

RECOMMENDATION ITU-R M.1747*

Protection of the Earth exploration-satellite service (EESS) (passive) in the band 1 400-1 427 MHz from unwanted emissions of MSS feeder links that may operate in the bands 1 390-1 392 MHz (Earth-to-space) and 1 430-1 432 MHz (space-to-Earth)

(2006)

Scope

This Recommendation provides unwanted emission power levels for the protection of EESS (passive) satellites operating in the band 1 400-1 427 MHz from MSS feeder links (space-to-Earth) that may operate in the band 1 430-1 432 MHz and MSS feeder links (Earth-to-space) that may operate in the band 1 390-1 392 MHz.

The ITU Radiocommunication Assembly,

considering

- a) that WRC-03 made a provisional allocation on a secondary basis to the FSS for MSS feeder links through No. 5.339A in the bands 1 390-1 392 (Earth-to-space) and 1 430-1 432 MHz (space-to-Earth);
- b) that these allocations are limited to use by feeder links for non-geostationary-satellite networks in the mobile-satellite service with service links below 1 GHz, and Resolution 745 (WRC-03) applies;
- c) that the band 1 400-1 427 MHz is allocated to the Earth exploration-satellite service (EESS) (passive), radio astronomy and space research (passive) services on a primary basis in all Regions and that No. 5.340 also applies to the band 1 400-1 427 MHz;
- d) that Resolution 745 (WRC-03) calls for compatibility studies, including the measurement of emissions from equipment that would be employed in operational systems, to validate that the MSS systems using this band meet all requirements for the protection of passive services in the band 1 400-1 427 MHz;
- e) that the band 1 400-1 427 MHz is most suitable for EESS (passive) for the measurement of soil moisture, sea surface salinity and vegetation biomass;
- f) that Recommendation ITU-R RS.1029 contains the protection criteria for the EESS (passive);
- g) that Recommendation ITU-R M.1184 provides technical characteristics of mobile-satellite systems in frequency bands below 3 GHz for use in developing criteria for sharing between the mobile-satellite service (MSS) and other services;
- h) that studies for MSS feeder links (Earth-to-space) as contained in Annexes 1 and 2 concluded that the most suitable criterion to protect EESS (passive) would be an unwanted power spectral-density specification applicable to MSS feeder-link stations in the band 1 400-1 427 MHz;

* This Recommendation was jointly prepared by Radiocommunication Study Groups 7 and 8 and any future revision will also be undertaken jointly.

j) that a margin of around 2 dB is advisable on top of the results obtained for an interference probability of 0.05% to account for the fact that only a limited number of feeder-link and passive sensor combinations could be studied and that actual MSS characteristics may deviate slightly from the ones assumed in the studies,

noting

a) that the reduction of unwanted emissions to levels required for adequate protection of passive services in the band 1 400-1 427 MHz is feasible with baseband processing techniques for typical combinations of data rates and modulation techniques without a specific post amplifier filter;

b) that an additional post amplifier filter can be used in cases where the baseband processing referred to under *noting* a) is not sufficient to meet the required unwanted emission levels;

c) that the unwanted emission level at the input to the MSS feeder-link satellite antenna required to protect the RAS is below the level given in *recommends* 1 (see Recommendation ITU-R M.1748,

recommends

1 that, in order to protect the Earth exploration-satellite (passive) service in the band 1 400-1 427 MHz, unwanted emissions of MSS feeder links should not exceed the following power levels in the band 1 400-1 427 MHz:

- –63 dBW at the input to the earth station antenna for MSS feeder links (Earth-to-space) operating in the band 1 390-1 392 MHz;
- –46 dBW at the input to the satellite antenna for MSS feeder links (space-to-Earth) operating in the band 1 430-1 432 MHz.

Annex 1

Protection of the Earth exploration-satellite service (passive) sensors in the band 1 400-1 427 MHz from mobile-satellite service feeder links that may operate in the FSS around 1 400 MHz

1 Technical characteristics of the EESS passive sensor satellite

Frequencies near 1 400 MHz are most suitable for measuring soil moisture, sea surface salinity and vegetation biomass. NASA is currently developing an instrument for measuring sea surface salinity (the Aquarius mission) which will collect measurements in the entire passive microwave band under consideration (1 400 to 1 427 MHz). NASA is also developing an instrument for measuring soil moisture (the HYDROS mission) in the 1 400 to 1 427 MHz band. The technical characteristics of the Aquarius and HYDROS passive sensing satellites are presented in Table 1.

