Antenna Basics

ZCG Help Guide

A general guide for antenna selection and installation techniques

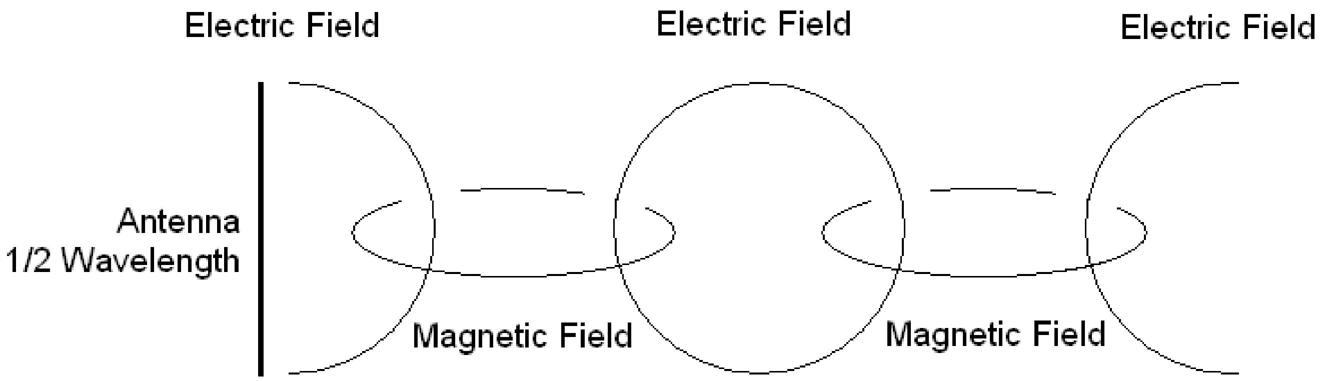
Victoria Head Office
PO Box 7, Lindenow, Victoria, Australia, 3865
Phone: +61 3 5157 1203
Fax: +61 3 5157 1641
Email: sales@zcg.com.au

Introduction to RF Antennas

What is an antenna, how does it work?

An antenna is a metallic device that releases electromagnetic waves from a transmitter via a coaxial cable into the atmosphere. In addition, an antenna captures electromagnetic waves from the atmosphere, and delivers them to a receiver via a coaxial cable.

Ideally, a perfectly tuned antenna will radiate an electromagnetic wave, whereby the length of the radiating element will be proportional to half of one wave-length of the transmission frequency.



