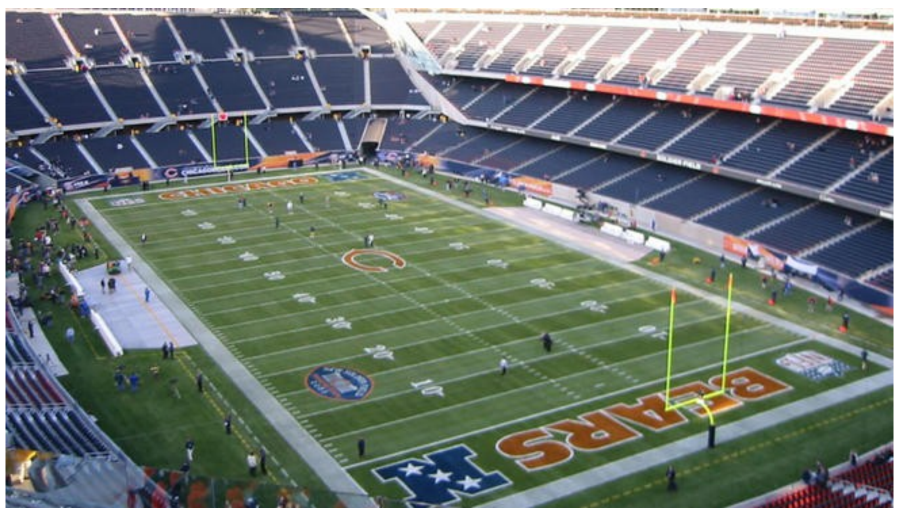
# Brass Tacks

***An in-depth look at a radio-related topic***

## Radio football

This article attempts to answer (at least) the following mysteries:

- *Why do my friend and I, who are across town, but in **line-of-sight** from each other, hear a lot of static in our QSO?*
- *How is it that the same friend can hear me clearly on the repeater, which is also **line-of-sight** to us, but twelve times the distance away from us?*
- *When I'm traveling down the freeway, why do people report that I'm picket-fencing, even though I'm **line-of-sight** with the repeater we're on, the entire time?*




## The super ball

Imagine you and your friend, each with an HT (handheld transceiver), communicating on simplex, in line-of-sight with each other. Also imagine a huge, football-shaped volume whose ends are fixed at your two radios, and whose maximum diameter is defined as

*diameter = 10√(3d / f )*

where d = the distance between your radios in meters and f is your radio frequency in MHz. For example, if you're communicating on 146.520 MHz and you are 17 kilometers from each other (say, one in Orem and the other in Lehi), then the maximum diameter of your imaginary football is

*diameter = 10√(3d / f ) = 10 X √(3 X 17000 / 146.520) = 186.5 meters* thick, at about halfway between you two.

This roughly ellipsoidal region is the space you should always imagine as the *zone of interference*. It's the space where, if any electrically polarized object (cars, people, trees, buildings, hills, bodies of water, or other conductive thing) enters, can obstruct the signal between you two, to some degree.

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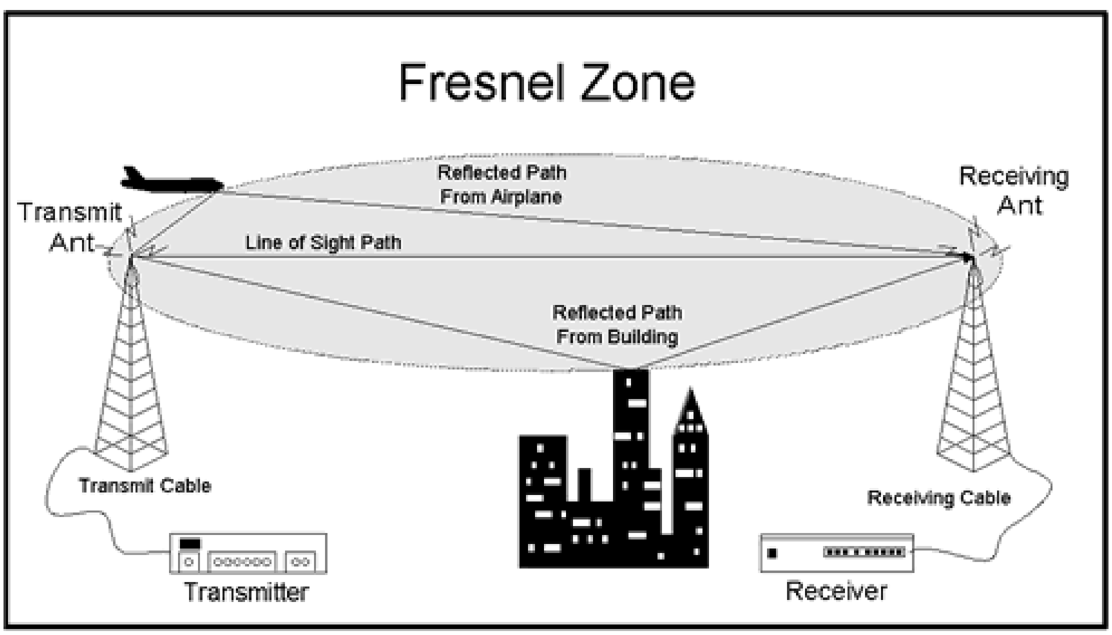
## End zone

