba-V and Proba-V CubeSat Companion

The operations of the Vegetation instrument on-Board Proba-V have ended as planned in October 2021 and the Proba-V CubeSat Companion (PVCC) in September 2024. The Proba-V programme element remained into a period of minimal activities until the start of the activities for the tasking interface and data production of the Proba-V CubeSat hyperspectral companion (IperLite), to be launched around October 2025.

The Proba-V CubeSat Companion (PV-CC), developed within the GSTP programme, was launched on 9 October 2023 with the Vega flight VV23. The In Orbit Commissioning Review (IOCR) of PV-CC close out meeting was held and the decision was to not proceed with an operational phase due to several issues affecting the satellite.

The operations of the Vegetation instrument on-Board Proba-V have ended as planned in October 2021, followed by an experimental phase of 1 year, while the Proba-V secondary instruments (e.g. EPT instrument) are operated regularly. Currently all the 3 cameras of the VGT instrument are in the dark, therefore only Moon and dark current calibrations are performed.

6. THE COPERNICUS SENTINEL PROGRAMME

The Copernicus programme of Sentinel satellites is designed to provide reliable, timely and accurate services to manage the environment, understand and mitigate the effects of climate change and help respond to crises. Copernicus provides access on a full, free, and open basis to its Sentinel data and the Copernicus services information products. In addition to data provided by the Sentinel satellites, the missions contributing to Copernicus – the Copernicus Contributing Missions – play a crucial role, delivering complementary data to ensure that a whole range of observational requirements is satisfied.

This activity is operated by ESA as entrusted entity on behalf of the European Commission (COM). The primary users of the Contributing Missions activity are the six Copernicus services, mainly the Land, Emergency, Security and Marine services, while other users, such as EU Public Authorities, are secondary users (currently over 3000 registered users). The existing or planned Contributing Missions

include commercial missions from EU Member States or Copernicus Participating States, commercial Very High Resolution (VHR) optical and radar mission operators, and other emerging European mission operators that make some of their data available for Copernicus.

Highlights from the Copernicus missions since the last reporting period include:

- Sentinel-2C was declared fully operational on 19 December 2024, and ownership was formally handed over from ESA to the EU at the occasion of the17th EU Space Conference.
- On 22 January 2025, COM gave the formal go ahead for 1-year extension of Sentinel-2A operations, together with Sentinel-2B and Sentinel-2C. Sentinel-2C took over the Sentinel-2A operations on 21 January 2025.
- On 19 March 2025, COM authorised ESA to initiate Sentinel-3C de-storage activities in support of Sentinel-3C readiness in time for a launch in Q3 2026.
- After authorisation from COM to ESA to place a contract with Arianespace for the Launch Services of Sentinel-1D on Ariane 6.2 the contract was signed on 28 January 2025.
- The updated Draft Programme Proposal for CSC-4 Phase 3 and the Draft Revision of the Declaration on the Copernicus Space Component (CSC) Programme were submitted to ESA's PB-EO.

6.1. Sentinel-1

The Sentinel-1 mission is a polar-orbiting satellite system for the continuation of Synthetic Aperture Radar (SAR) operational applications. Sentinel-1 is a C-band imaging radar mission that provides all-weather day-and-night images for GMES user services. The SAR operates in two main modes: Interferometric Wide Swath and Wave. The first has a swath width of 250km and a ground resolution of 5×20m.

The first Sentinel-1A satellite was successfully launched on 3 April 2014 and commissioned in September 2014. The second Sentinel-1B was launched on 25 April 2016 and commissioned in September of the same year. Sentinel-1C was launched on 5 December 2024 and is currently in the commissioning phase. After authorisation from COM to ESA to place a contract with Arianespace for the launch services of Sentinel-1D on Ariane 6.2, the contract was signed on 28 January 2025 with a target launch of Q4 2025.

Sentinel-1A operations continue to take place in very challenging conditions because of the propulsion system degradation. During this reporting period, there has been no further degradation, and the mission operations underwent smoothly.

Sentinel-1B satellite unavailability started on 23 December 2021 and on 3 August 2022, the end of exploitation was announced by ESA and COM.

