

RECOMMENDATION ITU-R SM.1542

The protection of passive* services from unwanted emissions

(Question ITU-R 211/1)

(2001)

The ITU Radiocommunication Assembly,

considering

- a) that it is desirable that unwanted emissions of new stations in any radio service should not render existing stations, operating in accordance with the Radio Regulations (RR) in those or other services, unable to operate effectively;
- b) that, in some cases, passive services and services employing high-power transmitters have been allocated to adjacent or nearby frequency bands;
- c) that in many cases passive services and space services (space-to-Earth) have been allocated to adjacent or nearby frequency bands;
- d) that in some cases space-based passive services and services using uplink earth stations or high density terrestrial stations have been allocated to adjacent or nearby frequency bands;
- e) that, in making these allocations, transmitter and receiver compatibility may not have been considered;
- f) that the RAS, the EESS (passive) and SRS (passive) are based on the reception of emissions at much lower power levels than are generally used in other radio services;
- g) that, due to these low received power levels, these passive services are generally more susceptible to interference from unwanted emissions than other services;
- h) that several footnotes to the Radio Regulations (RR) (such as Nos. 5.149, 5.340, 5.372) draw attention to the protection of these passive services, particularly from spaceborne, airborne, or high altitude platform stations (HAPSs), (for the radio astronomy stations) and from earth stations, HAPS, and high density fixed system (HDFS) stations (for the space-based passive services);
- j) that there are various operational practices and mitigation techniques that can be used by the passive and active services to minimize the impact of interference on the passive services;
- k) that there may be practical and economic limitations on the applicability of these mitigation measures;
- l) that general limits for spurious emissions may not protect to the desired extent the passive services from interference;

* The radio astronomy service (RAS), the Earth exploration-satellite service (EESS) (passive) and the space research service (SRS) (passive) are considered in this Recommendation.

m) that Recommendation 66 (Rev.WRC-2000) requests in *recommends that ITU-R 5* “study those frequency bands and instances where, for technical or operational reasons, more stringent spurious emission limits than the general limits in Appendix 3 may be required to protect safety services and passive services such as radio astronomy, and the impact on all concerned services of implementing or not implementing such limits”;

n) that Recommendation 66 (Rev.WRC-2000) requests in *recommends that ITU-R 6* “study those frequency bands and instances where, for technical or operational reasons, out-of-band limits may be required to protect safety services and passive services such as radio astronomy, and the impact on all concerned services of implementing or not implementing such limits”;

o) that the RR state (No. 29.5) that the locations of the radio astronomy stations to be protected and their frequencies of observation shall be notified to the Radiocommunication Bureau in accordance with RR No. 11.12,

noting

a) that explanations of why passive services are more vulnerable to interference from unwanted emissions than other services are presented in Annex 1;

b) that Recommendation ITU-R SM.1540 provides guidance with regard to unwanted emissions in the out-of-band domain falling into adjacent allocated bands;

c) that an expeditious conclusion of band-by-band studies and the identification of other interference situations where more stringent limits on unwanted emission levels than those given in RR Appendix 3 and Recommendation ITU-R SM.1541 are needed for the protection of passive studies;

d) that appropriate levels for those situations need to be established and the impact be considered on all concerned services of implementing or not implementing such limits,

recommends

1 that when allocating frequency bands to the satellite services, their proximity to frequency bands allocated to the RAS, the EESS (passive), and the SRS (passive) should be taken into account;

2 that when designating frequency bands for specific terrestrial applications such as HAPS or HDFS, their proximity to frequency bands allocated to the RAS or the EESS (passive), and the SRS (passive) be taken into account;

3 that where possible allocations adjacent to existing passive services bands should be such as to minimize the potential for interference;

4 that the use of zones around stations used for radio astronomy observations where active services are excluded or restricted should be considered as a means of minimizing interference due to unwanted emissions from terrestrial transmitters;

5 that mitigation techniques such as those described in Annex 2 and Annex 3 should be considered as appropriate means and employed as much as practicable by active services and passive services, to minimize the interference generated by unwanted emissions to passive services, bearing in mind the constraints placed on system design and operational effectiveness;

6 that the passive service frequency bands identified in Annex 4 are bands for which more stringent spurious emission limits than the general limits in RR Appendix 3 may be used to protect passive services;

7 that the active service frequency bands identified in Annex 4 are bands for which out-of-band limits may be used to protect adjacent or nearby passive service bands;

8 that the following measures should be taken to minimize the potential of interference to passive services:

- consultation and exchange of technical and operational information between the relevant parties,
- cooperation on the selection and implementation of the most suitable measures between operators of passive systems and active systems, and
- appropriate spectrum management techniques.

ANNEX 1

Vulnerability of passive services

Passive services are dedicated entirely to the study of naturally-occurring radio emissions. The extreme weakness of these emissions compared with man-made transmissions make facilities being used to observe them extremely susceptible to interference. In the case of radio astronomy, receiver sensitivities are as high as practicable. Making radio astronomical measurements may require large receiver bandwidths and integration and correlation of signals over hours or days. The extreme sensitivity of radio astronomy receivers together with long observing times give rise to interference thresholds lower than in any other service, leading to special protection needs and a consequent need for special consideration.

