Antenna Alignment White Paper

Antenna alignment most common issues and challenges

One of the most important stages of installing a microwave point-to-point link is proper alignment of the antenna system. Any misalignment can cause unstable operation and will decrease the fade margin that will affect the overall link reliability. While usually straight-forward, alignment on some links can become time-consuming and frustrating if done incorrectly.

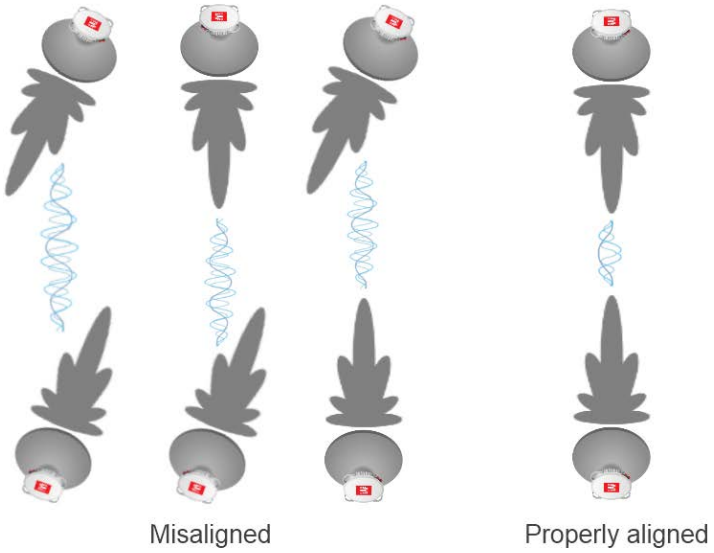

Figure 1. Antenna alignment scenarios.

Before starting the antenna alignment:

- Know your target received signal level (and according radio RSSI voltage) from link budget calculation. Typically, the target received signal level in the field is within +/- 3dB of the calculated value;
- Know the azimuth and elevation angles for alignment;
- Ensure radios are fully configured and tested on the bench before taking them into the field;
- Start by disabling ACM and ATPC and configuring both radios in accordance with link budget (Tx power, modulation, bandwidth). After successful pre-calculated Rx level achievement you can enable ACM and ATPC as required. If the alignment is not successful with the calculated modulation or bandwidth (for example, if the link is really long), you can try to align the antennas with minimum modulation, minimum bandwidth, and maximum Tx power set in radio configuration;
- Agree on antenna polarization. It can be frustrating to attempt aligning the antenna only to discover that the other team is using a different polarization. Do not forget of 17/24 GHz unlicensed band radio cross-polarization requirement. This should be agreed before starting the alignment. If Rx levels remain stubbornly low, double check polarizations on both ends. Radios installed with incorrect polarizations may have a signal loss of 20 - 30dB or greater.

Alignment should be seen as a two-stage process: coarse alignment and fine alignment.

Coarse alignment

1) Vertical

- It is recommended to begin with vertical alignment. Using a level tool, set both antennas to null position vertically. This will ensure a better starting point for long links with limited eye visibility typically requiring large diameter antennas with narrow beamwidths.

2) Horizontal

- Position the antenna horizontally using a compass or GPS (note the difference between true and magnetic azimuth). Azimuth angles should be known from link planning report. When using a compass, be aware that large metal structures such as towers may distort compass readings.
- Position the antenna approximate horizontal direction by using Google Earth (or equivalent) to align with a landmark located close to your antenna (for example, a mountain, building, etc.). If you are building a link in an area with a few landmarks, self-made landmark such as a kite, balloon, floodlight, flare, or reflection from a mirror might help.

Fine alignment

Before:

- Get a good quality voltmeter that you will connect to the radio;
- Have a team at each end to make the alignment process easier and faster;
- Remember to adjust only one side of the link at a time;
- Remember that point-to-point systems must have a clear radio line-of-sight. Even if the remote site has clear eye visibility, radio line-of-sight is defined by 60% of the first **Fresnel Zone**. The Fresnel zone for a radio beam is an elliptical area immediately surrounding the visual path. It varies in width depending on the length of the signal path and the frequency of the signal. If an object, such as a mountain ridge or building, is too close to the signal path, it can reduce strength of the radio signal and desired Rx level will not be achieved. This happens even though the obstacle does not obscure the direct, visual line-of-sight. The necessary clearance for the Fresnel zone can be calculated, and it must be taken into account when designing a link.
- Remember that the key characteristic of any antenna is its radiation pattern. It describes how the antenna will transmit the signal. Looking at the radiation pattern (see Figure 3 and Figure 4 below in the section ''Notes''), it's clear that the signal propagates in multiple paths (directions). These paths are called lobes. Each antenna has a main lobe and several side lobes. The difference in amplification (signal strength) between the main lobe and side lobes is typically around 20 dB. This, of course, varies with antenna size,

frequency, and class. Small antennas in low frequency range typically have strong side lobes, which sometimes results in installation crews aligning the antenna on a side lobe instead of the main lobe.
When an antenna sweep is performed and an initial signal is found, installers typically stick with this first signal and do not continue the antenna sweep (as seen in Figure 2 below, for example, ''Common 1st Try''). If this initial signal happens to be a side lobe, the antenna will most likely be aligned to it, resulting in poor link performance.

