



**Recommendation ITU-R P.1144-9**  
(12/2017)

**Guide to the application of the  
propagation methods of  
Radiocommunication Study Group 3**

**P Series**  
**Radiowave propagation**



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## Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

## Policy on Intellectual Property Right (IPR)

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Annex 1 of Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from <http://www.itu.int/ITU-R/go/patents/en> where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

### Series of ITU-R Recommendations

(Also available online at <http://www.itu.int/publ/R-REC/en>)

| Series     | Title                                                                                |
|------------|--------------------------------------------------------------------------------------|
| <b>BO</b>  | Satellite delivery                                                                   |
| <b>BR</b>  | Recording for production, archival and play-out; film for television                 |
| <b>BS</b>  | Broadcasting service (sound)                                                         |
| <b>BT</b>  | Broadcasting service (television)                                                    |
| <b>F</b>   | Fixed service                                                                        |
| <b>M</b>   | Mobile, radiodetermination, amateur and related satellite services                   |
| <b>P</b>   | <b>Radiowave propagation</b>                                                         |
| <b>RA</b>  | Radio astronomy                                                                      |
| <b>RS</b>  | Remote sensing systems                                                               |
| <b>S</b>   | Fixed-satellite service                                                              |
| <b>SA</b>  | Space applications and meteorology                                                   |
| <b>SF</b>  | Frequency sharing and coordination between fixed-satellite and fixed service systems |
| <b>SM</b>  | Spectrum management                                                                  |
| <b>SNG</b> | Satellite news gathering                                                             |
| <b>TF</b>  | Time signals and frequency standards emissions                                       |
| <b>V</b>   | 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 P.1144-9

**Guide to the application of the propagation methods  
of Radiocommunication Study Group 3**

(1995-1999-2001-2001-2007-2009-2012-2015-06/2017-12/2017)

**Scope**

This Recommendation provides a guide to the Recommendations of Radiocommunication Study Group 3, which contain propagation prediction methods. It advises users on the most appropriate methods for particular applications as well as the limits, required input information, and output for each of these methods.

**Keywords**

Radiowave propagation, prediction methods, digital products, spatial interpolation, height reference system

The ITU Radiocommunication Assembly,

*considering*

*a)* that there is a need to assist users of the ITU-R Recommendations P Series (developed by Radiocommunication Study Group 3),

*recommends*

**1** that the information contained in Table 1 be used for guidance on the application of the various propagation methods contained in the ITU-R Recommendations P Series (developed by Radiocommunication Study Group 3);

**2** that the information contained in Table 2 and Annex 1 be used for guidance on the use of the various digital maps of geophysical parameters necessary for the application of the propagation methods in *recommends* 1 above.

NOTE – For each of the ITU-R Recommendations in Table 1, there are associated information columns to indicate:

*Application:* the service(s) or application for which the Recommendation is intended.

*Type:* the situation to which the Recommendation applies, such as point-to-point, point-to-area, line-of-sight, etc.

*Output:* the output parameter value produced by the method of the Recommendation, such as path loss.

*Frequency:* the applicable frequency range of the Recommendation.

*Distance:* the applicable distance range of the Recommendation.

*% time:* the applicable time percentage values or range of values of the Recommendation; % time is the percentage of time that the predicted signal is exceeded during an average year.

*% location:* the applicable per cent location range of the Recommendation; % location is the percentage of locations within, say, a square with 100 to 200 m sides that the predicted signal is exceeded.

*Terminal height:* the applicable terminal antenna height range of the Recommendation.

*Input data:* a list of parameters used by the method of the Recommendation; the list is ordered by the importance of the parameter and, in some instances, default values may be used.

The information, as shown in Table 1, is already provided in the Recommendations themselves; however, the Table allows users to quickly scan the capabilities (and limitations) of the Recommendations without the requirement to search through the text.

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TABLE 1  
ITU-R radiowave propagation prediction methods

