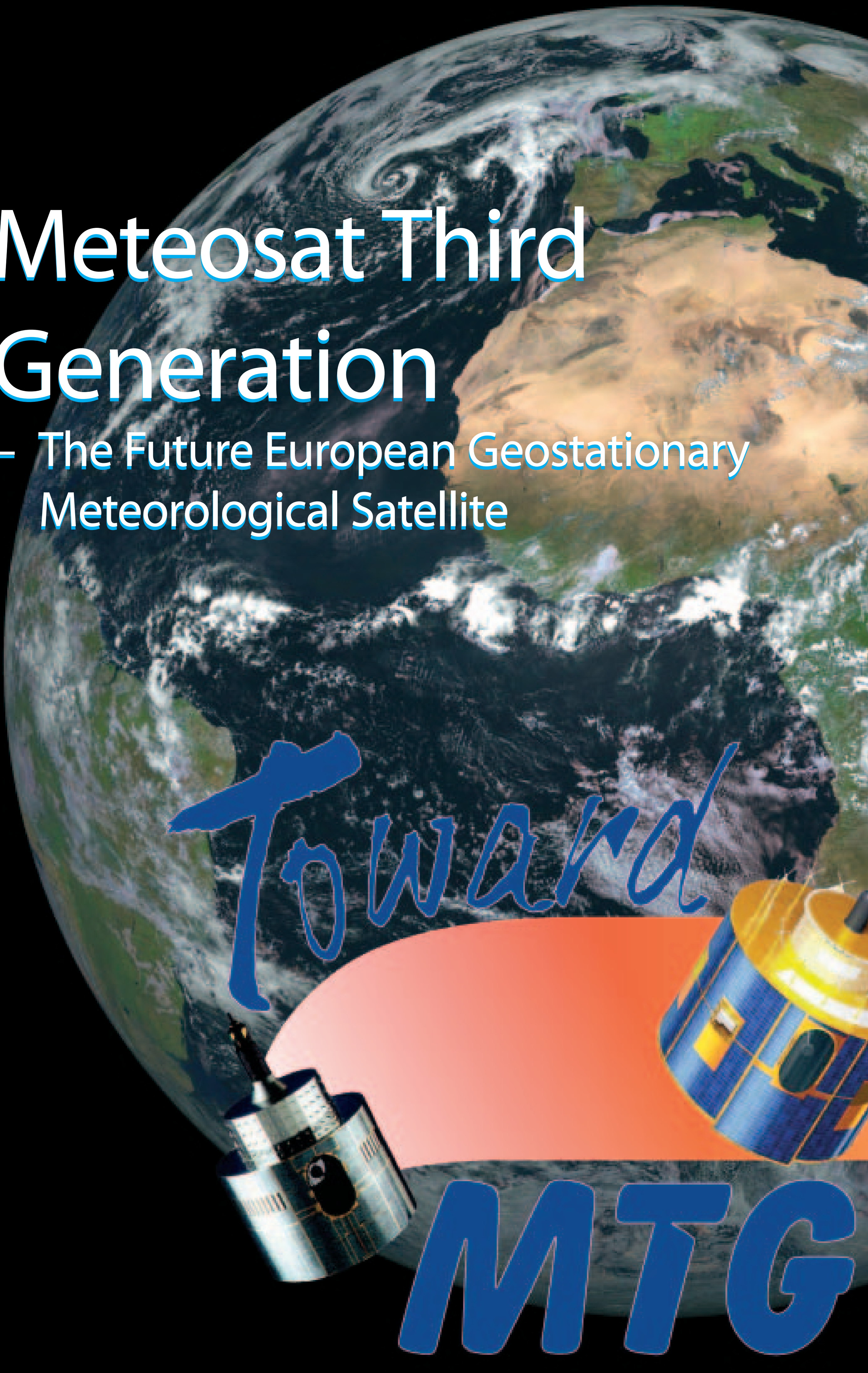
Meteosat Third Generation

– The Future European Geostationary Meteorological Satellite



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Today, the Meteosat geostationary meteorological satellites play a key role in providing continuous atmospheric observations both for weather forecasting and for monitoring a wide variety of environmental phenomena. Following the successful commissioning of the first satellite in the Meteosat Second Generation (MSG) series, Eumetsat and ESA are already actively planning the next European operational geostationary meteorological satellite system in the form of the Meteosat Third Generation (MTG). Being considered for launch in 2015, MTG will revolutionise weather forecasting and environmental monitoring as we now know them, by providing a very significant improvement over the capabilities of the current Meteosats.

