Technical Information

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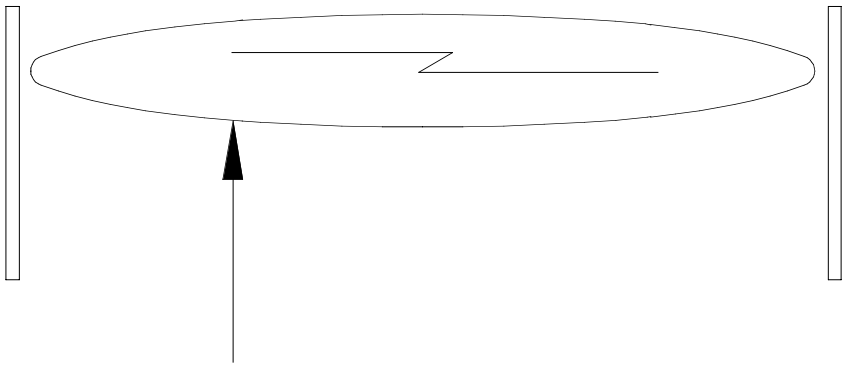
Factors Influencing Radio Communications

Line-of-Sight

Ideal Radio Transmission occurs under conditions whereby a visually clear path exists between Receiver and Transmitter antennas. A visually clear path or ***line of sight*** ensures the strongest possible signal with minimal attenuation (reduction) due to environmental factors. To have a clear line of sight there must be no obstacles between the two locations. Line of sight can be verified using binoculars to ensure a clear path between Receiver and Transmitter antennas. However, even under line of sight conditions, signal attenuation occurs depending on the distance between the two antennas as well as proximity of obstacles to the line of sight path. When RF radiates from one antenna to another it spreads out such that an elliptical pattern is created between the two antenna; this elliptical area is known as the Fresnel Zone. The cross-section or height of the Fesnel Zone depends on the distance between antennas and the frequency of the signal. Obstacles protruding into the Fresnel Zone affect signal strength and integrity. Hard obstacles protruding into the Fresnel Zone can deflect signals resulting in short reception delays or in some cases prevent the signal from reaching its intended destination. Soft obstacles such as trees typically attenuate the signal resulting in shorter, less reliable transmissions. The Fresnel Zone can be calculated based on signal path distance and signal frequency. The height of the Fresnel Zone can be used to estimate the required height of antennas to provide sufficient clearance from obstacles. As a general rule, antennas should be raised/located to ensure 60% of the First Fresnel Zone is clear of obstructions. The radio link will then behave essentially the same as it would with a clear path.



First Fresnel Zone

As the signal path distance exceeds about 7 miles, the curvature of the earth further requires that the antenna height be increased.

The following formula is used to calculate minimum antenna height (above obstructions) considering the Fresnel Zone as well as the curvature of the earths surface:

$$H = 13.7 \sqrt{D + \frac{D^2}{8}}$$

where

H = Height of Antenna (feet)

D = Distance between Antennas (miles)

Distance (miles)	* Antenna Height (feet)
1	13.8
2	19.9
3	24.8
4	29.4
5	33.7
10	55.8
15	81.1
20	111

