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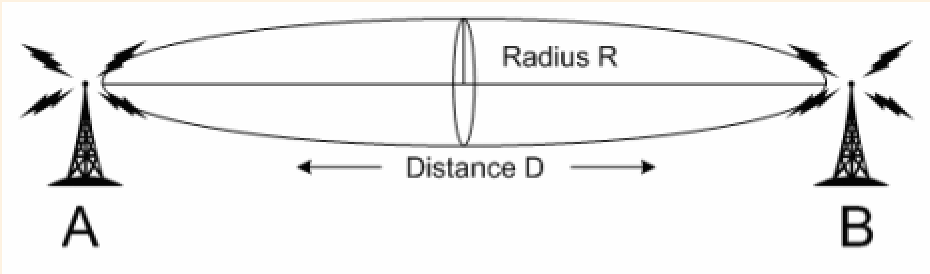
Weird & Wireless: RF "Line of Sight"



Welcome again to the wonderful but sometimes weird world of wireless comms, written by Joel Young, [CTO of Digi International]

What does "Line of Sight" really mean in the RF world?

When discussing wireless solutions, invariably the first question asked is something like, "What kind of range will I get?" or "How far away can the radios be placed?"

Rather than give the proverbial "It depends" answer, I've noticed that those of us talking about wireless solutions tend to give the theoretical maximum distance followed by the phrase "line of sight."

I admit that I personally do it all the time. I've found that it's almost a technical-macho thing to espouse that my radio has a longer range, and "line of sight" statements provide that safe justification in the same way that EPA mpg ratings do for vehicle gas mileage.

So, what does "RF line of sight" really mean? I've found that most people take the phrase literally so as to mean, if my eyes can actually see the other point, then I must have "RF line of sight" as well.

In this context, a couple of points should be noted: (1) in many cases this assumption will work out just fine and (2) not having pure RF line of sight doesn't meant that your signal won't get through.

We know that, even though we like to think of everything in perfectly straight lines, waves don't necessarily act that way.

If you are trying to transmit a signal from, say, point A to point B, some waves will travel the straight line, while others will effectively spawn new waves at each wave front (i.e. wave length) which interfere both constructively and destructively.

Since, on a relative scale, we are dealing with very small points or origin and destination, we can describe the clear zone path of these waves as a sort of football shape.

A really smart French mathematician and physicist, Augustin Fresnel, did some really cool work with optics and wave theory in the early 19th century. Many of you probably know him from the Fresnel lens, which is used in lighthouses to focus a light beam.

Anyway, I won't go into the details of his work, but Fresnel did some amazing math. As part of his work, he showed that there are ring shaped zones, the area of a circle defining this ring at the mid-point between points was equal to pi times the distance between the two points times the wavelength divided by 4 or ??D / 4 (see some similarities to the previous blog on isotropic antenna apertures). Hence the radius R of this zone at the mid-point is v(?D) / 2.

Ignoring the math details, the important thing to note this that the definition of line of site broadens with wavelength - meaning for low frequency, high wavelength signals, you need to have a larger Fresnel radius free of obstructions.

For comparison, let's assume that the distance D is 1 km and then calculate the Fresnel radius at the mid-point for a VHF signal at 150 Mhz, a WiFi signal at 2400 Mhz and visible green light at about 600 Thz.

Description	Frequency	Wavelength	Midpoint Radius at 1Km
VHF	150 Mhz	2 m	31.6 m
WiFi	2400 Mhz	0.125 m (12.5 cm)	7.9 m
Green	600 Thz	0.0000005 m (500 nm)	0.016 m (1.6 cm)

Notice that the radius for VHF is a whopping 32 meters. However, before you get you get too disenchanted about low frequencies and too excited about using really high frequencies, remember that the definition of obstruction varies.

For example - visible green light generally doesn't get through foliage at all - making trees a complete obstruction. WiFi sees foliage as a significant obstruction and VHF doesn't really see foliage as too much of an obstruction at all. The other thing to note is that waves tend to find a way so you need to have a pretty major obstruction to really stop your signal.

Finally, notice that, for visible light, line of sight really is the line of sight.

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Prior to joining Digi, Joel was VP of Sales & Marketing at Transcrypt International where he was responsible for sales, marketing, and product development for all information security products. During his tenure at Transcrypt, he also served as VP of Product Development and VP of Engineering where he was responsible for engineering, research and product development for wireless communications products, cellular telephony, wireline telephony and land mobile radio, data security and specialized digital radio products.

He also served as District Manager for AT&T Business Communications Services where he was responsible for the creation and implementation of voice processing and network database strategies, including deploying new voice processing platforms into the AT&T switched network for private network and other outbound calling services.