RECOMMENDATION ITU-R RA.1031-1*

PROTECTION OF THE RADIOASTRONOMY SERVICE IN FREQUENCY BANDS SHARED WITH OTHER SERVICES

(Question ITU-R 145/7)

(1994-1995)

The ITU Radiocommunication Assembly,

considering

a) that the radioastronomy service is based on the reception of natural emissions at much lower power levels than are generally used in other radio services, and that the radioastronomy service is therefore particularly vulnerable to interference from transmitters in shared frequency bands;

b) that many frequency bands allocated to the radioastronomy service are also allocated to other services which transmit in those bands;

c) that protection from interference is essential to the advancement of the radioastronomy service, and that the preferred frequency bands for radioastronomy are given in Recommendation ITU-R RA.314;

d) that protection criteria used for radioastronomical measurements are given in Recommendation ITU-R RA.769;

e) that the detailed characteristics of the interference and the particular type of radioastronomical measurement may need to be taken into account when developing sharing criteria;

f) that radioastronomy sites are carefully chosen, and that site characteristics may strongly affect the sharing calculations;

g) that frequency sharing is generally impossible for transmitters within direct line-of-sight of a radioastronomy observatory,

recommends

1 that, in making assignments to services which share frequency bands with the radioastronomy service, administrations should take all practicable steps to avoid interference detrimental to the radioastronomy service;

2 that consideration be given to protecting radioastronomy sites from interference in shared bands through the establishment of coordination zones for transmitters used for terrestrial radiocommunications or in earth stations used for space radiocommunications, as defined in Annex 1;

3 that the size of a coordination zone be calculated, taking account of:

– the protection criteria contained in Recommendation ITU-R RA.769;

– the specific characteristics of the service sharing the band;

– the latest available propagation models such as those contained in Recommendations ITU-R P.452, ITU-R P.526 and ITU-R P.617; and

– the requirement that interference variations which may result from variable propagation should be based upon the probability that the interference should not exceed the thresholds of interference detrimental to the radioastronomy service for more than 10% of the time.

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* This Recommendation should be brought to the attention of Radiocommunication Study Groups 2, 3, 4, 8, 9, 10 and 11.

ANNEX 1

Coordination considerations

1 General

Radioastronomy sites are chosen specifically to minimize interference from Earth based transmitters. The sites are usually at a considerable distance from the major fixed sources of terrestrial interference and may be screened by nearby high ground.

For the assessment of interference to radioastronomy from transmitters used for terrestrial radiocommunications or in earth stations used for space radiocommunications, a value of 0 dBi is adopted for the gain of the radioastronomy antenna in the direction of the horizon. On this basis, potentially interfering signals at the threshold levels defined in Recommendation ITU-R RA.769 will not cause interference detrimental to observations made at elevation angles greater than 19°.

Many radioastronomy measurements can tolerate levels of interference from a shared service which exceed these thresholds for 10% of the time. However, certain other types of measurements such as those involving transient phenomena and those depending upon simultaneous observations at many sites on Earth, may be severely damaged by interference at inopportune times.

2 Separation distances required for sharing

If geographical sharing is to be successful the interfering transmitter and the interfered-with receiver must be separated by a distance at which the interference is not considered harmful. The attenuation over this distance must be sufficient to reduce the received signal below the appropriate level of Tables 1, 2 or 3 of Recommendation ITU-R RA.769, for all but 10% of the time. Appendix 28 to the Radio Regulations defines a basic transmission loss $L_b(p)$ as:

$$L_b(p) = P_t + G_t + G_r - P_r(p) \quad (1)$$

where:

$L_b(p)$: minimum permissible basic transmission loss (dB) for p% of the time; this value must be exceeded by the actual transmission loss for all but p% of the time

P_t : transmitting power level (dBW) in the reference bandwidth at the input to the antenna

G_t : gain (dBi) of the transmitting antenna in the direction of the radioastronomy antenna

G_r : gain (dBi) of the radioastronomy antenna in the direction of the transmitter

$P_r(p)$: maximum permissible interference power (dBW) in the reference bandwidth to be exceeded for no more than p% of time at the receiver input.

With $G_r = 0$ dBi, equation (1) assumes the form:

$$L_b(p) = P_t + G_t - P_r(p) \quad (2)$$

where P_r is to be taken from column 7 of Table 1 or Table 2 of Recommendation ITU-R RA.769.

$L_b(p)$ should be calculated using appropriate models, such as those contained in Recommendations ITU-R P.452, ITU-R P.526 and ITU-R P.617, using $p = 10\%$ in the case of time-variable propagation loss.

It should be noted that the free-space propagation loss is not variable and the percentage of time criterion is not pertinent in this case. For line-of-sight transmission, L_b has a simple analytical form and equation (2) may be written as:

$$20 \log (4\pi d) - 20 \log \lambda = P_t + G_t - P_r \quad (3)$$

where:

d : distance (m) between transmitter and receiver

λ : wavelength (m).

In the above analysis P_t is the power transmitted within the bandwidth B_r of the radioastronomy receiver. If the transmitter power P_T is distributed over a bandwidth $B_t > B_r$ then:

$$P_t \text{ (dBW)} = P_T \text{ (dBW)} - 10 \log (B_t / B_r) \qquad \text{for } B_t > B_r \quad (4)$$

assuming that the transmitter power has a uniform spectral density.