*** Refers to height above obstructions**

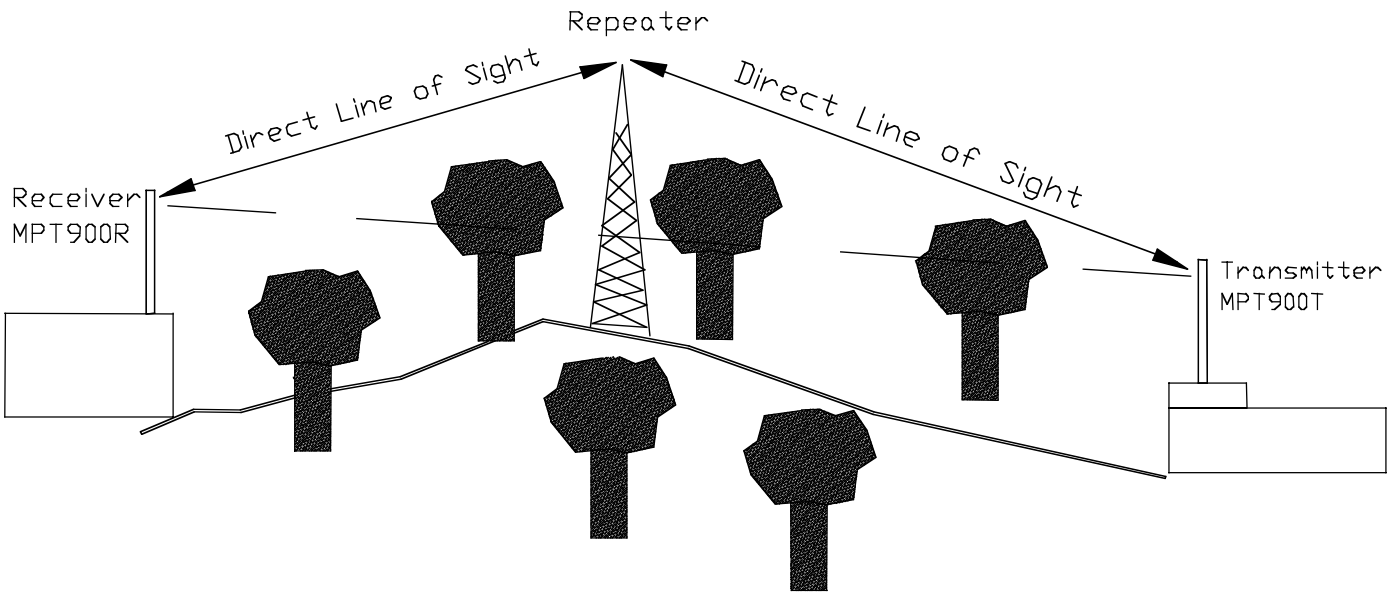
The importance of antenna height cannot be overstated in achieving and maintaining a reliable radio communications link.

It is important to recognize that even with an apparently clear line of sight, signal losses naturally occur over distance and additionally, protrusion of obstacles into the signal path (Fresnel Zone) further degrade signal strength and reliability.

Options for improving line of sight include:

- Raise one or both antennas to minimize protrusion of obstacles into the signal path (Fresnel Zone)
- Relocate one or both antennas to improve line of sight condition
- Remove or trim trees protruding into signal path
- Build towers or install poles for mounting antennas

In situations where direct line of sight between Receiver and Transmitter is not possible, Repeaters can be installed to direct signals around or over obstacles. This creates multiple point-to-point transmissions effectively linking Receiver and Transmitter.



Repeater Installation to Avoid Obstacles

Weather (Rain)

Except under the most extreme conditions, rain has little effect on signal strength in the 902-928 MHz range and is therefore not a serious concern in planning a Network installation.

Lightning

In planning an installation, consideration should be given to lightning protection including the use of lightning rods or arrestors to protect antennas from direct strikes. Additionally, proper grounding of cables and equipment is essential to provide low impedance paths for lightning currents.

Mil-Ram offers a variety of products for lightning protection. Please consult factory for recommendations regarding a specific installation.

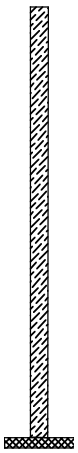
Antenna Selection

Warning: Never work on antenna when there is lightning in the area. Ensure power is removed from Receiver/Transmitter during antenna installation.

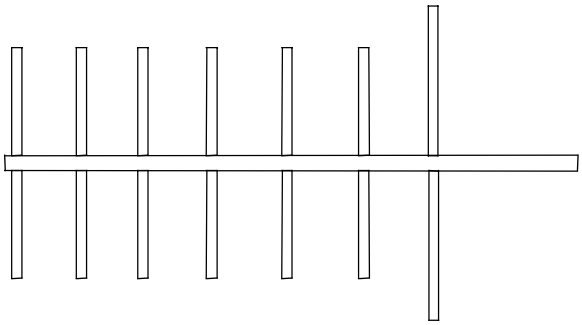
Proper selection of antennas is critical to the success of a wireless installation and is influenced by several factors including transmission distance, obstacles (size and construction), terrain profile and overall Network topography.

Types

1. **Omni directional antenna:** Receives signal evenly from all directions. Transmits signal evenly in all directions. An omni directional antenna provides a 360 degree radiation pattern. Typically in the form of a vertical rod although other shapes are available. Commonly used inside structures (buildings) to provide best possible reception from all directions. Also used outdoors at Receiver to communicate with Transmitters that are geographically spread out over the terrain. An omni directional antenna is typically used at each of the Transmitters. Ideal for point-to-multipoint communications with transmitters.



