



Recommendation ITU-R P.680-4
(08/2022)

**Propagation data required for
the design of Earth-space maritime
mobile telecommunication systems**

P Series
Radiowave propagation



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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.680-4

Propagation data required for the design of Earth-space maritime mobile telecommunication systems

(Question 207-5/3)

(1990-1992-1997-1999-2022)

Scope

This Recommendation describes propagation effects applicable for the planning of Earth-space maritime mobile telecommunication systems. It identifies the relevant propagation effects occurring in the troposphere and ionosphere, and references the ITU-R Recommendations that provide prediction methods for these effects. This recommendation also provides methods for the prediction of fading in the frequency range 0.8 to 8 GHz due to reflections from the sea surface, for elevation angles between 5 and 20 degrees, and interference from adjacent satellite systems.

Keywords

Tropospheric attenuation, tropospheric scintillation, ionospheric scintillation, Faraday rotation, sea surface reflection, fade depth, down-link interference, up-link interference

Related ITU-R Recommendations

Recommendation ITU-R P.527

Recommendation ITU-R P.531

Recommendation ITU-R P.618

Recommendation ITU-R P.676

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

The ITU Radiocommunication Assembly,

considering

- a) that for the proper planning of Earth-space maritime mobile systems it is necessary to have appropriate propagation data and prediction methods;
- b) that the methods of Recommendation ITU-R P.618 are recommended for the planning of Earth-space telecommunication systems;
- c) that further development of prediction methods for specific application to maritime mobile-satellite systems is required to give adequate accuracy for all operational conditions;
- d) that, however, methods are available which yield sufficient accuracy for many applications,

recommends

that the current methods set out in Annex 1 be adopted for use in the planning of Earth-space maritime mobile telecommunication systems, in addition to the methods recommended in Recommendation ITU-R P.618.

Annex 1

1 Introduction

Telecommunications over Earth-space links for maritime mobile-satellite systems lead to propagation problems that are substantially different from those arising in the fixed-satellite service. For instance, the effects of reflections and scattering by the sea surface can be quite severe, in particular where antennas with wide beamwidths are used. Furthermore, maritime mobile-satellite systems may operate on a world-wide basis, including paths with low elevation angles.

This Annex deals with data and models specifically needed to characterize the sea-space path impairments which include:

- tropospheric effects, including rain attenuation, gaseous absorption, refraction, scintillation and anomalous propagation occurring at low elevation angles;
- ionospheric effects such as scintillation and Faraday rotation;
- surface reflection effects (multipath due to secondary paths arising from the reflection of radio waves from the sea surface);
- local environment effects (ship motion and sea conditions);
- interference effects due to differential fading between a desired signal and an interference signal, both affected by multipath fading.

2 Tropospheric effects

2.1 Attenuation

Signal losses in the troposphere are caused by atmospheric gases, rain, fog and clouds. Except at low elevation angles, tropospheric attenuation is negligible at frequencies below about 1 GHz, and is generally small at frequencies up to about 10 GHz. Above 10 GHz, the attenuation can be large for significant percentages of the time on many paths.

Prediction methods are available for estimating gaseous absorption (see Recommendation ITU-R P.676) and rain attenuation (see Recommendation ITU-R P.618). Fog and cloud attenuation is usually negligible for frequencies up to 10 GHz.

2.2 Scintillation

Irregular variations in received signal level and in angle of arrival are caused by both tropospheric turbulence and atmospheric multipath. The magnitudes of these effects increase with increasing frequency and decreasing path elevation angle, except that angle of arrival fluctuations caused by turbulence are independent of frequency. Antenna beamwidth also affects the magnitude of these scintillations. These effects are observed to be at a maximum in the summer season. A prediction method is given in Recommendation ITU-R P.618.

3 Ionospheric effects

Ionospheric effects (see Recommendation ITU-R P.531) may be important, particularly at frequencies below 1 GHz. For convenience these have been quantified for frequencies of 0.1, 0.25, 0.5, 1, 3 and 10 GHz in Table 1 for a high value of total electron content (TEC).

3.1 Ionospheric scintillation

Inhomogeneities of electron density in the ionosphere cause refractive focusing or defocusing of radio waves and lead to amplitude fluctuations termed scintillations. Ionospheric scintillation is maximum near the geomagnetic equator and smallest in the mid-latitude regions. The auroral zones are also regions of large scintillation. Strong scintillation is Rayleigh distributed in amplitude; weaker scintillation is nearly log-normal. These fluctuations decrease with increasing frequency and depend upon path geometry, location, season, solar activity and local time. Table 2 tabulates fade depth data for VHF and UHF in mid-latitudes, based on data in Recommendation ITU-R P.531.

Accompanying the amplitude fluctuation is also a phase fluctuation. The spectral density of the phase fluctuation is proportional to $1/f^3$, where f is the Fourier frequency of the fluctuation. This spectral characteristic is similar to that arising from flicker of frequency in oscillators and can cause significant degradation to the performance of receiver hardware.

3.2 Faraday rotation

A linearly polarized wave propagating through the ionosphere undergoes a progressive rotation of the plane of polarization. Effects are summarized in Table 1.

The axial ratio of an incident elliptically polarized wave may be increased or decreased upon reflection (particularly at small angles) since Faraday rotation varies the orientation of the principal polarization axis of the incident wave. This results from the difference in reflection coefficient to be expected between vertical and horizontal components in most multipath situations.

The effects of Faraday rotation on wideband signals can be of significance to system performance. The differential rotation effects cannot be fully corrected at VHF by reorientation of the antenna axis of a linearly polarized antenna. On circularly polarized antennas, the effect is to introduce differential phase shifts of signal components across the band. Thus, signal components separated in frequency may be expected to be subject to frequency and phase selective distortion.