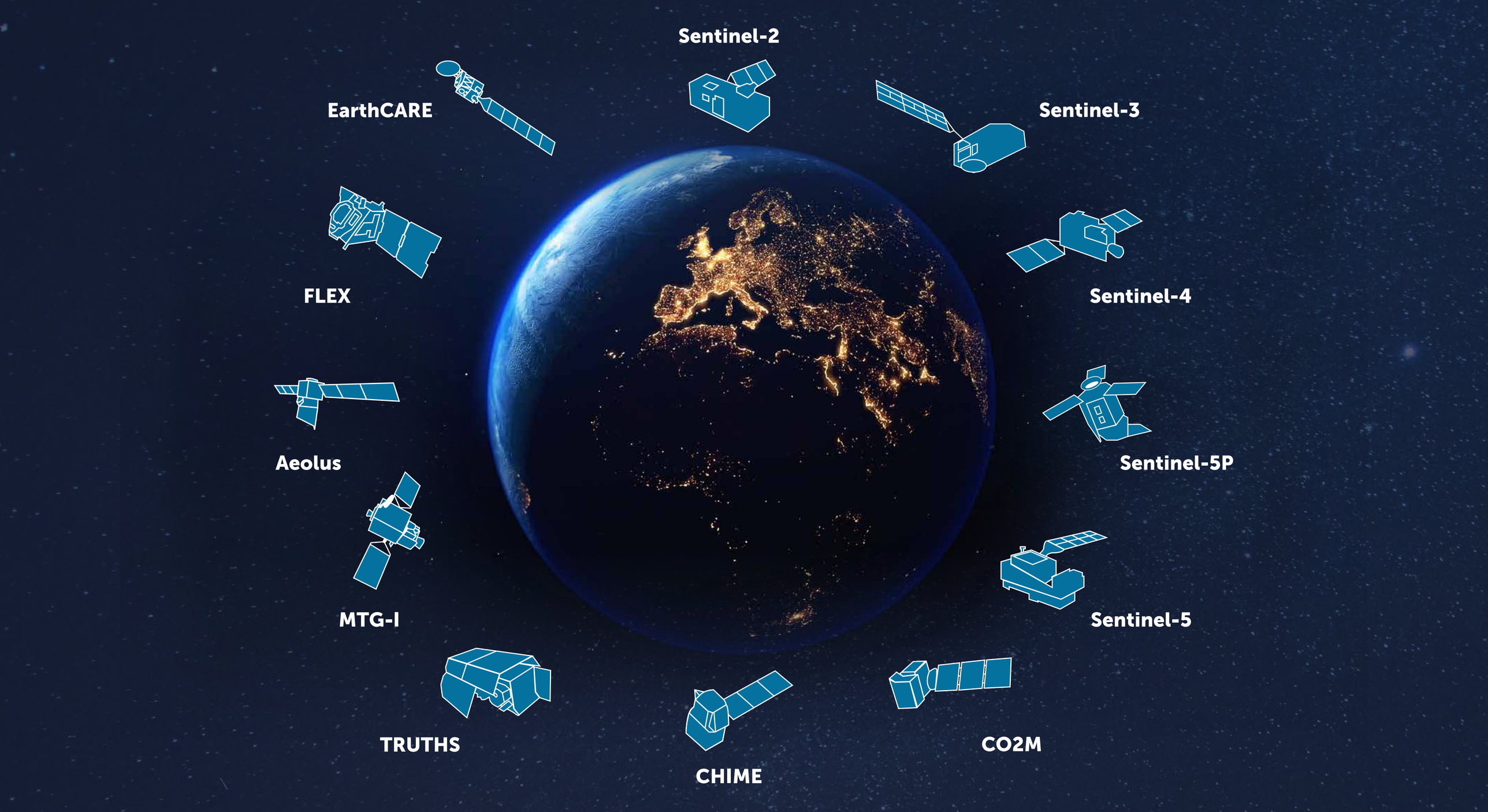

Sentinel-2
EarthCARE
Sentinel-3
FLEX
Sentinel-4
Aeolus
Sentinel-5P
MTG-I
Sentinel-5
TRUTHS
CHIME
CO2M

Teledyne e2v in ESA's Earth Observation Fleet

Earth Observation is key to the protection of our favourite planet.

