

RECOMMENDATION ITU-R M.1748*

**Protection of the radio astronomy service 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 epfd values for the protection of radio astronomy stations 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, as well as a methodology to determine separation distances between radio astronomy stations operating in the band 1 330-1 427 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 allocated the bands 1 390-1 392 MHz and 1 430-1 432 MHz provisionally on a secondary basis to the fixed-satellite service (FSS) for feeder links for non-geostationary mobile-satellite systems (MSS) operating below 1 GHz in the Earth-to-space and space-to-Earth directions, respectively (see No. 5.339A of the Radio Regulations (RR)) and that Resolution 745 (WRC-03) applies;
- b) that Resolution 745 (WRC-03) calls for studies, including the measurement of emissions from equipment that would be employed in operational systems, to validate that these systems meet all requirements for the protection of passive services in the band 1 400-1 427 MHz from unwanted emissions from MSS feeder links;
- c) that the band 1 400-1 427 MHz is allocated to the Earth exploration-satellite service (EESS) (passive), radio astronomy (RAS) and space research (passive) services on a primary basis in all Regions, and that No. 5.340 of the RR applies to this band;
- d) that the 1 400-1 427 MHz band is extensively used by radio astronomers worldwide for observations of the neutral hydrogen spectral line, as well as for continuum observations;
- e) that the threshold levels of interference detrimental to the radio astronomical observations are given in Tables 1 and 2 of Annex 1 to Recommendation ITU-R RA.769;
- f) that Recommendation ITU-R RA.1513 provides criteria for recommended levels of data loss to the RAS from any one network and that both the uplink and downlink associated with a network may contribute to data loss to the RAS in the 1 400-1 427 MHz band;

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

g) that data losses from earth stations operating in the 1 390-1 392 MHz band to the RAS operating in the 1 400-1 427 MHz band may be minimized using relatively modest separation distances, of the order of 100 km or less;

h) that Recommendation ITU-R RA.1631 describes the radio astronomy antenna pattern to be used in compatibility studies involving satellite constellations, 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 MSS and other services, and Recommendation ITU-R M.1583 describes the methodology to be used in interference calculations between non-geostationary mobile-satellite service or radionavigation-satellite service systems and radio astronomy sites,

noting

a) that, for typical combinations of data rates and modulation techniques, it is feasible to reduce unwanted emissions in the 1 400-1 427 MHz band to the interference levels detrimental to the RAS given in Recommendation ITU-R RA.769, without a specific post-amplifier filter, by employing baseband processing techniques;

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

c) that the band 1 330-1 400 MHz, which is used to observe the red-shifted neutral hydrogen spectral line, is also included in No. 5.149 of the RR,

recommends

1 that unwanted emissions of non-GSO MSS feeder links (space-to-Earth) of a single network that may operate in the band 1 430-1 432 MHz should be less than:

- an epfd of $-259 \text{ dB(W/m}^2\text{)}$ in any 20 kHz bandwidth of the band 1 400-1 427 MHz for more than 98% of integration periods of 2 000 seconds for spectral line observations; and
- an epfd of $-243 \text{ dB(W/m}^2\text{)}$ in the entire 1 400-1 427 MHz band for more than 98% of integration periods of 2 000 seconds for continuum (broadband) observations;

2 that the methodology contained in Recommendation ITU-R M.1583 should be used to derive a pfd limit per satellite from the epfd limits given for MSS networks in *recommends* 1 above;

3 that earth stations that may operate in the band 1 390-1 392 MHz in conjunction with a given non-GSO MSS network should be separated from radio astronomy stations which conduct observations in the band 1 400-1 427 MHz, so that the total data loss due to uplink and downlink does not exceed 2%;

4 that the methodology described in Annex 2 should be used to derive the separation distance between the radio astronomy station and the MSS feeder-link earth station on a case-by-case basis.

Annex 1

Example calculation of the pfd per satellite required to respect epfd limits for the protection of the radio astronomy service operating in the band 1 400-1 427 MHz from unwanted emissions of MSS feeder links that may operate in the band 1 430-1 432 MHz

1 Methodology

Recommendation ITU-R S.1586 (or Recommendation ITU-R M.1583) provides a methodology to evaluate the levels of unwanted emissions produced by a non-geostationary satellite system at a radio astronomy site. It is based on a division of the sky into cells of nearly equal size and a statistical analysis where the pointing direction of the RAS antenna and the starting time of the satellite constellation are the random variables. For each trial, the unwanted emission level (expressed in terms of epfd) is averaged over a 2 000 s period.

Moreover, Annex 1 to Recommendation ITU-R RA.769 provides the threshold levels for interference detrimental to the RAS and Recommendation ITU-R RA.1513 provides a criterion of 2% for maximum allowable data loss to the RAS due to interference from any one network, which is determined as the percentage of integration periods of 2 000 s in which the average spectral power flux-density (pfd) at the radio telescope exceeds the levels defined in Recommendation ITU-R RA.769.

The purpose of the present study is to determine the maximum pfd level required for unwanted emissions of non-GSO MSS system feeder links in the band 1 430-1 432 MHz to comply with the criteria for the protection of radio astronomical observations in the band 1 400-1 427 MHz as given in Recommendations ITU-R RA.769 and ITU-R RA.1513, using the methodology of Recommendation ITU-R S.1586, which is designed to take into account the non-geostationary nature of these systems when assessing their unwanted emission levels at radio telescope sites.

2 MSS system characteristics

The characteristics of the MSS system are summarized in Table 1. It is assumed that the satellites are outfitted with an isoflux antenna, capable of producing a constant pfd on the ground.

TABLE 1
MSS system characteristics

Orbital altitude	1 000 km
Orbital inclination	50° (and 83° for polar coverage)
Number of planes	6 (+ one more for polar coverage)
Number of satellites per plane	4

3 RAS station characteristics and protection criteria

The Effelsberg radio telescope in Germany was chosen for this analysis. Its geographical coordinates are: latitude: N 50.7°, longitude: E 7.0°.

The antenna pattern and peak gain at boresight used are given in Recommendation ITU-R RA.1631.

TABLE 2
pfd levels detrimental to the RAS

Frequency band (MHz)	Interference level (dB(W/m ²))	Reference bandwidth (MHz)	Type of observation
1 330-1 400	-196 ⁽¹⁾	0.02	Spectral line
1 400-1 427	-180	27	Continuum
1 400-1 427	-196	0.02	Spectral line

⁽¹⁾ There is no detrimental threshold level defined in Recommendation ITU-R RA.769 for the band 1 330-1 400 MHz (see RR No. 5.149). The protection criterion listed above for this band was derived from the one used in the band 1 400-1 427 MHz in case of for spectral line observations.

The simulations were performed considering minimum telescope elevation angles of 0° and 3°.

In terms of an epfd level, the detrimental pfd threshold level corresponds to:

$$epfd_{lim} = pfd_{lim} - G_{max}$$

TABLE 3
epfd levels detrimental to the RAS

Frequency band (MHz)	epfd interference level (dB(W/m ²))	Reference bandwidth (MHz)	Type of observation
1 330-1 400	-259	0.02	Spectral line
1 400-1 427	-243	27	Continuum
1 400-1 427	-259	0.02	Spectral line

4 Determination of the required maximum pfd per satellite level for the protection of the radio astronomy service

4.1 Procedure

The following approach is used (see Recommendation ITU-R S.1586):

Step 1: Select a pfd value per satellite. In a first approximation (and as a worst-case scenario) this value may be considered constant for all elevation angles.

In the particular example under consideration, the satellite is assumed to be equipped with an isoflux antenna.