RECOMMENDATION 517-2

PROTECTION OF THE RADIOASTRONOMY SERVICE FROM TRANSMITTERS IN ADJACENT BANDS

(Question 145/7)

(1978-1982-1992)

The CCIR,

considering

a) the value of the scientific results achieved by the radioastronomy service through the exploration of the Universe;

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

c) the levels of harmful interference to the radioastronomy service given in Annex 1 to Recommendation 769;

d) the desire on the part of both active and passive users of the radio-frequency spectrum to operate in harmony without mutual interference as evidenced by the provisions of Article 6, Nos. 339 to 343 of the Radio Regulations (RR);

e) that No. 344 of the RR in many cases does not unambiguously provide needed protection for radioastronomy from transmitters operating in frequency bands adjacent to a band allocated to the radioastronomy service;

f) the difficulties currently being experienced by radio services in the design and utilization of transmitters to operate in frequency bands adjacent to a band allocated to the radioastronomy service, in such a manner as to afford adequate protection from harmful interference to the radioastronomy service (cf. Annex 1);

g) the possible future increase in the level of usage of frequency bands adjacent to bands allocated to the radioastronomy service, particularly by airborne and satellite transmitters;

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

recommends

1. that all practical, technical means, for example, the use of filters, be adopted both in radioastronomy receivers and in adjacent band transmitters to the maximum practicable extent, in order to reduce interference to the radioastronomy service;

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 radioastronomy, attempts should be made to limit the edge of the necessary band adjacent to the radioastronomy band, so that the power radiated within this band should produce no harmful interference to a station of that service;

3. that when future frequency assignments are made by administrations in bands adjacent to those allocated to radioastronomy, account should be taken, to the maximum extent practicable, of the special risk of interference to radioastronomy 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 the band-edge interference problem be sought by administrations individually and if necessary in cooperation.

ANNEX 1

Interference to the radioastronomy service from transmitters in adjacent bands

1. Introduction

The sensitivity limit of most radioastronomy observations is at a flux-density level far below that used for reception of radiocommunication signals. Harmful interference and protection criteria for frequency sharing between radioastronomy and other services are discussed in Annex 1 to Recommendation 769; in Tables 1, 2 and 3 of the latter, the sensitivity limits are listed for different frequencies. However, as a consequence of the sensitivity of radioastronomy observations, interference can occur from transmitters which do not share the same band. This may be classified as band-edge interference and interference from harmonic and intermodulation signals. (Interference to the radioastronomy service from spurious emissions is treated in Recommendation 611.)

Band-edge interference, resulting from a transmitter in an adjacent band, can arise by three mechanisms of interaction. It can occur if the response of the radioastronomy receiver to signals outside the radioastronomy 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 signals near the edge of the passband, give rise to intermodulation products falling within the passband of the receiver. Thirdly, interference may result from low-level signals from a transmitter (modulation sidebands, etc.) which fall within the radioastronomy band. In dealing with band-edge interference, the problem common to both transmitting and receiving services is the design of filters which will adequately suppress the unwanted energy without introducing unacceptable modifications, e.g. attenuation or phase distortion, into the wanted signals. Cases of possible band-edge interference are listed in Table 1.

2. The role of the transmitter in the production of interference

Some of the mechanisms of interaction depend strongly upon the characteristics of the transmitter involved, and therefore should be examined separately for different services. UHF television and services using satellite transmissions are examples of services which have been found to be troublesome to radioastronomy. In particular, transmitters on satellites or aircraft present a problem because when there are line-of-sight paths to observatories, interference cannot always be avoided. To make matters worse, the requirements for radioastronomy instruments such as extensive arrays or millimetre-wavelength telescopes do not always allow observatory sites to be chosen primarily for their freedom from man-made interference.

2.1 Interference from satellite transmissions

Satellite transmissions, in particular those associated with television and sound broadcasting, may cause severe interference to radioastronomy. By the nature of a satellite broadcasting system, large areas of the Earth will be illuminated and line-of-sight conditions will exist. Terrestrial interfering sources are normally in the far side-lobe region of a radio telescope, whereas a satellite transmission is likely to be received also in the main beam and near side lobes, with considerably higher gain. For example, as far as 5° from the main beam, the gain may be 25 dB higher than in the far side-lobe region (see Recommendation 509).