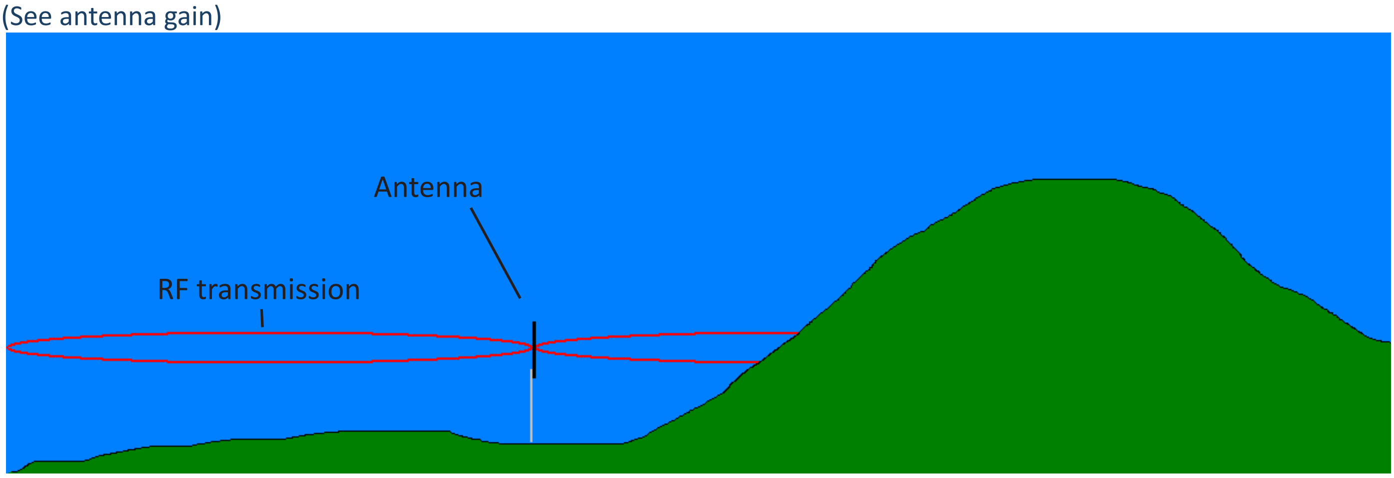
Terrain and Vegetation

How does terrain affect RF communications?

Terrain plays a significant role in the overall performance on radio transmission. The influence of terrain is not just limited to mountains and other natural obstacles, but also man made structures such as buildings and other metallic objects.

Hills and mountains have the ability to block radio communications systems, if the transmission path between two points is obstructed by undulating terrain, the radio signals will be absorbed by the earth and as such, radio communications will not be possible. Always endeavour to locate radio communications antennas in a line of sight from point A to B, in addition, consideration must be applied to the gain of the antenna as the transmission beam-widths will have an impact on the overall quality of the radio signal.

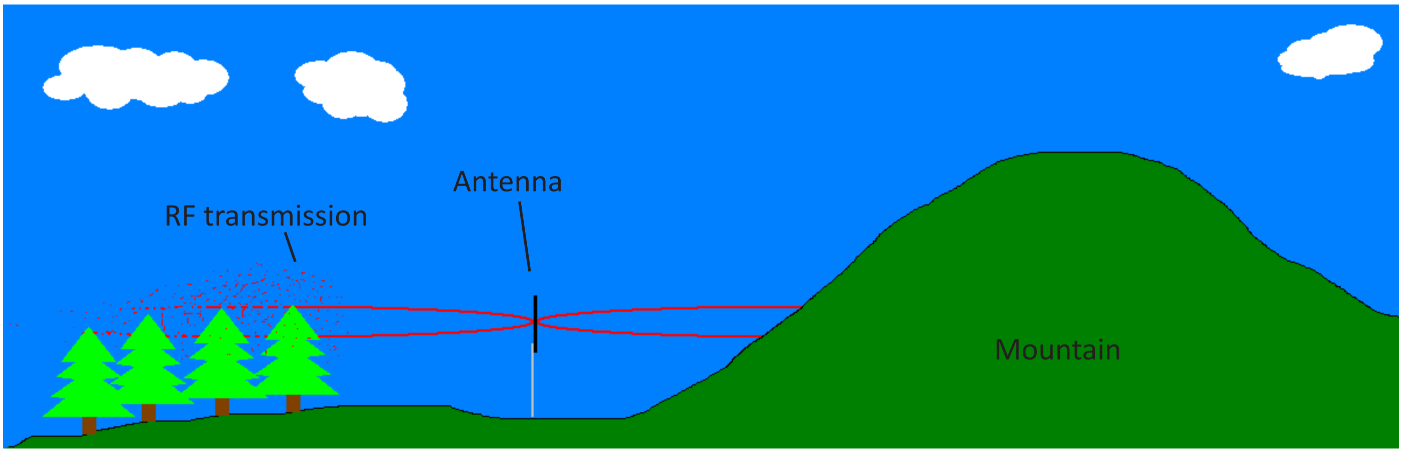
(See antenna gain)



This diagram visualises the RF transmission pattern being absorbed by mountainous terrain.

How does vegetation affect RF Communications?

Vegetation also has a detrimental effect on radio transmission; radio waves are naturally absorbed by plants. When planning the installation of a radio based communications site, consideration must be applied to the surrounding vegetation, over time trees will grow in height, and scrub-land will become denser. Forward planning is vital to overcome the changes to the surrounding environment of your radio site installation. In some instances, it is advantageous to elevate the height of the antenna to overcome the effects of surrounding plant life.



