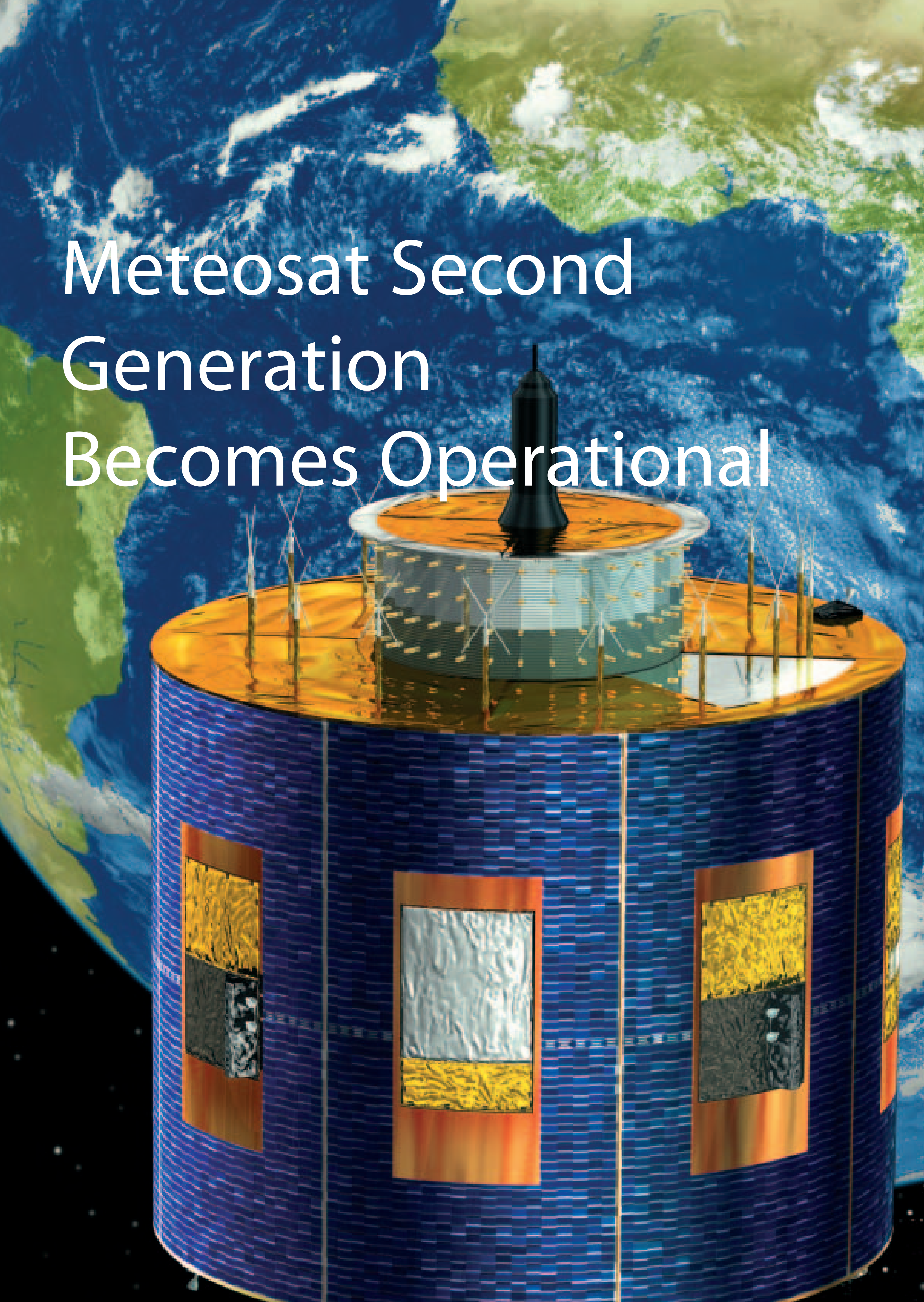
Meteosat Second Generation Becomes Operational



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A series of four Meteosat Second Generation (MSG) satellites will provide more comprehensive and more frequent data to meteorologists and climate-monitoring scientists for at least the next 14 years. They will bring about a step change in the accuracy of our weather forecasting systems, with considerable benefits for people both in Europe and further afield.

