



Recommendation ITU-R P.620-7
(06/2017)

**Propagation data required for the
evaluation of coordination distances
in the frequency range 100 MHz to 105 GHz**

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RECOMMENDATION ITU-R P.620-7*

**Propagation data required for the evaluation of coordination distances
in the frequency range 100 MHz to 105 GHz**

(Question ITU-R 208/3)

(1986-1992-1995-1997-1999-2003-2005-2017)

Scope

This Recommendation contains a prediction method for the determination of the coordination area around an earth station in the frequency range 100 MHz to 105 GHz. Prediction methods are provided to calculate the coordination area during periods of both clear air and scatter from hydrometeors (e.g. rain scatter).

Keywords

Coordination area, Coordination distance, Clear air, Hydrometeor scatter

The ITU Radiocommunication Assembly,

considering

- a) that the coordination area is that area, around an earth station, so defined that any interference between the earth station in question and terrestrial stations outside this area may be considered as negligible;
- b) that the determination of the coordination area should be based on the best propagation data available and should be adequately conservative;
- c) that the World Radiocommunication Conference (Istanbul, 2000) (WRC-2000) approved a revision of Appendix 7 of the Radio Regulations (most recently updated at WRC-15) based on material in Recommendation ITU-R SM.1448 which in turn is based on material in Recommendation ITU-R P.620 covering the frequency range 100 MHz to 105 GHz;
- d) that Resolution 74 (WRC-03) describes a process to keep the technical bases of Appendix 7 current,

recommends

that, for the determination of the coordination area with respect to frequencies above 100 MHz, administrations use the propagation calculation methods set out in Annex 1.

* This Recommendation should be brought to the attention of Radiocommunication Study Group 1.

Annex 1

1 Introduction

This Annex provides propagation data for use in the calculation of a coordination area and sets out a straightforward method for the assessment of the propagation factors concerned in the determination of coordination distances.

The coordination area represents the area outside of which interference between an earth station and terrestrial stations (or between bidirectionally operating earth stations), operating within the conservative assumptions given elsewhere, may be considered negligible. In the remainder of this Recommendation the words terrestrial stations may also represent bidirectionally operating earth stations. The determination of coordination distance therefore necessitates the comparison of the required transmission loss (minimum permissible basic transmission loss, $L_b(p)$ (dB), not exceeded for a given annual percentage time p), based on system and interference model considerations, with the transmission loss contributed by the propagation medium. The required coordination distance is that at which these two losses become equal.

Various propagation models are provided to cover different frequency ranges and to take account of different propagation mechanisms. These models predict propagation loss as a function of distance. Coordination distances are determined by calculating propagation loss iteratively with distance until either the required transmission loss is achieved or a limiting distance is reached.

It is important to note that the coordination area does not represent a zone within which the sharing of frequencies between the earth station and the terrestrial station is excluded. Such sharing is often possible, and the coordination area serves to assist this arrangement by indicating where the potential for interference between the earth station and any terrestrial stations needs to be evaluated using a more detailed analysis based on the relevant ITU-R Recommendations.

In addition to providing the method of calculation for the coordination contour, this Recommendation also provides information that enables the preparation of auxiliary contours to assist in the rapid elimination of the majority of potential interference cases during the subsequent coordination analysis for terrestrial stations falling within the coordination contour.

2 Structure of the Recommendation

The structure of the Recommendation is as follows:

Annex 1: The overall methodology for determining the coordination area

Attachment 1 to Annex 1: The definition of the input parameters

Attachments 2 and 3 to Annex 1: The equations required to calculate the coordination contours

Attachment 4 to Annex 1: A reference radiation pattern for line-of-sight radio-relay system antennas

Attachment 5 to Annex 1: The definition of all parameters.

3 General considerations

3.1 Assumptions

The determination of coordination distance propagation characteristics for an earth station is based on the assumption that:

- the locations of terrestrial stations with which coordination is to be sought are not known;
- in the interference path geometry, only information pertaining to the earth station is available;
- for the geometry over the remainder of the interference path, cautious limiting assumptions must be made as shown in the following text.

In this Annex, propagation phenomena are classified into two modes as follows:

- *mode (1)*: propagation phenomena in clear air:
 - affected by the presence of the Earth's surface (diffraction, refraction, ducting and layer reflection/refraction), and
 - via tropospheric scatter. These phenomena are confined to propagation along the great-circle path;
- *mode (2)*: hydrometeor scatter, which is not limited to the great-circle path, but is, as dealt with in this Annex, limited to earth stations operating with geostationary satellites.

