Understanding GPS Antenna Alignment Tool Errors

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DISCLAIMER

Multiwave Sensors Inc. is the manufacturer of the Smart Aligner Tool which is a GPS Antenna Alignment Tool. Multiwave has designed the Smart Aligner Tool to minimize or eliminate the error conditions described in this paper and quotes accuracy as absolute.

ABSTRACT

The use of GPS Antenna Alignment Tools to align (or orient) antennas is becoming a requirement from the telecommunication carriers. Based on the accuracy specified by the Tool manufacturer, the carrier will approve the use of that Tool for its network. Usually the Tool manufacturer will specify the accuracy based on ideal conditions, however, being on a tower or rooftop is not an ideal condition. This paper will outline some of the conditions that can adversely affect the azimuth error by up to 12X the "published accuracy". The most prominent error is that of GPS multi-path. The Smart Aligner Tool has been designed to minimize or eliminate multi-path errors by a patent pending antenna extension and folding mechanism.

INTRODUCTION

The overall accuracy of a GPS Antenna Alignment Tool is made up of several factors such as the Ideal Condition Accuracy, GPS multi-path effects, mounting and RF interference. For this paper, we will assume that the tool is square with the backplane of the antenna and, thus, presents no mounting errors. We will briefly discuss RF interference and how it can be mitigated. We will, therefore, only focus on the Ideal Condition Accuracy and GPS multi-path errors.
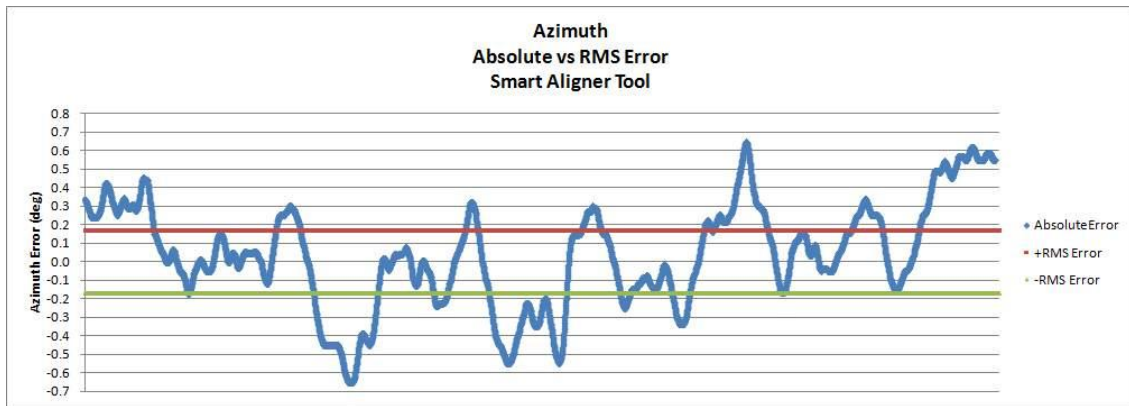
IDEAL CONDITION ACCURACY

Most of the Tool manufacturers quote the accuracy of the core board manufacturer. The core board manufacturer specifies the azimuth accuracies as RMS under ideal conditions. This accuracy can be very misleading as it does not represent the absolute accuracy. The absolute accuracy is the total deviation of the azimuth at any time during the azimuth verification. The RMS accuracy quoted is very high, but the absolute accuracy can be 3-4X the RMS accuracy. The absolute accuracy is very close to the R99 accuracy as specified by some tool manufacturers. Some of the published Tool accuracies are shown in the table below. The absolute accuracy, shown in the table below, is a Multiwave derived value, based on extensive testing , which compares the RMS accuracy (from the core board manufacturer) to the absolute accuracy of the Tool.

Tool	RMS Accuracy (deg)	R99 Accuracy (deg)	Absolute Accuracy (deg)
Tool #1	0.75	Not specified	2.25 to 3.0
Tool #2	0.30	0.75	0.9 to 1.2
Tool #3	0.15	0.40	0.45 to 0.6
Tool #4	0.08	0.25	0.24 to 0.32
Tool #5	0.5	Not specified	1.5 to 2.0
Smart Aligner	0.17	Not specified	0.5 to 0.7

As can be seen from the table above, the absolute accuracies range from 0.25° to 3.0°. The difference is due to the GPS receiving antenna spacing on the Tool. The larger the separation, the better the absolute accuracy; however the trade-off becomes accuracy vs size. For the very high accuracies, the Tool length is greater than 2m (6.6 ft). This can present handling difficulties while on the tower. The shorter separation Tools result in degraded accuracy of up to 3.0°. The Smart Aligner Tool has been designed with a separation of 0.5m (1.6 ft), but is able to be folded to under 0.5m (19") when being transported.

