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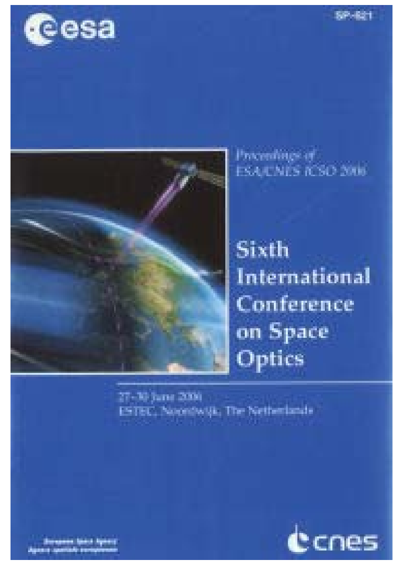

Meteosat third generation: preliminary imagery and sounding mission concepts and performances

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METEOSAT THIRD GENERATION: PRELIMINARY IMAGERY AND SOUNDING MISSION CONCEPTS AND PERFORMANCES

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ABSTRACT

The operational deployment of MSG-1 at the beginning of 2004, the first of a series of four Meteosat Second Generation (MSG) satellites, marks the start of a new era in Europe for the meteorological observations from the geostationary orbit[(1)]. This new system shall be the backbone of the European operational meteorological services up to at least 2015. The time required for the definition and the development of new space systems as well as the approval process of such complex programs implies to plan well ahead for the future missions.
EUMETSAT have initiated in 2001, with ESA support, a User Consultation Process aiming at preparing for a future operational geostationary meteorological satellite system in the post-MSG era, named Meteosat Third Generation (MTG). The first phase of the User Consultation Process was devoted to the definition and consolidation of end user requirements and priorities in the field of Nowcasting and Very Short Term Weather Forecasting (NWC), Medium/Short Range global and regional Numerical Weather Prediction (NWP), Climate and Air Composition Monitoring and to the definition of the relevant observation techniques. The following missions have been analysed and preliminary concepts studied:

- High Resolution Fast Imagery Mission (successor to MSG SEVIRI HRV mission), aiming at 2 - 5 minutes revisit time with 0.5 km resolution;
- Full Disk High Spectral Resolution Imagery Mission (successor to the mission of other MSG-SEVIRI channels), with a large number of spectral channels and with high radiometric performance aiming for less than 10 minutes repeat cycle for full Earth disc coverage;
- Lightning Imagery Mission, capable of detecting very low energy events with high reliability;
- IR Sounding Mission, supporting NWP through the provision of atmospheric motion vectors, temperature and water vapour profiles;
- UV-VIS-NIR Sounding Mission dedicated to atmospheric chemistry.

After an initial post-MSG mission study (2003-2004) where preliminary instrument concepts were investigated allowing in the same time to consolidate the technical requirements for the overall system study, a MTG pre-phase A study has been performed for the overall system concept, architecture and programmatic aspects during 2004-2005 time frame.

This paper provides an overview of the outcome of the MTG sensor concept studies conducted in the frame of the pre-phase A. It namely focuses onto the Imaging and Sounding Missions, highlights the resulting instrument concepts, establishes the critical technologies and introduces the study steps towards the implementation of the MTG development programme.

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1. MTG MISSION DEFINITIONS AND ASSUMPTIONS

The MTG user requirements have been discussed extensively elsewhere[2, 3]. As far as the imaging missions are concerned, the user needs for the imagery are three-fold:

- The Full Disk High Spectral resolution Imagery (FDHSI) mission;
- The High Resolution Fast Imagery (HRFI) mission;
- The Lightning Imagery (LI) mission;

As far as the sounding is concerned, the users have defined two missions:

- The Infrared Sounding (IRS) mission focused on operational meteorology, with some relevance to atmospheric chemistry;
- The UV/Visible sounding (UVS) mission dedicated to atmospheric chemistry.

The overall requirements of those missions are summarized in table 1.

