International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R RA.517-4

(05/2006)

Protection of the radio astronomy service from transmitters operating in adjacent bands

RA Series

Radio astronomy

International Telecommunication Union

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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SM	Spectrum management
SNG	Satellite news gathering
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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R RA.517-4*

Protection of the radio astronomy service from transmitters operating in adjacent bands

(Question ITU-R 145/7)

(1978-1982-1992-2003-2006)

Scope

This Recommendation provides guidance for administrations and/or operators to protect the radio astronomy service (RAS) from interference by out-of-band emissions that may be caused by active services with allocations adjacent to the RAS bands.

The ITU Radiocommunication Assembly,

considering

a) the value of the scientific results achieved by the radio astronomy service (RAS) through the exploration of the Universe;

b) the need for interference-free bands at intervals throughout the radio spectrum in order that radio astronomy measurements can be made;

c) that the threshold levels of interference detrimental to the RAS are given in Annex 1 to Recommendation ITU-R RA.769;

d) that Recommendation ITU-R RA.1513 provides the acceptable levels of data loss to radio astronomy observations and percentage-of-time criteria resulting from degradation by interference for frequency bands allocated to the RAS on a primary basis;

e) that emissions in the out-of-band domain generally result from the modulation process;

f) that in some cases either there are no limits specified in the Radio Regulations for out-of-band emissions, or the limits do not provide the protection required by radio astronomy from transmitters operating in frequency bands adjacent to a band allocated to the RAS, which may cause interference detrimental to the radio astronomy service due to the unwanted emissions of these transmitters;

g) the difficulties experienced by radio services in the design and utilization of transmitters to operate in frequency bands adjacent to a band allocated to the RAS, in such a manner as to afford adequate protection from interference detrimental to the RAS (see Annex 1);

h) the increase in the level of usage of frequency bands adjacent to bands allocated to the RAS, particularly by airborne and satellite transmitters;

j) that it is incumbent on both active and passive radio services to find means to minimize interference that may be detrimental to the services, acting both separately and in cooperation with each other, with due consideration for the efficient use of the radio-frequency spectrum,

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* NOTE – The levels of the detrimental interference to the RAS referred to in Annex 1 to Recommendation ITU-R RA.769 are not accepted by the Arab Administrations, being unrealistic, as confirmed by previous Radiocommunication Conferences in 1995, 1997 and 2000 dealing with Recommendation 66.

recommends

1 that in order to reduce interference detrimental to the RAS, all practical, technical means, for example, the use of filters in transmitters to confine emissions to the allocated band, and in radio astronomy receivers to avoid sensitivity to signals outside the allocated band, should be adopted to the maximum practicable extent;

2 that when frequencies are assigned to a station in a service operating in a band adjacent to one allocated on a primary basis to RAS, attempts should be made to limit the edge of the necessary band adjacent to the radio astronomy band, so that the power radiated within this band should not produce interference detrimental to a station of that service;

3 that when future frequency assignments are made by administrations in bands adjacent to those allocated to RAS, account should be taken, to the maximum extent practicable, of the special risk of interference to radio astronomy observations from space-to-Earth and airborne transmissions, within the adjacent bands;

4 that taking into account § 1, 2 and 3 above, practical solutions to limit interference due to unwanted emissions to levels below those detrimental to the RAS be sought by administrations, individually and if necessary in cooperation.

Annex 1

Interference to the RAS from transmitters operating in adjacent bands

1 Introduction

The sensitivity limit of most radio astronomy observations is at a flux-density level far below that used for reception of radiocommunication signals. Thresholds of interference that are detrimental to the RAS and criteria for frequency sharing between RAS and other services are discussed in Annex 1 to Recommendation ITU-R RA.769; in Tables 1, 2 and 3 of the latter, the sensitivity limits are listed for different frequencies. However, interference can also occur from transmitters that do not share the same band. This may be classified as band-edge interference and interference from harmonic and intermodulation signals. Interference to the RAS from emissions in the spurious domain are treated in Recommendation ITU-R RA.611. Additional considerations pertaining to protection of the RAS from unwanted emissions resulting from application of wideband digital modulation are given in Recommendation ITU-R RA.1237.