Below is a graph showing the azimuth fluctuation of the Smart Aligner Tool under ideal conditions. The data shown is the error for any azimuth verification measured by the Smart Aligner Tool. The core board manufacturer specifies a 0.17° RMS, but as can be seen, the absolute accuracy is 0.5° to 0.7°. The majority of measurements (>99%) are between -0.5° and 0.5°.
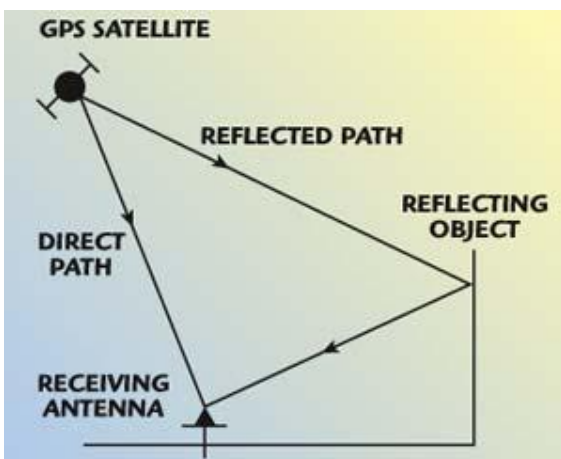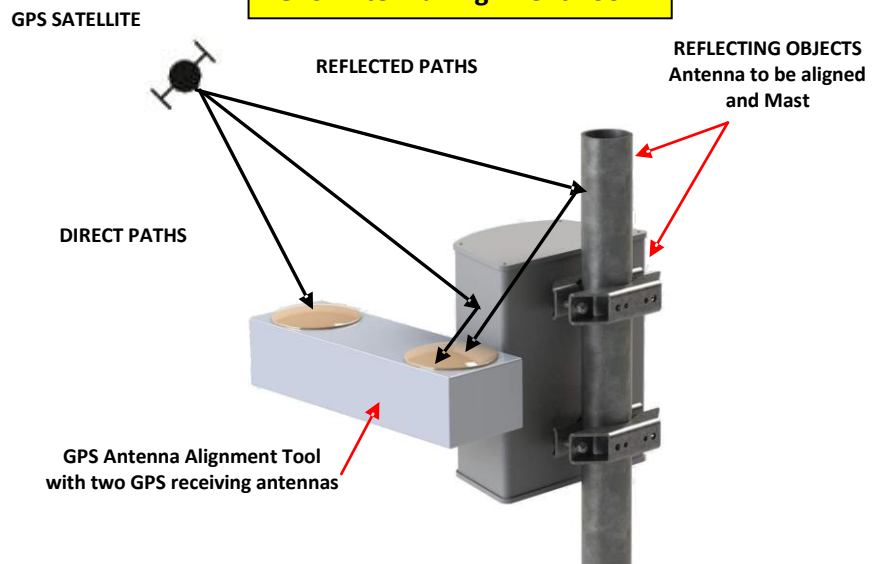

GPS MULTI-PATH ERRORS

GPS multi-path errors are a result of the signal from the GPS satellites not reaching the GPS receiving antennas on the Tool in a straight path.