The user requirements led to very ambitious mission requirements and thereby to demanding system concepts. EUMETSAT in coordination with ESA and industry recommendations, has established priorities vis-à-vis of the overall mission. The highest priority is for the imaging missions (HRFI + FDHSI), which provide enhanced continuity to the MSG mission and must be ready in 2015. The infrared sounding mission and the lightning imagery mission are the second priority. The UVS sounding mission has the lowest priority. As a matter of fact, at the end of the pre-phase A study, it has been decided to reduce the mission size which led to the de-scoping of both LI and UVS missions. The UVS mission may be reconsidered in the frame of GMES sentinel 4/5. With the aim of a first MTG-I launch compatible to year 2015, four satellite-series for each mission should be able to fully meet the 15 years lifetime required with a margin of 5 years as depicted in the MTG deployment in Figure 1 here after, where MTG-I stands for the Imagery mission and MTG-S for the Sounding mission. A single spacecraft carrying all the missions has also been considered but the results have shown that such a system would not be compatible to a launch date of 2015, thus endangering the first priority imagery mission continuity with 95% availability rating.

After the studies[3, 4] on the various concepts initiated by ESA and ran by two industrial consortia (headed by Alcatel Space Industries in France and Astrium GmbH in Germany), the results of the discussions with EUMETSAT and the end users[2] led to the decision of implementing a single instrument for the 2 imagery missions. This is justified by the commonality of the 2 imagery missions (HRFI and FDHSI) for which a common front telescope with a pupil of 300 mm (diffraction limited) and 2-axes scanning mirror are used. In addition, an on-board blackbody planned for the FDHSI can be used also for the HRFI and all the HRFI channels are included in the FDHSI but with narrower bandwidth. Furthermore, the HRFI and FDHSI instruments feature similar technical concept with comparable volume and mass. The so-called Combined Imager (CI) would be programmable for shorter repeat cycle on smaller area coverage. In such a way, the CI will be operated in an exclusive way to satisfy one of the two imagery missions at a time. With 2 satellites in hot redundancy, both the Local Area Coverage (LAC) and the full disc coverage will be met.

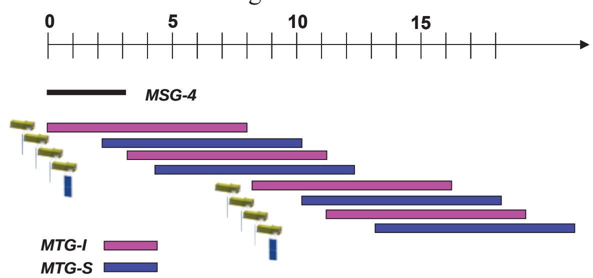


Figure 1: MTG deployment in the two- satellite type implementation (MTG-I and MTG-S).

For what concerned the IR Sounding mission, the 2 concepts consisting of a Dispersive Spectrometer (DS) and a Fourier Transform Spectrometer (FTS) have been analyzed.

The UVS and LI missions (being of the lowest priority) have been put off the MTG for the time being (pre-phase A study) and will not be discussed in this paper.

2. IMAGERY MISSIONS: Preliminary concepts and Performances

The HRFI mission will be a high spatial and temporal resolution imagery application with 5 broad-band spectral channels; the spatial sampling distance of 500 m in the short wavebands and 1 km in the long wavebands for a repeat cycle of 5 minutes or less, with possible rapid access to any part of the Earth disk for monitoring of small scale phenomena.

The FDHSI mission will include a total of 15 core channels from the blue range to the Long Wave Infra-Red. The spatial sampling distance is 1 km for short wavelengths and 2 km for long wavelengths for a repeat cycle lower or equal to 10 minutes. Significant enhancements are requested in the number of channels and radiometric performances if compared to MSG satellite series [1, 3]. The main objective is to provide systematic Earth coverage over the specified repeat cycle.

Supported by the first post-MSG trade-off completed in March 2004, the assumptions taken for this paper are all based on a 3-axes stabilized satellite [3, 4].

