**Annex 1.5**

##### Propagation fundamentals for FS calculations

# Preface

This annex contains the basic propagation mode of RF signals in Fixed Service. The main part of the transmitted energy spreading directly path between transmitter and receiver. It is called line of sight (LOS) propagation method. For more information see Appendix 1.

## Line-of-sight propagation

The following should be evaluated for both LoS and transhorizon paths.

Basic transmission loss due to free-space propagation and attenuation by atmospheric gases:

Lbfsg  = 92.5 + 20 log f [GHz]   + 20 log d [km]  + Ag               dB (1)

where:

Ag: total gaseous absorption (dB):

 (2)

where:

γo, γw (ρ) : specific attenuation due to dry air and water vapour, respectively, and are found from the equations in Recommendation ITU‑R P.676

ρ: water vapour density:

                g/m3 (2a)

ω: fraction of the total path over water

# Interference propagation mechanisms

Interference may arise through a range of propagation mechanisms whose individual dominance depends on climate, radio frequency, time percentage of interest, distance and path topography. At any one time a single mechanism or more than one may be present. The principal interference propagation mechanisms are as follows:

Line-of-sight: The most straightforward interference propagation situation is when a line‑of‑sight trans­mission path exists under normal (i.e. well‑mixed) atmospheric conditions. However, an additional complexity can come into play when subpath diffraction causes a slight increase in signal level above that normally expected. Also, on all but the shortest paths (i.e. paths longer than about 5 km) signal levels can often be significantly enhanced for short periods of time by multipath and focusing effects resulting from atmospheric stratification (see Fig. 2).

Diffraction (Fig. 1): Beyond line-of-sight (LoS) and under normal conditions, diffraction effects generally dominate wherever significant signal levels are to be found. For services where anomalous short-term problems are not important, the accuracy to which diffraction can be modelled generally determines the density of systems that can be achieved. The diffraction prediction capability must have sufficient utility to cover smooth‑earth, discrete obstacle and irregular (unstructured) terrain situations.

Tropospheric scatter (Fig. 1): This mechanism defines the “background” interference level for longer paths (e.g. more than 100-150 km) where the diffraction field becomes very weak. However, except for a few special cases involving sensitive receivers or very high power interferers (e.g. radar systems), interference via troposcatter will be at too low a level to be significant.

Surface ducting (Fig. 2): This is the most important short-term propagation mechanism that can cause interference over water and in flat coastal land areas, and can give rise to high signal levels over long distances (more than 500 km over the sea). Such signals can exceed the equivalent “free‑space” level under certain conditions.



Figure 1.: Line-of-Sight propagation mechanism

Elevated layer reflection and refraction (Fig. 2): The treatment of reflection and/or refraction from layers at heights up to a few hundred metres is of major importance as these mechanisms enable signals to overcome the diffraction loss of the terrain very effectively under favourable path geometry situations. Again the impact can be significant over quite long distances (up to 250‑300 km).

Figure 2.: Anomalous (short-term) interference propagation mechanisms

Hydrometeor scatter (Fig. 2): Hydrometeor scatter can be a potential source of interference between terrestrial link transmitters and earth stations because it may act virtually omnidirectionally, and can therefore have an impact off the great‑circle interference path. However, the interfering signal levels are quite low and do not usually represent a significant problem.

A basic problem in interference prediction (which is indeed common to all tropospheric prediction procedures) is the difficulty of providing a unified consistent set of practical methods covering a wide range of distances and time percentages; i.e. for the real atmosphere in which the statistics of dominance by one mechanism merge gradually into another as meteorological and/or path conditions change. Especially in these transitional regions, a given level of signal may occur for a total time percentage which is the sum of those in different mechanisms. The approach in this procedure has been to define completely separate methods for clear-air and hydrometeor-scatter interference prediction, as described in Appendix 1.

The clear-air method consists of separate models for diffraction, ducting/layer-reflection, and troposcatter. All three are applied for every case, irrespective of whether a path is LoS or transhorizon. The results are then combined into an overall prediction using a blending technique that ensures for any given path distance and time percentage that the signal enhancement in the equivalent notional line-of-sight model is the highest attainable.

Reference:

- Appendix 1 to Annex 1.5 (ITU-R P.452-16)