Critical Factors for

Infrastructure Antenna Installation

There are several factors that should be considered to ensure good wireless communication. Some of these factors include line-of-sight, height & distance between antennas, curvature of the earth, and the Fresnel zone.

Line-of-sight is an important factor that affects radio frequency links. This is because barriers such as buildings tress, and even hills can block some of the transmitted signal or produce multipath reflections which attenuate the strength and quality of the signals being received. Some signals will bounce and will scatter at random. Also, the amount of signal bounce varies based on weather conditions (for example, wet trees absorb more signal than dry trees). Therefore, it's critical to have a clear line-of-sight between the transmitter and receiver.

It's also important to understand that for long distances, such as links of 1 mile (1600m) at 150 MHz, or links of 0.05 miles (80m) at 5.9 GHz, the curvature of the earth becomes an obstruction that also causes signal loss. This is because the longer the distance between the transmitter and receiver, the great the radius of the Fresnel zones. Therefore, the height of transmitter and receiver antenna as well as the lowest point between ground level are important factors that must be considered to ensure maximum signal strength.

In general, installing RF antennas well above ground will provide best free space and best performance. However, it's best to practice use the Fresnel Zone to calculate optimum height for transmitter and receiver antennas. The Fresnel Zone is an ellipsoid that stretches between the receiving and transmitting antennas. To guarantee a consistent communication at least 60% of Fresnel Zone must be clear of obstructions. However, more than 80% clearance is recommended. It is highly recommended that links requiring high reliability have a direct line of sight. Factors such as atmospheric refraction and curvature of the earth are not calculated into the Fresnel Zone.

D	distance between transmitter and receiver antenna
d1	distance from transmitter antenna
d2	distance from receiver antenna
r	radius of the Fresnel zone (n=1) at point P above the lowest ground level

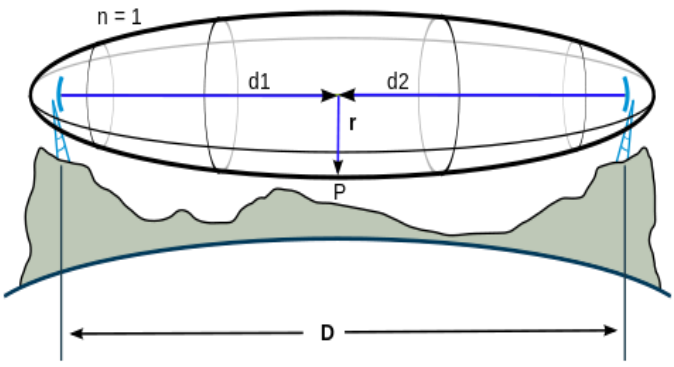


Fig. 1 Fresnel Zone Calculation (Source: Wikipedia)

Here's an example of a Fresnel Zone calculation for a transmitter and receiver antennas that are 1000 meters apart from each with a 700MHz operational frequency.

D	1000	Total Distance Between Tx and Rx Antennas Installed in Meters (m)
r	?	Calculate 1st Fresnel Zone Radius needed to be away from the Obstacle and Above the Ground
f	700	Frequency Transmitted in Megahertz (MHz)

$$r = 8.657 \cdot \sqrt{\frac{D}{f}}$$

$$r = 10.347$$

Therefore, the minimum Fresnel zone height distant " r " is 10.347m above ground level or above objects for both transmitter and receiver antennas is required for 700 MHz wireless systems to operate close to free space performance operating at 1000m away. The Fresnel distant "r" is located at middle point or at 500m between the two 700 MHz transceivers.

Frequency (MHz)	Distant (m)	Antenna Installation Height (m)
150	1000	22.4
450	1000	12.9
600	1000	11.2
700	1000	10.3
900	1000	9.1
2000	1000	6.1
2400	1000	5.6
3700	1000	4.5
4200	1000	4.2
5900	1000	3.6