The Full Disk High Spectral Imagery (FDHSI) mission is an evolution of the MSG SEVIRI full disk mission [1], featuring high radiometric performances in a larger number of spectral channels from the visible up to the thermal infrared and full Earth disk coverage. It is also more demanding on temporal (10 minutes) and spatial (SSD=1 - 2 km) sampling distance than the MSG SEVIRI mission. The FDHSI mission is composed of a core set of 15-channel and three optional sets of channels located in the visible (FD-OPT 1, FD-OPT3) and infrared (FD-OPT 2) parts of the spectrum.

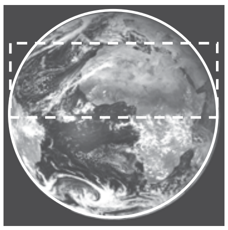
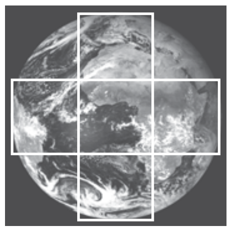
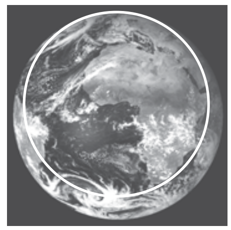
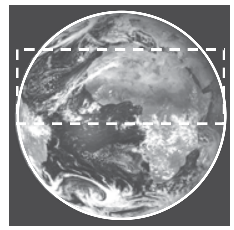
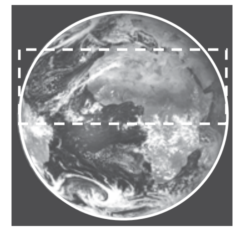
	FDHSI (CI)	HRFI (CI)	LI	IRS	UVS
Coverage					
BRC	FDC: 10 min LAC: ~ 10/3 min	18ºx6º: < 5 min	~ 10^{-3} sec	FDC: 30 min LAC: 10 min	FDC: 60 min LAC: 20 min
λ	15 core channels 8 optional channels	5 channels	OI line at 774.4 nm	4 µm – 15 µm	UV: 290-550 nm O_2-A: 750-780 nm SWIR: 2310-2440 nm
SSD	VNIR-SWIR: 1 km MWIR-TIR: 2 km	VNIR-SWIR: 0.5 km MWIR-TIR: 1 km	8 km	4 µm – 8.3 µm: 3 km 8.3 µm – 15 µm: 6 km	6 km

Table 1: Summary of MTG Observation Missions:
BRC: Baseline Repeat Cycle (FDC: Full Disk Coverage – LAC: Local Area Coverage (dashed line))
λ: Spectral channels / spectral range - SSD: Spatial Sampling Distance at SSP.

In the nominal imaging mode, the FDHSI covers the full Earth disk with a 10 minutes repeat cycle (table 1). A reduced scan mode is also proposed with a coverage equivalent to 1/3 of the full disk (18º E/W x 6º N/S) referred to as Local Area Coverage (LAC) at a shorter repeat cycle. The LAC can be variably placed anywhere over the Earth (operational issues).

The core and optional spectral channels of the CI mission are listed in Table 2, 3 and 4 respectively. The FD-OPT 1 channels are dedicated to cloud top height determination by differential absorption in the oxygen A-Band. The FD-OPT 2 mission would be necessary on top of the Infrared Sounding mission for height assignment by CO_2-slicing in the 14µm CO_2 band at high repeat cycle. The FD-OPT3 will be dedicated to improved aerosol detection and true colour imagery.

In addition, some core channels are sized for fire detection applications. Those are namely FD-IR3.8 with its top dynamic range being 450 K and FD-IR8.5 with its top dynamic range being at 400 K, with no saturations.

The imaging principle is based on a fast continuous scan performed from East to West and West to East alternatively and a step like scan in the NS direction to complete the Earth acquisition. The EW and NS scans are performed with a single mirror on a 2-axes gimbaled mount. The spectral channels are in-field and beam splitter separated. A field de-rotator may be implemented within the telescope to compensate for the image rotation (an effort is being made to avoid such a mechanical de-rotator). The imager cooling is driven by the performance of the LWIR channels, especially the CO_2 14µm channels. The infrared detectors are cooled down to 50 - 55 K with active cryo-coolers. Figure 2