These four geostationary satellites are being developed based on the combined expertise of ESA and EUMETSAT (the European Organisation for the Exploitation of Meteorological Satellites). With a thorough understanding of users' needs, EUMETSAT is making a major investment in the overall programme, including development of the ground segment, procurement of the launchers and follow-on satellites and operation of the MSG system from its own Mission Control Centre in Darmstadt, Germany.

Geostationary meteorological satellites deliver frequent and high-quality images of one quarter of the Earth's disc. In this orbit, a satellite circles the Earth at the same speed as the planet rotates, and therefore seems to 'hover' in one place – in the case of MSG above the Gulf of Guinea at 3.4 degW off the west coast of Africa. From this vantage point it provides imagery of Europe, Africa, part of the Indian Ocean, and the eastern part of South America.

With its first-hand experience from the first generation of Meteosats, ESA was ideally placed to develop the MSG satellites for EUMETSAT. For the development of the first of the four satellites, MSG-1, ESA contributed two-thirds of the initial investment, with the remaining third coming from EUMETSAT. The satellites are built by Alcatel Space, involving more than 50 subcontractors from 13 European countries. EUMETSAT funds all of the MSG-2/3/4 related activities, with ESA retaining the technical and procurement role for the satellite prime contractor.

MSG-1 sets out on its mission, with its Ariane-5 launch on 28 August 2002

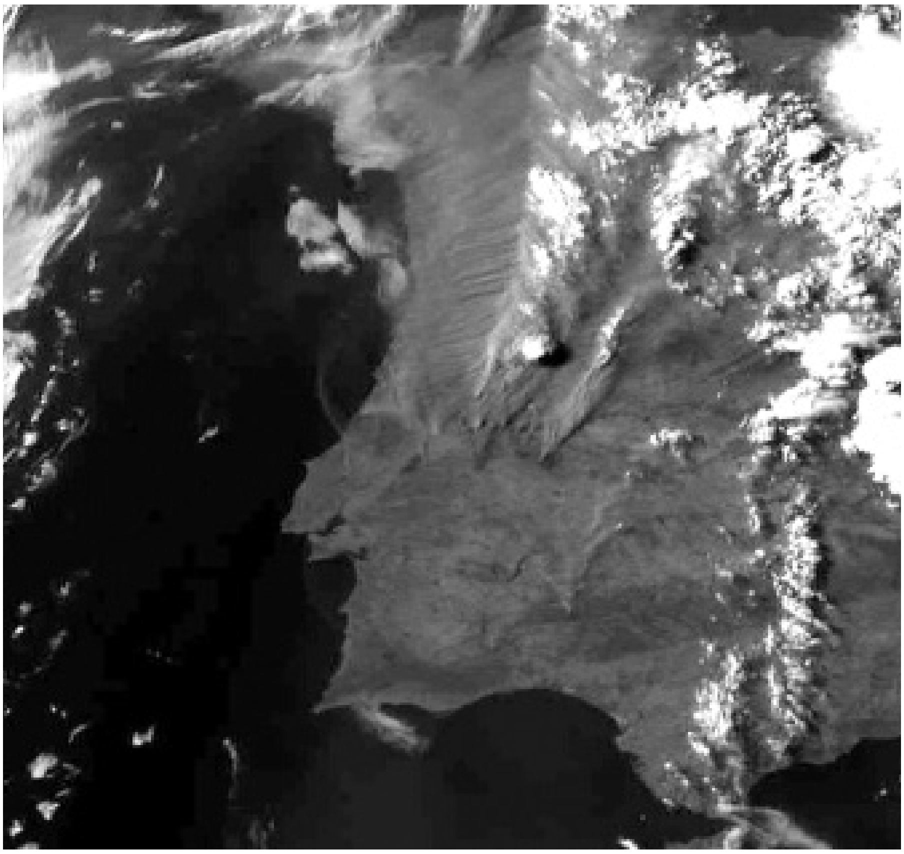
The Launch and Early Life of MSG-1

MSG-1 was successfully launched, with its co-passenger Atlantic Bird, on 28 August 2002 by an Ariane-5. The accuracy of the orbital injection provided by Ariane was excellent. ESA's European Space Operations Centre (ESOC) in Darmstadt, Germany, assumed control of the spacecraft after its separation from the launcher and successfully performed the manoeuvres required to take it from the Ariane injection orbit to a quasi-geostationary orbit drifting slowly towards the commissioning longitude of 10.5 degW. During this drift phase the spacecraft successfully survived several eclipses, the protective covers of its main instrument, SEVIRI (Spinning Enhanced Visible and Infrared Imager), were jettisoned, and the Imager's launch-locking device was released.