Sentinel-1C commissioning activities started in mid-January 2025 after reaching the orbital node for cross-calibration at 1 day interval with Sentinel-1A. After 4 cycles in this configuration, the satellite was transferred to its final orbital node (6-days apart) until the end of the IOC, planned for early May 2025. From 27 March 2025 onwards, the level of sensing was significantly increased, and the data has been made available to the public.

The Sentinel-1 Next Generation (NG) Mission is designed to provide enhanced C-band Synthetic Aperture Radar imaging continuity, with a primary objective of achieving data quality that is equal to or better than the current Sentinel-1. This ensures compatibility with all current products and facilitates a seamless transition for users from the first-generation Mission. Key advancements identified for the Sentinel-1 NG include improved spatial resolution of 25 m² for dual polarization at wider swaths exceeding 400 km, compared to the current Sentinel-1 generation which operates at 250 km and 100 m² in the main Interferometric Wide Swath mode. The Sentinel-1NG orbit will remain consistent with that of the first generation, shared with ROSE-L, featuring a repeat cycle of 6 days and an average local revisit time of 4 days. In line with COM's guidelines on hybrid constellation within the Copernicus Space Component (CSC), the Sentinel-1NG Mission is intended to complement small-sats constellations typically from the 'New Space' industry.

6.2. Sentinel-2

A pair of Sentinel-2 satellites routinely deliver high-resolution optical images globally, with 5-day revisit, providing enhanced continuity of SPOT- and Landsat-type data. Sentinel-2 carries an optical payload with visible, near infrared and shortwave infrared sensors comprising 13 spectral bands: 4 bands at 10 m, 6 bands at 20 m and 3 bands at 60 m spatial resolution (the latter is dedicated to atmospheric corrections and cloud screening), with a swath width of 290 km.

The Sentinel-2A satellite was successfully launched on 22 June 2015, Sentinel-2B on 6 March 2017 and Sentinel-2C on 5 September 2024. In accordance with the Copernicus data policy, Sentinel-2 data products are made available systematically and free of charge to all data users including the general public, scientific and commercial users.

Sentinel-2 operations are proceeding nominally, with a good overall performance for all mission/system operational domains. During the reporting period, the start of Sentinel-2C operations, taking up the relay from Sentinel-2A, took place on 21 January 2025. An exceptional temporary acquisition campaign is being performed with Sentinel-2A from 13 March 2025 and will last one year. The data acquired with

Sentinel-2A will temporally complement the nominal two-satellite mission constellation (with Sentinel-2B and Sentinel-2C).

6.3. Sentinel-3

The main objective of the Sentinel-3 mission is to measure sea surface topography, sea and land surface temperature, and ocean and land surface colour with high accuracy and reliability to support ocean forecasting systems, environmental monitoring, and climate monitoring. The mission definition is driven by the need for continuity in provision of ERS, Envisat and SPOT-Vegetation data, with improvements in instrument performance and coverage.

Sentinel-3A was launched on 16 February 2016 and Sentinel-3B was on 25 April 2018. In March 2025, COM authorised ESA to initiate Sentinel-3C de-storage activities in support of Sentinel-3C readiness in time for a launch in Q3 2026.

Both Sentinel-3A and Sentinel-3B are operating nominally and the overall performance is good. Discussions between ESA, EUMETSAT, and COM continue about Sentinel-3C tandem phase and in-orbit standby scenarios. The proposed plan includes a 3-months tandem phase for cross-calibration after Sentinel-3C IOCR, followed by Sentinel-3A operating in the optimised TOPO-ONLY scenario. These scenarios are currently being evaluated by COM.

6.4. Sentinel-4

The Sentinel-4 instrument data, jointly with other data from future meteorological missions, will cover the need for continuous monitoring of atmospheric composition and air quality over Europe with a revisit time of about one hour. The main data products will be O3 (Ozone), NO2 (Nitrogen dioxide), SO2 (Sulphur dioxide), HCHO (Formaldehyde), CHOCHO (Glyoxal) and the aerosol optical depth.

Two Sentinel-4 instruments will be delivered to the Meteosat Third Generation (MTG) programme to be embarked on the two sounder satellites (MTG-S1 and MTG-S2), as Customer Furnished Items, fully verified, qualified and calibrated together with the necessary ground support equipment, test models and system deliverable inputs.