Antenna Types

There are many different types of antennas in use throughout the radio communication arena. Various antennas designs have advantages in different types of applications; the advantages may be specific to beamwidth, radiation pattern or simply the cost of manufacture. This section is intended to provide a basic familiarisation with the most common types of antennas encountered in the fixed telemetry industry.

Collinear

A collinear antenna is an omni directional (radiates equally in all directions) antenna, the construction is typically a single brass, aluminium or braided section and may be housed in a fibreglass radome (exterior housing); The antenna is installed in a vertical position.

Coaxial Dipole

A coaxial dipole antenna is an omni directional (radiates equally in all directions) antenna, the internal construction is a series of coaxial cables cut into ¼ wavelength sections, and is housed in a fibreglass radome (exterior housing). The antenna is installed in a vertical position.

Sidemount Dipoles

A side-mounted dipole antenna is an omni directional (radiates equally in all directions) antenna. Typically a dipole antenna is constructed from aluminium or stainless steel, and is a measured ½ wavelength of the transmission frequency, folded to form an oval radiating element. The radiating element is mounted vertically on a horizontal extended boom attached to a mast or tower.

Dipole Stack Array

A dipole stack array, is a series of side-mounted dipole antennas, the antennas are stacked at precise measured distances specific to the transmit and receive frequencies in a vertical pattern. The method of installation enables a significant increase in overall antenna gain and performance.

Yagi

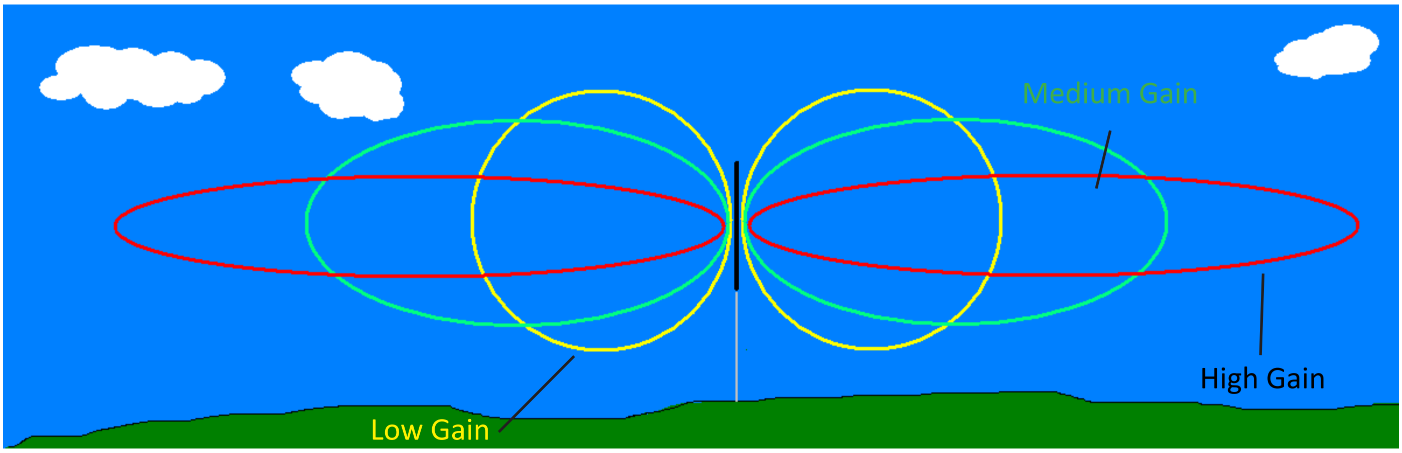
The directional Yagi antenna is one of the most popular antennas encountered for fixed telemetry installations. The Yagi antenna consists of a dipole section with a rear reflector element, followed by a series of director elements. Typically constructed of Aluminium or Stainless Steel.

Antenna Gain

What is antenna gain?

Antenna gain is a mathematical measurement of the overall operational characteristics of the antenna. In many cases, antenna gain is misrepresented as a measurement of overall performance, this is not the case.