Following a successful Commissioning Readiness Review, Eumetsat assumed control of MSG-1 on 25 September 2002 as planned, after two days of interleaved spacecraft operations with ESOC. EUMETSAT began commissioning the satellite at the beginning of October, with spacecraft platform and communication payload tests.

The MSG-1 spacecraft in the Integration Hall in Kourou, French Guiana, shortly before launch

In the early hours of Thursday 17 October, an amplifier on the satellite switched off unexpectedly, at a time when operating conditions were otherwise nominal. After the occurrence of this anomaly, the solid-state power amplifier (SSPA) in question could not be switched back on, causing substantial delays and changes in the execution of commissioning tasks. An Inquiry Board was set up by ESA and, following its initial recommendations, commissioning activities were restarted in November 2002 with the communication payload in minimum-output-power mode supporting only the raw data downlink. The onboard data-dissemination capability was not reactivated, although redundant SSPA units were available, in order to safeguard the mission. The first SEVIRI



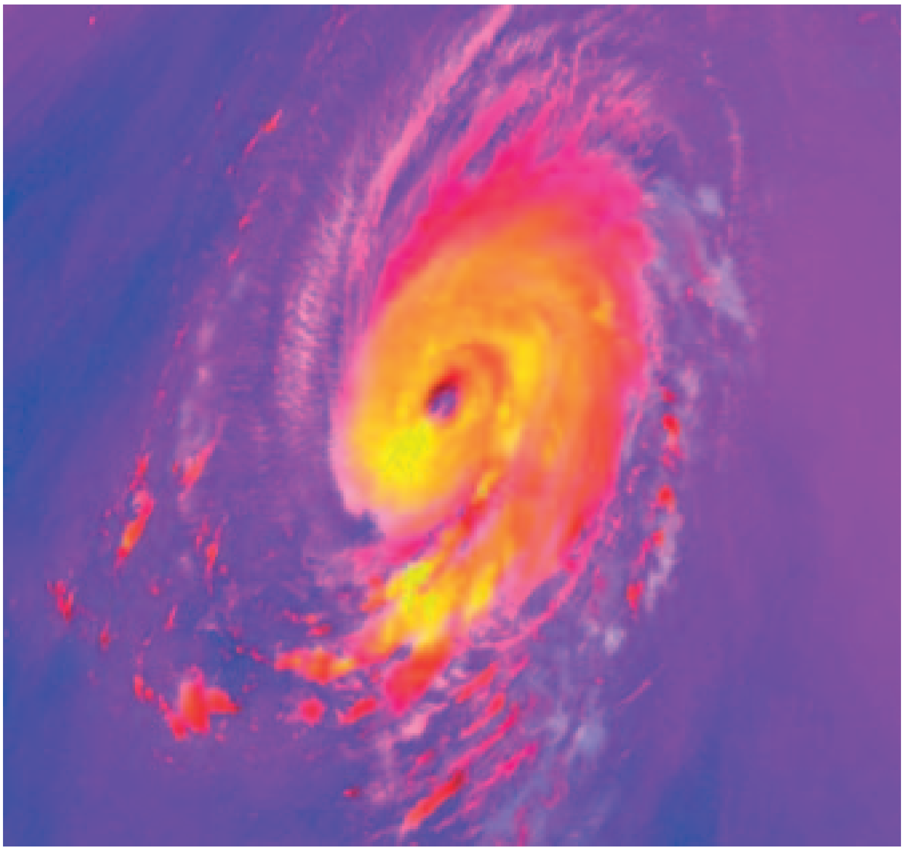
At the beginning of August 2003, in conjunction with the heat-wave over Western and Central Europe, Portugal was hit by the most devastating forest fires of the last 100 years. Thousands of firemen battled for weeks to keep the blazes under control. More than 10 people were killed and more than 50 000 hectares of forest were burned. Spain was also affected, but to a lesser extent. MSG, with its channels in the visible and near-infrared spectral range, provided near-real-time information concerning the locations of the fires and the extent of the smoke plumes.
Meteosat-8, 03 August 2003, 17:00 UTC, Channel 12 (HRV)

image was successfully acquired on 28 November, and the first GERB (Global Earth Radiation Budget) instrument image on 12 December 2002.

