

**EUMETSAT plans for frequency bands above 275 GHz**  
In response to CGMS action 37.22

**In response to CGMS action 37.22, this contribution is aimed to provide information on planned frequency spectrum use in bands above 275 GHz for passive sensing in the framework of the future EUMETSAT EPS Second Generation (EPS-SG) system.**

**The Microwaver Imaging Mission (MWI) of EPS-SG is planned to perform cloud measurements in bands above 275 GHz at 325.15 GHz, 448 GHz and 664 GHz.**

**Those frequency bands are not fully covered by the current ITU regulations in footnote RR 5.565. However, this footnote is subject to revision at WRC-12 under Agenda Item 1.6.**

**All preparatory activities in the framework of the ITU, in regional groups (CITEL, CEPT, APT) as well as in SFCG and WMO appropriately reflect the planned frequency use of MWI in bands above 275 GHz.**

## **EUMETSAT plans for frequency bands above 275 GHz**

### **1 INTRODUCTION**

EUMETSAT is currently in the planning phase for a follow-on system of the European EUMETSAT Polar System (EPS) with its series of three Metop satellites (Metop-A is operational since October 2006), called EPS Second Generation (EPS-SG).

For this, EUMETSAT is currently in the process of determining the mission requirements in terms of observations, instruments and user-services for EPS-SG. The need date for EPS-SG is in the timeframe 2018 - 2020.

The user requirements relevant to the definition of EPS-SG, are determined in consultation among others with the National Meteorological Services (NMSs), resulting in currently 14 candidate instruments (12 candidate missions) with different priorities.

This selection has not only been based on the long-term strategic objectives of the main users of EUMETSAT, namely the National Meteorological Services, but also on the objectives of other operational environmental organisations from EUMETSAT Member and Cooperating States, the European Centre for Medium-Range Weather Forecasts (ECMWF), EUMETNET and the World Meteorological Organization (WMO).

The only candidate mission retained within the "short list" of candidate missions for which a use of frequency bands above 275 GHz is considered is the Microwave Imaging Mission (MWI).

### **2 CANDIDATE MISSIONS/INSTRUMENTS PLANNING TO USE BANDS ABOVE 275 GHz**

#### **2.1 Microwave Imaging Mission (MWI)**

The EPS-SG MicroWave Imager (MWI) is a cross-purpose multi-spectral microwave imager serving operational meteorology, oceanography, sea-ice/snow/land surface observation and climate applications as derived by the EPS-SG application experts.

The primary objective of the Microwave Imaging Mission is to support Numerical Weather Prediction (NWP) at regional and global scales, through the provision of:

Cloud and precipitation products including bulk microphysical parameters

Water vapour and temperature gross profiles

All weather surface imagery including:

- Sea surface temperature (SST) and ocean salinity
- Sea ice coverage (and type)
- Snow coverage, depth and water equivalent
- Soil moisture products

Sea surface winds (complementary to the scatterometer))

Other mission objectives include:

To provide continuity of other key microwave imager channels (e.g. SSMI, TRMM TMI, SSMIS, AMSR-E and SMOS) in support of long-term climate records.

The instrument will be a passive satellite radiometer capable of measuring thermal radiance emitted by the Earth, at high spatial resolution in specified spectral bands in the microwave region of the electromagnetic spectrum.

Microwave imager data greatly enhances the National Meteorological Services' (NMS) ability to initialise global and regional NWP models with realistic estimations of clouds and precipitation which although are fundamental to the prediction of weather conditions, are currently not well assimilated into NWP models as data of this type is still relatively new compared to clear air temperature and humidity soundings.

The availability of high quality retrievals of cloud, precipitation and all weather land surface parameters would also contribute to fulfil other key requirements common to Nowcasting and very short-range forecasting (VSRF) at regional scales.

The main users of the MWI mission will be the WMO real time users, i.e. NWP centres of National Meteorological Services and ECMWF. Operational nowcasting services of National Meteorological Services may also be users of the MWI mission. The MWI mission is also relevant to non real-time users.

Primary products to be derived from the MWI mission are:

- cloud liquid water/ice water content (total column and gross profile)
- cloud and precipitation detection;
- precipitation content (liquid and frozen; total column and gross profile);
- precipitation rate near the surface;
- total column water vapour;
- atmospheric water vapour and temperature (gross profiles also in presence of clouds);
- sea surface wind (speed and direction);
- soil moisture;
- snow parameters including;
- sea surface temperature;
- sea ice imagery including;
- ocean surface salinity;
- long-wave (LW) Earth radiation budget product;
- land surface temperature;
- cloud drop/ice effective radius (total column and gross profile);
- freezing level height in clouds;
- melting layer depth in clouds;

In order to achieve the mission objectives, the EPS-SG MWI will have to measure scene radiances in a number of frequency bands and channels covering the spectrum between 1.4 GHz and 700 GHz to cover the envisaged application areas, namely:

- clouds,
- precipitation,
- land surfaces and oceans.

