



Recommendation ITU-R F.1096-1
(04/2011)

**Methods of calculating line-of-sight
interference into fixed wireless systems
to account for terrain scattering**

F Series
Fixed service



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 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
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, 2011

© ITU 2011

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

RECOMMENDATION ITU-R F.1096-1

Methods of calculating line-of-sight interference into fixed wireless systems to account for terrain scattering¹

(1994-2011)

Scope

This Recommendation is intended for the calculation of a terrestrial surface impact on formation of interference signal to the fixed wireless systems.

The ITU Radiocommunication Assembly,

considering

- a) that interference from other fixed wireless systems and other services can affect the performance of a line-of-sight fixed wireless system;
- b) that the signal power from the transmitting antenna in one system may propagate as interference to the receiving antenna of another system by a line-of-sight (LoS) great-circle path;
- c) that the signal power from the transmitting antenna in one system may propagate as interference to the receiving antenna of another system by the mechanism of scattering from natural or man-made features on the surface of the Earth;
- d) that terrain regions that produce the coupling of this interference may not be close to the great-circle path, but must be visible to both the interfering transmit antenna and the receive antenna of the interfered system;
- e) that the component of interference power that results from terrain scattering can significantly exceed the interference power that arrives by the great-circle path between the antennas;
- f) that efficient techniques have been developed for calculating the power of the interference scattered from terrain,

recommends

- 1** that the effects of terrain scatter, when relevant, should be included in calculations of interference power when the interference is due to signals from the transmitting antenna of one system into the receiving antenna of another and when either or both of the following conditions apply (see Note 1):
 - 1.1** there is a LoS propagation path between the transmitting antenna of the interfering system and the receiving antenna of the interfered system;
 - 1.2** there are natural, or man-made, features on the surface of the Earth that are visible from both the interfering transmit antenna and the interfered receive antenna;
- 2** that the methods given in Annex 1 be used to calculate the contribution of interference due to terrain scatter.

¹ Recommendation 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, in Radiocommunication Study Group 3 addresses other propagation mechanisms.

NOTE 1 – Specular reflections or propagation by diffraction are not treated by the calculation methods described in this Recommendation.

Annex 1

Interference to fixed wireless systems caused by terrain scattering

1 Introduction

Terrain scattering has been found to be a particularly strong mechanism for coupling interference between radio-relay systems in cases where two paths cross each other and the terrain at the intersection is visible from both the transmitting antenna of one hop and the receiving antenna of the other. In this case, the main lobes of the two antennas couple through a common area of terrain and the interference is like ground clutter received in a bi-static radar system.

In the past, interference between fixed wireless systems was determined by calculations based on the mechanism of near great-circle propagation which includes LoS paths, the effects of atmospheric refraction, diffraction by the surface of the Earth and tropospheric forward scatter. Such great-circle techniques combined with antenna side-lobe coupling have also been used for many years by some administrations to determine intra- and inter-system interferences in terrestrial fixed wireless systems. Field measurements in recent years have indicated that great-circle propagation is often a minor contributor compared to terrain scattering.

In contrast to the case of inter-system interference, the discrepancies between great-circle predictions and measurements become smaller for intra-system interference, where the major cases have usually been between two adjacent hops on the same route.

In the case of interference between an earth station and a terrestrial station, coupling may also occur through the main beam of the terrestrial antenna, the area around the earth station, and the side lobes of the earth station antenna. Depending on geometric circumstances, either ground scattering or great-circle coupling may be the predominant interference mechanism.

2 Mathematical model of terrain scatter

The interference power, P_r , received through the mechanism of ground scatter from a transmitting antenna radiating power, P_t , may be determined from the bi-static radar equation:

$$P_r = P_t \frac{\lambda^2}{(4\pi)^3} \int_{\Omega} \frac{G_t G_r}{R_t^2 R_r^2} \gamma dA_e, \quad (1)$$

where t and r denote transmitter and receiver respectively, $G(\theta, \varphi)$ is the respective antenna power gains in the direction of the scatterers in the elemental scattering area dA_e , θ represents the azimuth and φ the elevation from the centerline of the antenna (see Fig. 1), R_t and R_r are the respective slant distances from the antennas to the scattering element, λ is the wave length, and γ is the modified scattering coefficient describing the incoherent energy scattered by the elemental area. The elemental area dA_e is defined to be the minimum of the areas of the scatterer normal to the slant vectors from the transmitter and the receiver.

Equation (1) assumes that the scattered fields from different areas or objects are incoherent, and the region Ω contains all elemental regions that contribute to the received scattered energy. In evaluating the integral for a portion of the surface of the Earth, it is necessary to account for the shadowing of individual elemental areas. Only unshadowed areas, which are visible to both the transmitting and receiving antennas, will contribute.

Comparison of measured and calculated interference values has shown that the modified scattering coefficient γ can be assumed to be constant over fairly large areas of terrain. Characteristic values of γ , which were determined by one administration for several different land covers, are given in Table 1.

