The MSG System

W. Schumann, H. Stark, K. McMullan, D. Aminou & H-J. Luhmann
MSG Project, ESA Directorate of Earth Observation, ESTEC, Noordwijk, The Netherlands

The MSG System consists of a Space Segment and a Ground Segment. It is designed to provide data, products and services over a system lifetime of at least 12 years, based on a series of three satellites called MSG-1, -2 and -3. The MSG System will perform regular operations with one satellite at the nominal location of 0 deg longitude over the equator, and foresees a stand-by satellite that would be used in case of emergencies or during major configuration changes.

The MSG Space Segment is being implemented by ESA, which is responsible for:
- **the development and procurement of the first satellite, called MSG-1**
- **the procurement, on behalf of Eumetsat, of the two subsequent satellites, MSG-2 and MSG-3.**

The MSG Ground Segment has been developed by Eumetsat and consists of:
- **a control, acquisition, pre-processing and dissemination ground segment composed of central facilities located at Eumetsat's Headquarters, and remote ground stations**
- **an Application Ground Segment, which extracts meteorological and geophysical products from the calibrated and geo-located image data generated by the Mission Control Centre, and performs data-management functions.**

Eumetsat is procuring the launch services for the MSG satellites, on the Ariane launch vehicle, and the Launch and Early Orbit Phase (LEOP) services, which are controlled and provided by ESA's European Space Operations Centre (ESOC) in Darmstadt, Germany.

The mission objectives
As the successor to the first-generation Meteosat Programme, MSG (Fig. 1) is designed to support nowcasting, very-short-range and short-range forecasting, numerical weather forecasting and climate applications over Europe and Africa, with the following mission objectives:
- the multi-spectral imaging of the cloud systems, the Earth's surface and radiance emitted by the Earth's atmosphere, with improved radiometric, spectral, spatial and temporal resolution compared to the first-generation Meteosats
- the extraction of meteorological and geophysical fields from the satellite image data for the support of general meteorological, climatological and environmental activities
- the collection of data from Data-Collection Platforms (DCPs)
- the dissemination of the satellite image data and meteorological information after processing to the meteorological user community in a timely manner for the support of nowcasting and very-short-range forecasting
- the support to secondary payloads of a scientific or pre-operational nature which are not directly relevant to the MSG programme (i.e. GERB and GEOSAR)
- the support to the primary mission (e.g. archiving of data generated by the MSG System).

The mission objectives were subsequently refined by Eumetsat, taking into account further evolutions in the needs of operational meteorology. This updating resulted in:

- the provision of basic multi-spectral imagery, in order to monitor cloud-system and surface-pattern developments in support of nowcasting and short-term forecasting over Europe and Africa
- the derivation of atmospheric motion vectors in support of numerical weather prediction on a global scale, and on a regional scale over Europe
- the provision of high-resolution imagery to monitor significant weather evolution on a local scale (e.g. convection, fog, snow cover)
- the provision of air-mass analysis in order to monitor atmospheric instability processes in the lower troposphere by deriving vertical temperature and humidity gradients
- the measurement of land- and sea-surface temperatures and their diurnal variations for use in numerical models and in nowcasting.

The Imaging Mission
To support the above mission objectives, a single imaging radiometer concept known as the Spinning Enhanced Visible and Infra-Red Imager (SEVIRI) has been selected. This concept, while yielding significant development/recurrent cost savings, allows the