The main elements of the Sentinel-4 system are:

- The Proto-Flight Model (PFM) and the Flight Model (FM2) instruments, consisting of three main components: the Optical Instrument Module (OIM), the Instrument Control Unit (ICU) and the Scan Drive Electronic (SDE) unit.
- The Level 0 to Level 1b processor (L1OP) and the Level 1b to Level 2 Processor (L2OP), both

hosted by the MTG Ground Segment. They include the interfaces to the users, the mission performance functions and the performance analyses, related, for example, to the instrument monitoring and trending together with the algorithms' maintenance and validation.

6.5. Sentinel-5

The Sentinel-5 mission, jointly with data from other future meteorological missions, will cover the need for continuous global monitoring of atmospheric composition and air quality. The main data products will be O3 (Ozone), NO2 (Nitrogen dioxide), SO2 (Sulphur dioxide), HCHO (Formaldehyde), CHOCHO (Glyoxal), aerosol optical depth and layer height, CH4 (Methane), CO (Carbon monoxide), UV index and vegetation fluorescence (through the NIR channel extension).

The Sentinel-5 project comprises the development and production of three instruments to be embarked on subsequent MetOp-SG satellites (type A):

- The Sentinel-5A Proto-Flight Model (PFM) unit development, including the Level 1b and Level 2 ground processor prototypes, covered by the GMES Space Component Programme; and
- The Sentinel-5B and -5C units' development up to the pre-storage review covered by the Copernicus programme, and including the long term storage of both instruments subject to approval by COM.

The Sentinel-5 Precursor mission (Sentinel-5P) is a gap-filler between the end-of-life of the current atmospheric chemistry mission (OMI on EOS/Aura) and the operational availability of Sentinel-5. As a joint initiative between ESA and the Netherlands, the mission comprises a satellite and a UVNS instrument called TROPOMI (TROPOspheric Monitoring Instrument). Since April 2018, Sentinel-5P has been in routine operations, having reached full operational capacity in early March 2019. Sentinel-5 Precursor operations continued nominally during the reporting period.

6.6. Sentinel-6

The Jason-CS satellites form the space component of the Jason Continuity of Service mission, within the Copernicus Space Component Segment 3. Jason-CS will extend high-accuracy ocean topography measurements, thanks to the participation of all partners (EUMETSAT, ESA, CNES, NOAA and NASA/JPL).

Sentinel-6A Michael Freilich (Sentinel-6MF / Jason-CS) was launched on 21 November 2020. NASA and NOAA jointly act as the US party responsible for providing the launch services for both Sentinel-6 A and B satellites, US payload instruments and ground segment support, and contribute to the

operations. Sentinel-6 MF satellite was handed over to Mission Operations (Phase E2) after its successful In-Orbit Commissioning Review on 16 November 2021. EUMETSAT is responsible for the mission's operations. The mission's operational performance fully meets or exceeds expectations.

7. FUTURE ESA SATELLITE SYSTEMS

7.1. Future Earth Explorer and Earth Watch missions

The Earth Explorers are research missions designed to address key scientific challenges identified by the science community while demonstrating breakthrough technology in observing techniques. Involving the science community right from the beginning in the definition of new missions and a peer-reviewed selection process ensures that a resulting mission is developed efficiently and provides the exact data required by the user.

7.1.1. Biomass: Earth Explorer 7th

The Biomass mission was selected in May 2013 as the 7th Earth Explorer mission of the Living Planet programme. The satellite has been designed to provide, for the first time from space, P-band radar measurements optimised to determine the amount of biomass and carbon stored in the world's forests with greater accuracy than ever before. This information is poorly known in the tropics and is essential to understanding the role of forests in Earth's carbon cycle and in climate change. The Biomass mission will allow us to measure forest height at a resolution of 200 m and forest disturbances at 50 m.

Reliable knowledge of tropical forest Biomass also underpins the implementation of the UN Reducing Emissions from Deforestation and forest Degradation (REDD+) initiative – an international effort to reduce carbon emissions from deforestation and land degradation in developing countries. In addition, the measurements made by Biomass offer the opportunity to map the elevation of Earth's terrain under dense vegetation, yielding information on subsurface geology and allowing the estimation of glacier and ice-sheet velocities, critical to our understanding of ice-sheet mass loss in a warming Earth. Biomass also has the potential to evolve into an operational system, providing long-term monitoring of forests – one of Earth's most important natural resources.

