



Recommendation ITU-R P.617-4
(12/2017)

**Propagation prediction techniques and data
required for the design of trans-horizon
radio-relay systems**

P Series
Radiowave propagation



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SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
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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 P.617-4

Propagation prediction techniques and data required for the design of trans-horizon radio-relay systems

(Question ITU-R 205/3)

(1986-1992-2012-2013-2017)

Scope

This Recommendation contains a propagation prediction method for the planning of trans-horizon radio-relay systems.

Keywords

Anomalous/layer-reflection, diffraction, trans-horizon, tropospheric scatter

The ITU Radiocommunication Assembly,

considering

- a) that for the proper planning of trans-horizon radio-relay systems it is necessary to have appropriate propagation prediction methods and data;
- b) that methods have been developed that allow the prediction of most of the important propagation parameters affecting the planning of trans-horizon radio-relay systems;
- c) that as far as possible these methods have been tested against available measured data and have been shown to yield an accuracy that is both compatible with the natural variability of propagation phenomena and adequate for most present applications in system planning,

recommends

that the prediction methods and other techniques set out in Annex 1 be adopted for planning trans-horizon radio-relay systems in the respective ranges of parameters indicated.

Annex 1**1 Introduction**

The only mechanisms for radio propagation beyond the horizon which occur permanently for frequencies greater than 30 MHz are those of diffraction at the Earth's surface and scatter from atmospheric irregularities. In addition propagation due to ducting or layer-reflection may occur occasionally. Attenuation for diffracted signals increases very rapidly with distance and with frequency, and the anomalous propagation probability is relatively small, eventually the long term principal mechanism is that of tropospheric scatter. These mechanisms may be used to establish "trans-horizon" radiocommunication.

Because of the dissimilarity of the three mechanisms it is necessary to consider diffraction, ducting/layer reflection and tropospheric scatter paths separately for the purposes of predicting transmission loss and enhancements.

This Annex relates to the design of trans-horizon radio-relay systems. One purpose is to present in concise form simple methods for predicting the annual and worst-month distributions of the total transmission loss due to tropospheric scatter and ducting/layer reflection, together with information on their ranges of validity. Another purpose of this Annex is to present other information and techniques that can be recommended in the planning of trans-horizon systems.

2 Integral digital products

Only the file versions provided with this Recommendation should be used. They are an integral part of the Recommendation. Table 1 gives details of the digital products used in the method.

TABLE 1
Digital products

Filename	Ref.	Origin	Latitude (rows)			Longitude (columns)		
			First row (°N)	Spacing (degrees)	Number of rows	First col (°E)	Spacing (degrees)	Number of cols
DN50.txt	Att.1 Annex 1	P.452	90	1.5	121	0	1.5	241
N050.txt	Att.1 Annex 1	P.452	90	1.5	121	0	1.5	241

The “First row” value is the latitude of the first row.

The “First col” value is the longitude of the first column. The last column is the same as the first column ($360^\circ = 0^\circ$) and is provided to simplify interpolation.

“Spacing” gives the latitude/longitude increment between rows/columns.

The files are contained in the Supplement file R-REC-P.617-4-201712-I!!!ZIP.

3 Transmission loss for diffraction paths

For radio paths extending only slightly over the horizon, or for paths extending over an obstacle or over mountainous terrain, diffraction will generally be the propagation mode determining the field strength. In these cases, the methods described in Recommendation ITU-R P.526 should be applied.

4 Transmission loss distribution due to tropospheric scatter

Signals received by means of tropospheric scatter show both slow and rapid variations. The slow variations are due to overall changes in refractive conditions in the atmosphere and the rapid fading to the motion of small-scale irregularities. The slow variations are well described by distributions of the hourly-median transmission loss which are approximately log-normal with standard deviations between about 4 and 8 dB, depending on climate. The rapid variations over periods up to about 5 min are approximately Rayleigh distributed.

In determining the performance of trans-horizon links for geometries in which the tropospheric scatter mechanism is predominant, it is normal to estimate the distribution of hourly-median transmission loss for non-exceedance percentages of the time above 50%.

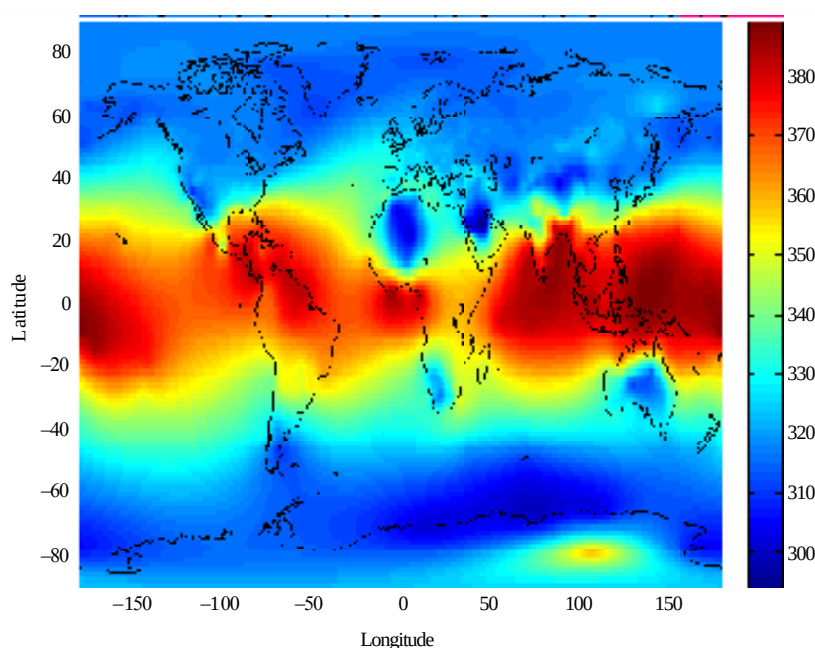
A simple semi-analytical technique for predicting the distribution of average annual transmission loss in this range is given in § 4.1. The method for conversion of these annual time percentages to those for the average worst month is given in § 4.2. Attachment 1 includes additional supporting information on seasonal and diurnal variations in transmission loss, on frequency of rapid fading on tropospheric scatter paths and on transmission bandwidth.

4.1 Average annual median transmission loss distribution

The following step-by-step procedure is recommended for estimating the average annual median transmission loss $L(p)$ not exceeded for percentages of the time p . The procedure requires the link parameters of great-circle path length d (km), frequency f (MHz), transmitting antenna gain G_t (dB), receiving antenna gain G_r (dB), horizon angle θ_t (mrad) at the transmitter, and horizon angle θ_r (mrad) at the receiver:

Step 1: Obtain the average annual sea-level surface refractivity N_0 and radio-refractive index lapse-rate dN for the common volume of the link in question using the digital maps of Fig. 1 and Fig. 2, respectively. These maps are available electronically from the ITU-R SG 3 website under the specification in § 2.

FIGURE 1
Average annual sea-level surface refractivity, N_0



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