The results of the SSPA Inquiry Board investigations were presented on 7 April 2003. Extensive analyses and a testing campaign at equipment and component level followed, resulting in proposed design modifications to the SSPAs destined for the MSG-2/3/4 satellites. For MSG-1, the initial precautions that had been taken were substantially confirmed as correct and the onboard data-dissemination capability was not re-activated, maintaining the spare SSPA for the Raw Data channel instead. EUMETSAT therefore assessed alternative dissemination methods, based on commercial services providing Digital Video Broadcasting (DVB). The dissemination trial began over Europe at the end of April 2003 using the Ku-band. In parallel, a C-band dissemination service was studied and its implementation over Africa initiated.

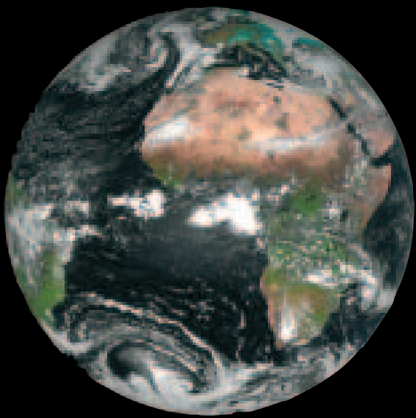
The Satellite and System Commissioning

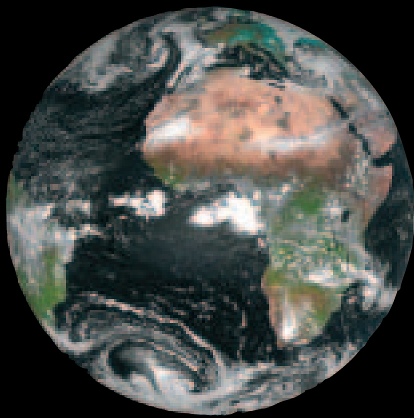
Commissioning is the final phase of verification of the performance of the complete system versus the applicable

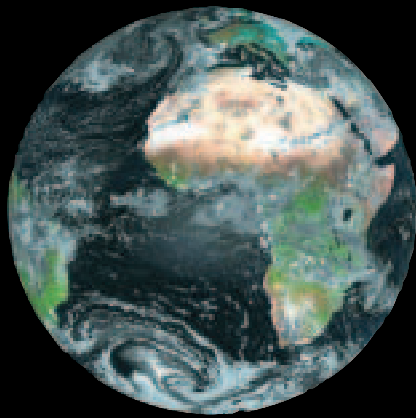


In September 2003, MSG monitored the development of Hurricane Isabel, which was 'born' on 7 September southwest of the Cape Verde Islands. On 13 September, it developed into the first category-5 hurricane (mean wind speed of more than 260 km/h) since Hurricane Mitch in 1998. It then degraded to a category-2 hurricane on 16 September, before making landfall in Northern Carolina and Virginia on 18 September, with winds of up to 160 km/h. In this image, orange to red shows high-level ice clouds with large ice particles, while yellow represents high-level ice clouds with small ice particles. The most active parts of the hurricane with the most severe precipitation are visible in an intense yellow colour to the southwest of the eye of the storm, and in the spiral band further to the south of the storm centre.
Meteosat-8, 8 September 2003, 12:00 UTC, RGB composite WV6.2-WV7.3, IR3.9-IR10.8, NIR1.6-VIS0.6

The Applications of Met







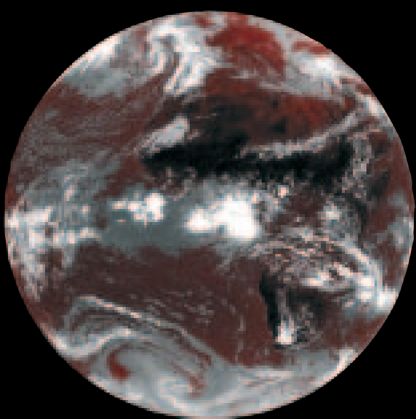
CHANNEL 1: VISIBLE 0.6
(0.56 - 0.71 µm)

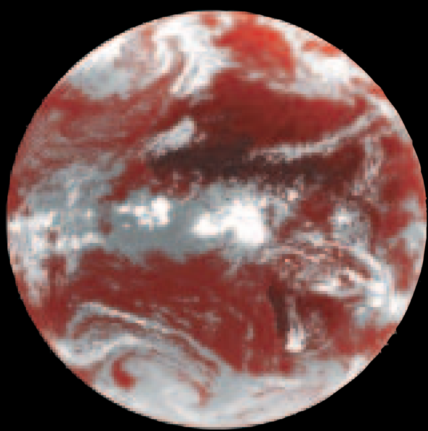
CHANNEL 2: VISIBLE 0.8
(0.74 - 0.88 µm)