Monitoring the land, air, ice and sea from space, allows us to see, measure, predict and react to the changes, both long-term and in real-time. It gives us the data to make decisions: be it mitigating climate change, 'nowcasting' the weather, warnings on seismic activity or responding to emergencies.

ESA's Earth Observation fleet – Copernicus and the Earth Explorers– set the standard in earth observation.

Teledyne e2v is a key technology enabler with the design of high-performance hyperspectral imaging sensors, which are on board a number of instruments in the Earth observation satellites.

They cover a wide range of applications including environmental protection, agriculture, forestry, climate change, sustainable development, civil protection and emergency response.

The Copernicus Missions

Mission: ESA's Sentinel-2 satellites

Objective: Polar-orbiting, multispectral high-resolution imaging mission for land and sea monitoring
Teledyne e2v sensor: CMOS sensors on Multispectral Instrument (MSI)
Date of launch Sentinel-2A: June 2015
Date of launch Sentinel-2B: March 2017
Date of launch of Sentinel-2C: 2024
Date of launch of Sentinel-2D: TBC
More on Teledyne e2v supply: Teledyne e2v utilized its space-dedicated manufacturing capabilities to package, space qualify and deliver 'flight model' CMOS sensors to Airbus Defense and Space, which designed the imaging device. The instrument covers 13 spectral bands (443nm–2190nm) with a swath width of 290km and spatial resolutions ranging from 10m to 60m.

Sensor Image format: 10 Multilinear CMOS arrays, 2596 pixels, 7.5 microns pitch and 1298 pixels, 15 microns pitch.

Mission: ESA's Sentinel-3 satellites

Objective: Multi-instrument mission to support ocean forecasting systems, as well as environmental and climate monitoring
Teledyne e2v sensor: CCD55-20 on Ocean and Land Color Instrument (OLCI)
Date of launch Sentinel-3A: February 2016
Date of launch Sentinel-3B: April 2018
Date of launch Sentinel-3C: 2024
Date of launch Sentinel-3D: TBC
More on Teledyne e2v supply: Teledyne e2v delivered CCD55-20, a high-performance, back-illuminated frame transfer CCD image sensor optimized for hyperspectral imaging. The instrument has a spatial resolution of 300m for all measurements and a swath width of 1270km. The optimized CCD includes the use of a 'gated dump drain' allowing the readout of selected image lines and the dumping of unwanted data. It also includes the use of graded thickness anti-reflection coating to minimize sun-glint, giving the minimum possible reflection from the silicon surface for all targeted wavelengths.

CCD55-20 Image format: 770 x 576 Pixels, 22.5 microns square, frame transfer operation.

Mission: Sentinel-4 flies on EUMETSAT's and ESA's Meteosat Third Generation-Sounder (MTG-S) satellites in geostationary orbit

Objective: Atmospheric monitoring
Teledyne e2v sensor: CCD374 and CCD376 on Ultraviolet Visible Near-infrared (UVN) instrument/ESA's Sentinel-4 mission
Date of launch Sentinel-4A: 2024
Date of launch Sentinel-4B: 2034
More on Teledyne e2v supply: Teledyne e2v have supplied space qualified, custom CCD374 optimized for ultraviolet and visible wavelengths and CCD376 optimized for near-infrared. They are both back illuminated for best Quantum Efficiency (QE) and Modulation Transfer Function (MTF) over the wavelength range of interest for this hyperspectral imaging system. The sensors are mounted in a Teledyne e2v designed package assembly which manages the electrical, thermal, mechanical and optical interfaces to the instrument.

CCD374 Image format: 600 x 1310 Pixels, 27.5 microns x 15 microns, split frame transfer operation with 260 rows transferring upwards, 1310 rows transferring downwards.
CCD376 Image format: 600 x 713 Pixels, 27.5 microns x 15 microns, frame transfer operation.