The second generation of Meteosat satellites is expected to provide operational services at least until 2015. However, when one considers the time needed for the definition phases of new space systems, their typical development cycles, and the approval process for such complex programmes, it is already time to start planning for follow-up geostationary missions.

Some time ago, therefore, Eumetsat established a User Consultation Process aimed at capturing the foreseeable high-level user/service needs and priorities of its customers for the 2015 – 2025 time frame. This process has led to a preliminary definition of objectives for the European MTG geostationary satellite system, which currently consists of a total of five candidate observation missions selected for feasibility studies at system level under ESA contract.

The overall mission will be implemented using the same ESA/Eumetsat cooperation scheme that has been successfully exploited for both the MSG and MetOp satellite series. ESA will be the development and funding agency for both the basic technologies and the first satellite of the MTG system, and will also be the overall procurement agent for all MTG satellites. Eumetsat will define the requirements for each mission and be responsible for the overall programme. Eumetsat will also fund and develop the ground segment, as well as all operations and follow-on satellites.

The Candidate Observation Missions

Following the consolidation of user requirements and assessment of observing techniques, five candidate observation missions for MTG were proposed:

- Three distinct imaging missions dedicated to operational meteorology, with the emphasis on 'nowcasting' and very-short-term forecasting:
  - a High-Resolution Fast Imagery (HRFI) mission, based on enhancement of the MSG High-Resolution Imagery mission
  - a Full-Disk High-Spectral-resolution Imagery (FDHSI) mission, as the successor to the MSG SEVIRI instrument
  - a Lightning Imagery (LI) mission.

- Two atmospheric-sounding missions:
  - an Infrared Sounding (IRS) mission focusing on operational meteorology, with potential relevance to atmospheric chemistry applications
  - a UV/Visible Sounding (UVS) mission dedicated to atmospheric chemistry.

Complementing the observational missions, the MTG Programme will also support:

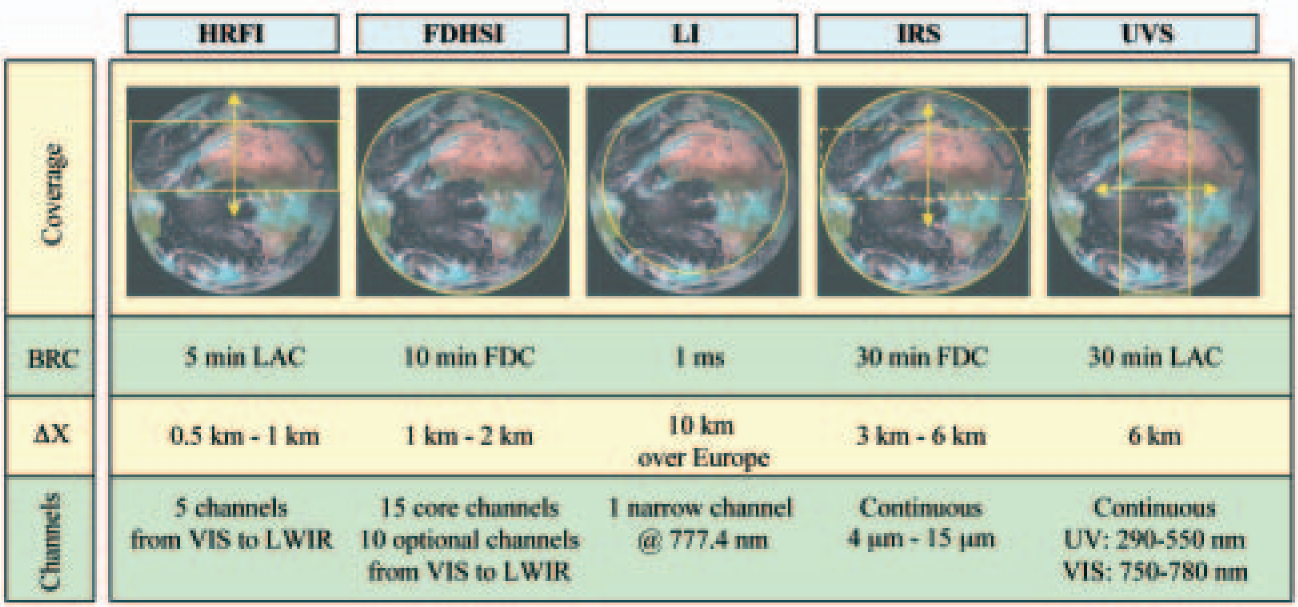
- a data-collection mission
- a Level-2 product-extraction mission
- an external data-collection mission.

