International Telecommunication Union

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Recommendation ITU-R S.1855
(01/2010)

Alternative reference radiation pattern for earth station antennas used with satellites in the geostationay-satellite orbit for use in coordination and/or interference assessment in the frequency range from 2 to 31 GHz

S Series
Fixed-satellite service

International Telecommunication Union

Foreword

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RA	Radio astronomy
RS	Remote sensing systems
S	**Fixed-satellite service**
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

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 S.1855

Alternative* reference radiation pattern for earth station antennas used with satellites in the geostationary-satellite orbit for use in coordination and/or interference assessment in the frequency range from 2 to 31 GHz

(2010)

Scope

This Recommendation provides alternative reference radiation patterns to the ones given in Recommendation ITU-R S.465 which may be used for both circular and non-circular earth station antennas used with satellites in the geostationary-satellite orbit (GSO) and which, in the absence of particular information concerning the radiation pattern, may be used for coordination and/or interference assessment between earth stations in the fixed-satellite service (FSS) and stations of other services sharing the same frequency band as well as coordination and/or interference assessment between systems in the FSS.

The ITU Radiocommunication Assembly,

considering

a) that, for coordination and for the assessment of mutual interference between radiocommunication-satellite systems and between earth stations of such systems and stations of other services sharing the same frequency band, it is convenient to use a commonly agreed upon radiation pattern that is met by most antennas for the earth station antenna;

b) that, for the determination of coordination distance and for the assessment of interference between earth and terrestrial stations, a radiation pattern based on the level met by all but a small percentage of the side-lobe peaks may be appropriate;

c) that, for coordination and for the assessment of interference between earth stations and space stations, a radiation pattern for the region near the main beam based on the envelope of the peak gain of the side lobes in this region may be appropriate;

d) that, at angles relative to the axis of the main beam where effects peculiar to the particular feed system used do not contribute appreciably to the gain in the side lobes, the radiation patterns for numerous existing earth station antennas show only moderate scatter about a simple generalized radiation pattern, at least within the frequency range from 2 to 31 GHz;

e) that, for antennas of the Cassegrain type over the range of angles relative to the axis of the main beam where contributions to the side-lobe gain occur primarily as a result of spill-over, the patterns of a number of existing antennas also show reasonable agreement;

f) that, at large off-boresight axis angles, the likelihood of local ground reflections needs to be considered;

g) that the use of antennas with the best achievable radiation patterns will contribute to a more efficient use of the radio-frequency spectrum and the geostationary-satellite orbit (GSO);

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* This Recommendation provides an alternative reference radiation pattern to be considered in those cases where use of this reference pattern results in improved sharing conditions, as compared to Recommendation ITU-R S.465 which also addresses reference earth station radiation pattern for use in coordination and/or interference assessment. See also *noting* c).

h) that in the case of smaller antennas (diameter-to-wavelength (D/λ) ratio less than 46.8), some relaxation in the radiation pattern for far side lobes and back lobes relative to the radiation pattern envelope of Recommendation ITU-R S.465 may be necessary,

recognizing

a) that for the radiation pattern envelope of any non-rotationally symmetric antenna aperture shape, the minimum off-axis angle at which an antenna reference pattern applies may vary depending upon the angle of rotation about the antenna main-lobe axis,

noting

a) that by the principle of reciprocity, for the same or a nearby frequency band, the antenna pattern envelope for receiving antennas should be similar to that for transmitting antennas;

b) that increased utilization of the orbital arc has resulted in the increased use of small antennas having the larger physical dimension aligned with the GSO arc as seen from the earth station location (defined in this Recommendation as D_{GSO}) therefore improving the off-axis characteristics in the GSO plane;

c) that in the case of small antennas, where the far side lobes and back lobes do not meet the radiation pattern of Recommendation ITU-R S.465 but do meet the radiation pattern of this Recommendation, there is little impact to spectrum and orbit efficiency, however use of such antennas could make coordination more difficult with other services sharing the same frequency band, and thus such use should be confined to frequency bands that do not share primary allocations with other services or to situations where either there has been no previous coordination or where sharing conditions with other services have not yet been developed,

recommends

1 that, in the absence of particular information concerning the radiation pattern of the antennas used with satellites in the geostationary orbit, the reference radiation patterns depicted in *recommends* 2 and subject to the Notes in *recommends* 3 may be used for:

1.1 coordination and/or interference assessment between earth stations in the fixed-satellite service (FSS) and any station in other services sharing the same frequency band;

1.2 coordination and/or interference assessment between systems in the FSS;

2 that the following reference radiation patterns may be used for antennas used with satellites in the GSO for angles between the direction of interest and the axis of the main beam towards the GSO:

2.1 for earth station antennas with a diameter-to-wavelength[1] (D/λ) ratio greater than or equal to 46.8 (see Note 1):

$$G(\varphi) = 29 + 3\sin^2(\theta) - 25\log(\varphi) \quad \text{dBi} \quad \text{for} \quad \varphi_{min} \le \varphi \le 7°$$

$$G(\varphi) = 7.9 + \left(3\sin^2(\theta)\right)\left(\frac{9.2-\varphi}{2.2}\right) \quad \text{dBi} \quad \text{for} \quad 7° < \varphi \le 9.2°$$

$$G(\varphi) = 32 - 25\log(\varphi) \quad \text{dBi} \quad \text{for} \quad 9.2° < \varphi \le 48°$$

$$G(\varphi) = -10 \quad \text{dBi} \quad \text{for} \quad 48° < \varphi \le 180°$$

[1] In the case of a circular antenna aperture, D is the antenna diameter. The ratio D/λ, in *recommends* 2.1 and 2.2 is referred to as the diameter-to-wavelength ratio for the sake of simplicity (see Note 1).

$$\varphi_{min} = 15.85\left(\frac{D}{\lambda}\right)^{-0.6} \text{ or } 118\left(\frac{D}{\lambda}\right)^{-1.06} \text{ degrees, whichever is greater}$$

where:

φ : the off-axis angle between the direction of interest and the boresight axis (degrees)

φ_{min} : the minimum off-axis angle at which the envelope gain of $29 + 3\sin^2(\theta) - 25\log(\varphi)$ applies (degrees)

$G(\varphi)$: the antenna gain relative to an isotropic antenna (dBi)

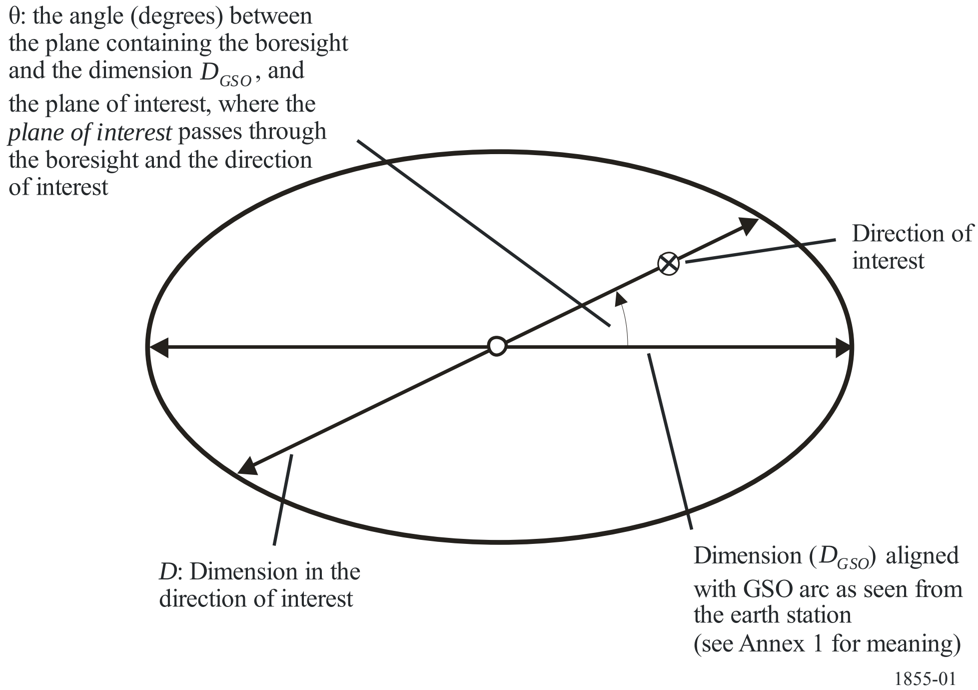
D : the dimension (m) of the antenna aperture in the plane of interest as shown in Fig. 1

λ : wavelength (m)

θ : the angle (degrees) between the plane containing the boresight and the dimension D_{GSO}, and the plane of interest, where the *plane of interest* passes through the boresight and the direction of interest (see Fig. 1)[2];

FIGURE 1

Parameters related to the antenna aperture



NOTE 1 – The ellipse and the dimensions D and D_{GSO} depict the physical aperture, whereas the angle θ and the direction of interest are used for specifying the reference radiation pattern.

[2] In the case of a circular antenna aperture, the factor $3\sin^2(\theta)$ is set to zero for all angles of θ for cases where the performance is the same for all angles (θ).