Interference problems in a radio astronomy receiver, by a transmitter operating in an adjacent band, can arise by three mechanisms. It can occur if the sensitivity of the radio astronomy receiver to signals outside the radio astronomy band is not sufficiently low. This may be due to the practical limitations on the fall-off of receiver gain at the band edges. Secondly, non-linear effects in the receiver may, in the presence of two or more strong signals at frequencies near the edge of the receiver passband, give rise to intermodulation products falling within the radio astronomy band. Thirdly, interference may arise through unwanted emission by the transmitter (modulation sidebands, phase-noise in oscillators, etc.) falling within the radio astronomy band. In dealing with band-edge interference, the problem common to both transmitting and receiving services is the design filters that will adequately suppress the unwanted energy without introducing unacceptable modifications, (e.g. attenuation or phase distortion), into the wanted signals.

2 Interference from satellite transmissions

Satellite transmissions have the potential to cause severe interference to the RAS. Whereas terrestrial interference sources are usually in the far side-lobe region of the radio telescope antenna, and possibly further attenuated by the topography of the surroundings of the radio observatory, interference by satellite transmitters is likely to be received via the main beam and inner side lobes, with considerably higher gain. The nature of the interference depends on the type of transmitter and service provided by the system, whether the satellites are in geostationary or non-geostationary orbit, and the number of satellites in the system under consideration that are above the horizon at the radio observatory. Some of the situations when a satellite service operates in a band adjacent to a primary radio astronomy band, and that present the greatest potential difficulties for the RAS are described in Recommendation ITU-R SM.1633[1].

2.1 Geostationary satellites

Multiple geostationary satellites are visible from almost all the radio telescopes currently in operation, and occupy a more-or-less constant range of azimuths and elevations. They have therefore the potential to be troublesome sources of interference to radio astronomy observations. The radius of the GSO is approximately 6.6 times the radius of the Earth. At that radial distance a single satellite can illuminate a third of the Earth's surface – and consequently many radio telescopes – with line-of-sight signals.

Figure 1 shows the position of the geostationary satellite belt in celestial coordinates as seen from the latitudes of some major radio astronomy observatories. Plans for the development of some active services call for a large number of geostationary satellites. Such a series of potential sources of interference that may be received through the near side lobes of the radio telescope antenna pattern could present a unique interference problem to radio astronomers.

Threshold levels of interference detrimental to radio astronomy are given in Annex 1 to Recommendation ITU-R RA.769. Listed there is the level, in each radio astronomy band, of the power into the receiver that is just sufficient to cause interference which is detrimental to the operation of the RAS. Also listed are the equivalent pfd (dB(W/m^2)) levels associated with this interference, which are calculated with the assumption that the gain of the radio telescope is 0 dBi in the direction of the interfering source. Such a gain is appropriate for consideration of terrestrial sources of interference confined to the neighbourhood of the horizon. For the case of geostationary sources, the situation is different.

If we assume that the RAS antenna has the side-lobe characteristics assumed in Recommendation ITU-R SA.509, the side-lobe gain would fall to 0 dBi at 19° from the axis of the main beam. For such an antenna the interference level detrimental to the RAS will be exceeded if the main beam is pointed within 19° of a satellite that produces within the radio astronomy bandwidth a pfd at the radio observatory equal to the threshold level in Annex 1 to Recommendation ITU-R RA.769. A series of satellites spaced at intervals of about 30° along the GSO radiating interference at this level would result in a zone of width approximately 38° centred on the orbit in which radio astronomy observation free from detrimental interference would be precluded. The width of this precluded zone would increase with the number of interfering satellites in the orbit, and could, in principle, cover the whole sky. The effective number of interfering satellites will depend upon whether the interfering signals are spot beamed from the satellites' transmitting antennas or are more widely radiated. Out-of-band emissions that is not widely separated from the satellite's transmitter frequency are likely to be directed by the antennas in a way similar to that of the intended signals.