High-Resolution Fast Imagery mission

The HRFI mission expands the MSG High Resolution Visible (HRV) mission in the spectral domain. The emphasis is on high temporal (5 min) and spatial (0.5 - 1.0 km) resolution requirements, for a limited number (five) of spectral channels. The coverage is limited to selectable fractions of the full Earth disk, with a coverage equivalent to one-third of the full disk (18º E/W x 6º N/S) referred to as Local Area Coverage (LAC). The LAC can be variably placed over the Earth.

The main objective of the HRFI mission is to support nowcasting and very-short-range forecasting of convection, and its relationship to the 'fast' component of the hydrological cycle. This will be achieved through observations of cloud patterns, their horizontal movement, the vertical

Main characteristics of the MTG observation mission



BRC: Baseline Repeat Cycle FDC: Full Disk Coverage LAC: Local Area Coverage (18° x 6°) ΔX: Spatial resolution UV: ultraviolet VIS: visible LWIR: longwave infrared development of clouds, and the micro-physical properties at cloud top. A second objective of the HRFI mission is to complement the MTG Full-Disk High-Spectral-resolution Imagery and the Infrared Sounding missions, by providing more detailed, 'targeted' observations over selected regions where active weather patterns are developing.

Full-Disk High-Spectral-resolution Imagery mission

The FDHSI mission is an evolution of the MSG SEVIRI full-disk mission, featuring high radiometric performances in a larger number of spectral channels and full Earth-disk coverage. It is also more demanding on temporal and spatial resolution than the MSG SEVIRI mission, and has a core set of 15 channels and 10 optional channels located in the visible and infrared parts of the spectrum. The main objectives are to support:

- nowcasting and very-short-term fore-casting
- Numerical Weather Prediction at regional and global scales
- climate monitoring.

The FDHSI mission will cover the full Earth's disk, with a 10 minute repeat cycle and a 1 to 2 km spatial resolution for the solar and infrared channels, respectively.

A single multi-channel imager operated in an optimised sequence of full-disk and LAC coverage will support both the FDHSI and HRFI missions.

Lightning Imagery mission

The LI mission is designed for the continuous mapping, day and night, of lightning discharges into a geostationary orbit. Detection on a geostationary Earth-disk basis and real-time observation of the total lightning-flash activity represent valuable improvements for all operational applications. The sensor will be capable of detecting all forms of lightning with a high spatial resolution and detection efficiency. Since the data will be distributed in real time, it will be an invaluable tool to aid weather forecasters in detecting severe storms in time to give advance warning to the public. The LI mission will also support atmospheric-chemistry applications, as lightning plays a significant role in generating nitrous oxides. The natural nitrous-oxide budget is currently a matter of great uncertainty, and long-term observations of one of its sources will prove valuable as the research develops.

The observation technique selected is based on the detection of the strongest lightning emission feature within the cloud-top optical spectra produced by the neutral oxygen line at 777.4 nm.

Infrared Sounding mission

The primary objective of the IRS mission is to support Numerical Weather Prediction (NWP) on regional and global scales, through the provision of:

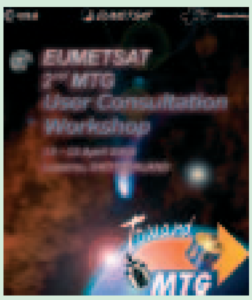
- Atmospheric Motion Vectors (AMV) with higher vertical resolution in clear air, to be extracted from the tracking of three-dimensional water-vapour patterns
- more frequent information on temperature and water-vapour profiles.

The full-disk AMV capability has the highest priority for global NWP, as this geostationary observing technique is unique for the extraction of three-dimensional wind fields in clear air. Infrared soundings with high vertical, horizontal, vertical/spectral resolution and temporal sampling of a fraction of an hour will also greatly enhance the National Meteorological Services' (NMS) ability to initialise regional NWP models with more realistic information on temperature and moisture. The high temporal frequency achieved from geostationary orbit will increase the likelihood of getting clear-sky soundings over dynamically important regions such as the North Atlantic. This will enable regional and global NWP models to better identify areas of rapidly developing atmospheric instability responsible for vertical motion, convection, and precipitation development.