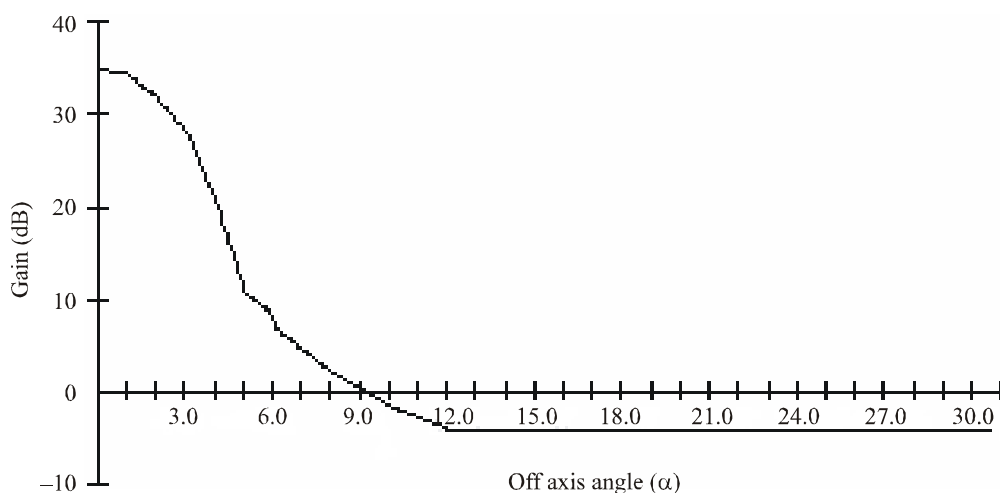
The Aquarius science goals are to observe and model the processes that relate salinity variations to climatic changes in the global cycling of water, and to understand how these variations influence the general ocean circulation. The HYDROS science goal is to measure soil moisture which is a key variable in the hydrologic cycle with significant influence on evaporation, infiltration and runoff.

TABLE 1
Aquarius and HYDROS passive sensor parameters

Parameter	Aquarius	HYDROS
Peak antenna gain (for each beam)	31.1 dBi	35 dBi
3 dB beamwidth (for each beam)	5.5°	2.6°
Antenna polarization	Horizontal and vertical	Horizontal and vertical
Antenna pointing (degrees from nadir)	<u>Beam 1</u> Cross track: 37.2° Along track: 4.8° <u>Beam 2</u> Cross track: 28.9° Along track: -9.5° <u>Beam 3</u> Cross track: 20.7° Along track: 4.8°	40° off-nadir Antenna scans about nadir at 6 rpm with a sampling time of 72 ms/cell
Orbit	600 km altitude 98° inclination	670 km altitude 98° inclination
Receiver bandwidth (3 dB)	25 MHz	27 MHz
Permissible interference level	-174 dB(W/27 MHz)	-174 dB(W/27 MHz)
Percentage of time interference may be exceeded	0.1%	0.1%

HYDROS uses a scanning antenna at a 40 degree offset from nadir. The gain pattern for the HYDROS antenna is illustrated in Fig. 1. Aquarius uses a three-beam push-broom radiometer configuration with each sensor beam having a gain pattern similar to HYDROS. Each beam represents a single pixel with an average integration time of 10 s.

FIGURE 1
HYDROS antenna pattern



1747-01

2 Technical characteristics of the MSS system

The 1 390-1 392 MHz and 1 430-1 432 MHz bands are under consideration for feeder links between non-geostationary mobile-service satellites and fixed earth stations located worldwide. These feeder links would transmit data to and receive data from a constellation of MSS satellites. In addition, telemetry, tracking and command functions would be carried out via these links.

Four MSS constellations comprising 128 satellites were considered in this study as shown in Table 2. The parameters for constellations “L”, “M”, “Q”, and “S” were obtained from Annex 2 of Recommendation ITU-R M.1184. A slight modification was made to the number and inclination of the satellites in the “Q” constellation in order to make this constellation consistent with actual planned systems. The number of satellites composing the “Q” constellation was reduced from 32 to 26 for this study and the inclination for 24 of the 26 satellites was increased from 51° to 66 degrees.

TABLE 2
MSS constellation characteristics

	Recommendation ITU-R M.1184						
	Constellation L	Constellation M		Constellation S	Constellation Q ⁽¹⁾		
Number of satellites	48	48		6	26		
Altitude (km)	950	825	775	692	1 000		
Inclination (degrees)	50	45	0	70, 108	98	66	83
Orbit planes	8	3	1	2	2	6	2
Satellites per plane	6	8		3	4	1	

⁽¹⁾ The number of satellites composing the “Q” constellation was reduced from 32 to 26 for this study and the inclination for 24 of the 26 satellites was increased from 51° to 66° for consistency with the constellation used in Document 7C/8.

The MSS Earth-to-space and space-to-Earth feeder-link characteristics used for this study are described in Tables 3 and 4, respectively. Feeder-link characteristics were assumed to be identical for the four MSS constellations, and were obtained from previous ITU-R sharing studies.

The pattern on the left in Fig. 2 illustrates the gain pattern of the non-GSO MSS satellite circularly polarized feeder-link antenna used in this analysis for both transmit and receive. The pattern on the right in Fig. 2 illustrates the gain pattern of the MSS earth station antenna. This pattern is taken from Appendix 8, Annex III of the Radio Regulations. Each MSS constellation is supported by 15 earth stations distributed throughout the world in representative locations, resulting in a total of 60 earth stations.

