



Advanced IR sounder requirements for Post-EPS

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Introduction: Post-EPS

Preparatory activities are ongoing for the definition of the follow-on EUMETSAT Polar System (Post-EPS). Post-EPS will be the evolution of the current EUMETSAT Polar System (EPS).

Based on the initial iterations of the EUMETSAT Post-EPS user consultation process initiated in 2005, mission requirements for potential post-EPS missions have been drafted in the Post-EPS Mission Requirements Document (most recent version available at <u>www.eumetsat.int</u>). All requirements have currently draft status.

20 tentative missions have been initially identified to fulfil users' requirements for the Post-EPS era.

The priority is to secure the continuity of the main missions of EPS identified in the relevant re-launch policy with at least a minimum payload complement fulfilling the Microwave Sounding, Optical Imaging, and the **High-resolution Infrared Sounding (IRS)** missions.

The nominal launch of the Post-EPS is 2020.





Some Definitions

Threshold, breakthrough and objective performance levels have been defined within Post-EPS:

Threshold is the minimum performance level that is useful for a particular application.

The **breakthrough** performance is the level that, if achieved, would give a significant delta impact on the targeted user service and would justify new instrument developments.

The **objective** level of performance is the level beyond which any improvement does not bring a clear advantage anymore in a cost effective way.

The overall approach taken is to identify and implement a suite of 'baseline' missions covering a wide range of applications rather than few very complex missions, covering only a small set of requirements.

The baseline level of expected performance is determined by the driving requirements and taking into account feasibility and maturity of the observation techniques. As a baseline, the minimum expected performance of the IRS mission is that of the IASI mission.



High Resolution Infra-red Sounding Mission (IRS)

The **primary objective** of the IRS mission is to support Numerical Weather Prediction (NWP) at regional and global scales, providing:

Atmospheric temperature profiles at high vertical resolution in clear and partly cloudy air; Atmospheric water-vapour profiles at high vertical resolution in clear and partly cloudy air; Surface temperature over sea, ice, and land surfaces; Cloud parameters; A number of atmospheric trace gases.

The secondary objective of the IRS mission is to support:

Pollution monitoring and air quality forecasting at global and regional scales; Trace gas measurements and the assessment of composition – climate interaction.

The IRS shall cover contiguously the spectral range from 645 cm⁻¹ to 2760 cm⁻¹ (i.e. 3.62 μ m to 15.5 μ m). Extensions on the short-wave side to 2900 cm⁻¹ (3.45 μ m) to capture CH₄ and, on the long-wave side, to 550 cm⁻¹ (18 μ m) so as to observe upper tropospheric water vapour in the rotational H₂O band, are options that could be considered.



IRS: Priority of Requirements

The mission requirements have been expressed according to levels of priority assigned to each product, ranging from 1 (highest priority) to 4 (lowest priority).

Spectral and radiometric resolution shall have priority over spatial sampling distance as long as the spatial sample equivalent diameter is less than the specified threshold value (12 km).

Radiometric resolution has priority over spectral resolution for the NWP application.

Spectral resolution shall have priority over radiometric resolution for the atmospheric chemistry application as long as the threshold values are not exceeded.



Spectral and Radiometric Requirements

Spectral and radiometric requirements are expressed separately for NWP and for Atmospheric Chemistry (AC)

Spectral resolution requirements are referred to as non-apodised spectral resolution

Radiometric resolutions are given for a non-apodised spectrum. The NEΔT value is to be understood as one standard deviation. It is specified at a reference temperature of 280 K and depends on the spectral range.

NWP requirements are from a recent iteration, Atmospheric Chemistry requirements are from MRD 1.M



Radiometric Requirements



- Variations (RMS) of systematic errors in the measured TB during any single orbit

 Variations (RMS) of the running average over one orbit of systematic errors in the measured TB



Radiometric Requirements: Dynamic Range













Spectral and radiometric requirements seem to be "safe"

A "IASI-2" fulfils most of the breakthrough requirements (CNES study ongoing)

Band IRS-5b ("Chemistry") is not driving both radiometric and spectral resolution requirements

For various chemical species retrieval of total column values would be available.