Biomass was successfully launched on 29 April 2025 and is currently in the early commissioning phase.

7.1.2. FLEX: Earth Explorer 8th

In November 2015, ESA's Member States selected FLEX as the 8th Earth Explorer mission upon

recommendation from the Earth Science Advisory Committee. The Fluorescence Explorer (FLEX) mission will map vegetation fluorescence to quantify photosynthetic activity.

The conversion of atmospheric carbon dioxide and sunlight into energy-rich carbohydrates through photosynthesis is one of the most fundamental processes on Earth – and one on which we all depend. Information from FLEX will improve our understanding of the way carbon moves between plants and the atmosphere and how photosynthesis affects the carbon and water cycles. In addition, information from FLEX will lead to better insight into plant health and stress. This is of relevance since the growing global population is placing increasing demands on the production of food and animal feed.

So far, it has not been possible to measure photosynthetic activity from space, but FLEX's novel fluorescence imaging spectrometer will observe this faint glow, which serves as an indicator of photosynthesis. The FLEX satellite will orbit in tandem with one of the Copernicus Sentinel-3 satellites, taking advantage of its optical and thermal sensors to provide an integrated package of measurements.

The driver for the launch date remains the availability of a Vega-C launcher and the possibility of a combined launch with Sentinel-3, with a launch period for a combined FLEX/Altius launch currently set as April-June 2027.

7.1.3. FORUM: Earth Explorer 9th

FORUM was selected in September 2019 as Earth Explorer 9 and has an expected launch date of Q4 2027. The Far-infrared Outgoing Radiation Understanding and Monitoring (FORUM) mission will provide new insight into the planet's radiation budget and how it is controlled, and therefore improve climate models. More than half of Earth's outgoing longwave energy is in the far-infrared part of the electromagnetic spectrum, which has not been measured. FORUM will fill this gap.

Thanks to new technical developments, the FORUM mission would measure radiation emitted from Earth across the entire far-infrared part of the electromagnetic spectrum. Significantly, it measures in the 15–100-micron range, which has never been done from space before. These observations are important because Earth emits infrared radiation to space, which is affected by water vapour and cirrus clouds, which, in turn, play key roles in Earth's temperature.

FORUM's benchmark measurements would improve our understanding of the greenhouse effect and, importantly, contribute to the accuracy of climate change assessments that form the basis for policy decisions.

7.1.4. HARMONY: Earth Explorer 10th

Harmony was selected in September 2022 as Earth Explorer 10 and has an expected launch date of

2029. Harmony will provide a wealth of new information about our oceans, ice, earthquakes, and volcanoes and will help to address societal issues, such as those laid out in the World Climate Research Programme's Grand Challenges and several of the UN's Sustainable Development Goals.

The mission will comprise two identical satellites orbiting Earth in convoy with a Copernicus Sentinel-1 satellite. Each Harmony satellite will carry a receive-only synthetic aperture radar and a multiview thermal-infrared instrument. Together with observations from Sentinel-1, Harmony will deliver a wide range of unique high-resolution observations of motion occurring at or near Earth's surface.

7.1.5. Earth Explorer 11th

Following ESA's Scientific Evaluation in November 2023, two missions were selected as candidates for the 11th Earth Explorer missions and to proceed to Phase A: CAIRT (Changing-Atmosphere Infrared Tomography) and WIVERN (Wind Velocity Radar Nephoscope).

CAIRT would provide the measurements needed to make a necessary step change in understanding the links between climate change, atmospheric chemistry and dynamics in the altitude range of about 5 to 115 km. CAIRT would be the first limb-sounder with imaging Fourier-transform infrared technology in space.

WIVERN (Wind Velocity Radar Nephoscope) would provide the first measurements of wind within clouds and precipitation. There is a notable gap in global observations of wind in cloudy regions. The mission would also deliver profiles of rain, snow, and ice water. Carrying a dual polarisation, conically scanning, 94 GHz Doppler radar with an 800 km swath, the mission would improve forecasts of hazardous weather and provide new insights into severe storms. It would also contribute to the climate record of cloud and precipitation profiling.

