Europe's New Weather Satellite

- Satellite for weather and climate research
- Mirror control developed with dSPACE prototyping system
- Long-term weather forecasts, extensive data for climate research

The European weather satellite MetOp (Meteorological Operational Satellite) was launched from Baikonur in Kasakhstan on October 19, 2006. At the heart of the satellite is the Infrared Atmospheric Sounding Interferometer (IASI), an instrument for measuring the distribution of temperature and humidity, and the chemical composition of the atmosphere. The high quality of the measurements is largely determined by an optical delay line control developed by Swiss company Centre Suisse d'Electronique et de Microtechnique (CSEM), using a dSPACE prototyping system.

▶ *The weather (such as the storm front shown here) takes place at altitudes of up to 20 km. The MetOp satellite collects weather data from various altitudes, which is important for more accurate weather forecasts.*

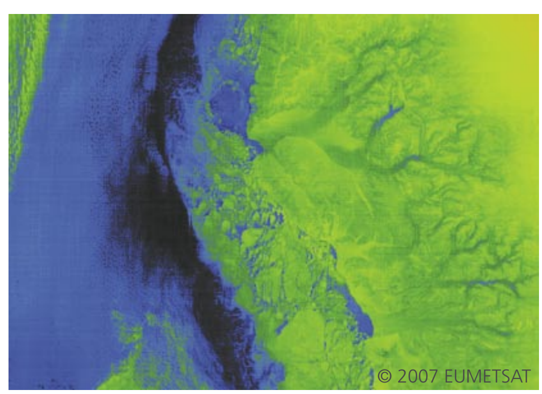
The Atmosphere Is Not Flat

In the satellite picture shown in television weather forecasts, the atmosphere appears flat. In actual fact, the weather occurs in an atmospheric layer 20 km thick, and varies considerably according to altitude. This is where the MetOp satellite comes in: orbiting low at an altitude of 820 km, in contrast to the high-flying geostationary satellites providing current meteorological images, it studies the atmosphere in layers and gives meteorologists a three-dimensional image of the weather. Moreover, it passes over the north and south poles. Its low polar orbit gives it a detailed view of the oceans and the polar regions, which are thought to be the Earth's "weather kitchen" but are not sufficiently covered by other satellites and weather buoys.

The Weather's Fingerprint

The three-dimensional weather images are produced from measurements made by the Infrared Atmospheric Sounding Interferometer (IASI). The IASI makes use of interference, i.e., the overlapping of light waves – the same thing that gives a film of oil on a puddle its rainbow-colored sheen. This is caused by interference between light waves reflected at the top and bottom surfaces of the oil film, and the film must have just the right thickness. In the IASI, it is the distance between the mirrors that must be right, and because one of the mirrors is movable, thus forming an optical delay line, the distance is constantly

> *"With the dSPACE Prototyping System we could easily adjust the controller for the scanning mirror of the meteorological interferometer on the MetOp weather satellite."*
> ***Emmanuel Onillon, CSEM***



▲ *The western coast of Greenland as seen by MetOp. Its infrared images provide data on the distribution of temperature and humidity.*

changing. Precise, periodic mirror movements are vital – it is these that cause an interference pattern in the detector, and this interference pattern is the atmosphere's "fingerprint". CSEM developed the control system for the mirror using a dSPACE prototyping system. Apart from precision, another essential objective was reliability – once in orbit, the satellite cannot be repaired.

Regular as Clockwork for 7 Years

The mirror must move 13 mm backward and forward at a constant speed of 132 mm/s, and continue to do so for up to 7 years – the useful life planned for the satellite. This can add up to 400 million motion cycles, during which the mirror must never get out of sync. In the development setup, the control system (based on the DS1005) captures the position of the movable mirror at a sampling rate of 2 kHz via an optical encoder and calculates the optimum control input from this. The control system for the mirror motion is based on a PID controller and is self-adaptive, repeatedly optimizing the control algorithm to minimize the deviations between the ideal and the actual mirror positions. After it was finalized, the control was successfully validated in fixed-point mode. To rule out optical error, we used what are called corner cube mirrors, which always reflect back the incident light precisely, even if slightly tipped. This principle is well known in everyday life, for example, in rear reflectors on bicycles. Nevertheless, the straighten of motion is critical (less than 1 µm deviation from a straight line over the full scan range).

Long-Term Weather Forecasts

The MetOp satellite is a giant step forward for our knowledge of the Earth's weather and climate. Meteorologists can use the data it collects to predict the weather more accurately, and also to refine existing climate models – helping them to gain a better understanding of ongoing climate change, for example. Long-term weather forecasts have invaluable advantages: advance warning benefits both people and nature, transportation can be organized better, and the human and material resources needed in weather-dependent industries are easier to plan (construction, tourism, agriculture, power, etc.)

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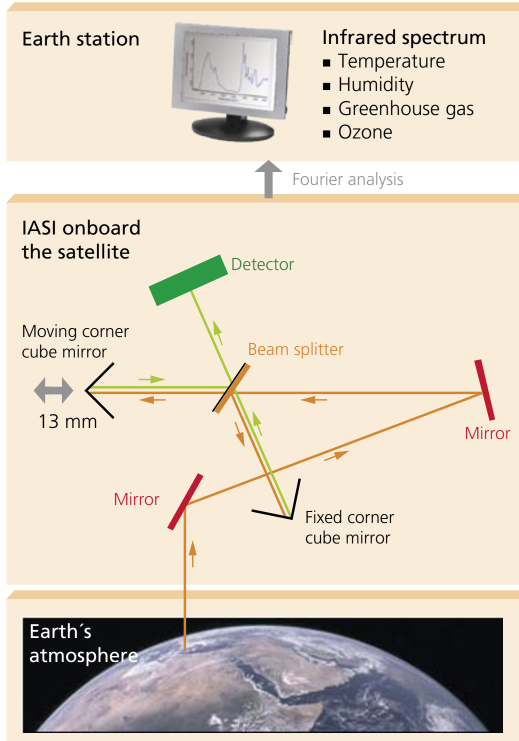

◀ The Infrared Atmospheric Sounding Interferometer. The periodic motion of a corner cube mirror produces a "fingerprint" of the weather in the detector. Precise mirror control is vital; a dSPACE prototyping system was used to develop it.

◀ The MetOp satellite orbits the Earth over the north and south poles at an altitude of 820 km. Its Infrared Atmospheric Sounding Interferometer (IASI) scans the atmosphere constantly during orbit. Small picture: MetOp in the assembly shop.