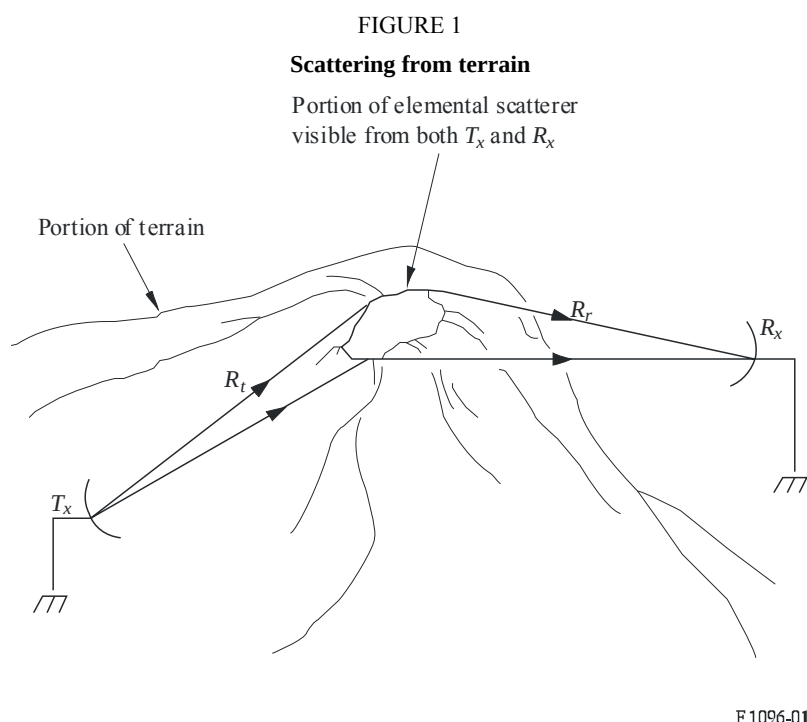


TABLE 1

Scatterer type	γ (dB)
Land cover types (from United States of America database)	
– urban residential	–8
– commercial and services	–7
– deciduous forest	–16
– mixed forest	–20
Man-made structures from Federal Aviation Administration database	10.4

The integral for determining the interference power, (1), may be expressed as a finite summation:

$$P_r = C_t \sum_{\Omega} \frac{G_t(p_i) G_r(p_i)}{R_t^2(p_i) R_r^2(p_i)} \gamma_i A_{e,i} \quad (2)$$

$$C_t = P_t \frac{\lambda^2}{(4\pi)^3} \quad (3)$$

where:

γ_i : coefficient of the i -th cell

p_i : cell midpoint

$A_{e,i}$: effective area of the i -th cell contained in the universe of cells, Ω .

Interference measurements made at a fixed frequency typically show time fluctuations around the mean value computed by equation (2). This is due to the movement of scattering objects like trees and vegetation or to temporal variations in atmospheric conditions, which may induce amplitude and phase variations between scatter returns from different scattering areas. Similarly, fluctuations about the same mean value are observed when the carrier frequency in the experiment is changed. Fortunately, for the important case of interference between digital radio systems, only the mean value given by equation (2) is of importance. On the other hand, if the strong carrier of a low-index FM signal is the source of interference then fluctuations of this carrier above the mean (up fades) have to be taken into account.

2.1 Application of the model

Practical considerations of computer resources impose a limit on the physical size of the portion of the region Ω over which the integral will be evaluated. One approach is to take the region of integration as a quadrilateral region on the surface of the Earth defined by the intersection of an azimuthal sector centered on the transmit interfering antenna with an azimuthal sector centered on the receiving interfered antenna. Figure 2 shows such a region for the case where the path from station 1 to station 4 intersects with that from station 3 to station 2, resulting in terrain scatter interference from station 1 into station 2. The sectors would be centered on the main beam azimuth of the respective antennas and could include the azimuths where the directive gain in the azimuthal direction is no more than, say, 30 dB below the maximum gain. Evaluation of the interference integral over such a region is described in § 3.1.

Bounding techniques offer a less arbitrary, more accurate, and more efficient means of evaluating the scatter interference power. Since most of the received energy, which has been scattered by the terrain, is usually contributed by scattering from the regions close to the intersection of the main beams of the interfering and interfered antennas, an accurate integration is only required in the vicinity of this intersection. The contribution from the remainder of Ω can be determined from an upper bound. The application of bounding techniques is described in § 3.2.

An elemental terrain area can have a non-zero contribution to the interference integral only if it is not shadowed. That is, it must be visible to both the transmitting and receiving antennas. In evaluating the shadowing of an elemental area it is necessary to consider both macro- and micro-shadowing. In macro-shadowing, an element is not visible because of obstruction by higher terrain that is closer to one of the antennas; in micro-shadowing, the element presents no effective area, $A_{e,i}$ to one of the antennas because of its orientation. The conditions necessary to determine whether an elemental region is macro- or micro-shadowed are described in §§ 4.1 and 4.2, respectively.