Core channels	Central wavelength µm	Width µm	Minimum Signal	Maximum Signal	Reference Signal	SNR/NEDT at Reference signal	Spatial Sampling Distance
FD-VIS 0.4	0.470	0.02	1%	120%	1%	25	1 km
FD-VIS 0.6	0.645	0.05	1%	120%	1%	25	0.5 km
FD-VIS 0.8	0.865	0.04	1%	120%	1%	30	1 km
FD-NIR 1.3	1.375	0.03	1%	100%	1%	40	1 km
FD-NIR 1.6	1.61	0.06	1%	100%	1%	40	1 km
FD-NIR 2.1	2.13	0.05	1%	100%	1%	25	0.5 km
FD-IR 3.8	3.8	0.30	165 K	400 K	300 K	0.1 K	0.5 km
FD-IR 6.7	6.7	0.40	165 K	270 K	250 K	0.3 K	2 km
FD-IR 7.3	7.35	0.30	165 K	285 K	250 K	0.3 K	1 km
FD-IR 8.5	8.55	0.30	165 K	330 K	300 K	0.1 K	2 km
FD-IR 9.7	9.70	0.30	165 K	310 K	250 K	0.3 K	2 km
FD-IR 10.8	10.8	0.50	165 K	340 K	300 K	0.1 K	1 km
FD-IR 12.0	12.0	0.70	165 K	340 K	300 K	0.1 K	2 km
FD-IR 13.0$^+$	13.08	0.40	165 K	300 K	270 K	0.2 K	2 km
FD-IR 13.9$^+$	13.91	0.40	165 K	290 K	250 K	0.2 K	2 km

Table 2: CI Spectral Core Channels; (+) Channels FD-IR 13.0/ FD-IR 13.9 will be discarded if the 14µm CO_2 band optional channels (OPT 2) are selected.

OPT 1 channels	Central wavelength µm	Width µm	Minimum Signal $Wm^{-2}sr^{-1}\mu m^{-1}$	Maximum Signal $Wm^{-2}sr^{-1}\mu m^{-1}$	Reference Signal $Wm^{-2}sr^{-1}\mu m^{-1}$	SNR at Reference signal	Spatial Sampling Distance
FD-OPT 1-1	0.755	0.005	5	100	380	100	1 km
FD-OPT 1-2	0.761	0.003	5	100	380	100	1 km
FD-OPT 1-3	0.764	0.006	5	100	380	100	1 km
FD-OPT 1-4	0.775	0.005	5	100	380	100	1 km

Table 3: FDHSI oxygen A-Band optional channels. SNR computation over 2x2 km^2

OPT 2 channels	Central wavelength µm	Width µm	Minimum Signal	Maximum Signal	Reference Signal	NEdT at Reference signal	Spatial Sampling Distance
FD-OPT 2-1	13.03	0.3	165 K	300 K	270 K	0.3 K	2 km
FD-OPT 2-2	13.33	0.3	165 K	300 K	250 K	0.3 K	2 km
FD-OPT 2-3	13.66	0.3	165 K	300 K	250 K	0.3 K	2 km
FD-OPT 2-1	14.07	0.3	165 K	300 K	250 K	0.3 K	2 km

Table 4: FDHSI 14µm CO_2 band optional channels

illustrates the scanning principle and a potential optical layout of the CI imager.

The proposed common telescope provides a circular unobstructed 300 mm entrance pupil diameter for an f/12 F-number, delivering 100µm/km scaled at focal plane level. The orientation of the telescope is optimized to prevent direct solar entry into the instrument and with reduced stray light impact. With such a design optimization, the instrument radiometric performances are reached leading to a simpler and compact design allowing a scanning profile independent of the scan mirror position. The channels' separation is based on a combination of in-field separation along East/West direction and spectral separation using dichroic beam splitters.

For what concerns the image geometric quality, the requirements include a MTF template, similar for both HRFI and FDHSI missions. This template calls simultaneously for a high MTF below the Nyquist frequency and for a low MTF above that frequency (aliasing rejection). For that, the focal plane concept consists of having a detector array for each channel. Several optical benches will support these arrays. Else, the trade-off's have demonstrated that the CMOS technology seems to be the most appropriate candidate because of the large number of required detector elements.