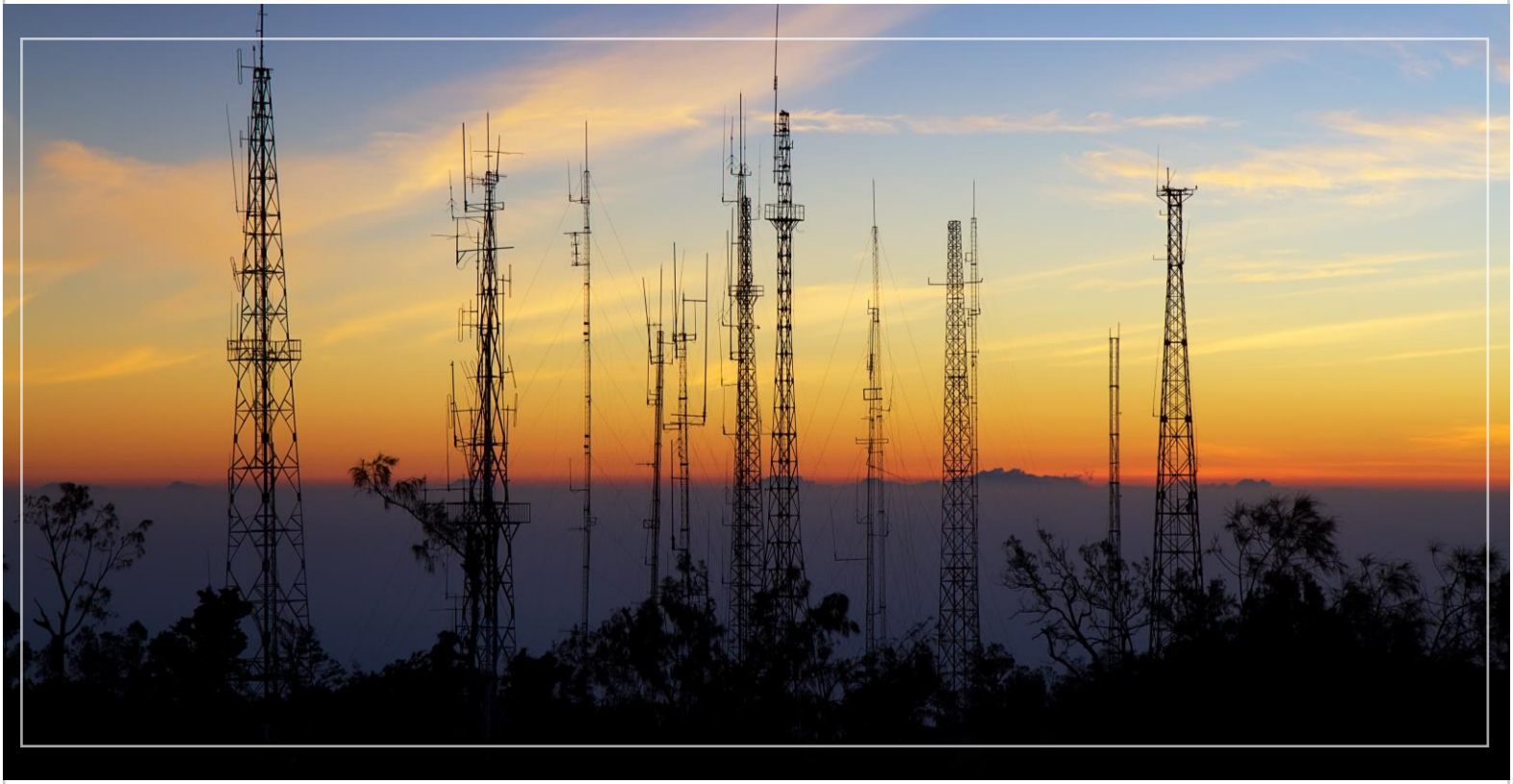
MobileMark
antenna solutions

Table 1:
Calculation for
Optimum Antenna Height Installation
versus
Frequency of Operation

From Table 1, the frequency of wireless communication varies from 150 MHz to 5900 MHz at a fixed tower distant of 1000 meters (m), the transmitter and receiver antennas Optimum Height to be install are calculated. For the 150 MHz wireless system at 1000m apart, the transmitter and receiver antennas must be installed at least 22.4m above lowest ground level to achieve optimum range and free space wireless communication. With the same distant at 1000m apart for 5900 MHz wireless system, its transmitter and receiver antennas must be installed at least 3.6m above ground level to achieve optimum range and free space wireless communication. Therefore, the optimum antenna installation heights for both transmitter and receiver antenna are greatly decreased from lower frequency to much higher frequency of operation.

In conclusion, line of sight, height & distance between antennas, curvature of the earth, and the Fresnel zone are all critical factors that must be considered to ensure good wireless communication. Antennas must be mounted as high as possible due to the line-of-sight range restrictions, and with VHF signals, height is more important than power output. Also, wireless communications can easily achieve free space and best range performance when the transmitter and receiver antennas are installed at calculated optimum height using Fresnel Zone calculation as demonstrated in this technical brief.

By Tam Chau, P.E.
Antenna Design Engineer



Mobile Mark, Inc. designs and manufactures site, mobile and device antennas for 30 MHz – 6 GHz. Applications include GPS Tracking & Fleet Management, Cellular 4G LTE & 5G Ready, Wi-Fi, RFID, Public Safety FirstNet, M2M & IoT, Smart City Networks and Autonomous & Connected Cars. Engineering and custom design services are available. Mobile Mark's global headquarters, research facilities and manufacturing plant, are located near Chicago, IL. An additional manufacturing and sales facility is located near Birmingham, UK.

MobileMark
antenna solutions

Moving Wireless Forward®

www.MobileMark.com | Toll Free: 1.800.648.2800 (US & Canada) | Phone 1.847.671.6690