7.1.6. Earth Explorer 12th

The call for ideas for the next Earth Explorer 12 (EE12) research mission opened in 2023. The motivation behind this Call of Mission Ideas was ESA's wish to engage the scientific community as far as possible in determining and advancing the research mission activities within FutureEO-1 Segment 2. Through the Call the Agency gathered the science community's views on which mission ideas could maximise scientific impact and innovation whilst responding to scientific and societal challenges, within the guidelines and constraints established within the Call. Considering the experience from previous calls, and in line with the spirit of the FutureEO programme, the call solicited innovative and scientifically excellent ideas to be implemented as ESA-led Earth Explorer research missions.

In March 2024, the Advisory Committee for Earth Observation (ACEO) recommended the following four

Mission Ideas to be selected for Phase 0 assessment studies:

CryoRad - A Low frequency wideband radiometer for the study of the cryosphere

ECO - The Earth Climate Observatory

Hydroterra+ - A mission to observe rapid processes of the water cycle

Keystone - Unlocking the Upper Atmosphere.

To note, each of the four recommended mission ideas are variants/improvements of previously submitted Earth Explorer proposals.

7.1.7. NGGM Gravity Mission

In orbit from March 2009 to November 2013, the Gravity field and steady-state Ocean Explorer (GOCE) measured the Earth's gravity field with unprecedented detail to advance our understanding of ocean circulation, sea-level change and Earth- interior processes. GOCE successfully completed its last measurement cycle at an altitude of 223.88 km on 19 October 2013. The satellite re-entered into the Earth atmosphere on 11 November 2013.

In the frame of Missions of Opportunity made possible by international cooperation, ESA and NASA have coordinated studies of optimal gravity monitoring constellations formed by two or more pairs of satellites to observe mass changes in the Earth system. In 2016, the ESA-NASA Science Working Group issued the document “Towards a sustained observing system for mass transport to understand global change and to benefit society”.

Programmatic discussions were also held in March 2020 between ESA and NASA, based on a series of meetings and teleconferences held in 2019, to identify the most suitable scenario for implementation of a joint mass change mission based on a joint constellation of 2 pairs of satellites in an optimum orbit configuration, leveraging on technology developments, and technical and scientific expertise available both in Europe and in the US. The proposed mission architecture responds to user requirements previously established by the Interagency Gravity Science Working Group and builds upon the heritage from CHAMP, GOCE, GRACE, GRACE-FO.

The global science and user requirements were consolidated in a uniform traceable manner together with NASA. These requirements and a corresponding traceability matrix have been used to establish the mission requirements. The first issue of the Mission Requirements Document (Next Generation Gravity Mission as a Mass-change And Geosciences International Constellation (MAGIC) - A joint ESA/NASA double-pair mission based on NASA's MCDO and ESA's NGGM studies) - was released on 18 December 2020, following signatures of ESA and NASA. The MRD was distributed to

Delegations in early 2021. In close coordination with NASA the Joint Mass Change Mission Expert Group (JMCMEG), consisting of 9 European members and 9 US members, was established to support the Phase A.

An ESA/NASA Joint Engineering Team (JET) has been set up with the goal to support and coordinate the technical interaction between ESA and NASA to enable the implementation of an affordable, technically feasible and scientifically valuable observing architecture for MAGIC. The JET was kicked-off on 20 May 2021 and the JET subsequently agreed. The JET scope is to technically assess the conditions of delivery to ESA of the potential NASA contribution items (i.e., the cavity, Scale Factor Unit and the LRP with no adaptations from GRACE-C) on the P2 Laser Tracking Instrument (LTI). JET is also working on the evaluation of the environmental requirements applicable to US units and the discrepancies with the ESA requirements, and the high level interfaces between the ESA and NASA science data systems for the exchange of P1 and P2 Level-0 and Level-1 products.

7.1.8. Aeolus-2

Aeolus-2 is a Doppler Wind Lidar designed to measure atmospheric winds through measurement of doppler shifts in the backscatter of emitted laser light from molecules, water droplets and aerosols in the atmosphere. The measurement principle has been successfully demonstrated on the first Aeolus mission and the Aeolus Doppler Wind Lidar instrument has been ranked by ECMWF as having the second highest impact on the accuracy of Numerical Weather Prediction of any single Satellite instrument.

The Aeolus-2 development is based on an evolution of the Aeolus heritage, taking into account the lessons learned from the Aeolus development and in-orbit performances / operations, as well as from other similar spaceborne laser projects. The objective of the Aeolus-2 mission is to provide Europe and, by extension, the international community, with the unique capability to measure atmospheric winds for the support of Numerical Weather Prediction and to improve the understanding of atmospheric dynamics and associated processes.