2.2 for earth station antennas with a diameter-to-wavelength (D/λ) ratio less than 46.8 and greater than or equal to 15 (see Notes 1, 2 and 3):

$$G(\varphi) = 29 + 3\sin^2(\theta) - 25\log(\varphi) \quad \text{dBi} \quad \text{for} \quad \varphi_{min} \le \varphi \le 7^\circ$$

$$G(\varphi) = 7.9 + \left(3\sin^2(\theta)\right)\left(\frac{9.2-\varphi}{2.2}\right) \quad \text{dBi} \quad \text{for} \quad 7^\circ < \varphi \le 9.2^\circ$$

$$G(\varphi) = 32 - 25\log(\varphi) \quad \text{dBi} \quad \text{for} \quad 9.2^\circ < \varphi \le 30.2^\circ$$

$$G(\varphi) = -5 \quad \text{dBi} \quad \text{for} \quad 30.2^\circ < \varphi \le 70^\circ$$

$$G(\varphi) = 0 \quad \text{dBi} \quad \text{for} \quad 70^\circ < \varphi \le 180^\circ$$

φ, φ_{min}, θ and $G(\varphi)$ are as defined in *recommends* 2.1;

3 that the following Notes should be considered as part of this Recommendation.

NOTE 1 – In the case of non-circular antenna apertures, the equivalent diameter should be used for the purpose of determining D/λ in order to apply *recommends* 2.1 or 2.2.

NOTE 2 – The radiation pattern of *recommends* 2.2 represents a maximum envelope, especially with respect to the back lobes. Measurements have demonstrated that some antennas with $D/\lambda < 46.8$ can meet the more stringent radiation pattern envelope in *recommends* 2.1.

NOTE 3 – For the purpose of this Recommendation, it is assumed that the minimum (D/λ) ratio in any direction of interest is not less than 15.

NOTE 4 – This Recommendation only applies where the off-axis angle φ between the direction of interest and the boresight axis is greater than or equal to φ_{min}.

NOTE 5 – Measurements of antenna radiation patterns need only be made in two planes, the first containing the boresight and D_{GSO}, and the second containing the boresight and being orthogonal to the first for off-axis angles greater than or equal to φ_{min} to demonstrate compliance with the reference radiation pattern in *recommends* 2. The reference radiation patterns in *recommends* 2 allow the determination of gain in all other directions for off-axis angles greater than or equal to φ_{min} for the purpose of applying this Recommendation.

NOTE 6 – The calculation of the minimum angle φ_{min} used in *recommends* 2 requires the determination of the cross-sectional dimension D of the antenna aperture. In the case of a circular or elliptical antenna, Annex 1 should be consulted for details on the calculation of D at an angle of rotation θ, in a counter-clockwise direction, around the boresight axis.

NOTE 7 – For the coordination of earth station receiving antennas, where the formula for φ_{min} in *recommends* 2 results in a value greater than 2.5° in the direction of interest, a value of 2.5° should be used for φ_{min}.

Annex 1

For application in coordination using data filed in accordance with the format of Appendix 4 of the Radio Regulations (RR) the dimensions of an equivalent area antenna aperture can be determined for any circular or elliptical aperture. In order to facilitate the use of this reference earth station antenna pattern in the Bureau's *Antenna Pattern Library*, two parameters, D_{GSO} and D_{eq}, are necessary in order to properly characterize the reference antenna pattern using the equations in *recommends* 2. The parameter D_{GSO} is a data element of RR Appendix 4 in general that needs to be provided for all cases where there is relaxation of the radiation envelope in accordance with *recommends* 2, for directions not aligned with the GSO arc. In the event that the antenna is the case of a circular aperture where the performance is the same for all angles (θ) as in the direction of interest where $\theta = 0°$ and $\theta = \pm 180°$ and there is no relaxation of the radiation envelope for directions not aligned with the GSO arc, no value for D_{GSO} is specified.

The equivalent diameter (D_{eq}) can be calculated using the following expression:

$$D_{eq} = \sqrt{\frac{G_{max}}{\eta}} \cdot \frac{\lambda}{\pi} \tag{1}$$

where:

- G_{max} : antenna gain in the direction of the antenna boresight expressed as a ratio
- λ : wavelength (m)
- η : antenna aperture efficiency expressed as a fraction.

Knowing D_{eq} and D_{GSO}, the cross-sectional dimension D (see Fig. 1) of an antenna described by an equivalent area ellipse can be specified at an angle of rotation θ in a counter-clockwise direction from the GSO plane. The expression for D is:

$$D = \frac{\frac{D_{GSO}}{K}}{\sqrt{\sin^2\theta + \left(\frac{1}{K}\right)^2 \cdot \cos^2\theta}} \tag{2}$$

where the parameter $K = \left(\frac{D_{GSO}}{D_{eq}}\right)^2$

The value of D, in the direction of interest at a rotation angle θ, may be used directly in the calculation of the minimum angle φ_{min} in *recommends* 2.