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| **Document Title:** WORKING DOCUMENT TOWARDs a PRELIMINARY DRAFT REVISION OF 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 |
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| **Purpose/Objective:**  |
| **Abstract:** This document provides revisions for Rec. ITU-R RA.1631. Specifically, it adds a scope to the recommendation and updates the table of typical maximum RAS antenna gain, extending values to frequencies from 43.5 – 275 GHz. |

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| WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT REVISION OF RECOMMENDATION ITU-R RA.1631 |
| **Reference radio astronomy antenna pattern to be used for compatibility analyses between non-GSO systems and radio astronomy service stationsbased on the epfd concept** |

**Introduction**

Based on proposed edits for the last WP 7D meeting, we provide a reconciled working document for consideration. Modifications over Rec. ITU-R RA.1631 are indicated with track changes.

Summary of revisions:

* Adding of a scope to the Recommendation
* Updating of the table of typical maximum RAS antenna gain in *recommends* 3, to extend the frequencies above 43.5 GHz until 275 GHz.
* Minor edits under considering and recommends

**Attachment**

ATTACHMENT

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

(Question ITU-R 146/7)

(2003-202X)

Scope

This Recommendation provides a reference antenna pattern for the radio astronomy service to be used for compatibility analyses between non-GSO systems and radio astronomy service based on the equivalent power flux-density (epfd) concept, where appropriate, for frequencies up to 275 GHz.

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 established;

*c)* that Recommendation [ITU-R SA.509](https://www.itu.int/rec/R-REC-SA.509/en) gives a reference antenna pattern which represents the side-lobe gain levels that are not expected to be exceeded;

*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 interference entries, the predicted interference will result in values that are greater than values that are experienced in practice;

*f)* that Recommendation [ITU-R S.1586](https://www.itu.int/rec/R-REC-S.1586/en) and Recommendation [ITU-R M.1583](https://www.itu.int/rec/R-REC-M.1583/en) 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, an analytic mathematical formula is preferable to the radiation pattern representing average side-lobe levels;

*i)* 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 considered for use in compatibility analyses between non-GSO systems and RAS stations for frequencies above 150 MHz:

 *G*() *Gmax* – 2.5  10–3                 dBi for 0    *m*

 *G*() *G*1 for *m*    *r*

 *G*() 29 – 25 log                 dBi for *r*    10

 *G*() 34 – 30 log                 dBi for 10    34.1

 *G*() –12               dBi for 34.1    80

 *G*() –7                dBi for 80    120

 *G*() –12               dBi for 120    180

where:

                dBi

                dBi

                 degrees

                 degrees

 *D*: diameter of the telescope (m)

λ: wavelength (m).

2that 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:

                (expressed as a ratio not in dB)

where:

J1(*x*):first order Bessel function

 *Gmax*  **:maximum gain (expressed as a ratio not in dB)

 *Aeff* π(*D*/2)2: area of the aperture of the telescope (m2)

 *D*: diameter of the telescope (m)

 λ: wavelength (m).

and where:

 *x*   with ϕ off-boresight angle (degrees) (  ϕ  ϕ0)

ϕ0 : 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:

                 (expressed as a ratio not in dB)

where:

 with ϕ off-boresight angle (degrees) (ϕ0 ≤ ϕ ≤ 1°)

 D: diameter of the telescope

 λ: wavelength.

 and:

*B* = 103.2 π2 ((π*D*/2)/(180 · λ))2

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

3that 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 |
| 48.94-49.04  | 94 |
| 76-77.5  | 98 |
| 79-81 | 98 |
| 81-86  | 99 |
| 86-92 | 99 |
| 92-94 | 100 |
| 94.1-100 | 100 |
| 100-102 | 91 |
| 102-105 | 92 |
| 105-109.5 | 92 |
| 109.5-111.8 | 92 |
| 111.8-114.25 | 92 |
| 114.25-116 | 93 |
| 130-134 | 94 |
| 136-148.5 | 94 |
| 148.5-151.5 | 95 |
| 151.5-158.5 | 95 |
| 164-167 | 96 |
| 182-185 | 97 |
| 200-209 | 98 |
| 209-217 | 98 |
| 217-226 | 98 |
| 226-231.5 | 98 |
| 241-248 | 99 |
| 250-252 | 99 |
| 252-275 | 100 |

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

 Gmax =                 maximum gain (expressed as a ratio)

where:

 *Aeff* = π(*D*/2)2: area of the aperture of the telescope (m2)

 *D*: diameter of the telescope (m)

 λ: wavelength (m).