Antenna gain value is best described as a reference to the transmission beam height and width. As an example, an antenna with a lower gain has a much shorter beam length, but is offset by a greater beam width when viewed side on, when compared to an antenna with a higher gain, has a much longer beam length, but is restricted by a narrow beam width when viewed from side on.



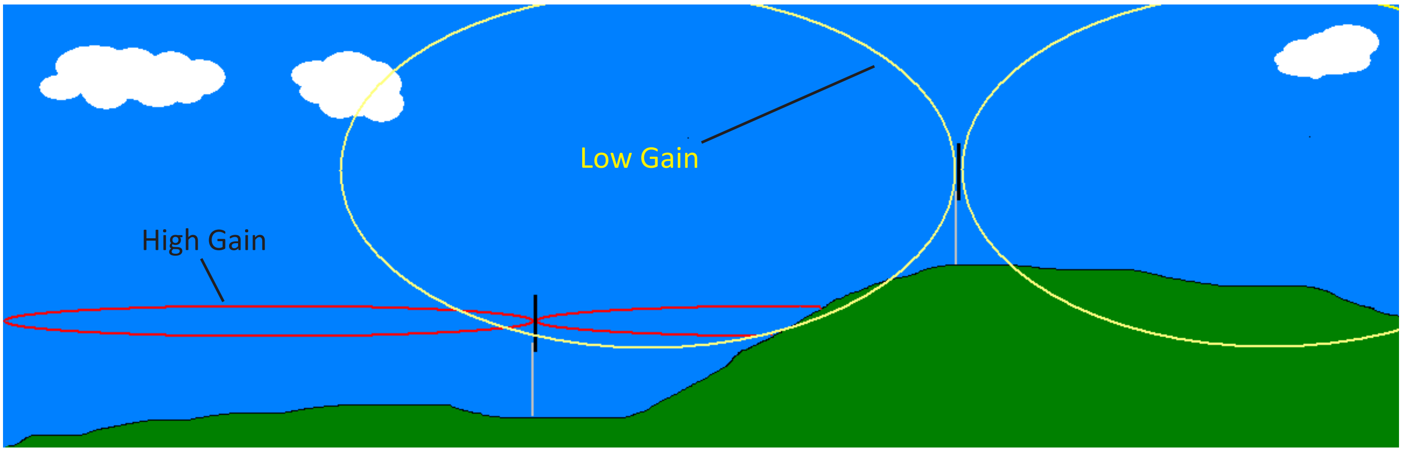
How does antenna gain affect the overall performance?

Antenna gain and beam height / width characteristics are the crucial considerations that need to be made when selecting an antenna. A common myth that exists within the radio world is that when radio communications equipment is commissioned into an isolated or poor coverage area; an antenna with the highest gain is required. This is correct if you are in a topographically flat environment such as a desert region, but if you are in a mountainous location, this can have severe effects on the performance of your radio equipment.

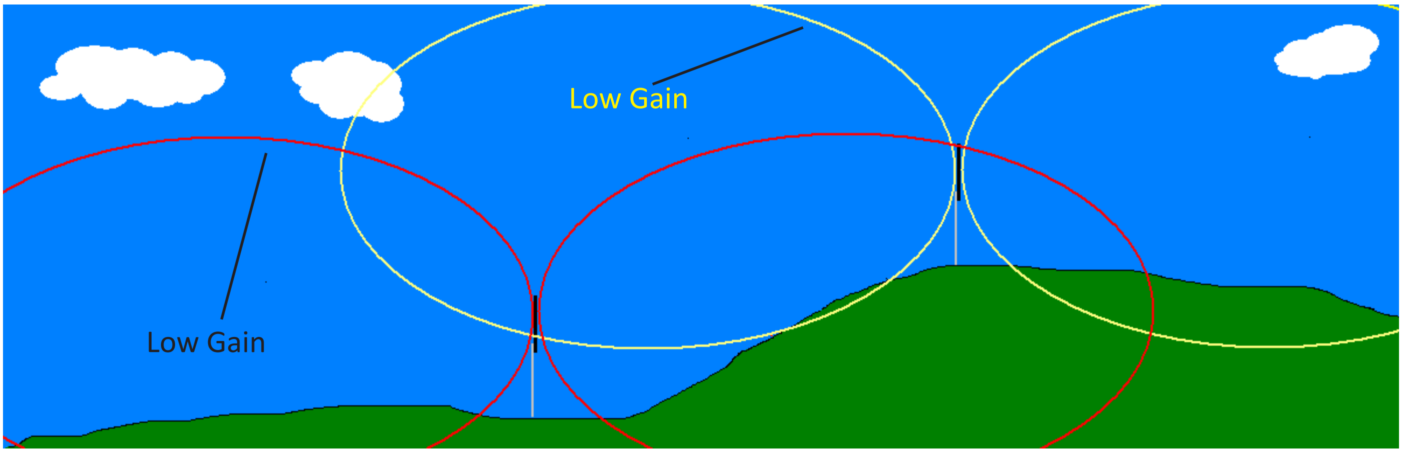
Let's assume that a radio based installation is to be commissioned in a valley, and this radio telemetry site will be required to communicate with a communications tower high up on a hill top.