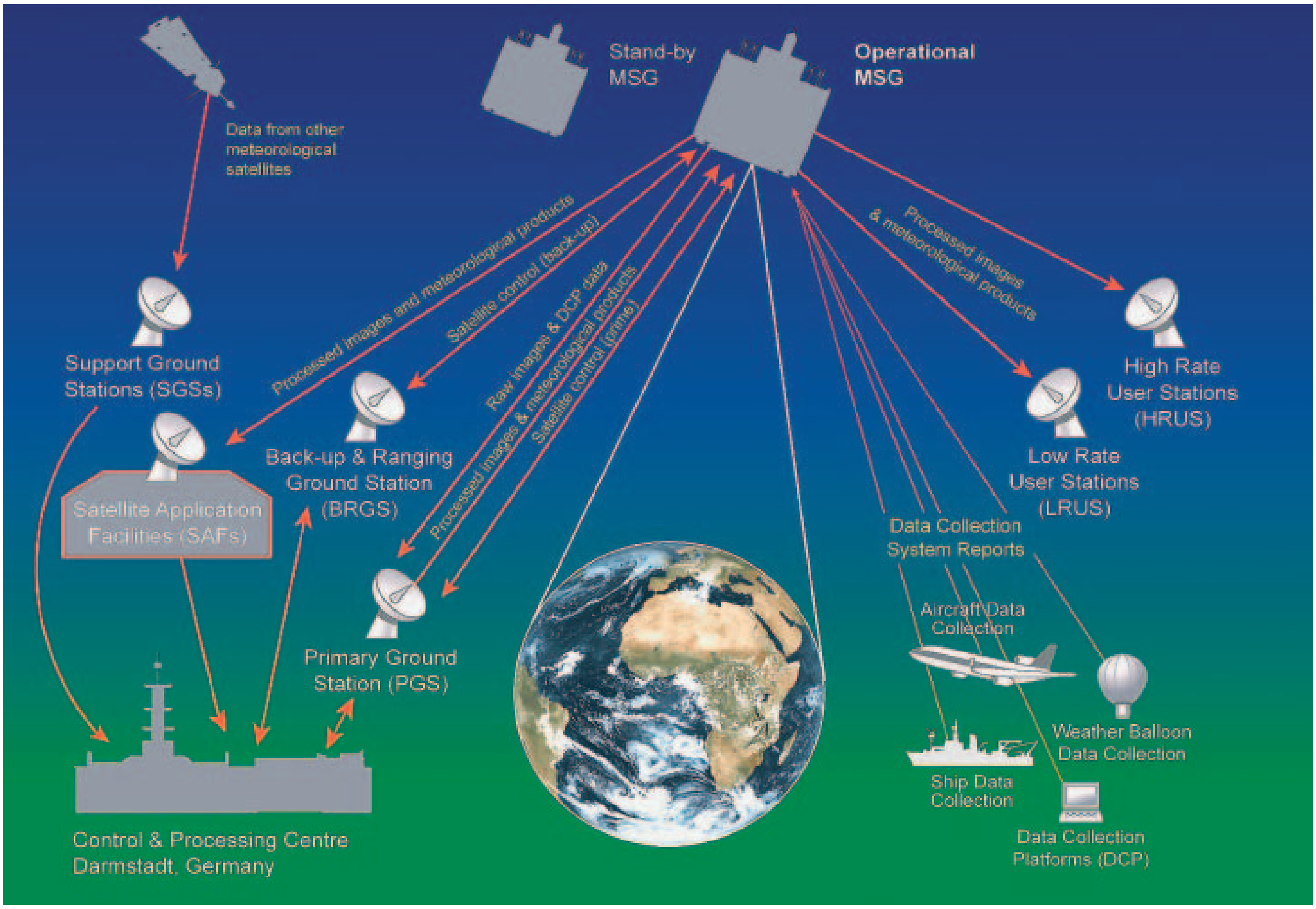


Figure 1. The MSG System configuration

simultaneous operation of all of the radiometer channels with the same sampling distance. It therefore provides the users with improved image accuracy and such products as atmospheric motion vectors and surface temperature, and also new types of information on atmospheric stability. Moreover, as the channels selected for MSG are similar to those of the AVHRR instrument currently being flown on polar-orbiting spacecraft, the efficiency of the global system will be increased due to the synergy of the polar and geostationary orbit data.

An outline of the overall mission and performance evolution from first- to second-generation Meteosat is given in Figure 2.

The imaging mission provides continuous imaging of the Earth in the 12 spectral channels of the SEVIRI instrument, with a baseline repeat cycle of 15 min. The calibration of the infrared cold-channel radiometric drift can be performed every 15 min, using an internal black-body calibration unit. The imager provides data from the full image area in all channels, except for the high-resolution visible channel, where the scanning mode can be switched by telecommand from the normal to an alternative mode (Fig. 3).

The VIS 0.6, VIS 0.8, IR 1.6, IR 3.9, IR 10.8 and IR 12.0 channels correspond to the six AVHRR-3 channels on-board the NOAA satellites, while the HRV, WV 6.2, IR 10.8 and IR 12.0 channels correspond to the first- generation Meteosat VIS, WV and IR channels (Fig. 4). The following so-called 'split-channel pairs' provide similar radiometric information and may therefore be used interchangeably: VIS 0.6 & VIS 0.8, IR 1.6 & IR 3.9, WV 6.2 & WV 7.3, and IR 10.8 & IR 12.0.

The HRV channel will provide high-resolution images in the visible spectrum, which can be used to support nowcasting and very-short-range forecasting applications.