Current MTG Status

Meteosat Third Generation is an Eumetsat/ESA collaborative mission with the first satellite planned for launch in 2015. MTG preparatory activities started at the end of 2000, following the decision by Eumetsat's Council to proceed with a Post-MSG User Consultation Process. A joint work plan between ESA and Eumetsat has been established to consolidate the mission requirements and demonstrate the mission's feasibility.

The Eumetsat-led process aiming at capturing the needs of users for the 2015-2025 timeframe has been completed and presented at the first User Consultation Workshop in November 2001. Five candidate observation missions resulted from the user-consultation initiative. High priority has been given to the continuation of the MSG imagery missions, but with significantly improved performance. Lightning imagery and atmospheric sounding will complete the MTG mission and offer the operational meteorology community an outstanding tool for weather forecasting.



Since September 2004, the MTG mission has been the subject of two parallel ESA system studies led by Alcatel Space and EADS Astrium GmbH, respectively. The preliminary findings have been presented at the second User Consultation Workshop in April 2005.

The secondary objective of the IRS mission is to support, together with the UV/Visible Sounding mission, chemical weather and air-quality applications. IRS will provide dramatic improvements over current sounder data and products, including better spectral resolution, faster geographical coverage, and improved spatial resolution.

A high-spectral-resolution infrared spectrometer has been selected as the most efficient instrument to fulfil the mission requirements. Two possible concepts, namely a Fourier Transform Spectrometer and a Dispersive Spectrometer, are currently under investigation.

UV/Visible Sounding mission

Long-term observations have shown that the composition of the Earth's atmosphere is changing. A human influence is clearly discernible and in some cases firmly established. The change in atmospheric composition induces changes in climate, UV exposure and air quality. It therefore has important, often adverse, consequences for human health and safety, eco-system balance and socio-economic conditions. To understand, predict and control environ-mental change is one of the main challenges of the 21st century.

UV/Visible Sounding measurements could contribute substantially in these areas, and thus support the following primary applications:

– air-quality monitoring and forecasting
– detection and surveillance of unpredictable pollution clouds and plumes
– control of air-polluting emissions
– UV radiation monitoring and forecasting
– numerical modelling and weather forecasting.

Mission Implementation

Candidate system concepts for the implementation of the MTG mission are being defined and assessed in the framework of two parallel MTG System Architecture Studies, carried out by industrial consortia led by Alcatel Space and EADS Astrium GmbH.

The dramatic improvement in performance compared with the previous generations of Meteosat is made possible by the use of a three-axis-stabilised rather than a spin-stabilised platform, allowing a much higher duty cycle for observing the Earth.

To minimise the risks inherent in the development of the payload complement, and also to allow a flexible approach to the MTG system's operational deployment, two satellites supporting the imagery and the sounding missions, respectively, are being considered. The high availability required for the provision of operational meteorological satellite services implies the need for backup satellites in orbit. The MTG mission lifetime of 15 years will therefore require up to 8 satellites (4 nominal and 4 backup), each with a lifetime of 7.5 years.

Besides the definition of the system concepts, the ongoing studies will produce initial estimates of the overall system development costs and assess the critical technologies requiring specific pre-developments. The results of the studies will be jointly used by ESA and Eumetsat to consolidate the MTG mission and technical requirements at the MTG Mission Definition Review to take place in the first quarter of 2006. The selected concepts and the relevant requirements will then be used as inputs for the detailed feasibility studies at Phase-A level to be initiated in late 2006.

Planning Timeline

Based upon Eumetsat maintaining an 'in-orbit backup satellite' philosophy and hence MTG-1 replacing MSG-3, then with a nominal lifetime of 7 years for each MSG satellite, the first component of the MTG space segment needs to be launch-ready in 2015.

Eumetsat and ESA are conducting joint preparatory activities for the definition of the MTG mission, with the following planning assumptions for feasibility studies, design and development:

• 2004-2005

Pre-Phase-A studies conducted with ESA based upon the high-level user needs and priorities established in 2000-2003 through the post-MSG user consultation process.

• 2006-2007

MTG Phase-A studies for selected mission concepts, with approval processes for coordinated ESA and Eumetsat MTG preparatory programmes.

• 2008-2009

Phase-B activities under coordinated Eumetsat and ESA Preparatory Programmes, with approval processes for coordinated MTG development programmes.

• 2009-2014

Development and on-ground testing of the MTG system. r