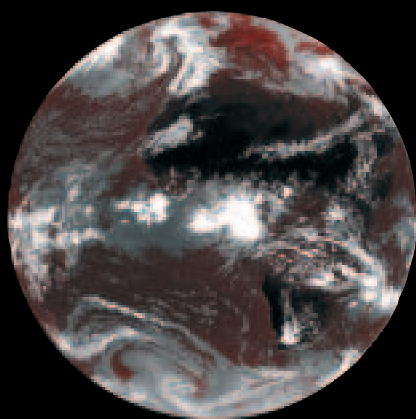
These channels are essential for cloud detection, cloud tracking, scene identification and the monitoring of land surfaces and aerosols. Together with channel 3 they can be used to generate vegetation indices.

CHANNEL 3: NEAR-INFRARED 1.6
(1.50 - 1.78 µm)

Helps to discriminate between snow and cloud, and between ice and water clouds. Also provides aerosol information.







CHANNEL 7: INFRARED 8.7
(8.3 - 9.1 µm)

Used mainly to provide quantitative information on thin cirrus clouds and to support the discrimination between ice and water clouds.

CHANNEL 8: INFRARED 9.7
(9.38 - 9.94 µm)

Responsive to ozone concentration in the lower stratosphere. It will be used to monitor total ozone and assess diurnal variability. Potential for tracking ozone patterns as an indicator of wind fields at that level.

CHANNEL 9: INFRARED 10.8
(9.8 - 11.8 µm)

The so-called split-window thermal infrared channels. Each responds to the temperature of clouds and the surface. By splitting this part of the thermal infrared, each channel has a slightly different response with respect to clouds and the Earth's surface. Used together helps to reduce atmospheric effects when measuring surface and cloud top temperatures. Also used for cloud tracking for atmospheric winds and for estimates of atmospheric instability.

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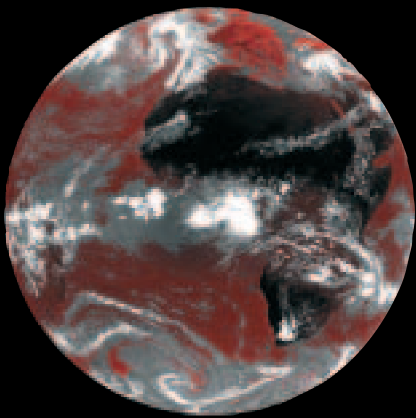
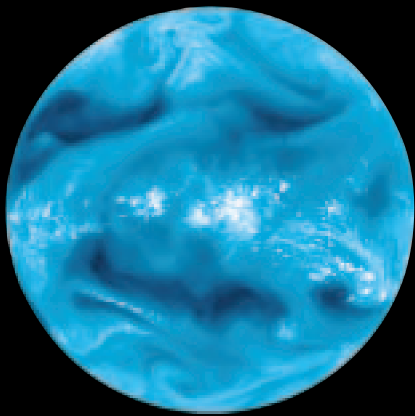
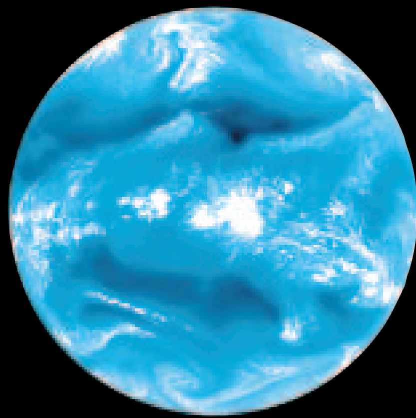






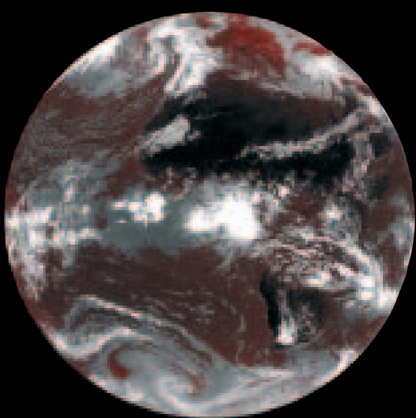
CHANNEL 4: INFRARED 3.9
(3.48 - 4.36 µm)