Launch of the first Aeolus-2 Satellite is foreseen in 2034, with a series of two Satellites providing over ten years of operations. The Aeolus-2 Space Segment consists of a series of two Satellites. The primary Payload is a Doppler Wind Lidar instrument operating in the ultra-violet spectrum (355 nm). In addition, provided the accommodation is confirmed to be feasible, a Radio Occultation sounder (to provide high vertical resolution, all-weather atmospheric sounding by tracking Galileo, GPS and Beidou satellites) will also be embarked. The Aeolus-2 Satellites will fly in a “dawn-dusk”, sun-synchronous orbit, with the Satellite orbiting above the day-night terminator and the Doppler Wind Lidar instrument

pointing 35° off-nadir, perpendicular to the ground track, to the night side of the Earth.

The Programme will be implemented in co-operation with EUMETSAT.

7.1.9. TRUTHS

Approved at the Space19+, TRUTHS will provide benchmark measurements that improve our ability to estimate the radiative imbalances underlying climate change. Reference datasets from TRUTHS will be used to calibrate other satellite sensors, such as those carried on the Copernicus missions and the emerging constellations of small satellites.

TRUTHS has a target launch date of 2030.

7.1.10. ALTIUS

ALTIUS (Atmospheric Limb Tracker for Investigation of the Upcoming Stratosphere) is a satellite mission proposed by the Belgian Institute for Space Aeronomy and currently under development by ESA. Its main objective is to monitor the distribution and evolution of stratospheric ozone in the Earth's atmosphere. The industrial consortium is led by QinetiQ Space, acting as mission prime. The satellite design is based on the PROBA small satellite bus. The payload, developed by OIP Sensor Systems, is an innovative UV, visible and NIR instrument.

The target launch readiness for Altius is April 2027.

7.2. Copernicus Expansion Missions

Data from the Copernicus Sentinels developed by ESA, feed into the Copernicus Services, which help address challenges such as urbanisation, food security, rising sea levels, diminishing polar ice, natural disasters and, of course, climate change. Looking to the future, six Copernicus Expansion missions are being studied to address EU policy and gaps in Copernicus user needs, and to expand the current capabilities of the Copernicus space component.

7.2.1. CHIME: Copernicus Hyperspectral Imaging Mission

The CHIME mission, which includes a constellation of two satellites, aims at augmenting the CSC with precise spectroscopic measurements to derive quantitative surface characteristics supporting the monitoring, implementation, and improvement of a range of policies in the domain of raw materials, agriculture, soils, food security, biodiversity, environmental degradation and hazards, inland and coastal waters, snow, forestry, and the urban environment. The mission would complement Copernicus

Sentinel-2 for applications such as land- cover mapping.

CHIME-A has a working launch date of 2028, while CHIME-B is planned to be launched in 2030. Both satellites have a design life of eight years.

7.2.2. CIMR: Copernicus Imaging Microwave Radiometer

The aim of the Copernicus Imaging Microwave Radiometer (CIMR) mission is to provide high-spatial resolution microwave imaging radiometry measurements and derived products with continuous global coverage (~95% daily, no gap at the poles) and sub-daily (6 hours average) revisit in the polar regions and adjacent seas, to address Copernicus user needs. The primary mission requirements are to acquire global observations to address Sea Ice Concentration (SIC) and Sea Surface Temperature (SST) with secondary requirements covering a very wide number of parameters related to COM Arctic Policy including: ice-type, sea-ice drift, thin sea-ice thickness, terrestrial snow extent, sea surface salinity, ice surface temperature, wind speed over the ocean, soil moisture, and vegetation indices. CIMR satellites will operate in synergy with MetOp-SG(B), providing collocated and contemporaneous measurements in the polar regions with MWI/ICI and SCA instruments.

CIMR-A is anticipated to be launched in 2029, and CIMR-B about six years later.

