RECOMMENDATION ITU-R RA.1631

Reference radio astronomy antenna pattern to be used for compatibility analyses between non-GSO systems and radio astronomy service stations based on the epfd concept

(Question ITU-R 146/7)

(2003)

The ITU Radiocommunication Assembly,

considering

a) that there is a need to determine the levels of interference which may occur at typical observatory sites, due to various sources of interference;

b) that, to determine these levels of interference, a reference antenna pattern needs to be defined;

c) that Recommendation ITU-R SA.509 gives a reference antenna pattern which represents the side-lobe gain levels that are not expected to be exceeded at most off-axis angles in the majority of antennas used in the service;

d) that the antenna pattern given in Recommendation ITU-R SA.509 is appropriate in some compatibility or sharing analyses;

e) that, if the peak envelope radiation pattern such as given in Recommendation ITU-R SA.509 is used in the assessment of the aggregate interference consisting of many interference entries, the predicted interference will result in values that are greater than values that would be experienced in practice;

f) that Recommendation ITU-R S.1586 and Recommendation ITU-R M.1583 provide a methodology based on the epfd concept as defined in No. 22.5C of the Radio Regulations to calculate the level of unwanted emission levels produced by a non-geostationary-satellite system at radio astronomy stations;

g) that it is necessary to use an antenna radiation pattern representing average side-lobe levels to predict interference to a radio astronomy station from one or more fast moving stations seen under continuously variable angle such as non-GSO systems;

h) that, a simple mathematical formula is preferable to the radiation pattern representing average side-lobe levels;

j) that, to derive the epfd resulting from unwanted emission levels produced by a non-geostationary-satellite system at radio astronomy stations, it is necessary to use the typical maximum antenna gain of radio astronomy service (RAS) stations, *recommends*

1 that, in the absence of particular information concerning the radiation pattern of the radio astronomy antenna involved, the mathematical model of the average radiation pattern as stated below should be used for compatibility analyses between non-GSO systems and RAS stations for frequencies above 150 MHz:

$G(\varphi) = G_{max} - 2.5 \times 10^{-3} \left(\frac{D}{\lambda} \varphi \right)^2$	dBi	for	$0 < \varphi < \varphi_m$
$G(\varphi) = G_1$		for	$\varphi_m \leq \varphi < \varphi_r$
$G(\varphi) = 29 - 25 \log \varphi$	dBi	for	$\varphi_r \leq \varphi < 10°$
$G(\varphi) = 34 - 30 \log \varphi$	dBi	for	$10° \leq \varphi < 34.1°$
$G(\varphi) = -12$	dBi	for	$34.1° \leq \varphi < 80°$
$G(\varphi) = -7$	dBi	for	$80° \leq \varphi < 120°$
$G(\varphi) = -12$	dBi	for	$120° \leq \varphi \leq 180°$

where:

$$G_{max} = 20 \log \left(\frac{D}{\lambda} \right) + 20 \log \pi \qquad \text{dBi}$$

$$G_1 = -1 + 15 \log \frac{D}{\lambda} \qquad \text{dBi}$$

$$\varphi_m = \frac{20\lambda}{D} \sqrt{G_{max} - G_1} \qquad \text{degrees}$$

$$\varphi_r = 15.85 \left(\frac{D}{\lambda} \right)^{-0.6} \qquad \text{degrees}$$

D: diameter of the telescope (m)

λ: wavelength (m);

2 that the following mathematical model of the radiation pattern may be adopted for a more accurate representation of the main beam radiation pattern for frequencies above 150 MHz:

$$G(\varphi) = G_{max} \left[\frac{\mathrm{J}_1(2\pi x)}{\pi x} \right]^2 \qquad \text{(expressed as a ratio not in dB)}$$

where:

$\mathrm{J}_1(x)$: first order Bessel function

$G_{max} = \left[\frac{4\pi A_{eff}}{\lambda^2} \right]$: maximum gain (expressed as a ratio not in dB)

$A_{eff} = \pi(D/2)^2$: area of the aperture of the telescope (m^2)

D: diameter of the telescope (m)

λ: wavelength (m)

and where:

$$x = \frac{\pi \cdot D \cdot \varphi}{360 \cdot \lambda}$$ with φ, off-boresight angle (degrees) ($0 \le \varphi < \varphi_0$)

φ_0: first null in this antenna pattern at 69.88/(D/λ) (degrees) off-boresight

and that the following mathematical model of the radiation pattern may be adopted for a more accurate representation of the radiation pattern of near side lobes up to 1° from the boresight for frequencies above 150 MHz:

$$G(\varphi) = B\left[\frac{\cos(2\pi x - 3\pi/4 + 0.0953)}{\pi x}\right]^2$$ (expressed as a ratio not in dB)

where:

$$x = \frac{\pi \cdot D \cdot \varphi}{360 \cdot \lambda}$$ with φ, off-boresight angle (degrees) ($\varphi_0 \le \varphi \le 1°$)

D: diameter of the telescope

λ: wavelength

and:

$$B = 10^{3.2}\,\pi^2\,((\pi D/2)/(180 \cdot \lambda))^2$$

This main beam model corresponds to the ideal case of 100% aperture efficiency;

3 that the following typical maximum RAS antenna gain be used in compatibility analysis between non-GSO systems and RAS antenna stations.

RAS allocated band (MHz)	**Typical maximum antenna gain**
150.05-153	44
322-328.6	51
406.1-410	53
608-614	56
1 400-1 427	63
1 610.6-1 613.8	64
1 660-1 670	65
2 690-2 700	69
4 990-5 000	74

RAS allocated band (GHz)	**Typical maximum antenna gain**
10.6-10.7	81
14.47-14.5	84
15.35-15.4	84
22.21-22.5	87
23.6-24	88
31.3-31.7	90
42.5-43.5	93

The corresponding antenna diameter may be derived using the following equations (see *recommends* 2):

$$G_{max} = \left[\frac{4\pi A_{eff}}{\lambda^2} \right]$$ maximum gain (expressed as a ratio)

where:

$A_{eff} = \pi(D/2)^2$: area of the aperture of the telescope (m^2)

D : diameter of the telescope (m)

λ : wavelength (m).