If priority 1 and 2 bands are retained then the spectral range is almost identical IASI











AC Requirements

Spectral and radiometric requirements in some cases quite demanding, even w.r.t. "IASI-2", e.g. IRS-3a (Ozone profile) and 4a (volcanic SO_2) NE Δ T

A "IASI-2" would not meet (but being very close) threshold spectral resolution requirements for bands 2b (HNO₃, CFC, Priority 2), 3a (Ozone profile, Priority 2), and 7a (CO profile, Priority 1).

For various chemical species retrieval of profiles would be available.

If priority 1 and 2 bands retained then spectral range is smaller than IASI (860-2250 cm⁻¹)



Alignment with Sentinel 5 Requirements

Spectral (apodised) resolution requirements not defined as in the Post-EPS MRD

2a: 0.35/0.13/0.1				
Band	Spectral	Spectral	NEdT [K] Priority	
Ю	range [cm ⁻¹]	resolution ⁽¹⁾ [cm ⁻¹]	2b/3a: 0.15/0.1/0.075	
LEO-TIR-1	800 - 850	0.17 - 0.25	0.05 - 0.1 3	
LEO-TIR-2	860 - 900	0.125 - 0.25	4a: 0.35/0.13/0.1 0.1 2	
LEO-TIR-3	1030 - 1080	0 125 - 0 25		
LEO-TIR-4	1120 - 1160	0.17 - 0.25	5b: 0.3/0.15/0.1 0.1 2 and with base or 8 an altern to band 5	and 7 ative
LEO-TIR-5	1280 - 1360	0.17 - 0.5 (6)	<u>11: 0.5/0.3</u> /0.1	
LEO-TIR-6	2140 - 2180	0.125 - 0.25	0.05-0.15 0.3/0	.2/0.1
LEO-TIR-7	2700 - 2760	0.17 - 0.25	12: 0.5/0.3/0.1 0.1 - 0.2 and the open set of the set o	ner 150
LEO-TIR-8	2760 - 2900	0.17 - 0.25	2 CH ₄ column $0.1 - 0.2$ 2 and 2 nd al native to ban	ter- 15 ⁽³⁾

 FWHM of the ISRF; in case of a Fourier-Transform Spectrometer, this is to be understood as apodised spectral resolution (1/OPD_{max}).



Geometrical requirements 1/2

The IRS shall maximise the useful viewing angle and provide 90% global coverage within 12 hours, and 100% within 24 hours, preferably with a single instrument.

The geolocation accuracy shall be known better than 5 km (threshold), 1 km (breakthrough), 500 m (objective).

Within a scan all the spatial samples shall be with constant SSA. On-ground sampling distance at nadir shall be < 10 km (Objective), < 15 km (Breakthrough), and < 50 km (Threshold) at nadir. Off-Nadir extrapolated after projection.

An amount of > 95% of the Integrated Energy (IE) of the respective PSF shall be contained within an on-ground spatial sample with an area described by an effective diameter D < 5 km (Objective), < 8 km (Breakthrough), < 12 km (Threshold), where D describes an area (circular or non-circular) of size π D²/4 at nadir.



Geometrical requirements 2/2

1. The IRS shall be synchronised with a medium-resolution (~1 km) optical imager for cloud detection within the IRS PSFs. As a minimum requirement the imager shall have spectral channels at 0.670, 0.865, 1.64, 3.75, 10.8 and 12.02 μ m. The band characteristics for these channels shall be those defined for the corresponding VII channels 12, 17, 24, 26, 37 and 39.

2. The temporal synchronisation shall be performed within < 10s.

3. The spatial co-registration shall allow for an assignment of imager pixel centres to any IRS PSF coordinates with an accuracy < 500 m (Breakthrough), < 1 km (Threshold) at nadir. For off-nadir spatial samples the requirement shall be extrapolated with distance scaled after projection on the earth and assuming constant SSA.



Conclusions and Outlook

IRS mission has very high priority in Post-EPS, as it serves several application areas

IRS requirements will likely be subject to further refinements (e.g. alignment of AC requirements IRS/Sentinel 5)

NWP requirements are reasonably consolidated

Current operational use of IASI data in NWP centres cannot be the only guideline, as IASI is not fully exploited yet and NWP systems will likely evolve in during the time until the post-EPS era.

Dedicated studies are being carried out to simulate the expected performance to guide further requirements refinement.