Geostationary satellites which are above the horizon at any observatory could be particularly troublesome. The radius of the geostationary-satellite orbit is approximately 6.6 times the radius of the Earth. The position of the orbit in celestial coordinates as seen from the latitudes of a number of major radioastronomy observatories is shown in Fig. 1. Plans for the development of some active services call for a large number of closely spaced geostationary satellites. Such a series of potential sources of interference which may be viewed in the near side-lobes of a telescope present an interference problem not otherwise faced by radioastronomers. In § 2.2 this problem is examined geometrically for two levels of interference but without considering the source or nature of the interference.

TABLE 1

Services in adjacent bands which could cause harmful interference to the radioastronomy service*

Band allocated to radioastronomy on world-wide primary basis	Adjacent band	Adjacent-band services ([1])
13.36-13.41 MHz	13.26-13.36 MHz	AERONAUTICAL MOBILE (R)
25.55-25.67 MHz	25.67-26.10 MHz	BROADCASTING
322-328.6 MHz	273-322 MHz	MOBILE, including satellite
	315-335.4 MHz ([2])	AERONAUTICAL RADIONAVIGATION
1 400-1 427 MHz	1 350-1 400 MHz	RADIOLOCATION MOBILE (Region 1)
1 610.6-1 613.8 MHz([2])	1 610.0-1 610.6 MHz ([2]) 1 613.8-1 626.5 MHz ([2])	AERONAUTICAL RADIONAVIGATION ([2]) MOBILE-SATELLITE (Earth-to-space) ([2]) RADIODETERMINATION-SATELLITE (Primary Region 2, Secondary Region 3) ([2])
		Mobile-Satellite (Space-to-Earth)([2])
1 660-1 670 MHz	1 656.5-1 660.5 MHz	LAND MOBILE-SATELLITE (Earth-to-space) ([3])
	1 670-1 675 MHz ([2])	METEOROLOGICAL AIDS METEOROLOGICAL-SATELLITE (space-to-Earth)
2 690-2 700 MHz	2 670([2])-2 690 MHz	MOBILE-SATELLITE ([2]) FIXED-SATELLITE (Regions 2 and 3)
	2 700-2 900 MHz	AERONAUTICAL RADIONAVIGATION Radiolocation
4 990-5 000 MHz	4 800-4 990 MHz	MOBILE
	5 000-5 250 MHz	AERONAUTICAL RADIONAVIGATION
10.6-10.7 GHz	10.55-10.6 GHz	Radiolocation
	10.7-11.7 GHz	FIXED-SATELLITE (space-to-Earth)
15.35-15.4 GHz	14.8-15.35 GHz	MOBILE Space research
	15.4-15.7 GHz	AERONAUTICAL RADIONAVIGATION
22.21-22.5 GHz	22.5-22.55 GHz	MOBILE
23.6-24 GHz	23.55-23.6 GHz	MOBILE
	24-24.05 GHz	AMATEUR AMATEUR-SATELLITE ISM

TABLE 1 *(continued)*

Band allocated to radioastronomy on world-wide primary basis	Adjacent band	Adjacent-band services ([1])
31.3-31.8 GHz	31-31.3 GHz	MOBILE Standard signals-Satellite (space-to-Earth) Space research
	31.8-32 GHz	RADIONAVIGATION SPACE RESEARCH ([2])
42.5-43.5 GHz	40.5-42.5 GHz	BROADCASTING-SATELLITE BROADCASTING Mobile
	43.5-47 GHz	MOBILE MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE
86-92 GHz	84-86 GHz	MOBILE BROADCASTING BROADCASTING-SATELLITE
	92-95 GHz	MOBILE RADIOLOCATION
105-116 GHz	102-105 GHz	FIXED-SATELLITE (space-to-Earth) MOBILE
	116-126 GHz	INTER-SATELLITE MOBILE
164-168 GHz	158-164 GHz ([2])	FIXED-SATELLITE (space-to-Earth) MOBILE
	168-170 GHz	MOBILE
182-185 GHz	176.5-182 GHz	INTER-SATELLITE MOBILE
	185-190 GHz	INTER-SATELLITE MOBILE
217-231 GHz	202-217 GHz	MOBILE
	231-235 GHz	FIXED-SATELLITE (space-to-Earth) MOBILE Radiolocation
265-275 GHz	252-265 GHz	MOBILE MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE

* Fixed and mobile except aeronautical mobile services are not included (see § 2.3).

([1]) The category of service of these allocations is shown in conformity with the provision of Nos. 413-418 of the Radio Regulations (RR).

([2]) These items are the result of decisions made at WARC-92.