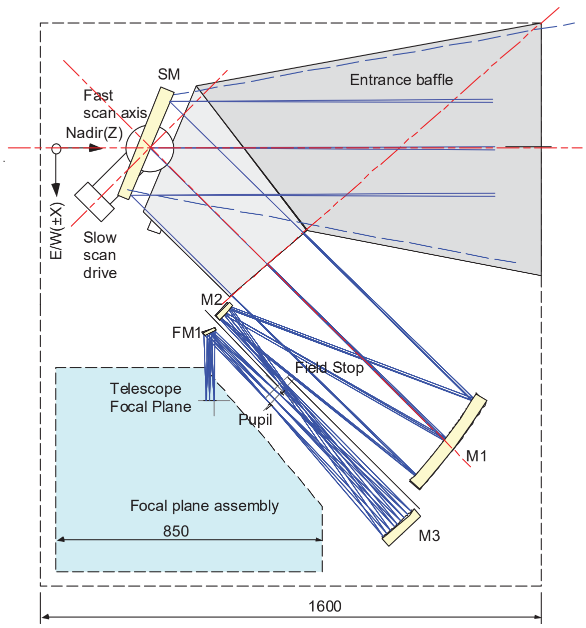


Figure 2: Combined Imager potential optical concept

The along South/North detector elements number is determined by the sizing of the radiometric performances. Trade-off's between over-sampling using staggered configuration (more pixel in the East/West direction) with digital filtering or the use of rhomboid shaped detectors to meet the geometric quality is still on-going. In both cases, the detector sensitive area shape and size are optimized to meet the MTF templates specified without penalizing the radiometric performances. The 2 concepts will be probably kept alive till the next phase of the MTG design. The digital filtering gives favorable ability for the MTF shape of the FDHSI applications. The channels are grouped to optimize detector arrays (similar cut-off), enhance the registration by putting detector packages together. In addition, channel groups requiring a high level of registration may be superimposed in the focal plane thanks to dichroic beam splitter separations. The detectors will be Si based for VIS channel (APS may be used) with a cut-off at 0.9 µm, HgCdTe for NIR and IR, all using CMOS ROIC. The ROIC may be used in low flux regime (CTIA injection stage for instance). TDI stages will be used wherever necessary. The operating temperature of the IR channels will be typically between 50 and 55K namely for SWIR/MWIR/LWIR channels, whereas for the VIS, 20°C will be the operating temperature. The NIR channels may be driven at 200 K or lower. A combination of active and passive cooling will be used to reach the required performances. The overall design of the imaging instrument considered also the thermal control of the telescope and the scan assembly.

The imagery is performed using an East/West strip swath (South /North width) including the number of lines necessary to fully sample the Earth. Additional lines will provide overlap between successive strips to avoid potential dead zones. The scanning principle and the imaging parameters are shown in table 5 for both FDHSI and HRFI missions.

	FDHSI mode	HRFI mode
Image coverage		
– Nominal	– 18°×18° in 10mn	– 18°×6° in 5mn (100s)
– LAC / target	– 18°×6° in 3.3mn (200s)	– 6°×6° in 100s
E/W strips	113	38
– S/N swath	100km	100km
– S/N overlap (required)	6km	6km
– S/N overlap (implemented)	14 km	14 km
– Period (Nom. Cov.)	4.8s	7.4s
Sampling	Solar / IR channels	Solar / IR channels
– SSD (final data)	1km / 2km	0.5km / 1km
– Spatial filter on raw samples	Yes	Yes

Table 5: Example of a Conceptual imaging parameters for FDHSI and HRFI mission

The instrument calibration will be performed by inserting in the useful beam path a black body for IR channels in addition to the deep space for offset correction and a diffuser target plate illuminated by the Sun through the front optic for VIS/NIR channels. Both are full pupil coverage.