For each azimuth from the earth station, and for each of the above two modes of propagation, it is necessary to determine a distance which gives a propagation loss equal to the required minimum permissible basic transmission loss. This distance (coordination distance) will be the greater of the two distances found.

The iteration method can always use a uniform step size, 1 km being recommended. In the case of mode (1) the functions defining propagation loss are monotonic with distance and, if preferred, a more efficient iteration procedure may be used.

3.2 Overview of propagation models

For the determination of coordination distances for propagation mode (1), the applicable frequency range has been divided into three parts:

- for VHF/UHF frequencies between 100 MHz and 790 MHz the model is based on an empirical fit to measured data;
- from 790 MHz to 60 GHz a propagation model taking account of tropospheric scatter, ducting and layer reflection/refraction is used;
- from 60 GHz to 105 GHz a millimetric model, based upon free-space loss and a conservative estimate of gaseous absorption, plus an allowance for signal enhancements at small time percentages, is used.

The parameter input ranges for each of the propagation mode (1) model mechanisms are in general different.

For the determination of coordination distances for propagation mode (2), isotropic scattering from hydrometeors in the common volume formed by the main beams of the potentially interfering stations is modelled. For the purposes of frequency coordination at frequencies below 1 GHz and above 40.5 GHz interference produced by hydrometeor scatter can be ignored. Below 1 GHz the level of the scattered signal is very low and above 40.5 GHz, although significant scattering occurs, the scattered signal is then highly attenuated on the path from the scatter volume to the terrestrial station.

For mode (1) the distance is incremented from a specified minimum which varies according to propagation factors relevant to each frequency range. For mode (2) distance is decremented from a maximum given in Table 2. For auxiliary mode (2), distance is decremented from the main mode (2) coordination distance for the same azimuth.

The loss due to shielding by terrain around an earth station should be calculated by the method described in § 1 of Attachment 2 according to the horizon elevation angles along different radials from the earth station. For all frequencies between 100 MHz and 105 GHz this additional loss should be taken into account.

4 Radio-climatic information

4.1 Radio-climatic data

For the calculation of the coordination distance for propagation mode (1), the world has been classified in terms of radio-climatic zones (see § 4.2) and a radiometeorological parameter, β_p , which reflects the relative incidence of clear-air anomalous propagation conditions.

The value of β_p is latitude dependent. The latitude to be used in determining the correct value for β_p is given by:

$$\zeta_r = \begin{cases} |\zeta| - 1.8 & \text{for } |\zeta| > 1.8^\circ \\ 0 & \text{for } |\zeta| \leq 1.8^\circ \end{cases} \quad (1a)$$

(1b)

where ζ is earth station latitude (degrees).

β_p is then determined using:

$$\beta_p = \begin{cases} 10^{1.67-0.015\zeta_r} & \text{for } \zeta_r \leq 70^\circ \\ 4.17 & \text{for } \zeta_r > 70^\circ \end{cases} \quad (2a)$$

(2b)

For frequencies between 790 MHz and 60 GHz the path centre sea level surface refractivity, N_0 , is used in the propagation mode (1) calculations. This can be calculated using:

$$N_0 = 330 + 62.6 e^{-\left(\frac{\zeta-2}{32.7}\right)^2} \quad (3)$$

4.2 Radio-climatic zones

In the calculation of coordination distance for propagation mode (1), the world is divided into four basic radio-climatic zones. These zones are defined as follows:

- *Zone A1*: coastal land and shore areas, i.e. land adjacent to a Zone B or Zone C area (see below), up to an altitude of 100 m relative to mean sea or water level, but limited to a maximum distance of 50 km from the nearest Zone B or Zone C area as the case may be; in the absence of precise information on the 100 m contour, an approximation (e.g. 300 feet) may be used;
- *Zone A2*: all land, other than coastal land and shore defined as Zone A1 above;
- *Zone B*: cold seas, oceans and large bodies of inland water situated at latitudes above 30°, with the exception of the Mediterranean and the Black Sea;
- *Zone C*: warm seas, oceans and large bodies of inland water situated at latitudes below 30°, as well as the Mediterranean and the Black Sea.

The following zone distance parameters are required in the various frequency models:

d_{lm} (km): longest continuous inland distance, Zone A2, within the current path distance;

d_{tm} (km): longest continuous land (i.e. inland + coastal) distance, Zone A1 + Zone A2 within the current path distance.

Where necessary, these distances must be re-evaluated for each total path distance within the iteration loops of the propagation models.