The two channels in the visible spectrum, VIS 0.6 and VIS 0.8, will provide cloud and land-surface imagery during daytime. The wavelengths that have been chosen allow the discrimination from the Earth's surface of different cloud types, as well as discrimination between vegetated and non-vegetated surfaces. These two channels also support the determination of the atmospheric aerosol content.

The IR 1.6 channel can be used to distinguish low-level clouds from snow surfaces and supports the IR 3.9 and IR 8.7 channels in discriminating between ice and water clouds. Together with the VIS 0.6 and VIS 0.8 channels, the IR 1.6 channel may also support the determination of aerosol optical depth and soil moisture.

The IR 3.9 channel can be utilised to detect fog and low-level clouds at night, and to discriminate between water clouds and ice surfaces during daytime. The IR 3.9 channel may also support the IR 10.8 and IR 12.0 channels in the determination of surface temperatures by estimating the tropospheric water-vapour absorption.

The two channels in the water-vapour absorption band, WV 6.2 and WV 7.3, will provide the water-vapour distribution for two distinct layers in the troposphere. These two channels can also be used to derive atmospheric motion vectors in cloud-free areas, and will support the IR 10.8 and IR 12.0 channels in the height assignment of semi-transparent clouds.

The IR 8.7 channel may also be utilised for cloud detection and can support the IR 1.6 and IR 3.9 channels in discriminating between ice clouds and the Earth's surface. Moreover, the IR 8.7 channel may also be applied together with the IR 10.8 and IR 12.0 channels to determine the cloud phase.

The SEVIRI channel that covers the very strong fundamental vibration band of ozone at 9.6 microns, namely IR 9.7, will be used to determine the total ozone content of the atmosphere and may also be applied to monitor the altitude of the tropopause.

The two channels in the atmospheric window, IR 10.8 and IR 12.0, will mainly be used together with the IR 3.9 channel to determine surface temperatures.

The IR 13.4 channel covers one wing of the fundamental vibration band of carbon dioxide

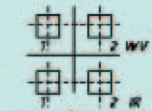
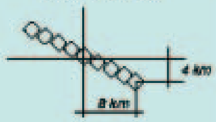
IMAGING/PSEUDO SOUNDING MISSION			
		MOP	MSG
Imaging Format / Imaging cycle		 30 mn	 15 mn
Channels		Wavelength	
	Visible	0.5 - 0.9	HRV VIS 0.6 VIS 0.8 IR 1.6
	Water Vapour	WV 6.4	WV 6.2 WV 7.3
	IR window	IR 11.5	IR 3.8 IR 8.7 IR 10.8 IR 12.0
	Pseudo sounding		IR 9.7 IR 13.4
Sampling distance		2.25 km (Visible) 4.5 km (IR + WV)	1 KM (HRV) 3 KM (others)
Pixel size		2.25 km (Visible)  5 km (IR + WV)	1.4 km (HRV)  4.8 km (others)
Number of detectors		4	42
Telescope diameter		400 mm	500 mm
scan principle		scanning telescope	Scan mirror
DATA CIRCULATION MISSION			
Transmission raw data rate		0.333 Mb/s	3.2 Mb/s
Disseminated image		0.166 Mb/s	1 Mb/s
Transmission burst mode		2.65 Mb/s	Search & Rescue package

Figure 2. Mission evolution from first- to second-generation Meteosat

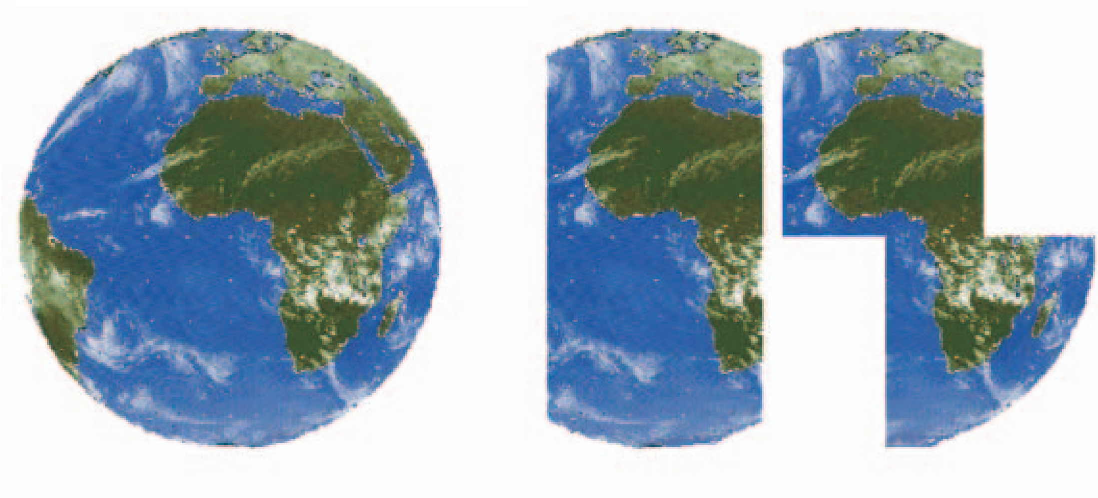


Figure 3. SEVIRI Earth-imaging frames: full image area, HRV channel normal mode and alternative mode

at 15 microns, and will therefore mainly be used for atmospheric-temperature sounding in support of air-mass instability estimation.