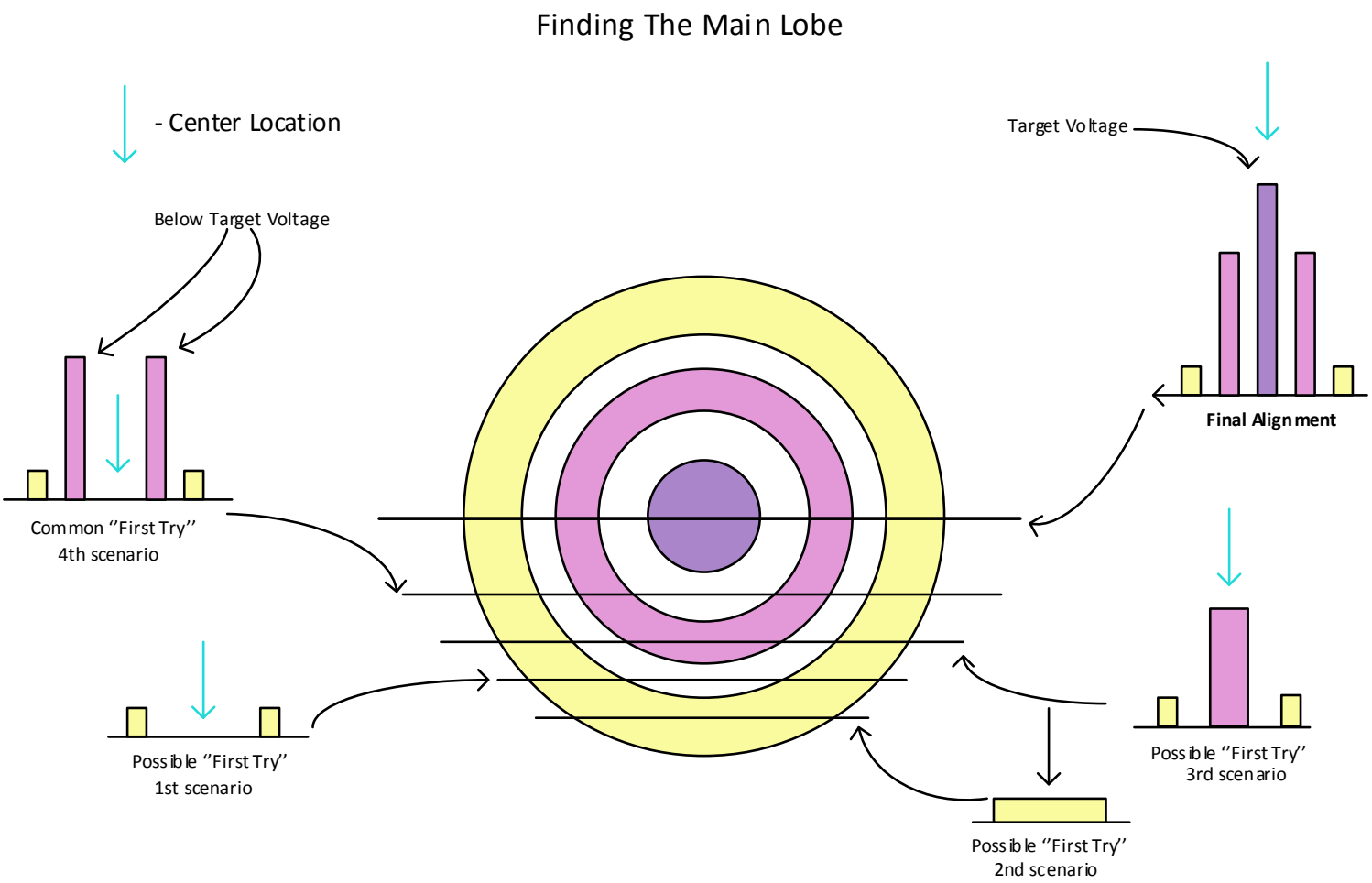

Figure 2. Possible alignment outcomes in the horizontal plane.