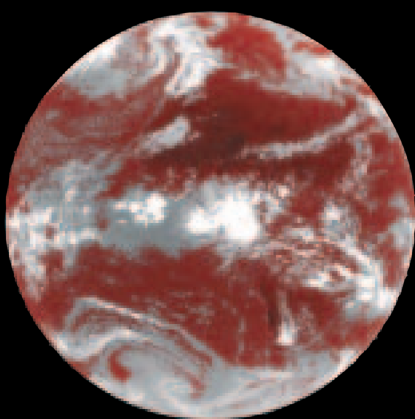
Primarily for detection of low cloud and fog at night, but also useful for measurement of land and sea temperatures at night and the detection of forest fires.

CHANNEL 5: WATER VAPOUR 6.2
(5.35 - 7.15 µm)

CHANNEL 6: WATER VAPOUR 7.3
(6.85 - 7.85 µm)

Provides continuity of the Meteosat first generation broadband water vapour channel to measure mid-atmospheric water vapour and to produce tracers for atmospheric winds. Also supports height assignment for semi-transparent clouds. Two separate channels representing different atmospheric layers instead of the single channel on Meteosat.





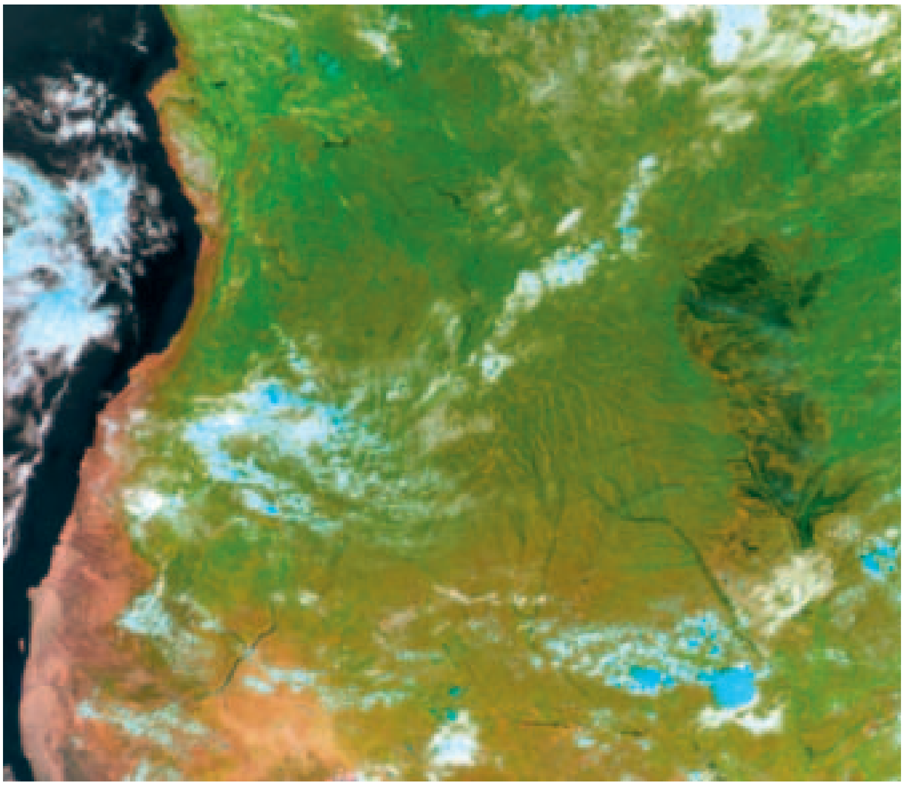
CHANNEL 10: INFRARED 12.1
(11 - 13 µm)

CHANNEL 11: INFRARED 13.4
(12.4 - 14.4 µm)

CO_2 absorption channel, to be used for the estimation of atmospheric instability, as well as contributing temperature information on the lower troposphere.

CHANNEL 12: HIGH RESOLUTION VISIBLE
(0.6 - 0.9 µm)

Broadband visible channel, as the current Meteosat VIS channel, but with an improved sampling interval of just 1 km (compared with Meteosat's 2.5 km).