Mission: ESA's and Netherlands Space Office (NSO) Sentinel-5P

Objective: Atmospheric monitoring and reducing data gaps between Envisat (in particular the Sciamachy instrument) and the launch of Sentinel-5
Teledyne e2v sensor: CCD275-42 on TROPOspheric Monitoring Instrument (TROPOMI)
Date of launch: October 2017
More on Teledyne e2v supply: Teledyne e2v delivered CCD275-42 for TROPOMI, an advanced spectrometer for the operational monitoring of air quality, ozone and surface. The back-illuminated CCD is optimized for different wavelengths, from ultraviolet and visible to near-infrared. It covers 7x7km^2 ground with a spectral range from 270–495nm to 710–775nm. The sensor is optimized for high frame transfer rates to reduce image smearing and it's delivered in a special ceramic package.

CCD275 Image format: 1024 x 1024 Pixels, 26 microns square, frame transfer operation.

Mission: Sentinel-5 is EUMETSAT's and ESA's MetOp Second Generation satellite in polar orbit

Objective: Air quality monitoring, stratospheric ozone monitoring, solar radiation measurements and climate monitoring
Teledyne e2v sensor: CCD314 on Ultraviolet Visible Near-infrared Shortwave (UVNS) instrument/ESA's Sentinel-5
Date of launch: 2025
More on Teledyne e2v supply: Teledyne e2v have supplied CCD314 optimized for this particular instrument design, covering different wavelengths from the ultraviolet to visible and near-infrared (270nm–733nm).
Its spatial resolution is below 8km for wavelengths above 300nm. Its operating frequencies fit the optical requirements of the instrument in terms of large pixels for good signal-to-noise ratio.

CCD314 Image format: 1404 x 1350 Pixels, 20 microns x 30 microns, split frame transfer operation.

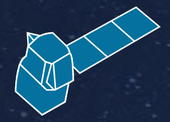
The Copernicus Expansion Missions

Mission: CO2M (Copernicus Anthropogenic Carbon Dioxide Monitoring) satellites

Objective: Measure and study how much carbon dioxide is released into the atmosphere specifically through human activity.
Teledyne e2v sensor: CIS120 on three instruments: CO2I, Multi-Angle Polarimeter (MAP), and Cloud Imager (CLIM).
Date of launch CO2M-A: December 2025
Date of launch CO2M-B: 2026
More on Teledyne e2v supply: CO2I will measure top of atmosphere (TOA) radiance in the Near Infrared (NIR) range at two wavelengths bands 734nm - 777nm and 410-490nm.
CLIM will have a spatial resolution of less than 0.4 km x 0.4 km and a swath width of 465 km. It will image in three bands in the Visible (VIS) and SWIR range at 670 nm, 752 nm and 1370 nm to provide images of cloud cover with a Signal-to-Noise Ratio (SNR) greater than 200. MAP is an assembly of a CIS120 CMOS image sensor and bespoke optical filter and polarising window. The spectral filter and polarising window are carefully aligned to the sensor to sub pixel accuracy. It will have a spatial resolution of 2 km x 2 km at nadir and a swath width of 300 km. It will measure TOA radiances in 6 narrow filter bands in the VIS and NIR ranges between 410 nm and 865nm.

CIS120 Image format: 2048 x 2048 Pixels, 10 microns square

Mission: CHIME (Copernicus Hyperspectral Imaging Mission for the Environment) satellites



Objective: Land cover monitoring and mapping, forest monitoring, and soil analysis to promote sustainable agriculture practices and biodiversity management
Teledyne e2v sensor: CHROMA-D on Hyperspectral Imager (HSI)
Date of launch: 2028
More on Teledyne e2v supply: Teledyne e2v will supply the CHROMA-D, a pushbroom-type grating Imaging Spectrometer with high Signal-to-noise ratio and data uniformity, to enable the novel HSI to image in over 200 bands over a wavelength range from 400 nm - 2500 nm in the Visible (VIS), Near Infrared (NIR), and Short-Wave Infrared (SWIR) spectrum at a spectral bandwidth less than 10 nm.
It will be able to measure at a ground resolution of 30 m for a swath width of 130 km with high radiometric accuracy for Level-1B data.