Large bodies of inland water

A large body of inland water, to be considered as lying in Zone B or Zone C as appropriate, is defined for the administrative purpose of coordination as one having an area of at least 7 800 km², but excluding the area of rivers. Islands within such bodies of water are to be included as water within the calculation of this area if they have elevations lower than 100 m above the mean water level for more than 90% of their area. Islands that do not meet these criteria should be classified as land for the purposes of the water area calculation.

Large inland lake or wetland areas

Large inland areas of greater than 7 800 km² which contain many small lakes or a river network should be declared as coastal Zone A1 by administrations if the area comprises more than 50% water, and more than 90% of the land is less than 100 m above the mean water level.

Climatic regions pertaining to Zone A1, large inland bodies of water and large inland lake and wetland regions are difficult to determine unambiguously. Therefore administrations are invited to register with the ITU Radiocommunication Bureau (BR) those regions within their territorial boundaries that they wish identified as belonging to one of these categories. In the absence of registered information to the contrary, all land areas will be considered as pertaining to climate Zone A2.

4.3 Use of radio-climatic information from other Recommendations

In certain sections for both mode (1) and mode (2) calculations, reference is made to radio-climatic information obtained from other ITU-R Recommendations. These are:

- a) Recommendation ITU-R P.836 for water vapour density;
- b) Recommendation ITU-R P.837 for rain rate;
- c) Recommendation ITU-R P.839 for rain height.

These Recommendations are referenced where necessary to obtain a radio-climatic parameter for a particular location defined by longitude and latitude. In other parts of the mode (1) and mode (2) calculations constant values of some radio-climatic parameters are used. In these cases no reference is needed to the other Recommendations.

5 Distance limits

5.1 Minimum distance limits

The coordination distance in any given direction is determined by a number of factors set out above and, based on propagation factors alone, the distances could extend from relatively close-in to the earth station to many hundreds of kilometres. However, for practical reasons and also to take account of assumptions which have to be made about the radio path, it is necessary to set lower limits to coordination distances (d_{min}), calculated as follows:

As a preliminary first step, calculate the minimum coordination distance as a function of frequency, f (GHz), up to 40 GHz, using:

$$d'_{min}(f) = 100 + \frac{(\beta_p - f)}{2} \quad \text{km} \quad (4)$$

Then calculate the minimum coordination distance at any frequency in the range 100 MHz to 105 GHz using:

$$d_{min}(f) = \begin{cases} d'_{min}(f) & \text{km} & \text{for } f < 40 \text{ GHz} & (5a) \\ \frac{(54 - f)d'_{min}(40) + 10(f - 40)}{14} & \text{km} & \text{for } 40 \text{ GHz} \leq f < 54 \text{ GHz} & (5b) \\ 10 & \text{km} & \text{for } 54 \text{ GHz} \leq f < 66 \text{ GHz} & (5c) \\ \frac{10(75 - f) + 45(f - 66)}{9} & \text{km} & \text{for } 66 \text{ GHz} \leq f < 75 \text{ GHz} & (5d) \\ 45 & \text{km} & \text{for } 75 \text{ GHz} \leq f < 90 \text{ GHz} & (5e) \\ 45 - \frac{(f - 90)}{1.5} & \text{km} & \text{for } 90 \text{ GHz} \leq f \leq 105 \text{ GHz} & (5f) \end{cases}$$

Note that in equation (5b) $d'_{min}(40)$ is evaluated using equation (4) with $f = 40$.

This minimum distance applies to mode (1) propagation only. For mode (2) propagation, a minimum distance of 55 km is to be used at all frequencies.

5.2 Maximum distance limits

It is also necessary to set upper limits (d_{max1} and d_{max2}) to the maximum distance used in the iterative calculations for propagation modes (1) and (2) respectively. The maximum calculation distance limit for propagation mode (1) (d_{max1}) is given by the following equation:

$$d_{max1} = \begin{cases} 1200 & \text{km} & \text{for } f \leq 60 \text{ GHz} & (6a) \\ 80 - 10 \log\left(\frac{p_1}{50}\right) & \text{km} & \text{for } f > 60 \text{ GHz} & (6b) \end{cases}$$

The maximum calculation distance limits for propagation mode (2) (d_{max2}) are given in Table 2.

5.3 Use of distance limits for iterative calculations

For mode (1) calculations, distance is incremented from the minimum distance limit and never continues beyond the maximum distance limit. For mode (2) calculations, distance is decremented from the maximum distance limit (or from the main contour in the case of auxiliary mode (2)), and never continues to distances less than the minimum.