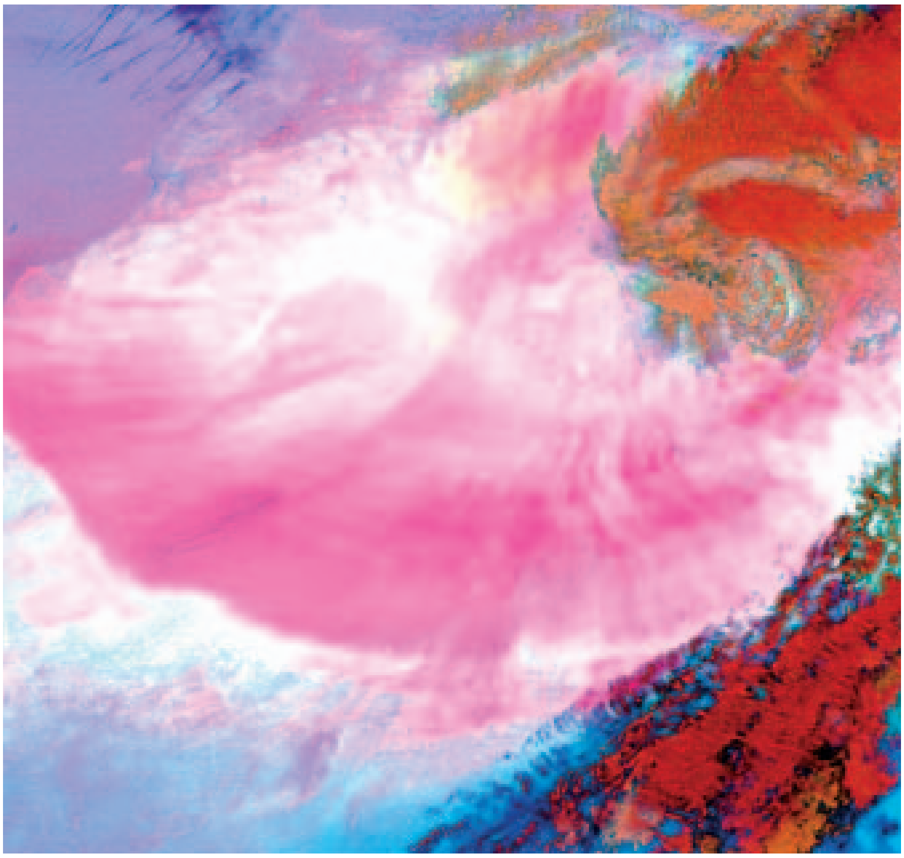


Between 1 and 10 February 2004, after days of torrential rainfall, large parts of Eastern Angola, Western Zambia and Northern Namibia were heavily flooded by the Okovango, Zambezi and cuando Rivers. In total, an area of about 600 000 sq km was affected by the floods. On 6 February 2004, floods inundated crops in the Kavango and Caprivi regions of Namibia, with the Okavango River reaching its highest levels in a decade.
Meteosat-8, 03 February 2004, 11:30 UTC, RGB composite NIR1.6, VIS0.8, VIS0.6

requirements, involving both the space and ground segments. It includes validation of the procedures to be used during the routine operations, calibration of the instruments in space, fine-tuning of the ground facilities, validation of the meteorological products themselves (e.g. comparisons with other satellite measurements), etc.

The Satellite Commissioning Results Review, begun in March and completed in June 2003, confirmed the good performance of all but the data-dissemination capability. The performance of the SEVIRI instrument was particularly promising. The Commissioning Operations Readiness Review was also successfully completed in the second half of June. Commissioning activities then continued in the second half of 2003 with the preliminary tuning and testing of the image-processing chain.

Once the satellite-commissioning phase had been completed and calibration both of the instruments and the imaging chain between satellite and ground was well underway, validation of the meteorological



In early March 2004, the passage of cold air from Europe to Western Africa caused a major dust storm over large parts of West Africa. As it travelled southwards, the cold air fanned out across the Sahara, diverging greatly over subtropical regions and giving the dust front (magenta colour) the form of a Spanish fan. In the following days, the dust was blown out across the Atlantic Ocean and reached the coast of South America. Due to the low emissivity of desert surfaces in the IR8.7 infrared channel, dust 'clouds' are clearly distinct from cloud-free desert surfaces in the IR10.8 - IR8.7 brightness-temperature-difference images (shown in green in this image). This feature, which was not well known before the launch of Meteosat-8, plus the brightness-temperature differences between the IR3.9, IR12.0 and IR10.8 channels, helps in monitoring dust storms over the deserts both during the day and at night.
Meteosat-8, 03 March 2004, 12:00 UTC, RGB composite IR12.0 - IR10.8, IR10.8 - IR8.7, IR10.8

products was begun. Dissemination of those meteorological products started via EUMETCast (the system name given to the alternative dissemination) on 21 October 2003, and was subsequently upgraded with the addition of other data and products. For example, Meteosat-5 images (over the Indian Ocean) were added in November, along with the dissemination in C-band for Africa.

