



Recommendation ITU-R P.1622-1
(08/2022)

**Prediction methods required
for the design of Earth-space systems
operating between 20 THz and 375 THz**

P Series
Radiowave propagation



International
Telecommunication
Union
Documents
Document Sharing Hub

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 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
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	Broadcasting service (television)
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
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.*

Electronic Publication
Geneva, 2022

© ITU 2022

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without written permission of ITU.

RECOMMENDATION ITU-R P.1622-1*

**Prediction methods required for the design of Earth-space systems
operating between 20 THz and 375 THz**

(2003-2022)

Scope

This Recommendation describes propagation effects applicable for the planning of Earth-space systems operating between 20 to 375 THz. It provides the propagation prediction methods for effects due to Rayleigh and Mei scattering, and turbulence occurring in the atmosphere. It also references Recommendation ITU-R P.676 which provides prediction methods for atmospheric absorption losses.

Keywords

Atmospheric absorption, turbulence, amplitude scintillation, Rayleigh scattering, Mie scattering

Related ITU-R Recommendations

Recommendation ITU-R P.676

Recommendation ITU-R P.1621

NOTE –The latest revision/edition of the Recommendation should be used.

The ITU Radiocommunication Assembly,

considering

- a) that the spectrum between 20 THz and 375 THz is suitable for certain space-based communications in near-Earth and deep space environments;
- b) that for the proper planning of Earth-space systems operating between 20 THz and 375 THz, it is necessary to have appropriate propagation prediction techniques;
- c) that methods have been developed for the prediction of the most significant propagation-related impacts to Earth-space systems operating between 20 THz and 375 THz;
- d) that as far as possible, these methods have been tested against available 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 planning of systems operating between 20 THz and 375 THz,

recognizing

that No. 78 of Article 12 of the ITU Constitution states that a function of the Radiocommunication Sector includes, "... carrying out studies without limit of frequency range and adopting recommendations ...",

* Radiocommunication Study Group 3 made editorial amendments to this Recommendation in June 2024 in accordance with Resolution ITU-R 1.

recommends

that the methods for predicting propagation-related system impacts given in Annexes 1 and 2 be used for planning Earth-space systems in the respective ranges of validity indicated in Annexes 1 and 2.

NOTE 1 – Supplementary information related to fundamental propagation data for frequencies between 20 THz and 375 THz may be found in Recommendation ITU-R P.1621.

Annex 1

1 Introduction

The Earth's atmosphere is complex and dynamic and will impact the performance of a system operating in the frequency range 20 THz to 375 THz between the Earth and an orbiting spacecraft. These system impacts include:

- an overall loss in signal amplitude due to absorption by molecules of atmospheric gasses present along the propagation path;
- an overall loss in signal amplitude and an increase in background noise due to scattering by particles ranging in size from fractions of a wavelength to many wavelengths present along the propagation path;
- fluctuations in the received amplitude and phase of the signal due to turbulence caused by thermal variations in the atmosphere.

The representative techniques and equations required to carry out the necessary prediction methods are presented in the following sections of this Annex.

2 Absorption losses

Calculations of atmospheric absorption are possible using a line-by-line method similar to that which is provided in Recommendation ITU-R P.676. However, as thousands of individual lines are present across the spectral range from 10 THz to 1 000 THz (30 μm to 0.3 μm), such a method is computationally intensive and cumbersome. The windows of low atmospheric absorption are identified within the astronomical community with standardized filters as described in Table 1. The centre frequencies of these filters provide an estimate of the regions of spectrum usable for communication along Earth-space paths in terms of the absorptive characteristics of the atmosphere only. As absorption is dependent, in part on local temperature, pressure, and atmospheric chemistry, the bandwidth of the filters does not necessarily correspond with the bandwidth of the regions of low atmospheric absorption. The four highest frequency bands represent a continuum of visible and ultraviolet spectrum with relatively low atmospheric absorption rather than distinct low absorption regions. Measurements of atmospheric absorption should be conducted whenever possible prior to the deployment of an earth station.