When a hi gain antenna is utilised for the radio telemetry site, it will have significant difficulty establishing a reliable signal with the hilltop communications tower. This is because a hi gain antenna will concentrate all of the RF energy into a long narrow beam, the issue here is that because the beam is narrow, no radiation will be directed in an upward direction to the hilltop, all the energy is directed forwards directly into the hill side.

To cause some confusion during diagnosis, lets assume that the hilltop communications tower has the correct type of antenna installed, and is capable of reaching the telemetry site below because it has a wide beamwidth, as the telemetry site can "hear" the radio signal from the hilltop site, it would still be unable to communicate back to the hilltop. Essentially "1 way" communication is achieved, despite diagnostic equipment reporting a good radio signal from the hill top site.



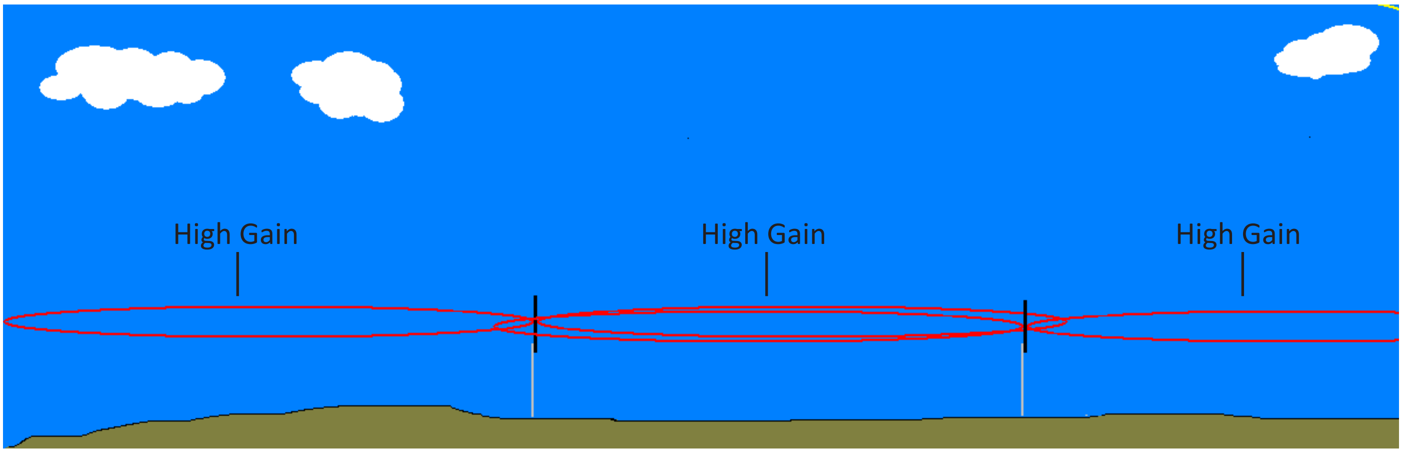
The above diagram demonstrates the effect of using a hi-gain antenna in a valley, **NOTE:** the beam with is narrow, and unable to reach the hilltop above.