If one of the GPS receiving antennas on the Tool is below and next to the antenna to be aligned, then multi-path effects may be happening. Check the literature and images of the Tool manufacturer to determine if one or both of the GPS receiving antennas are below and next to the antenna to be aligned. See images below for a description of multi-path and how it is related to a GPS Antenna Alignment Tool.
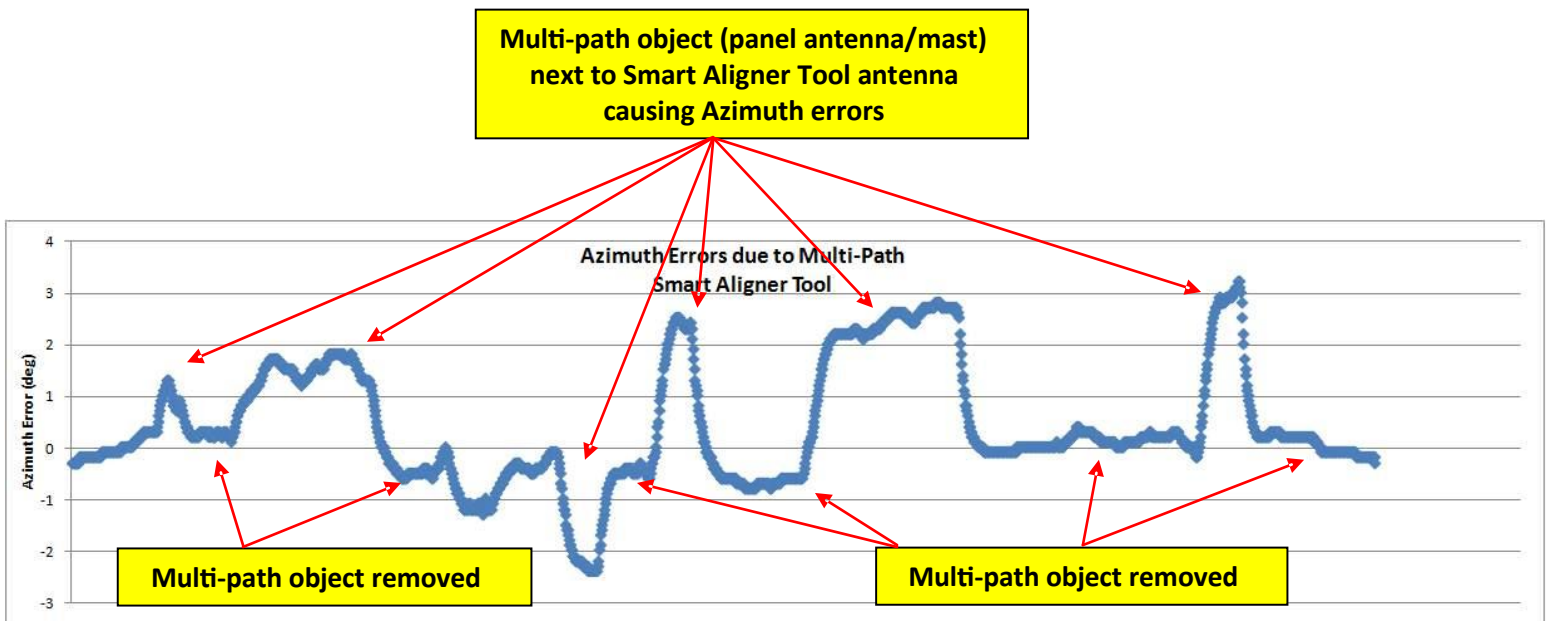

Multi-path description

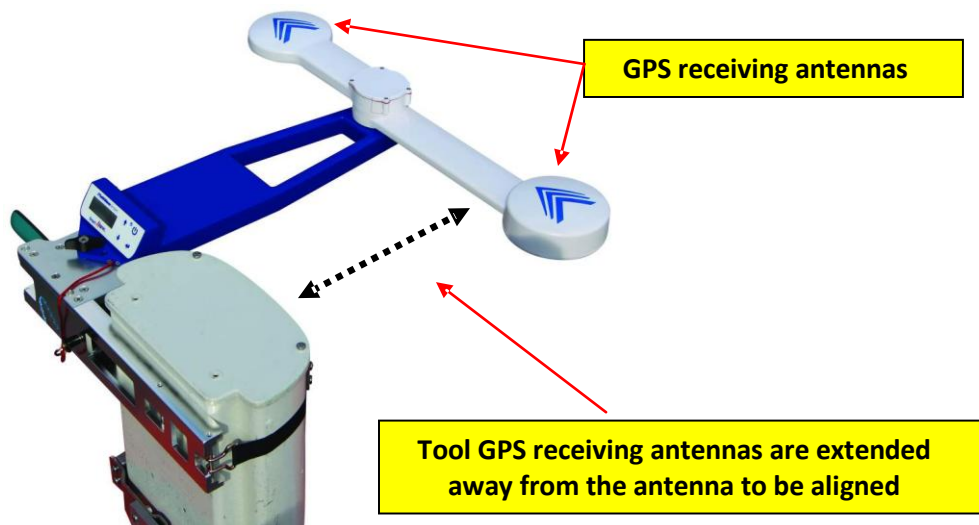Multi-path as related to a GPS Antenna Alignment Tool

The error caused by multi-path is dependent on the GPS satellite geometry, so that in some cases, the error may be negligible, but in other cases, it can be up to 3° or more. As can be seen from the images above, one of the GPS receiving antennas is receiving a signal from the GPS Satellite that is reflected off the mast and antenna to be aligned. The path of the reflected signal is longer than the direct path, resulting in an azimuth error.

