

MSG's SEVIRI Instrument

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The MSG satellite's main payload is the optical imaging radiometer, the so-called Spinning Enhanced Visible and Infrared Imager (SEVIRI). With its 12 spectral channels, SEVIRI will provide 20 times more information than the current Meteosat satellites, offering new and, in some cases, unique capabilities for cloud imaging and tracking, fog detection, measurement of the Earth-surface and cloud-top temperatures, tracking of ozone patterns, as well as many other improved measurements. The SEVIRI instrument has been manufactured by European industry under the leadership of Astrium SAS in Toulouse, France.

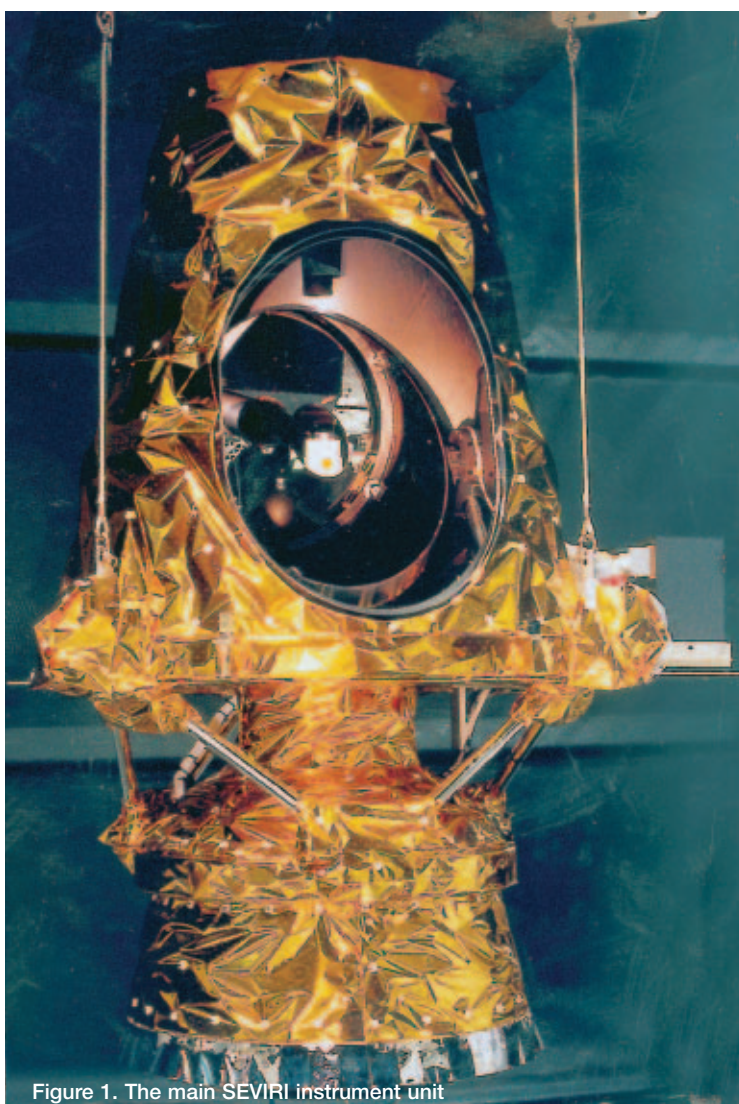


Figure 1. The main SEVIRI instrument unit

The instrument design

SEVIRI is a 50 cm-diameter aperture, line-by-line scanning radiometer, which provides image data in four Visible and Near-Infrared (VNIR) channels and eight Infrared (IR) channels. A key feature of this imaging instrument (Fig. 1) is its continuous imaging of the Earth in 12 spectral channels with a baseline repeat cycle of 15 min. The imaging sampling distance is 3 km at the sub-satellite point for standard channels, and down to 1 km for the High Resolution Visible (HRV) channel. The main characteristics of the instrument are summarised in Table 1.

The SEVIRI instrument is composed of a Telescope and Scan Assembly (TSA), a Focal Plane and Cooler Assembly (FPCA), and an Electronic Unit Assembly (EUA) (Figs. 2 & 3). The EUA, which controls SEVIRI and processes its data, consists of three electronics boxes located on the satellite main platform, namely the Functional Control Unit (FCU) and the Detection Electronics (DE), consisting of the Main Detection Unit (MDU) and the Preamplifier

Table 1. SEVIRI instrument characteristics

Spectral range:

- 0.4 – 1.6 μm (4 visible/NIR channels)
- 3.9 – 13.4 μm (8 IR channels)

Resolution from 35 800 km altitude:

- 1 km for the high-resolution visible channel
- 3 km for the infra-red and the 3 other visible channels

Focal plane cooled to 85/95 K

One image every 15 min

245 000 images over 7 yr nominal lifetime

Instrument mass: 260 kg

Dimensions:

- 2.43 m high
- 1 m diameter without Sun Shield

Power consumption: 150 W

Data rate: 3.26 Mbit/s

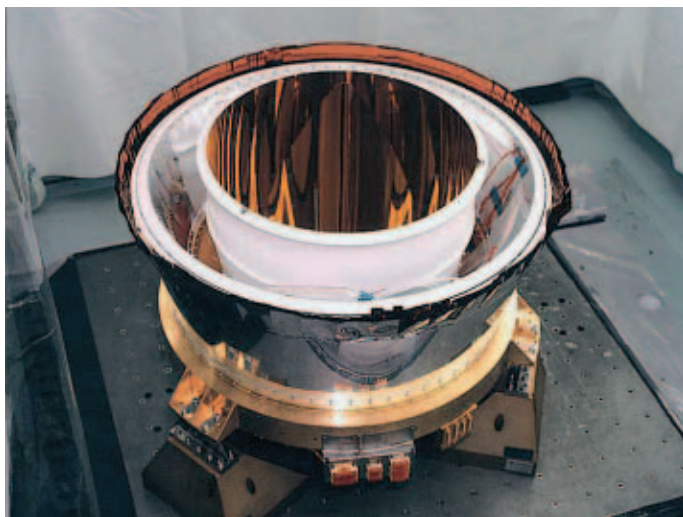


Figure 2. The SEVIRI radiator assembly

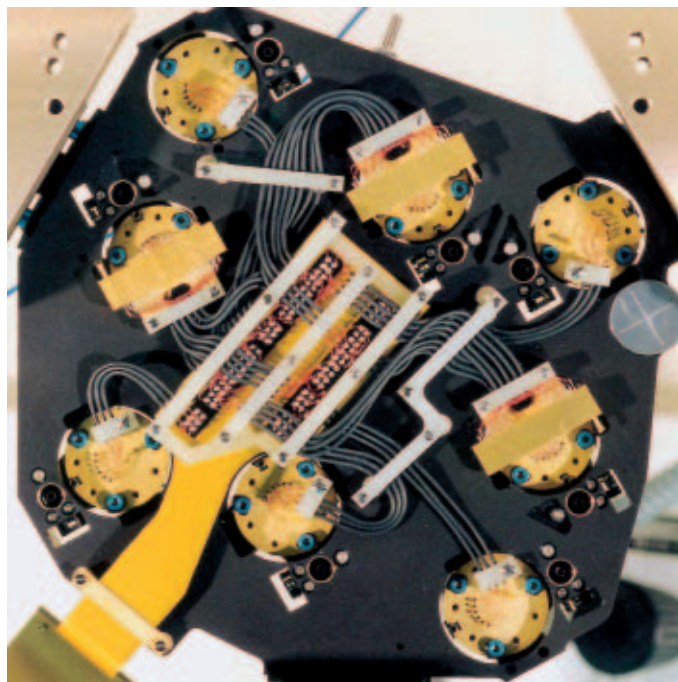


Figure 3. The SEVIRI cold-IR Optical Bench

Unit (PU). The FCU is responsible for SEVIRI's command and control, and it interfaces with the spacecraft's onboard data-handling subsystem.

The 12 SEVIRI channels consist of 8 InfraRed (IR) detector packages (3 detectors each), and 1 High Resolution in the Visible (HRV) channel (9 detectors), 2 Visible and 1 Near-IR (3 detectors each). The IR detectors are all made of mercury cadmium telluride, the visible detectors are in silicon and the NIR detectors

are made from indium-doped gallium arsenide. The detectors are shaped and sized to satisfy both the radiometric and imaging performances required by the end users.

The operating principle

The scanning mirror is used to move the instrument line-of-sight (LOS) in the south-north direction. The target radiance is collected by the telescope and focused onto the detectors. Channel separation is performed at telescope focal-plane level, by means of folding mirrors. A flip-flop type mechanism is periodically actuated to place the IR calibration reference source in the instrument's field of view. The image data are directly transferred from the Main Detection Unit (MDU) to the onboard data-handling subsystem. The FCU controls the SEVIRI functions and provides the telemetry and telecommand interfaces with the satellite.

The Earth imaging is achieved by means of a bi-dimensional Earth scan, relying on the spacecraft's spin and the scanning mirror, as shown in Figure 4. The rapid scan (line scan) is performed from east to west thanks to the spacecraft's rotation around its spin axis (spin rate 100 rpm). The spin axis is perpendicular to the orbital plane and is nominally oriented in the south-north direction. The slow scan is performed from south to north by means of a scanning mechanism, which rotates the scan mirror in steps of 125.8 microradians. A total scan range of $\pm 5.5^\circ$ (corresponding to 1527 scanning lines) is used to cover the 22° Earth imaging range in the south-north direction, and 1249 scan lines to cover the whole Earth in the baseline repeat cycle.