2. Yagi uni-directional antenna: Transmits signals in the direction antenna is pointed. Receives signals from direction antenna is pointed. Yagi antennas are effective in increasing signal strength as the signal radiates in a preferred direction with a comparatively small angle of view to the target. While signal strength is enhanced for maximum distances, proper alignment of the antenna becomes critical. Typically used in outdoor installations over long distances.



Antenna Gain

Antenna gain is a measure of the relative distance antenna can transmit a signal. Gain is expressed in dB units and for every 6dB increase in gain, transmission distance doubles. Accordingly, for every 6dB loss in gain, transmission distance is reduced in half. The performance of an antenna in a given direction is expressed in terms of **Effective Isotropic Radiated Power (EIRP)** and is limited to 36dB in compliance with **FCC** regulations. The **EIRP** is a function of radio Transmitter power, antenna gain and antenna cabling/connector losses:

EIRP = 20 dbm (Transmitter Power) - Antenna Cabling and connector Losses + Antenna Gain ≤ 36

Cables

Antenna cables introduce losses into the system effectively canceling some of the antenna gain. Therefore, cable lengths should be kept to a minimum and low-loss cable (LMR 600) is highly recommended.

The following table indicates signal loss (dB) for various grades of antenna cable:

Cable Loss Table

Cable Type	Loss (dB per 100 ft.)
LMR 195	11.1
LMR 240	7.6
LMR 400	3.9
LMR 600	2.5

The table below shows effective antenna gain related to cable type and length:

		Effective Antenna Gain (Antenna Gain - Cable Losses)		
Antenna Type	Antenna Gain	25ft. Cable LMR 400	50ft. Cable LMR 600	100ft. Cable LMR 600
Omni Directional	5 dB	4.0	3.8	2.5
Yagi Unidirectional	10dB	9.0	8.8	7.5

Transmit Distance

Indoor: **600-1500 ft. (obstructions)**

Outdoor: **up to 7 miles Line-of –Sight (half-wave omni antenna)**

Outdoor: **> 20 miles Line-of-Sight (high gain antenna)**

Actual transmission distances depend on several factors including terrain, obstacles, antenna type, antenna gain, **antenna height**, etc. A site survey form must be completed to make proper recommendations for each installation.

Comparison between 100mW and 1 Watt Radio Transmitters

The Mil-Ram radios provide 100mW transmit power and offer excellent range, interference rejection and receiver sensitivity. While more powerful radio transmitters are available, overall Effective Radiated Power is still limited by FCC part 15 regulations at less than or equal to 36 dB. This means that a 1Watt radio must use a lower gain antenna to stay in FCC Compliance compared to a 100mWatt radio for the same Effective Radiated Power. Since these radios are actually transceivers (transmit and receive) the 1 Watt radio with lower gain antenna is less effective in Receive Mode than the 100mW radio due to the use of a low gain antenna (assume 1 Watt and 100mW radios have equivalent Receiver sensitivity). The 100mW radio achieves the same Effective Radiated power for transmission as the 1 Watt radio but does not compromise the Receiver with the use of a low gain antenna. The 100mW radio offers the best compromise between Transmit and Receive functions for a Transceiver application. The 100mW radio also draws up to 70% less power in Transmit mode and is therefore ideally suited for solar panel/battery operation.

FCC Compliance

The MPT900R and MPT900T radio transceivers comply with FCC part 15 for operation in the license-free 902-928 MHz ISM band. Only approved antennas should be used with these radio devices. Mil-Ram offers a wide selection of approved antennas to meet the requirements of various installations.

Multi-Process Wireless Telemetry System

Power Requirements

Model	Wireless Device	12VDC Rx/Tx/Ave.	24VDC Rx/Tx/Ave.
MPT-900R	**Receiver**	**1.6/2.7/1.8 W**	**1.8/2.3/2.1 W**
MPT-900T	**Transmitter**	**1.1/2.0/1.9 W**	**1.3/2.2/1.5 W**
MPT-900RP	**Repeater**	**1.1/2.0/1.9 W**	**1.3/2.2/1.5 W**

*** MPT-900R Receiver also available 115/230VAC.**

Rx = Receive

Tx = Transmit

Ave = Average