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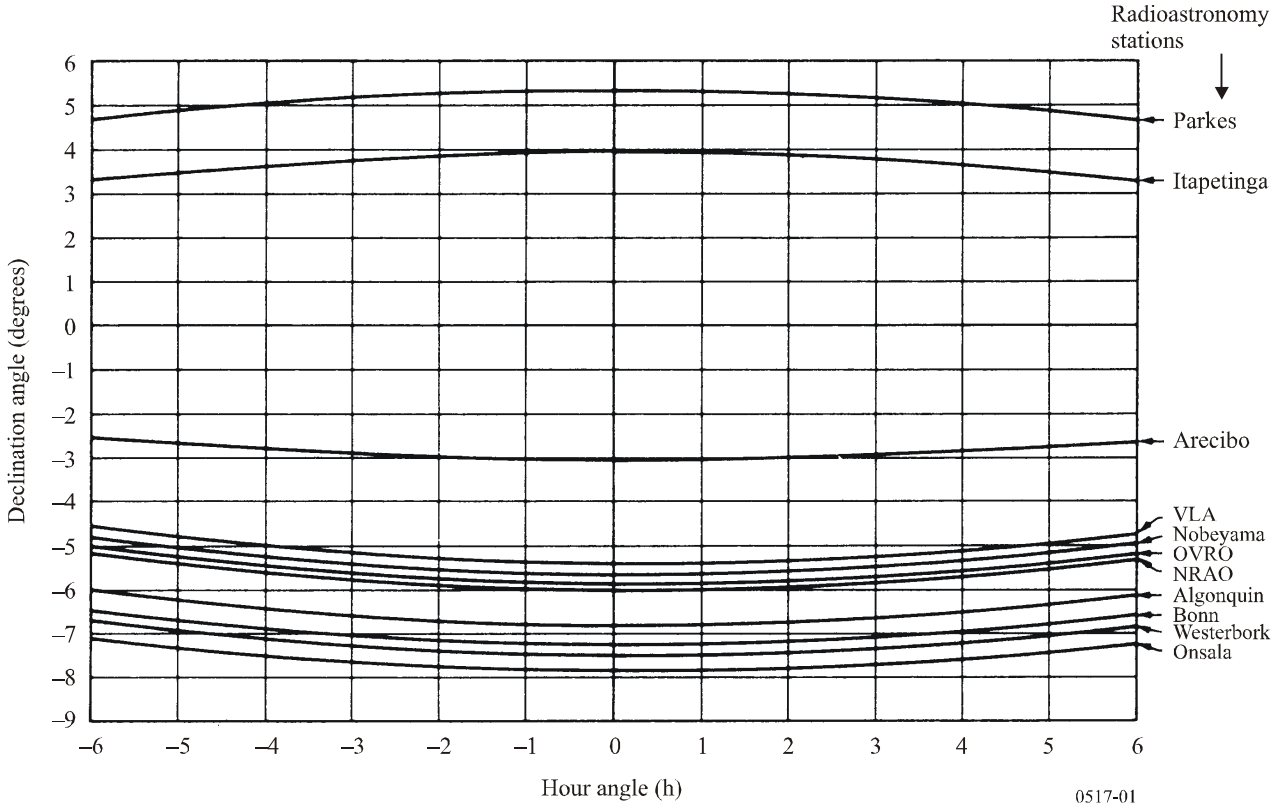
[1] Additional relevant technical material may be found on the Radiocommunication Working Party 7D website.

FIGURE 1

Projection of geostationary-saellite orbit on to the celestial sphere



2.2 Non-geostationary satellites

The potential for interference detrimental to the RAS from non-geostationary low-Earth orbit satellites is due to their operation in large numbers, which make it possible for many of them to be simultaneously above the horizon at a radio observatory, and in line-of-sight with the radio telescope antenna. This factor leads to a situation where the radio telescope antenna can receive unwanted emissions from those visible non-geostationary low-Earth orbit satellites through many near and far side lobes of the antenna beam, and also through the main beam. The interference problem is exacerbated by the continually changing directions of arrival of the interfering signals, and the need for the radio telescope antenna to track the celestial source under observation. Multiple inputs of strong signals may drive the operating point of the receiver into a non-linear region, resulting in the generation of intermodulation products.

The impact of unwanted emissions produced at radio astronomy sites by a constellation of satellites in (low) non-geostationary orbits may be determined using the epfd methodology described in Recommendation ITU-R S.1586 – Calculation of unwanted emission levels produced by a non-geostationary fixed-satellite service system at radio astronomy sites, or Recommendation ITU-R M.1583 – Interference calculations between non-geostationary mobile-satellite service or radionavigation-satellite service systems and radio astronomy telescope sites, and the antenna gains given in Recommendation ITU-R RA.1631.

These Recommendations may be used to determine the percentage of data loss during observations made at a particular radio astronomy site due to interference from a given satellite system. The acceptable percentage of data los is defined in Recommendation ITU-R RA.1513.