The MSG-1 System Commissioning Results Review and the Routine Operations Readiness Review were both successfully completed on 18 December 2003 and the raw images from MSG-1 were confirmed to be of excellent quality and rectifiable within the specified accuracy, and the specified radiometric and geometric performances were being met with ample margins. Relocation of the spacecraft to the closest possible position to the Equator (0 deg) was therefore authorised ready for the start of routine operations. By 27 January 2004 the satellite had reached 3.4 degW and the operational service was initiated from this orbital position two days later. The satellite was renamed Meteosat-8 as a sign of continuity within the geostationary meteorological service being provided by EUMETSAT.

The satellite's Search & Rescue secondary payload was also tested successfully and from the end of the year was being used pre-operationally by COSPAS-SARSAT. In fact, several people's lives have already been saved thanks to the acquisition of rescue signals by MSG-1.

The long-term calibration and validation of meteorological products has continued according to plan, with the Image and Product Validation Review (IPVR) being completed between February and early March 2004.

The commissioning of a meteorological system is, as the above story shows, a somewhat lengthy process compared to that for a telecommunications system. Extensive calibration of the instruments and validation of the images and products is essential before the users can start to apply the products with confidence. Despite the unforeseen problems experienced with MSG-1 during the satellite and system commissioning phases, these tasks have ultimately been completed according to the initial plans.

The MSG Operational Service

Significant benefits to society from the MSG mission are to be found in its contribution to the Global Observing System (GOS) of the World Weather Watch (WWW) as part of the global system of geostationary satellites fulfilling the new European requirements in terms of better weather forecasting methods, meteorological observations and climate monitoring. In support of these objectives, the MSG system provides multispectral imaging of cloud systems, the Earth's surface and atmospheric emissions with significantly improved capabilities compared with existing systems in terms of extraction of meteorological products and image and data dissemination to users. It is an operational mission designed to provide a high-quality, readily available and cost-efficient data service fully adapted to meeting the needs of the user, in this case primarily the national Meteorological Services and the World Meteorological Organization.

The agreed service availability figure for MSG is 95%. Given that predicted system availability always decreases with time, the problem is then to determine the critical availability threshold that represents an unacceptable risk to users. This leads in turn to the concept of an in-orbit configuration with a satellite performing the nominal mission and another one in standby mode just in case. The foreseen launch date for the replacement satellite needs to be defined such that it can be commissioned and available in orbit in time to maintain the statistical availability above the agreed threshold.

It was on the basis of such considerations that MSG-1's entry into operation was targeted for early 2004, to maintain a minimum overlap of two years with the first-generation Meteosats in order ensure a smooth transition for users to the new system. The same logic is driving the definition of launch dates for the other three satellites in the series, MSG-2, 3 and 4.

MSG-2, 3 and 4

In parallel with the commissioning of MSG-1, work on the other three MSG satellites has been progressing well. On 1 March, EUMETSAT took the decision to take MSG-2 out of storage and to resume work on its final preparation for launch some time between February and April 2005.

The concept of storage and de-storage became part of the MSG-2 baseline after the launch of MSG-1 was rescheduled. All MSG satellites are essentially the same from a technical standpoint, with most of the industrial production work being done in parallel after the end of the development phase. Following MSG-1's entry into storage, MSG-2 and MSG-3 were integrated, and to a large extent tested, in order to optimise the work at industry level. The satellites then remain in storage until their de-storage and preparation for launch is initiated by EUMETSAT.

The planned launch date for MSG-3 is in the period 2008-2009. Work on MSG-4 has also started, in April 2003, and it will be ready to enter storage in spring 2007, for a launch in the period 2010-2011. Together, the four MSG satellites will ensure continuity of the geostationary operational service from this unique mission until 2018.

Information on how to access MSG data can be found by visiting www.eumetsat.de, or by contacting the EUMETSAT User Service via e-mail at Ops@eumetsat.de.