The Product-Extraction Mission

This mission will provide meteorological, geophysical and oceanographic Level 2.0 products from SEVIRI Level 1.5 imagery. It will continue the product-extraction mission of the current Meteosat system, and also provide additional new products.

The MSG meteorological products will be delivered to the user community in near-real-time via the Global Telecommunications System (GTS) or via the satellite's own High-Rate Image Transmission (HRIT) and Low-Rate Image Transmission (LRIT) schemes.

The Data-Collection and Relay Mission

The data-collection and relay mission will collect and relay environmental data from the automated Data Collection Platforms (DCPs) via the satellite. It will be a follow-on from the current Meteosat Data Collection Mission, with some modifications:
- increased number of international DCP channels
- increased number of regional channels
- DCP retransmission in near-real-time via the LRIT link
- some of the regional channels will operate at a higher transmission rate.

The Dissemination Mission

The dissemination mission will provide digital image data and meteorological products via two distinct transmission channels:
- the HRIT scheme transmits the full volume of processed image data in compressed form
- the LRIT scheme transmits a reduced set of processed image data and other meteorological data.

Both transmission schemes will use the same radio frequencies as the current Meteosat system, but the coding, modulation scheme, data rate and data formats will be different. Different levels of access to the high- and low-rate information transmission data will be provided to different groups of users through encryption.

The Meteorological Data Distribution mission of the current Meteosat System will be integrated into the HRIT and LRIT missions of MSG.

Figure 4. The spectral characteristics of the SEVIRI channels

Channel	Absorption Band Channel Type	Nom. Centre Wavelength (μm)	Spectral Bandwith (μm)	Radiometric Noise - Assessed for MSG-1 at End of Life at Reference Targets
HRV	Visible High Resolution	nom. 0.75	0.6 to 0.9	0.63 at 1.3 W/(m^2.sr.μm)
VIS 0.6	VNIR Core Imager	0.635	0.56 to 0.71	0.27 at 5.3 W/(m^2.sr.μm)
VIS 0.8	VNIR Core Imager	0.81	0.74 to 0.88	0.21 at 3.6 W/(m^2.sr.μm)
IR 1.6	VNIR Core Imager	1.64	1.50 to 1.78	0.07 at 0.75 W/(m^2.sr.μm)
IR 3.9	IR / Window Core Imager	3.92	3.48 to 4.36	0.17 K at 300 K
WV 6.2	Water Vapour Core Imager	6.25	5.35 to 7.15	0.21 K at 250 K
WV 7.3	Water Vapour Pseudo-Sounding	7.35	6.85 to 7.85	0.12 K at 250 K
IR 8.7	IR / Window Core Imager	8.70	8.30 to 9.10	0.10 K at 300 K
IR 9.7	IR / Ozone Pseudo-sounding	9.66	9.38 to 9.94	0.29 K at 255 K
IR 10.8	IR / Window Core Imager	10.80	9.80 to 11.80	0.11 K at 300 K
IR 12.0	IR / Window Core Imager	12.00	11.00 to 13.00	0.15 K at 300 K
IR 13.4	IR / Carbon Diox. Pseudo-Sounding	13.40	12.40 to 14.40	0.37 K at 270 K

The Geostationary Earth Radiation Budget (GERB) experiment

The GERB payload is a scanning radiometer with two broadband channels, one covering the solar spectrum, the other covering the entire electromagnetic spectrum. Data will be calibrated onboard the satellite to support the retrieval of radiative fluxes of reflected solar radiation and emitted thermal radiation at the top of the atmosphere with an accuracy of 1%.

The Geostationary Search and Rescue (GEOSAR) relay mission

The satellite carries a small communications payload to relay distress signals from 406 MHz beacons to a central reception station in Europe, which will pass the signals on for the rapid organisation of rescue activities. GEOSAR will thereby allow continuous monitoring of the Earth's disc and hence the issuing of immediate alerts.