Technically, this is known as the *Fresnel Zone* (https://en.wikipedia.org/wiki/Fresnel_zone) (pronounced fra-NELL), after the young French genius who discovered the phenomenon by playing with light propagation back in the early 1800s. Essentially, just about anything within this zone can interfere with your signal by 1) blocking it, 2) reflecting it, or 3) refracting it. There are other causes and effects, but these are the most important to amateur radio interference due to obstruction.

When an object ***blocks*** your signal, it can prevent the energy from arriving at its destination. Like casting a shadow, the object absorbs your signal energy, so that the amount of signal reaching the target is reduced by the area facing your signal. Blocking your signal typically occurs in the general line-of-sight with your target, near the center of the zone of interference.

If an object is not in the direct path of your line-of-sight with your target, but within the zone of interference, it's still possible for it to ***reflect*** your signal, thereby causing more than one signal to reach your target. While that seems like a good idea (two signals are better than one, right?), the problem is that the multiple signals arrive at the target at different moments, causing one to reach the target out of phase with the other, resulting in actually cancelling each other out. This is known as multi-path, and can result in a distorted or even canceled signal, which often occurs within the zone of interference.

There are objects through which your signal can travel, but might bend your signal instead of reflect it, much like an optical lens can bend light coming through it. This ***refraction*** can occur because of the dielectric properties of the object, and can pass the signal in a distorted fashion, if the object lies within the zone of interference, whether or not it lies within your target line-of-sight.



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## Pass interference

So, which kinds of objects produce which of the above effects? Well, just about any somewhat-conductive object can result in any of them, but typically metallic equipment (storage tanks, cages, cars) tend to reflect, and water-based objects (trees, animals, ponds) tend to refract.

And just how large is this zone of interference? If you go through the above calculations, you can see that it's frequency-dependent, but it's also proportional to the distance to your target. In short, the diameter of the football is about 1% of the distance to the target on 2 meters, about 2/3% of the distance on 70 cm, and almost 2% of the total distance on 6 meters. So, the higher your frequency, the fewer things will fall within the same zone of interference, which in part explains the success of higher frequencies through objects, and the failure of 6 meters performing the same in the same area.

As you drive your car within line-of-sight of the repeater you're communicating through, using your mobile unit, you might notice a large conference hall about a quarter of a mile away. It's possible that your signal will sound good, then sketchy, then good again, about every fifteen feet or so. But at your current speed of 61 or 62 MPH (translated to 90 feet per second), you might hear that good-sketchy-good sound about (90 / 15 =) 6 times a second, which will sound like somebody blowing into a slow fan.

## Touchdown

Does this apply to skywave propagation? Absolutely. Think of each trip (direct path between radio and ionosphere, or ionosphere and ground), each with its own football, meaning multiple zones of interference from start to finish. What can interfere with them? Clouds, aircraft, trees, bodies of water, large populations of birds and insects, moist or dense air, static charge buildup, the ionospheric D-Layer, the solar wind (atmospherically absorbed solar particles), magnetic field aberration, and particulates such as dust, smoke, and pollution.

With so many obstructions against you, it's a wonder that amateur radio works at all. And it IS a wonder. Still, awareness is often the first step to overcoming problems when we encounter them, and that's the purpose of this article: to make you aware of this electromagnetic phenomenon and expand the way you look at radio propagation. So, the next time you get on the radio, and you encounter interference, it might be wise to keep football on your mind. No punt intended.

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