CHROMA-D Image format: 3072 x 512 Pixels, 18 microns square

Calibrating Earth Observation Capability

Mission: TRUTHS (Traceable Radiometry Underpinning Terrestrial- and Helio-Studies)

Objective: To enable high-accuracy traceability of climate data in accordance with the International System of Units (SI).
Teledyne e2v sensor: Chroma-D on Hyperspectral Imaging Spectrometer (HIS), and Cryogenic Solar Absolute Radiometer
Date of launch: 2030
More on Teledyne e2v supply: Teledyne e2v Space Imaging has been contracted to supply the TRUTHS hyperspectral sensor, and for the full design, manufacture and Technology Readiness Level (TRL) raising activities of the associated front-end electronics. The Chroma-D sensors will detect ultraviolet and infrared light to measure outgoing reflected radiation from the Earth's surface and Moon, and compare it to the incoming solar radiation from the Sun. Reference datasets from TRUTHS will also serve to calibrate other scientific observations.

CHROMA-D Image format: 2048 x 1024 Pixels, 18 microns square

Meteorological Missions

Mission: EUMETSAT's and ESA's Meteosat Third Generation - Imager (MTG-I)

Objective: MTG is the next-generation European operational geostationary meteorological satellite system designed for the continuity and enhancement of operational meteorological and climate data from geostationary orbit provided by the Meteosat Second Generation (MSG) system.
Teledyne e2v sensor: CIS111 on four Flexible Combined Imager (FCI) instruments
Date of launch MTG-I 1: December 2022
Date of launch MTG-I 2: 2026
Date of launch MTG-I 3: 2032
Date of launch MTG-I 4: 2036
More on Teledyne e2v supply: The FCI is a five channel, large pixel, programmable, radiation hard, front face illuminated, integrated sensor assembly. The image sensor utilizes very large (up to 100µm x 100µm) rhombus shaped pixels, as opposed to the usual square grid layout. A special black coating process on the die, developed in-house, minimizes reflections within the device.

Earth Explorers

Mission: Aeolus

Objective: Aeolus was the first satellite mission to acquire profiles of Earth's wind on a global scale. These observations improved weather forecasts and climate models.
Teledyne e2v sensor: CCD69 on Atmospheric LAser Doppler Instrument (Aladin)
Date of launch: August 2018
Date of Managed de-orbit: July 2023
More on Teledyne e2v supply: Teledyne manufactured a bespoke sensor for Aeolus with a novel design specifically for this application. It collected many signals from different altitudes, enabling Aeolus to measure wind speed at different heights throughout the atmosphere. Aeolus outlived its predicted lifetime of three years by over 18 months then made history with the first guided re-entry into the Earth's atmosphere, leaving no space debris at its end-of-life. Teledyne e2v is currently working on Aeolus 2.

CCD69 Image format: 16 x 16 Pixels, 27 microns square, Accumulation frame transfer operation.

Mission: FLuorescence EXplorer (FLEX)

Objective: The FLEX mission will provide global maps of vegetation fluorescence to quantify photosynthetic activity which helps track plant health and stress. This will increase our understanding of the global carbon cycle while bolstering agricultural management and food security efforts.
Teledyne e2v sensor: CCD325 on Fluorescence Imaging Spectrometer (FLORIS)
Date of launch: 2025
More on Teledyne e2v supply: FLORIS will acquire data in the 500 - 780 nm spectral range. It will have a sampling of 0.1 nm in the oxygen bands (759–769 nm and 686–697 nm) and 0.5–2.0 nm in the red edge, chlorophyll absorption and PRI (Photochemical Reflectance Index) bands. FLEX will fly in tandem with Copernicus Sentinel-3 to minimize the effects of moving clouds and gather complementary measurements acquired within 6 - 15 seconds of each other.

CCD325 Image format: 460 x 1072 Pixels, 28 microns x 42 microns, split frame transfer operation.

Mission: EarthCARE (Cloud, Aerosol and Radiation Explorer)

Objective: A collaboration between ESA and JAXA, EarthCARE will employ high-performance lidar and radar technology that has never been flown in space before, to gather data on the relationship of clouds, aerosols and radiation.
Teledyne e2v sensor: Custom CCD243 for the Atmospheric LIDAR (ATLID) instrument.
Date of launch: May 2024
More on Teledyne e2v supply: The Atmospheric Lidar (ATLID) will provide vertical profiles of aerosols and thin clouds. It will operate at a wavelength of 355 nm and have a high-spectral resolution receiver and depolarisation channel.

CCD243 Image format: 6 x 6 Pixels, 30 microns square. High speed binning into extended storage register.

TELEDYNE
Space Imaging