As far the radiometric performances are concerned, the CI (whisk-broom concepts) has shown promising performances. The preliminary parametric analysis of the radiometry of both FDHSI and HRFI cases has shown that most of the requirements can be met. The IR channels performances are driven by the detector dark current for the long wavebands (Optimization of cut-off wavelength and cooling down to 55 K is necessary to meet the NEdT requirements) whereas for the short wavebands (SWIR/MWIR), the photonic noise is mostly the dominant contributor. In the VIS/NIR range, up to 4-stage TDI (CTIA technology included) is necessary to meet the SNR required. The resulting radiometric performances can be found elsewhere[3]. The instruments have been sized to achieve the radiometric requirements within the specified constraints (e.g. the baseline repeat cycles), by starting from the parameters determining the spatial resolution (e.g. detector IFOV) and by considering some margins with respect to the specified SNR and NEdT. Most of the requirements can be met for instance with a 300 mm un-obscured telescope aperture, an East/West slow scan of about 4.8 sec per line for FDHSI and 7.4 for HRFI (to provide sufficient integration time) with the swath and strips sizes defined in table 5 above. As far as the geometric requirements are concerned, the spatial resolution of the FDHSI can be met using spatial sampling distance (SSD) of 1 km for VIS and NIR channels, whereas for the IR channels, SSD=2 km is selected. For the HRFI, the SSD=0.5 km for VIS, NIR and IR3.8 whereas for the remaining IR channels SSD=1 km could be reached.

The preliminary budget of such an imagery mission (CI) shows that the instrument would weight between 250 and 300 Kg with 300 W. The data rate for the FDHSI mode would be 43.5 Mb/s and 22.6 to 35 Mb/s for the LAC and HRFI modes respectivelly.

3. The IR Sounding Mission Preliminary Concepts and Performances

The IR Sounder mission (IRS) needs are well defined elsewhere[2]. The IRS will cover the full disk with a repeat cycle of 30 minutes. The mission also asks for Local Area Coverage of 18°x6° variably placed on any part of the Earth disk at shorter repeat cycle (Table 1). A summary of the sounder sizing requirements is given in Tables 6 and 7 for the sounding and synchronous imaging channels respectively. Synchronous imaging (cloud imager) at high spatial resolution is required for reliable characterization of the IRS footprint as sub-pixel scale. The exploitation of sounder measurements in heterogeneous footprint conditions is indeed an essential issue with regard to the fact that the majority of observations are obtained in partly cloudy conditions. Of course, the other imagers (HRFI and FDHSI) will also be used to enhance the knowledge of the scene for cloud decontamination for the sounding.

The IR atmospheric sounding requirements are challenging and require a careful trade-off between the two possible instrument candidate concepts: a dispersive spectrometer (DS) and a Fourier transform spectrometer (FTS). The IRS requirements put severe constraints on the optical design, array technology, and detection processing. For the dispersive system, not less than 5 grating systems are necessary to cover the spectral range with the required resolution, making the overall optical system rather complex, with some accommodation difficulties. For the Fourier transform concept, the optical system is less complex, but the resulting raw data rates are excessively high, with major consequences on array operation and performances. In consequence, the detection electronics budgets are seriously impacted. The concepts are being conducted under ESA contracts with Alcatel Space Industries in France and Astrium GmbH in Germany. Due to contractual aspects, the details of the designs will not be shown in this paper.

As for the imagers, a parametric analysis has been performed for both of the IR sounder concepts. Preliminary achievable radiometric resolution (NEdT) is shown in figures 2 and 3. In general, it seems easier to meet the radiometric specifications with the dispersive concept, but the study is not complete enough to allow any technically supported final choice. Aiming at the same applications, a fair comparison of the two concepts must be assessed before the final decision can be taken. What so ever, for both concepts, the photonic noise is the most important noise in the SWIR channels, whereas in the MWIR and LWIR, the detector dark current and the instrument parasitic fluxes remain the predominant noise contributor. In the LWIR bands, the low quantum efficiency and the low focal plane temperature are the critical points impacting the instrument design and performances.