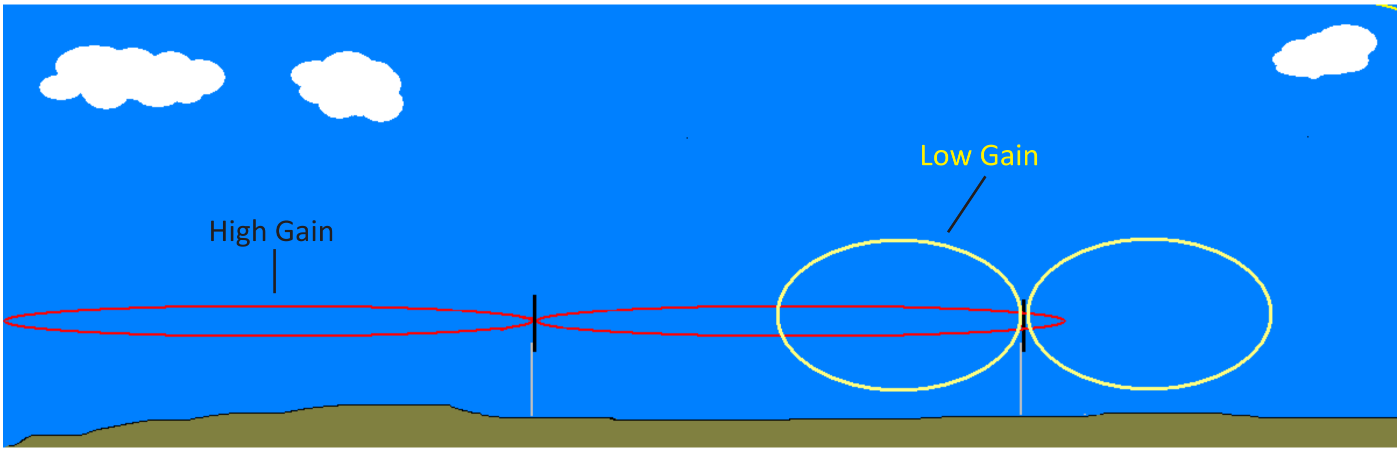
The above diagram demonstrates the correct antenna selection, here a low gain antenna is utilised at the telemetry site. **NOTE:** the wider beam width allows RF radiation to be directed in an upward direction and is able to reach to hill top above.

Let us now assume that a radio telemetry site is to be commissioned into a desert location, and that the ground surface is generally flat.

In this application, a Hi-gain antenna system would be more efficient as the beam widths are long and narrow. This would allow maximum reach and distance to be achieved as all the RF radiation would be directed in a long narrow beam between the radio sites.



The above diagram visualises the use of high gain antennas utilised in a flat location **NOTE:** long thin beam width enabling RF communications between sites.



This diagram visualises the use of a Low-gain antenna, note that the beam width is significantly shorter and unable to reach the RF destination in addition RF energy is being waisted radiating into a wide beamwidth.

Transmission Patterns

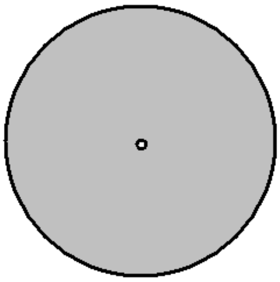
Omni directional

An omni directional antenna radiates RF energy equally in all directions. As such the antenna can be mounted vertically, without any consideration regarding orientation. An example of Omni directional antennas would be that of Dipole, Collinear and Dipole stack arrays.

Directional

Directional antennas are designed to concentrate RF energy into a pointed location; there are several advantages when using this antenna design. More RF energy is focused into a selected direction; this may be advantageous to reach a radio communications site that is located over an extended distance. The most common directional antennas are Yagi's or a Grid-pack/parabolic dish.