TABLE 3
Earth-to-space feeder-link characteristics

Parameter	Value
Number of earth stations	15 per MSS constellation, 60 total
Earth station locations	Distributed throughout the world for each constellation

Transmit antenna peak gain	30 dBi
3 dB beamwidth	5°
Gain floor	−1.5 dBi
Antenna pattern	RR Appendix 8, Annex III
Antenna polarization	Right hand circular
Antenna pointing	Tracks nearest satellite at elevations between 5° and 90°
Transmit power	10 Watts per 100 kHz
Line loss	1 dB
Modulation	GMSK ⁽¹⁾ , OQPSK ⁽²⁾ , 8-PSK ⁽²⁾ , 16-QAM ⁽²⁾
Channel bandwidth	100, 300, 855 kHz

⁽¹⁾ Gaussian baseband filtered with $BT_b = 0.5$.

⁽²⁾ Square root raised cosine baseband filtered with $BT_s = 1.0$.

TABLE 4
Space-to-Earth feeder-link characteristics

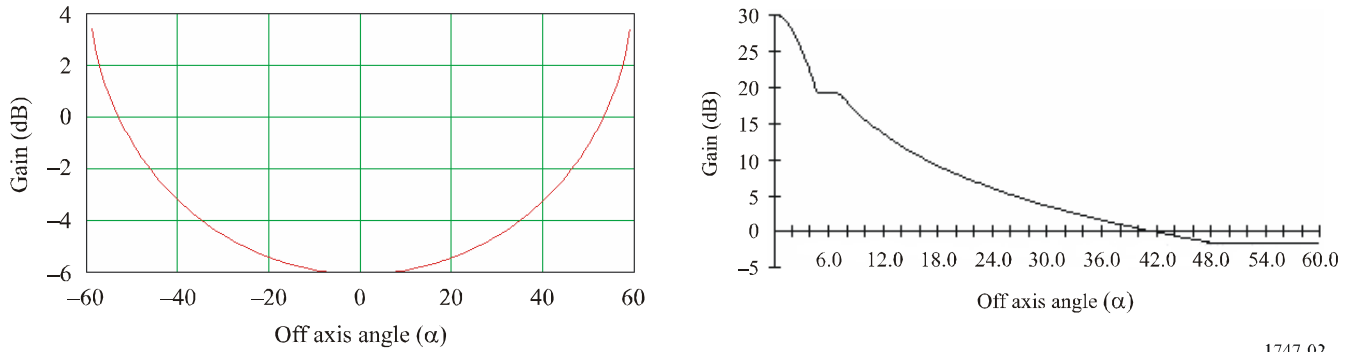
Parameter	Value
Transmit antenna peak gain	See Fig. 2
Gain floor	−6 dB
Antenna polarization	Right hand circular
Antenna pointing	Fixed, approx. 4 000 km diameter coverage area
Transmit power	1 Watt per 100 kHz
Line loss	1 dB
Modulation	GMSK ⁽¹⁾ , OQPSK ⁽²⁾ , 8-PSK ⁽²⁾ , 16-QAM ⁽²⁾
Channel bandwidth	100, 300, 855 kHz

⁽¹⁾ Gaussian baseband filtered with $BT_b = 0.5$.

⁽²⁾ Square root raised cosine baseband filtered with $BT_s = 1.0$.

FIGURE 2

Non-GSO MSS satellite receive and transmit antenna pattern (left) and
Earth station receive and transmit antenna pattern (right)



1747-02

3 Interference analysis

3.1 Overview

The dynamic interference model includes four MSS systems comprising 128 spacecraft and 60 earth stations. The simulation model calculated the cumulative distribution functions (CDFs) of co-channel interference power produced by an aggregate of an individual MSS system's uplinks and downlinks, and an aggregate of all MSS systems' uplinks and downlinks at the passive sensor receiver input.

At each step of the simulation, the model calculated the aggregate power at the output of a single sensor antenna beam produced by all visible and active MSS uplinks and downlinks, and these results were sorted into bins of 1.0 dB resolution for use in plotting the CDF. The simulations used one second time-steps for Aquarius and 50 ms time-steps for HYDROS to ensure adequate overlap with the sampling time per cell of the sensor beams. The simulations were run corresponding to a period of 14 days in real time.

The interference power level I (dBW) at the output of the passive sensor antenna was calculated using the following equation:

$$I = 10 \log P_t - L_l + G_t - (32.44 + 20 \log(f \cdot R)) + G_r - L_p - L_{atm} \quad (1)$$

where:

- P_t : interferer transmitter power (W)
- L_l : transmitter line loss
- G_t : interferer antenna gain in direction of victim station (dBi)
- f : victim station receive frequency (MHz)
- R : slant range between interferer and victim station (km)
- G_r : victim station antenna gain in direction of interferer (dBi)
- L_p : polarization discrimination loss
- L_{atm} : atmospheric absorption loss (dB).