Bands	Frequency range cm^{-1}	Main application	Resolving power (at center frequency)	NEDT at 280 K	Spatial Resolution
IRS-0	667 - 700	CO_2, *temperature profile*	1367	-	6 km
IRS-1	700 - 770	CO_2, *temperature profile*	1470	0.2 K	6 km
IRS-2	770 - 980	Surface, clouds	1400	0.24 K	6 km
IRS-3	980 - 1070	O_3, *tracer profile/chemistry*	2070	0.2 K	6 km
IRS-4	1070 - 1210	Surface, clouds	1344	0.3 K	6 km
IRS-5	1210 – 1600	H_2O, N_2O, CH_4, *humidity, tracer profile*	2248	0.2 K	3 km
IRS-6	1600 – 2000	H_2O, NO *humidity, tracer profile*	2880	0.35 K	3 km
IRS-7	2000 – 2250	CO, N_2O, *chemistry*	3400	0.2 K	3 km
IRS-8	2250 – 2400	CO_2, temperature profile	1860	-	3 km
IRS-9	2400 - 2500	Surface, clouds, N_2O	1000	-	3 km

Table 6: IRS atmospheric sounder requirements

Channels	Channel boundaries	Minimum Signal	Maximum Signal	Reference Signal	SNR/ NEDT	Spatial Resolution
VIS	λ_{min}>0.5 µm - λ_{max}<0.7 µm	1%	120%	1%	5	0.5 km
TIR 1	λ_{min}>3.5 µm - λ_{max}<4.1 µm	165 K	350 K	300 K	0.4 K	1.0 km
TIR 2	λ_{min}>10.3 µm - λ_{max}<12.5 µm	165 K	340 K	300 K	0.4 K	1.0 km

Table 7: IRS synchronous imager requirements (for cloud detection).

For what concerns radiometric performances, the results shown on figure 3 for the DS concept and on figure 4 for the FTS concept demonstrate how difficult to reach the required performances is. Both instrument using the same telescope type with the same scanning mechanism and the same type of detector array technologies. The entrance aperture of both instruments is 300 mm.
The cloud imager on-board the IRS has been also investigated. It is feasibility has been addressed and has shown that performances can be reached under highly demanding constraints TIR2 channel.

The preliminary budget of the IRS shows that a DS and FTS concepts would weight between 300 and 350 Kg with about 350 W for a DS concept and up to 500 W for a FTS concept. The data rate for the DS would be ~200 Mbps and up to 3 Gbps for the FTS concept if processing on-board is not considered.

As far as the spatial resolution is concerned, using a diffraction limited telescope and choosing customized detector arrays, it is possible to reach 67% integrated energy of the PSF at 6 km footprint even at the 700 cm^{-1} wavenumber.

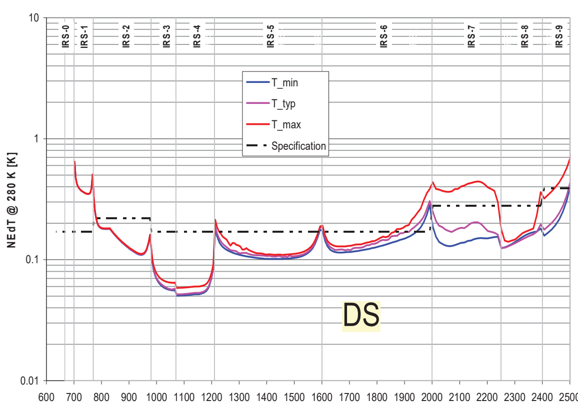


Figure 3: Radiometric Resolution (scaled to 280 K) reached with a DS concept of the IRS spectrometer.

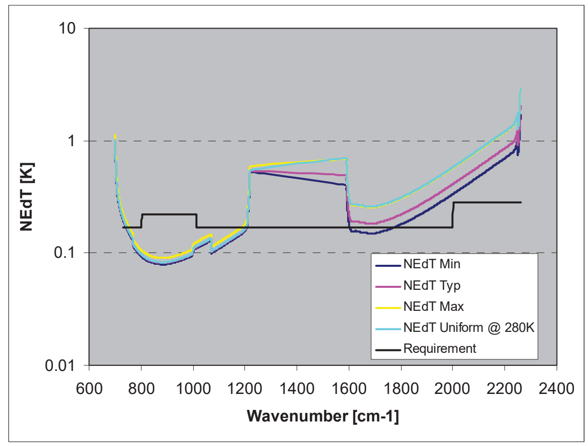


Figure 4: Radiometric Resolution reached with a FTS concept of the IRS Spectrometer with LWIR and MWIR bands (700 – 1210 cm^{-1} and 1600 – 2250 cm^{-1}).