3 Sharing within the line-of-sight

It is rarely possible for radioastronomy to share successfully with any active service whose transmitters are within line-of-sight of the observatory. Figure 1 illustrates this fact. The maximum e.i.r.p. which would not result in interference detrimental to the radioastronomy service has been calculated using equations (3) and (4) for two distances. One distance is representative of a terrestrial transmitter at a large distance within line-of-sight, namely an airborne transmitter on the horizon at a height of 20 km. The other distance is that of the geostationary orbit, and is thus representative of the maximum distance of most spaceborne transmitters not on deep-space missions. The interference levels of Recommendation ITU-R RA.769, Table 1, have been used in the case of the terrestrial transmitter. An additional protection of 15 dB is required for the case of the transmitter in the geostationary orbit, to allow observations within 5° of satellites in the orbit. The curves are applicable to a clear dry atmosphere.

It is clear from Fig. 1 that sharing with a terrestrial transmitter within line-of-sight is unlikely to be possible at frequencies below 10 GHz because of the severe restriction sharing would impose on the transmitter e.i.r.p. Even for frequencies up to 40 GHz either the transmitter power must be of the order of a few milliwatts, or the transmitting antenna must provide high discrimination towards the direction of the observatory, for sharing to be possible.

4 Sharing beyond the line-of-sight using coordination zones

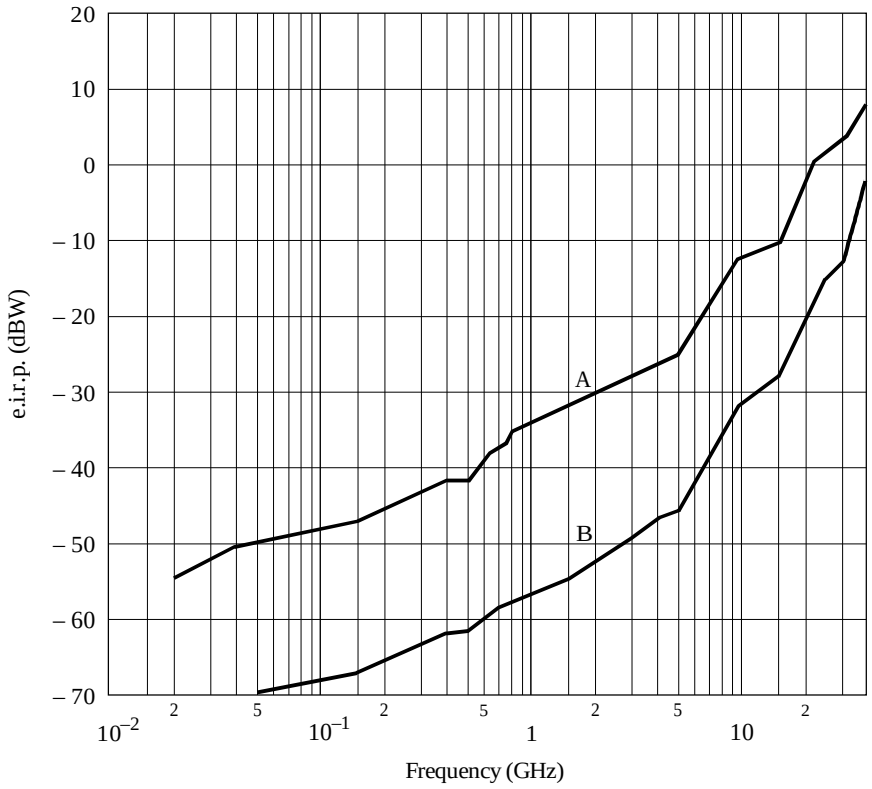
The establishment of coordination zones around radioastronomy sites provides a method of avoiding interference from transmitters used for terrestrial radiocommunications or in earth stations used for space radiocommunications sharing the band beyond the line-of-sight.

A coordination zone associated with a radioastronomy station is defined as the area for which the sum total of emissions from transmitters outside its boundary does not exceed the threshold levels of detrimental interference measured at the radioastronomy antenna.

The size of the coordination zone depends upon a number of factors. The types of measurements being made at the radioastronomy site determine the corresponding interference thresholds given in Recommendation ITU-R RA.769. The number and distribution of the transmitters outside the zone, the e.i.r.p. of the transmissions in the direction of the radioastronomy site, the fraction of the time they are active, and the propagation characteristics determine the interfering power flux-density at the radioastronomy site. The propagation characteristics depend upon factors such as the profile of the terrain, presence of trees, and the atmospheric conditions. Appropriate propagation models have been suggested in § 2.

FIGURE 1

e.i.r.p. as a function of frequency



NOTE 1 – The e.i.r.p. above which sharing is not feasible between radioastronomy and active services with transmitters within line-of-sight of a radioastronomy observatory. The reference bandwidths for the transmitter e.i.r.p. and the radioastronomy receiver are those allocated to the radioastronomy service. Curve A shows results for a transmitter in the geostationary orbit, and Curve B shows results for a terrestrial transmitter in line-of-sight at 600 km.

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Because of the number of factors involved, the boundaries of the coordination zones should be established individually for each radioastronomy site at which such a zone is required. It should be realized that the coordination distance is likely to be 100 km or more. For many small countries the coordination zone required may extend beyond the national boundaries into countries where the frequency allocations may be different. Thus special conditions may need to be applied when determining coordination zones to protect radioastronomy in small countries.

The coordination zone defines a region around a radio observatory outside of which the users of the active service can transmit freely without causing interference detrimental to radioastronomy observations. For users within the coordination zone technical means must be found to avoid such interference.

In principle, coordination zones can also be set up to protect radioastronomy sites from mobile transmitters. In this case the mobile user must have some means of determining when the coordination zone is entered, and some means of reducing the power received at the radioastronomy site to a level below the harmful threshold for interference.

For the case of mobile transmitters on aircraft the sizes of the zones need to be much larger than for ground-based transmitters since line-of-sight propagation conditions extend over much greater distances, and increase with aircraft height.