| Method           | Title                                                                                                                                   | Application                                                           | Type                         | Output                                                                                                            | Frequency                         | Distance                                                                                                    | % time                                                                                                                                    | % location     | Terminal height                                                                                                  | Input data                                                                                                                                                                                         |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|------------------------------|-------------------------------------------------------------------------------------------------------------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Rec. ITU-R P.368 | Ground-wave propagation curves for frequencies between 10 kHz and 30 MHz                                                                | All services                                                          | Point-to-point               | Field strength                                                                                                    | 10 kHz to 30 MHz                  | 1 to 10 000 km                                                                                              | Not applicable                                                                                                                            | Not applicable | Ground-based                                                                                                     | Frequency<br>Ground conductivity                                                                                                                                                                   |
| Rec. ITU-R P.452 | Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz | Services employing stations on the surface of the Earth; interference | Point-to-point               | Path loss                                                                                                         | 100 MHz to 50 GHz                 | Not specified but up to and beyond the radio horizon                                                        | 0.001 to 50<br>Average year and worst month                                                                                               | Not applicable | No limits specified, within the surface layer of the atmosphere.<br>(Not suitable for aeronautical applications) | Path profile data<br>Frequency<br>Percentage time<br>Tx antenna height<br>Rx antenna height<br>Latitude and longitude of Tx<br>Latitude and longitude of Rx<br>Meteorological data<br>Polarization |
| Rec. ITU-R P.528 | Propagation curves for aeronautical mobile and radionavigation services using the VHF, UHF and SHF bands                                | Aeronautical mobile                                                   | Point-to-area                | Path loss                                                                                                         | 125 MHz to 15.5 GHz               | 0 to 1 800 km<br>(for aeronautical applications<br>0 km horizontal distance does not mean 0 km path length) | 1 to 95                                                                                                                                   | Not applicable | H1: 1.5 m to 20 km<br>H2: 1 to 20 km                                                                             | Distance<br>Tx height<br>Frequency<br>Rx height<br>Percentage time                                                                                                                                 |
| Rec. ITU-R P.530 | Propagation data and prediction methods required for the design of terrestrial line-of-sight systems                                    | Line-of-sight fixed links                                             | Point-to-point line-of-sight | Path loss<br>Diversity improvement (clear air conditions)<br>XPD <sup>(2)</sup><br>Outage<br>Error<br>performance | Approximately 150 MHz to 1 00 GHz | Up to 200 km if line-of-sight                                                                               | All percentages of time in clear-air conditions; 1 to 0.001 in precipitation conditions <sup>(1)</sup><br>And worst month for attenuation | Not applicable | High enough to ensure specified path clearance                                                                   | Distance<br>Tx height<br>Frequency<br>Rx height<br>Percentage time<br>Path obstruction data<br>Climate data<br>Terrain information                                                                 |

TABLE 1 (continued)

| Method           | Title                                                                                                                        | Application                     | Type                          | Output                                                                                                                     | Frequency      | Distance                   | % time                                                                                                                                 | % location     | Terminal height                                                                                              | Input data                                                                                                                                                                                                                                                     |
|------------------|------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------------|----------------|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Rec. ITU-R P.533 | Method for the prediction of the performance of HF circuits                                                                  | Broadcasting<br>Fixed<br>Mobile | Point-to-point                | Basic MUF<br>Sky-wave field strength<br>Available receiver power<br>Signal-to-noise ratio<br>LUF<br>Circuit reliability    | 2 to 30 MHz    | 0 to 40 000 km             | All percentages                                                                                                                        | Not applicable | Not applicable                                                                                               | Latitude and longitude of Tx<br>Latitude and longitude of Rx<br>Sunspot number<br>Month<br>Time(s) of day<br>Frequencies<br>Tx power<br>Tx antenna type<br>Rx antenna type                                                                                     |
| Rec. ITU-R P.534 | Method for calculating sporadic-E field strength                                                                             | Fixed<br>Mobile<br>Broadcasting | Point-to-point via sporadic E | Field strength                                                                                                             | 30 to 100 MHz  | 0 to 4 000 km              | 0.1 to 50                                                                                                                              | Not applicable | Not applicable                                                                                               | Distance<br>Frequency                                                                                                                                                                                                                                          |
| Rec. ITU-R P.617 | Propagation prediction techniques and data required for the design of trans-horizon radio-relay systems                      | Trans-horizon fixed links       | Point-to-point                | Path loss                                                                                                                  | > 30 MHz       | 100 to 1 000 km            | 0.001 to 99.999                                                                                                                        | Not applicable | No limits specified within the surface layer of the atmosphere. (Not suitable for aeronautical applications) | Frequency<br>Tx antenna gain<br>Rx antenna gain<br>Path geometry                                                                                                                                                                                               |
| Rec. ITU-R P.618 | Propagation data and prediction methods required for the design of Earth-space telecommunication systems                     | Satellite                       | Point-to-point                | Path loss<br>Diversity gain and (for precipitation condition) XPD <sup>(2)</sup>                                           | 1 to 55 GHz    | Any practical orbit height | 0.001-5 for rain attenuation;<br>0.001-50 for total attenuation,<br>0.001-1 for XPD <sup>(2)</sup><br>Also worst month for attenuation | Not applicable | No limit                                                                                                     | Meteorological data<br>Frequency<br>Elevation angle<br>Height of earth station<br>Separation and angle between earth station sites (for diversity gain)<br>Antenna diameter and efficiency (for scintillation)<br>Polarization angle (for XPD <sup>(2)</sup> ) |
| Rec. ITU-R P.619 | Propagation Data Required for the Evaluation of Interference Between Stations in Space and those on the Surface of the Earth | Satellite                       | Point-to-point                | Basic transmission loss for single-entry interference<br>Clear-air basic transmission loss for multiple-entry interference | 0.1 to 100 GHz | Any practical orbit height | 0.001 to 50                                                                                                                            | Not applicable | No limit                                                                                                     | Frequency<br>Earth-station elevation angle<br>Angular path separation<br>Path length<br>Gaseous attenuation<br>Scintillation "gain"<br>Maximum allowed attenuation of the wanted signal                                                                        |