7.2.3. CO2M: Copernicus Anthropogenic Carbon Dioxide Monitoring

This mission, which includes a constellation of three satellites, aims to provide Copernicus with a CO2 monitoring and verification support capacity, capable of estimating anthropogenic CO2 emissions at country and megacity scales. This operational capacity shall allow evaluating the implementation and effectiveness of the CO2 emission reduction strategies proposed in the Paris Agreement. Such a system needs to provide accurate and consistent quantification of anthropogenic CO2 emissions and their trends. As part of the product portfolio and in support of the main mission objective, there will be also CH4, NO2, aerosol and solar-induced fluorescence of vegetation operationally retrieved at similarly high spatial resolution. Although this includes air quality relevant information, these products are not necessarily retrieved in near-real time.

The first satellite in the series, CO2M-A, is planned to be launched in 2025 which will be followed by CO2M-B about 6 months later and CO2M-C is expected about one year after CO2M-B.

7.2.4. CRISTAL: Copernicus Polar Ice and Snow Topography Altimeter

The Copernicus polaR Ice and Snow Topography ALtimeter (CRISTAL) Mission shall provide enhanced retrieval of land ice sheet/glacier elevation, sea ice thickness and freeboard and ocean surface

elevation, wave-height and wind speed by measurements implementing higher spatial resolution. The primary high-level objectives are to monitor critical climate signals: ice sheet, ice cap melting and sea level, as well as to monitor variability of Arctic and Southern Ocean sea-ice and its snow loading to support Copernicus operational products and services concerning the polar regions. Other objectives are to support applications related to coastal and inland waters and contribute to the observation of ocean topography. CRISTAL will carry a multi-frequency radar altimeter and a microwave radiometer.

CRISTAL has a planned launch date in 2027.

7.2.5. LSTM: Copernicus Land Surface Temperature Monitoring

Surface temperature is already being observed from space with thermal infrared (TIR) sensors, however at spatio-temporal resolutions insufficient for many applications and services, including agriculture. The LSTM mission, which includes a constellation of two satellites, will increase the spatial resolution of the TIR observations currently provided by Copernicus by a factor 400, bringing them to field scale. This mission shall be able to complement the current visible (VIS) and near-infrared (NIR) Copernicus observations with high spatio-temporal resolution TIR observations over land and coastal regions in support of agriculture management services and possibly a range of additional services.

The LSTM mission will consist of two satellites, with the first targeted for launch in 2028. The expected lifecycle is 7.5 years.

7.2.6. ROSE-L: L-band Synthetic Aperture Radar

ESA has undertaken the development of the L-band Synthetic Aperture Radar (SAR) Mission, referred to as Radar Observing System for Europe (ROSE-L). This mission, which includes a constellation of two satellites, will acquire systematically and provide routinely data and information products for the Copernicus Marine, Land, Climate Change and Emergency services, as well as to the recently proposed Copernicus Land European Ground Motion service (EGMS).

Its target applications are the measurement of surface deformation of vegetated and faster moving terrain, soil moisture, land cover classification, crop type discrimination and its temporal analysis. Furthermore, the mission will monitor Polar ice sheets and ice caps, and the sea-ice conditions (i.e. type, drift, deformation, concentration, lead fraction), as well as contribute to the European maritime situational awareness. Applications will be further enhanced through the combined use of ROSE-L and Sentinel-1. The ROSE-L mission will provide repeat-pass SAR interferometry (InSAR).

Launch of ROSE-L is targeted for 2028.

7.3. ESA Climate Change Initiative (CCI)

Combined satellite and in situ data archives can be used to produce data products for climate monitoring, modelling, and prediction. To this end, the ESA Climate Change Initiative (CCI) was launched in 2009. The CCI was created to address the GCOS Essential Climate Variable (ECV) requirements for satellite datasets and derived products. Its principal objective is “to realize the full potential of the long-term global Earth Observation archives that ESA together with its Member States have established over the last thirty years, as a significant and timely contribution to the ECV databases required by the UNFCCC”. The CCI focuses on the exploitation of data records primarily, but not exclusively, from past ESA satellite missions, for the benefit of climate monitoring and climate research. It complements existing efforts in Europe (e.g., led by EUMETSAT through the CM SAF) and internationally, with a focus on datasets characterising meteorological aspects of the climate system.

ESA, largely through the CCI, participates in the joint CEOS/CGMS Working Group on Climate (WGClimate). The last meeting was hosted by ESA at ECSAT, UK, in February 2025 and was held jointly with the GHG Task Team (currently led by ESA).