Step by step actions:

1. Perform full vertical sweep by moving the antenna up and down (vertically). Start by moving the antenna from the upper side to avoid alignment to a signal reflected from the ground. Look at the voltmeter and try to catch the moment where the received signal is the best.
2. After you have found the point where the signal is the highest vertically, perform full horizontal sweep by moving the antenna right and left (horizontally). Find the point where the signal is the best horizontally.
3. The point that has the highest received signal level horizontally will be the point where the received signal level is the strongest on the antenna.
4. When the highest signal level is obtained during the alignment of the first antenna, fix it and repeat the same steps with the second antenna.
5. After finding the highest signal level on the second antenna, repeat alignment steps again on the first antenna until the maximum calculated signal level (+/- 3dBm) is reached.
6. When finding the signal peaks, which are suspected to be side lobes, analyze the signal peaks found. See "First Try" scenarios on the Figure 2.
    a. In case of two approximately equal signal peaks, it is most likely that a side lobe has been found in the current adjustable plane. Aligning precisely on one of those peaks may result in an improper overall alignment result. 4th and 1st scenario on Figure 2.
    b. In case of a single prominent signal peak, it is most likely that an approximate center position is found. 2nd and 3rd scenario on Figure 2.
7. During short link alignment over urban areas, try to avoid alignment to reflected signal from reflective planes such as rooftops or lakes in the middle of the path. In order to avoid it, always start Vertical plane sweep from the top, meaning antenna should be aligned "into the sky" before you begin.

Notes

Difference between small antennas and big antennas:

- Antennas sized up to 1.2m have a wider main beam and more evident side lobes.
- Typical error – antenna is aligned on the side lobes.
- Bigger antennas with a higher gain have a narrow main beam and less relevant side lobes.
- Typical problem for installators – finding the first signal from the far side site.

Main Beam – the center of the radiated signal; has the highest power level.
Side Lobes – areas of increased signal strength; weaker than the main beam.
Nulls – areas between the side lobes; little or no signal.

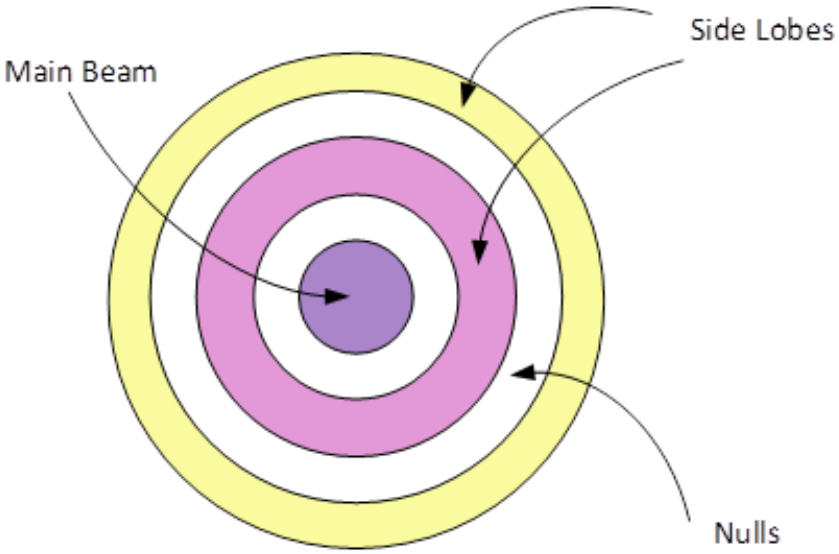

Figure 3. Front View

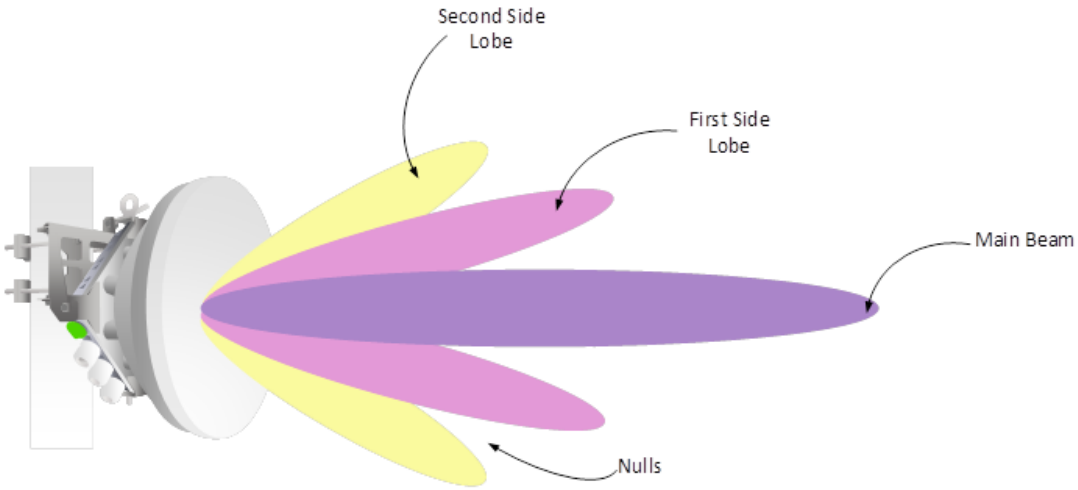

Figure 4. Side View