Omni-directional
Radiates equally in all directions



Directional Yagi
Focused Beam

Installation Techniques

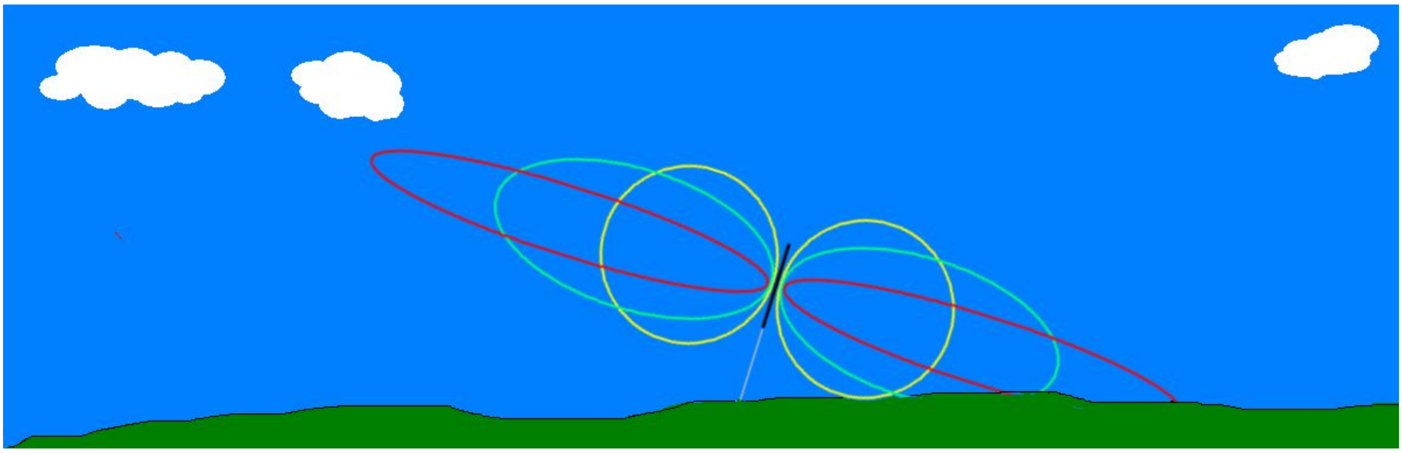
Environmental considerations

Whenever an antenna system is to be deployed, careful consideration must be applied to the surrounding environment to avoid interference with other services within the area.

1. If possible identify the frequency of other radio based systems that operate within close proximity. Investigate if any of these services are operating on radio frequencies close to the system that is about to be installed.
2. Never install radio communications antennas directly next to, or within close proximity to other radio communication antennas.
3. Wherever possible, ensure that a direct line of sight approach is applied between radio sites.
4. Take into effect the presence of vegetation, if possible; raise the overall height of the antenna mast to compensate for the future growth of trees and shrubs.

Antenna mounting

Always ensure that antenna systems are installed in a vertical position if a collinear, or parallel to horizon if a yagi or horizontally polarised antenna, because radio communication antennas radiate on a horizontal plane, if the antenna is not vertical, the transmission beam with will be affected. This will result in one side of the antenna system radiating into the Earth, and the other sire of the antenna radiating towards the sky. The overall effect of this would be that the transmission beam would radiate either over or under the intended target.



This diagram visualises the effect of an antenna that is not mounted in a vertical position. **NOTE:** that the RF transmission is radiated toward the Earth and Sky

In some circumstances, it is required to mount antennas inverted or upside down from a boom. Whenever an antenna is inverted, there is the enhanced risk of water egress into the antenna. Please follow these steps to avoid premature damage to the antenna.

1. Purchase an inverted designed antenna, which will have inverted drainage and improved watersealing around termination.
2. Remove the tip of the antenna using a pair of pliers, side-cutter or drill; be careful not to make contact with any of the internal components of the antenna. This will allow any water to drain out of the radome.
3. Apply a layer of self amalgamating tape, followed by a generous layer of Denso tape to the base of the antenna; this will prevent any moisture from entering the fibreglass radome of the antenna.