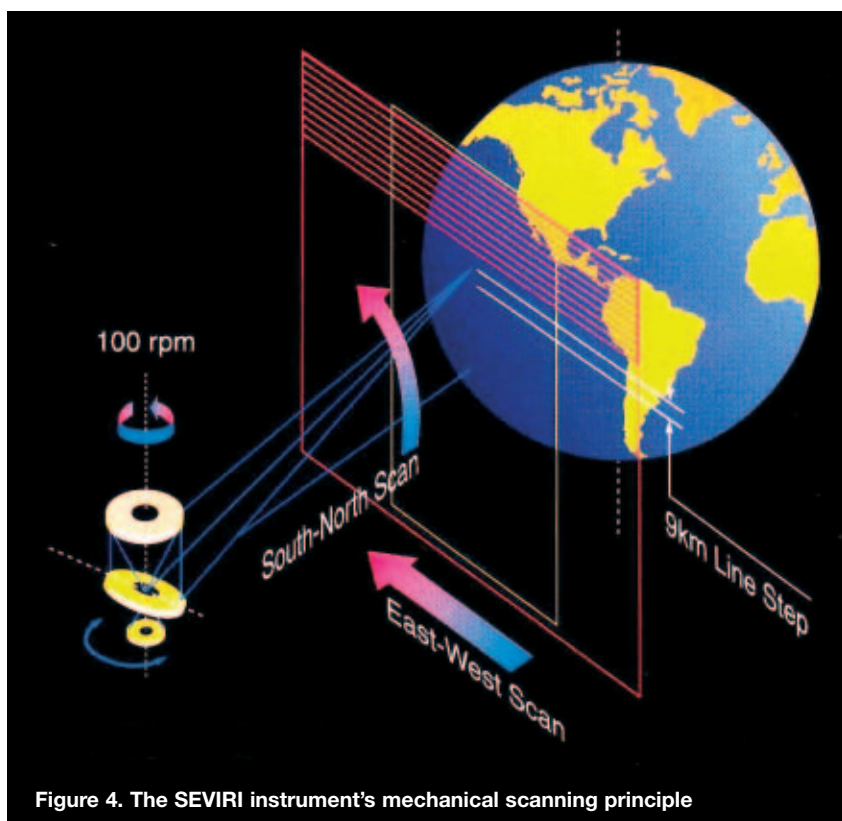


Figure 4. The SEVIRI instrument's mechanical scanning principle

The full Earth's disc image is obtained in about 12 min. The scanning mirror is then driven back to its initial position and the flip-flop mechanism is activated to insert the black body onboard the spacecraft into the optical path for the instrument calibration. The black body is removed from the calibration position after about 2 sec and Earth observation is resumed, leading to an overall repeat cycle of 15 min.

Performance verification

Radiometric performance

Characterisation of the SEVIRI instrument's radiometric performance centres on the determination of such parameters as the radiance response and its associated non-linearities, validation of the on-board calibration process, and the measurement of radiometric noise and drift. Constant and uniform targets are employed, as specified at system level.

The image data mean value (corresponding to one line) consists of samples coded over 10 bits, ranging from 0 to 1023. This results in up to 5751 samples for each HRV chain and 3834 samples for each of the other detection chains. A set of data is defined as the concatenation of the data lines corresponding to several consecutive Earth-acquisition windows, and corresponding to the same configuration (i.e. same illumination level and same detection-chain parameter settings). For all of the radiometric test results (spectral response, radiance response and noise), there are negligible differences between the operational temperatures of the IR focal plane at 85 K and 95 K. The MSG-1 environmental tests indicated that SEVIRI IR calibration is needed in the worst case once per nine images.

Imaging performance

Two major imaging-characteristic tests have been performed at SEVIRI and satellite level, addressing:

- the geometric imaging: checks were performed mostly in the ambient environment to determine the stability of SEVIRI's line of sight before and after environmental testing (e.g. thermal-vacuum and vibration)
- the Spatial Frequency Response (SFR): Modulation Transfer Function (MTF), sampling-distance and co-registration tests were performed in thermal vacuum.

The Central Line Of Sight (CLOS) instability due to thermo-elastic distortion of the radiometer is the most important contributor to geometric imaging errors. It was measured in vacuum for two extreme telescope temperatures during SEVIRI's thermal-vacuum testing. These

measurements were used for instrument geometric performance verification whilst validating the thermo-elastic model. The results have shown the SEVIRI instrument to be stable in terms of both its line of sight and its overall geometric parameters.

The two-fold objectives of the SFR determination were to provide:

- on-ground characterisation allowing the SEVIRI Radiometer/Imager MTF to be determined
- on-ground measurements for the verification and characterisation of the SEVIRI co-registration error (including its internal IFOV sampling accuracy, i.e. pixel positions).

All of the MTF data were within specification, with sufficient margins to accommodate measurement errors and focus evolution during the instrument's in-orbit lifetime. HRV is the most sensitive channel, but with a defocussing of up to 2.8 mm it still meets the specifications. The instrument's stability has been fully demonstrated for all specified environments.

Conclusion

This article has described the SEVIRI instrument's design and the environmental testing approach applied to assess the flight model's performance for the MSG-1 satellite. The tests that have been performed have shown that the instrument meets the performance requirements for all specified environments and is therefore fully flight-qualified.

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