6 Determination of the coordination distance for propagation mode (1) – Great circle propagation mechanisms

6.1 Coordination distances based on worst-month time percentages

The calculation of coordination distance is based on a level of interference which must not be exceeded for more than a specified average annual time percentage, p_1 . For cases where the coordination needs to be based on a worst-month time percentage, p_{w1} , the equivalent annual time percentage, p_1 , required by the method can be determined as follows.

Let:

$$G_L = \begin{cases} \sqrt{1.1 + |\cos 2\zeta_r|^{0.7}} & \text{for } \zeta_r \leq 45^\circ & (7a) \\ \sqrt{1.1 - |\cos 2\zeta_r|^{0.7}} & \text{for } \zeta_r > 45^\circ & (7b) \end{cases}$$

then:

$$p_1 = 10^{\frac{\log(p_{w1}) + \log(G_L) - 0.444}{0.816}} \quad (8)$$

where p_1 (%) is the average annual time percentage for propagation mode (1).

If necessary the value of p_1 must be limited such that $12p_1 \geq p_{w1}$.

6.2 Calculation of the coordination distance for propagation mode (1)

The following methods should be used to determine the coordination distances for propagation mode (1):

- for frequencies between 100 MHz and 790 MHz the method described in § 2 of Appendix 2;
- for frequencies between 790 MHz and 60 GHz the method described in § 3 of Appendix 2;
- for frequencies between 60 GHz and 105 GHz the method described in § 4 of Appendix 2.

7 Determination of the coordination distance for propagation mode (2) – Scattering from hydrometeors

7.1 General

The determination of the coordination contour for scattering from hydrometeors (e.g. rain scatter) is predicted on a path geometry which is substantially different from that of the great-circle propagation mechanisms. As a first approximation, energy is scattered isotropically by rain, so that interference may result for large scattering angles, and for beam intersections away from the great-circle path.

For this propagation mode the previous classification of the Earth's surface into inland, coastal and sea zones is no longer used.

7.2 Coordination distances based on worst-month time percentages

The calculation of coordination distance is based on a level of interference which must not be exceeded for more than a specified average annual time percentage, p_2 . For cases where the coordination needs to be based on a worst-month time percentage, p_{w2} , the equivalent annual time percentage, p_2 , required by the method can be determined as follows:

$$p_2 = 0.30(p_{w2})^{1.15} \quad (9)$$

where:

$$1.9 \times 10^{-4} < p_{w2} < 7.8$$

7.3 Calculation of contours for propagation mode (2)

In the case of propagation mode (2) coordination distances should be calculated using the method described in Appendix 3. This calculation is only necessary in the frequency range 1 GHz to 40.5 GHz. Outside this frequency range, rain scatter interference can be neglected and the mode (2) coordination distance is equal to the minimum coordination distance given by equation (5).

8 Auxiliary contours

8.1 General

Coordination contours are based upon worst-case assumptions regarding interference. Such assumptions do not necessarily apply in practice, and under certain conditions auxiliary contours can be drawn to eliminate terrestrial stations from further consideration.

For propagation mode (1), the derivation of auxiliary contours requires no additional propagation information. For propagation mode (2), auxiliary contours are generated for different values of the avoidance angle, this angle being the offset azimuth angle of the terrestrial station main beam axis away from the direction of the earth station. This involves additional propagation considerations which are addressed in § 8.2.

8.2 Hydrometeor scatter (propagation mode (2))

The coordination contour for mode (2) propagation around an earth station is calculated assuming a worst-case geometry, i.e. the two main beams intersect exactly in the great-circle plane containing both stations. This produces a large coordination area within which detailed calculations of hydrometeor scatter interference levels need to be performed. In practice, mode (2) propagation is far more likely to occur outside this great-circle plane than on it, and, furthermore, the antenna main lobes are unlikely to intersect exactly. In either case, it is possible to generate auxiliary contours which would yield areas that are smaller than the coordination area. Propagation mode (2) auxiliary contours, which take account of the azimuthal offset ϕ of a terrestrial station antenna beam from the direction of the earth station, should be calculated according to the method described in § 4 of Attachment 3. Any station which lies outside the relevant contour for its avoidance angle need not be considered as a significant source of interference.

The minimum coordination distance for propagation mode (2) is the same as that for propagation mode (1) i.e. d_{min} . The propagation mode (2) auxiliary contours should be prepared for avoidance angles of 2°, 5°, 10°, 20° and 30°, with additional angles as appropriate. It is essential that every effort be made to utilize the actual antenna pattern when determining the auxiliary contours; however, if this is not available the reference antenna pattern given in Attachment 4 may be used.