Similarly, spaceborne passive sensors detect very small changes in the ambient noise temperature of the observed phenomena. All matter emits and scatters electromagnetic energy. Spaceborne passive sensors measure the electromagnetic energy emitted and scattered by the Earth and constituents in its atmosphere. This means special consideration for protection of these passive services is required, because interference thresholds necessarily occur at significantly low power levels.

Airborne and spaceborne transmitters can be particularly serious sources of interference to the RAS. Space service downlinks close to frequency bands used by passive services, including the RAS, have the potential to cause interference to many radio astronomy stations. Reflections off the Earth from the space service downlinks also can cause interference to spaceborne passive sensors. Unwanted emissions from space service uplinks, HAPS uplinks and HDFS transmissions close to frequency bands allocated to EESS (passive) have the potential to cause interference to spaceborne passive sensors.

1 Satellite passive remote sensing

Interference thresholds for passive satellite remote sensing for various frequency bands are given in Recommendation ITU-R SA.1029. Performance criteria for satellite remote sensing are given in Recommendation ITU-R SA.1028. Permissible data loss for most passive sensing applications is less than 1%. That is, the interference levels given in Recommendation ITU-R SA.1029 should not be exceeded for more than 1% of the measurement cells (i.e. pixels) within the sensor's service area. However, for three-dimensional measurements of atmospheric temperature or gas concentration in the absorption bands, the interference levels should not be exceeded for more than 0.01% of the measurement cells in the sensor's service area. The frequency bands that require this greater degree of protection are: 50.2-50.4 GHz (see RR No. 5.340.1), 52.6-59.3 GHz, 114.25-122.5 GHz and 174.8-191.8 GHz.

2 Radio astronomy

Radio astronomy is the science of studying the properties of cosmic radio emissions. These emissions generally are noise-like, and indistinguishable in character from thermal noise radiated by the Earth or its atmosphere, or from noise generated in the receiver. Radio astronomical observations fall into two broad classes:

- continuum observations, where the average spectral power flux-density (spfd) and degree of polarization across the allocated band are measured. The type of observation being made might involve breaking the band into channels that are processed together or independently (as for example in imaging, interferometry or interference mitigation), but the final result is usually an average of observational quantities across the allocated band. These observations may be used in combination with measurements made in other radio astronomy bands in order to study broadband spectral structure or changes in the structure of the source of the emissions as a function of observing frequency;
- spectral line observations of narrow-band emissions from transitions in cosmic molecules, radicals or atoms. These are narrow-band emissions where the intensity, width, fine structure, Doppler shift, and polarization are of astrophysical interest. Observations involve dividing the band into many frequency channels in order to derive the properties of the line emission with frequency against the broadband background emission.

Astronomical sources range in angular size from degrees to milliarcseconds or less. Some emissions, such as the cosmic background, cover the entire sky. A single large antenna might have the angular resolution needed to map the area or source of interest with sufficient detail. Where this is not the case, arrays of antennas distributed over distances of up to thousands of kilometres may be used as interferometers (arrays with even larger spacings are possible when one or more of the antennas are located in space). Producing maps might require up to two weeks of continuous observation to produce a single image. Current radio telescopes can measure spfd's below $-290 \text{ dB(W/(m}^2 \cdot \text{Hz))}$; however, current research needs are driving the development of radio telescope systems capable of measuring spfd's in the region of $-320 \text{ dB(W/(m}^2 \cdot \text{Hz))}$.

Interference thresholds for the protection of radio astronomical observations are given in Recommendation ITU-R RA.769. Protection of radio astronomy from transmitters in adjacent bands is described in Recommendation ITU-R RA.517. Protection of radio astronomy from spurious emissions is described in Recommendation ITU-R RA.611.

The permissible rate of data loss to radio astronomy is described in Recommendation ITU-R RA.1513.

ANNEX 2

Mitigation techniques that may be used at the transmitter

Several examples of possible mitigation techniques have been described in ITU-R Recommendations such as Recommendation ITU-R SM.328, which may have direct relevance to the categories listed below. Consideration of all sources and modes of interference into the passive service should be taken into account when selecting mitigation methods to ensure that their application provides substantial benefit to the passive service. The implementation of mitigation techniques may impact the operational effectiveness of the systems involved, and also the nature and extent of user services that can be supported in the band under consideration. There may be a substantial technical and operational burden consequent to the implementation of such solutions. These factors will impact the practicabilities of mitigation techniques. Such measures may be considered at an early stage in the design of systems in order to reduce interference from unwanted emissions.

- Practical hardware and system measures, such as:
 - transmitter architecture;
 - guardbands;
 - radio frequency (RF) filters to reduce unwanted emissions;
 - design of the output power amplifier to avoid spectral regrowth of RF signals into adjacent bands, or intermodulation;
 - components that operate with linear characteristics, to the extent possible;
 - design of the modulation process to minimize unwanted emissions;
 - antenna patterns.
- Traffic loading management.
- Dynamic power control.
- Time sharing.
- In the case of multi-satellite systems, satellite constellation management.

Satellite communications provide vital telecommunication links around the world. The nature of satellite communications allows the implementation of networks especially in areas having minimal infrastructure, making them a communication medium well suited to reach many countries. The wide area that they serve also makes them well suited for broadcast applications.