### 2.2.1 MWI measurements in bands above 275 GHz

Among the above described application areas only the measurements of clouds are planned to use also frequencies in bands above 275 GHz.

The following table provides an overview of the frequencies to be used for cloud measurements in the framework of the MWI mission of EPS-SG, and for what kind of measurement these are used.

Center Frequency (GHz)	Offset(s) Center Freq.	Bandwidth (MHz)	Utilisation	Priority
23.8		400	Total column water vapour over sea	2
31.4		200	Cloud liquid water	1
50.3		400		1
53.750		400		1
89.0		4000		1
100.49		4000 (TBC)		1
118.7503	4.0 (TBC)	2x1000		2
	1.6			1
	1.2		2	
166.9	±1.2	1425	Quasi-window, water-vapour profile	1
183.31	8.4	2x3000	Water vapour profile, cloud ice water path retrieval	1
	3.4	2x1500		2
	2.0	2x1500		2
243.2	±2.5	2x3000	Quasi-window, cloud ice retrieval, cirrus clouds	1
325.15	±9.5	2x3000	Cloud ice effective radius	1
	±3.5	2x2400		2
	±1.5	2x1600		2
448	±7.2	2x3000	Cloud ice water path and cirrus	1
	±3.0	2x2000		2
	±1.4	2x1200		2
664	±4.2	2x5000	Cirrus clouds, cloud ice water path	2

## 2.2 Limb Millimetre-Wave Mission (MMW) (not further addressed within EPS-SG studies)

The principal objective of a millimetre-wave limb-sounding mission (MMW) would have been to profile key trace gases in the upper troposphere / tropopause region in the presence of cirrus, as well as cloud-free scenes, and in the stratosphere at the vertical resolution required to monitor composition – climate interaction, which would not be possible for nadir-sounders. Profiling over this height range by the MMW observations would be assimilated operationally into global models and into regional air quality models.

However, due to lack of operational demonstration this candidate mission will not be further addressed in the framework of EPS-SG studies.

### 2.2.1 MMW measurements in bands above 275 GHz

The following table provides an overview of the frequencies that would have been used for measurements in the framework of the MMW mission of EPS-SG, and for what kind of measurement.

Frequency Band (GHz)	Utilisation
298 – 305	O <sub>3</sub>
318 – 325.5	H <sub>2</sub> O
342.25 – 347.25	CO, HNO <sub>3</sub>
497.0 – 503.0	N <sub>2</sub> O, ClO, BrO
624.62 – 626.62	HCl

## 3 ITU REGULATORY STATUS OF BANDS ABOVE 275 GHz

Frequency bands above 275 GHz are governed by footnote 5.565 of the ITU Radio Regulations, which reads:

**“5.565** *The frequency band 275-1 000 GHz may be used by administrations for experimentation with, and development of, various active and passive services. In this band a need has been identified for the following spectral line measurements for passive services:*

- *radio astronomy service: 275-323 GHz, 327-371 GHz, 388-424 GHz, 426-442 GHz, 453-510 GHz, 623-711 GHz, 795-909 GHz and 926-945 GHz;*
- *Earth exploration-satellite service (passive) and space research service (passive): 275-277 GHz, 294-306 GHz, 316-334 GHz, 342-349 GHz, 363-365 GHz, 371-389 GHz, 416-434 GHz, 442-444 GHz, 496-506 GHz, 546-568 GHz, 624-629 GHz, 634-654 GHz, 659-661 GHz, 684-692 GHz, 730-732 GHz, 851-853 GHz and 951-956 GHz.*

*Future research in this largely unexplored spectral region may yield additional spectral lines and continuum bands of interest to the passive services. Administrations are urged to take all practicable steps to protect these passive services from harmful interference until the date when the allocation Table is established in the above-mentioned frequency band. (WRC-2000)”*

WRC-12 Agenda Item 1.6 calls for a review of this footnote with a view to update this list of frequency bands in order to better reflect the required frequency bands for current and future passive sensing missions without changing the regulatory status of usage of bands above 275 GHz.

#### **4 CONCLUSIONS**

The frequency bands above 275 GHz envisaged to be used in the framework of the EPS-SG MWI mission are not appropriately reflected in the current version of footnote RR 5.565.

However, in the framework of ITU-R preparation for WRC-12, the responsible ITU Working Party 7C developed a Draft New Report ITU-R RS.[above 275] on “Passive bands of interest to EESS/SRS from 275 to 3000 GHz” as well as a Preliminary Draft Revision of Recommendation ITU-R RS.515-4 in which the list of frequency bands above 275 GHz was updated in line with the spectrum use and requirements of current and future passive sensing missions.

In this proposed revision of this Recommendation ITU-R RS.515-4, the frequency bands above 275 GHz planned for the MWI mission are well reflected. This is also the case for the Draft CPM-Text for WRC-12 Agenda Item 1.6 which forms the technical basis for the discussions at WRC.