4. CRITICAL TECHNOLOGIES

For every instrument of the MTG mission, the technologies that are to be developed for the fulfillment of the requirements have been preliminary discussed [3]. ESA will launch the relevant R & D as soon as some of the concepts are well defined. The availability of VLWIR photodiodes and the associated in pixel electronics allowing to build large arrays with cut-off wavelength up to 15 µm is definitely the major challenge for the manufacturing of the detectors required to fulfil MTG needs. The VLWIR detector development will be launched mid-may 2006. For FTS and DS concepts, arrays pixel pitches are large with respect to the standard. The ROIC size should be a compromise between manufacturing cost of associated hybrids and MTG VLWIR requirements, i.e. up to 5x15 mm^2 for DS arrays and 13x13 mm^2 for the FTS case. Cooler technologies are on their way since a year (Large heat lift 40-80 K Pulse Tube Cooler), under ESA contract with Air Liquide of France. It also seems important to start a dedicated pre-development of the LI detector characteristics (APS), which requires specific in pixel electronics with a dedicated architecture. Most of the items for development will be part of a strategy that will be established by ESA either through direct contract with the item supplier or via satellite prime contractor at the entrance of phase B.

5. CONCLUSION

The Meteosat Third Generation (MTG) mission will substantially enhance the European capability in operational meteorology and climate applications with the implementation of five observation missions described in this paper. The MTG mission has been reviewed in detail and preliminary instrument concept discussed including the achievable performances, and the critical technologies have been highlighted. Due to its low priority, the UVS mission has been put off the MTG-S spacecraft at least for this on-going pre-phase A study. However, the UVS instrument concept has been assessed leading a certain favorable simplifications not discussed in this paper. It possibly will be considered in the frame of GMES programme.

The preliminary work performed on the MTG mission conceptual design has given a first overview of the possible designs and achievable performances of the 4 main missions (FDHSI+HRFI on one single instrument called CI, and IRS). The LI mission has been de-scoped by the users due to information gap concerning the capabilities of ground based lightning detection systems which made it difficult to judge the added value of space based LI mission. All missions present highly challenging performance requirements, which lead to complex and large optical instrumentations. The performances of the imager and sounder are reachable as shown in this paper; however lot of effort in technology development is necessary. The performed study allowed to extensively reviewing the mission requirements thus helping to consolidate the specifications taking into account users needs. For each mission and associated instrument concept, trade-off have been carried out, parametric analysis performed and critical areas identified. A major finding is on the focal plane array technology that is the main development axis to focus on and this is applicable to all missions. Associated cooling facilities, and related implications at Spacecraft level are also highlighted.
In addition, the Image Navigation and Registration (INR) shall be tackled together with the mission critical aspects. Namely, the thermo-elastic aspects against performance and availability shall be considered from the beginning to allow avoiding troubles vis-à-vis of the solar input to the spacecraft and its payload.

The resulting large resources in terms of volume, mass, power and data rate seem to impose a multi-platform scenario (Imagery mission on a satellite and Sounding mission on another satellite). This scenario leads to favour four-satellite series for the imagery mission (MTG-I) with or without the LI and four-satellite series for the sounding mission (MTG-S) allowing to meet the 15 years lifetime including margins. This, of course will be handled with the affordability aspects. The more precise identification of critical items is also one of the objectives of the next study. The MTG will enter its phase A activity including the review of the technical requirements, the selection of a system concept, the assessment of feasibility and the cost estimate (planned for third quarter 2006) for which the outcome will be presented next year.

The results achieved from this preliminary study have allowed ESA and EUMETSAT to consolidate the mission, system and programmatic requirements and to narrow down the architectural options prior to more detailed feasibility study in phase A.

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