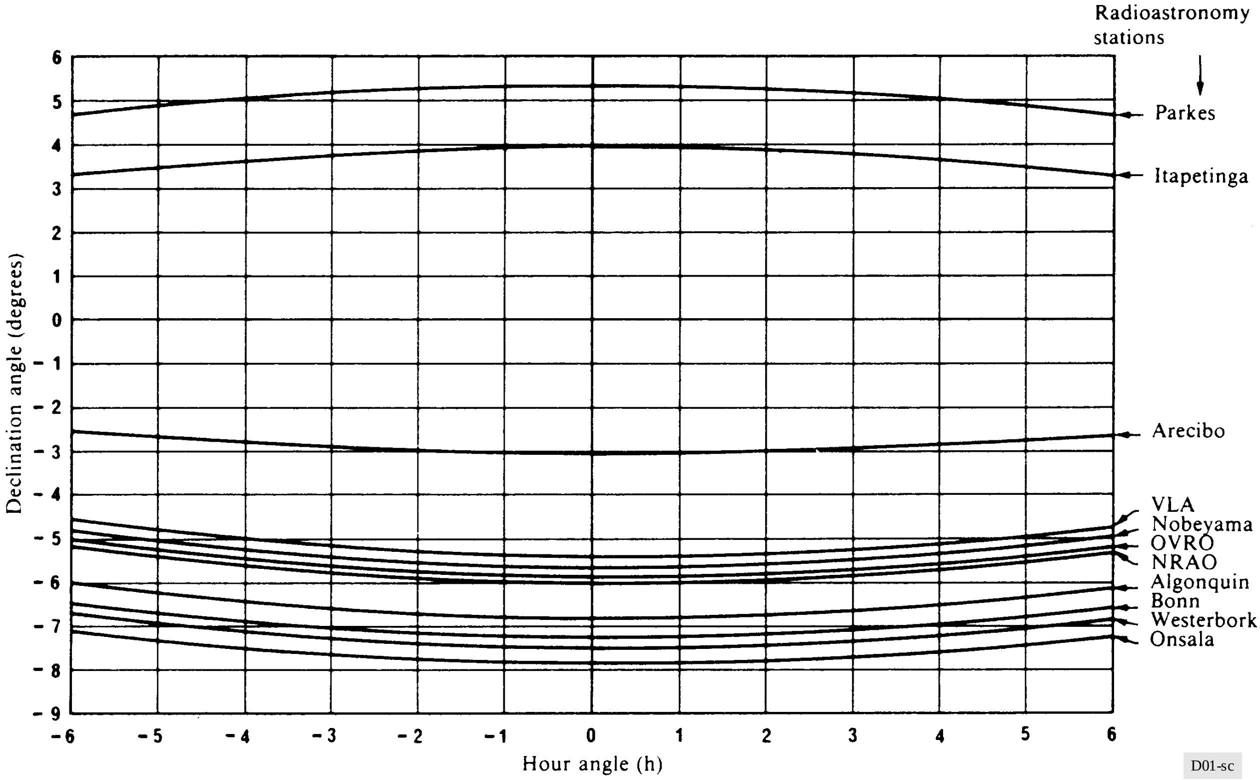
([3]) See also FN 730A (Mob-87) of the RR.

2.2 Regions of the sky denied to radioastronomy by emissions from geostationary satellites

Harmful thresholds for interference to radioastronomy are given in Annex 1 to Recommendation 769. Listed there is the level, in each radioastronomy band, of the power into the receiver which is just sufficient to cause harmful interference. Also listed are the power flux-densities (dB(W/m^2)) causing harmful 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. The very different result for geostationary sources is demonstrated in § 2.3.

FIGURE 1

Projection of geostationary-satellite orbit on to the celestial sphere



2.3 Interference at the interference threshold levels given in Annex 1 to Recommendation 769

If we assume that the radioastronomy antenna has the side-lobe characteristics assumed in Recommendation 509, the side-lobe gain would fall to 0 dBi at 19° from the axis of the main beam. For such an antenna the harmful interference level will be exceeded if the main beam is pointed within 19° of a satellite that produces within the radioastronomy bandwidth a power flux-density at the radio observatory equal to the harmful threshold in Annex 1 to Recommendation 769. A series of satellites spaced at intervals of about 30° along the geostationary-satellite orbit radiating interference at this level would result in a zone of width approximately 38° centred on the orbit in which radioastronomy observation free from harmful 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 beamed by the satellites' transmitting antennas or are more widely radiated. Out-of-band emission that is not widely separated from the satellite's transmitter frequency is likely to be beamed by a satellite antenna.