Training Program : Point-to-Point Radio Link Design

Course : Path Analysis, Obstructions

COMPLEMENTS to Lesson 3 : Obstruction Loss and Clearance Criteria

Obstruction Loss formulas

Theoretical formulas for Obstruction Loss are available in the cases of a "Knife Edge" obstacle and of "Smooth Spherical Earth" [1]. For practical cases, approximate expressions can be used.

In the case of a Knife Edge obstacle, a good approximation for Obstruction Loss(L_{KNIFE}) is given for Normalized Clearance C_{NORM} < 0,5 (that is in all cases of practical interest for radio link design).

$$L_{KNIFE}\,(dB) = 6.9 + 20 \cdot \mathrm{Log}_{10} \{ [(\nu - 0.1)^2 + 1]^{1/2} + \nu - 0.1 \}$$

where $\nu = - \sqrt{2} \cdot C_{NORM}$

The Loss caused by Smooth Spherical Earth (L_{SSE}) can be approximated by the following formulas:

$$L_{SSE}\,(dB) = 11 + 10 \cdot \mathrm{Log}_{10}(X) - 17.6 \cdot X + G(Y_1) + G(Y_2)$$

where : $X = 22 \cdot F^{1/3} \cdot R_E^{-2/3} \cdot D$

$$Y = 0.96 \cdot F^{2/3} \cdot R_E^{-1/3} \cdot H$$

$$G(Y) = 17.6 \cdot (Y - 1.1)^{1/2} - 5 \cdot \mathrm{Log}_{10}(Y - 1.1) - 8 \quad \text{for } Y > 2$$

$$G(Y) = 20 \cdot \mathrm{Log}_{10}(Y + 0.1 \cdot Y^3) \quad \text{for } Y \leq 2$$

and F is the frequency (GHz), R_E is the equivalent earth radius (8500 km for k = 1.33), D is the path length (km), H is the antenna height (m) over the earth surface. Y_1, Y_2 in the first formula refer to the first and second path terminal, respectively (in the Y formula, use the appropriate antenna height).

The approximation is valid for hop length $D > 30.5 \; F^{-1/3}$ (some 20 km for a 4 GHz link) and for frequencies above 1 GHz.

More on Obstruction Loss

Point-to-point radio hops should be usually designed in such a way to avoid a significant loss due to path obstructions [2]. More generally, obstruction loss estimate is in most cases useful to design the appropriate antenna height in order to guarantee path clearance or to limit obstruction loss to a sufficiently low value.

Obviously, there are cases where design constraints (hop length, limitation in antenna height, ...) make some (even significant) loss unavoidable.

A similar comment applies to radio paths with multiple obstructions. Several approximate methods have been suggested to estimate the obstruction loss produced by multiple obstacles. They find more usual application in mobile communications and radio coverage estimates.

To deal with multiple obstructions, we just mention the so-called Deygout model which provides a reliable procedure. It can be summarized according to the following steps:

1) Take each obstacle as the only obstacle in the path and estimate path clearance in each case.

2) From the previous result, identify the most significant obstacle in the path (the one with minimum normalized clearance).

3) Compute the obstruction loss due to that obstacle.

4) Divide the original path in two sub-paths (with the obstacle previously identified assumed as an intermediate site) and repeat iteratively the previous steps.

ITU-R Rec. P.526 [1] describes a revised Deygout method.

Fresnel Ellipsoid vs. Frequency

The Fresnel ellipsoid radius is proportional to wavelength, so that the ellipsoid dimension is smaller and smaller as the frequency increases.

Therefore, we can expect it is convenient to increase the frequency to reduce the Fresnel ellipsoid percentage obstructed by a given obstacle. This is true as far as the obstacle is below the ellipsoid axis (that is when Clearance is positive, under the convention adopted for the Clearance sign).

However, in a severely obstructed path (for example, in long over-the-sea hops) it is not possible to avoid the condition of a negative Clearance (the obstacle above the ellipsoid axis). In that case, the use of a lower frequency is advisable, so that Normalized Clearance is higher (even if negative).

The Table below gives some numerical examples for an over-the-sea radio hop. The first two rows indicate a positive clearance, with no loss for the 11 GHz link. The third and fourth rows refer to a longer hop, with negative clearance and a lower loss in the 2 GHz link.

Frequency [GHz]	Hop Length [km]	Ant. Height (a.s.l.) [m]	Fresnel Ell. Max Radius [m]	Norm. Clearance	Obstruction Loss [dB]
2	50	45	43.3	0.30	5.5
11	50	45	18.5	0.71	0.0
2	90	90	58.1	-0.71	28.2
11	90	90	24.7	-1.15	47.2

Useful References

[1] ITU-R Rec. P.526-15, "Propagation by Diffraction", 2019

[2] Vigants A., "Microwave Radio Obstruction Fading", BSTJ, vol. 60, n.8, August 1981, 785-801