DEMONSTRATING MULTI-PATH ERRORS USING A GPS ANTENNA ALIGNMENT TOOL

Multiwave performed a series of tests with the Smart Aligner Tool to show how the error is manifested. The Smart Aligner Tool was set up in an ideal condition. The antenna /mast was brought close to the Smart Aligner GPS receiving antennas (close to the first antenna, second antenna and in between the two antennas) and the azimuth increased or decreased by up to 3°. See graph below.
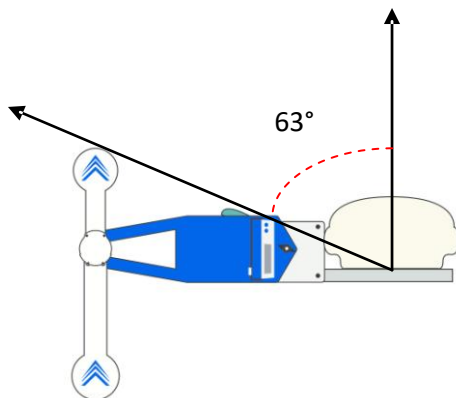

As can be seen from the graph above multi-path can cause a positive or negative error to the azimuth depending on where the multi-path object is placed. Therefore it is very important to have the Tool GPS receiving antennas extended away from the antenna to be aligned. The Smart Aligner Tool extends the GPS receiving antennas away from the antenna to be aligned in order to eliminate the errors as seen in the graph above. See image below.
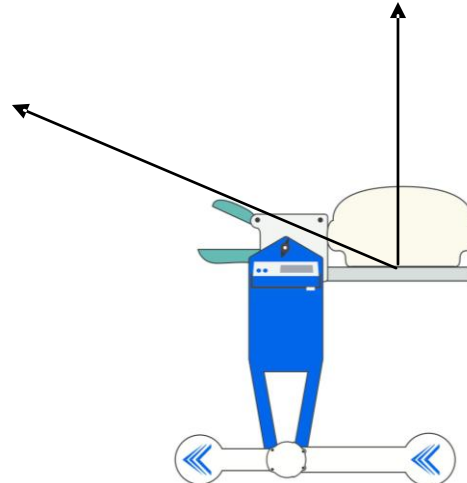
RF INTERFERENCE

RF interference occurs when live antennas are being aligned. If the GPS receiving antennas on the Tool are in the path of the live antennas, there is a possibility that the interference will cause excessive noise in the Tool, resulting in no azimuth solution being obtained. Most of the Tools are well designed to shield RF, however, since the GPS receiving antennas cannot be shielded, there is the possibility of interference occurring. Some Tool manufacturers recommend turning on the Tool in a different location that is away from the live antenna and then moving and mounting the Tool to the live antenna. When mounted on the live antenna, it will be swamped with noise and will start to rely on the gyros. This is a last resort method as the gyro can be affected by how the tool is carried (tilting and rolling or carrying it upside down) and the solution will only last for 3 minutes due to excessive drift of the gyro. The ideal scenario is to move the GPS receiving antennas on the Tool out of the path of the RF. The Smart Aligner Tool can be mounted on an antenna in 18 different positions so that the Tool GPS receiving antennas can be moved out of the way of the live antenna. See images below which show two of the ways that the antennas can be moved out of the live antenna RF path. The azimuth, tilt and roll offsets are then calculated automatically.

Smart Aligner Tool mounted on the left side of antenna with the GPS receiving antennas extended to mitigate RF and multi-path	Smart Aligner mounted to back of antenna with the GPS receiving antennas extended to mitigate RF and multi-path

63°

CONCLUSIONS

This paper illustrates that the GPS Antenna Alignment Tool absolute accuracy can be much larger than the "published accuracy". If the two errors (Absolute error and Multi-Path error) are combined it is possible that the antenna could be misaligned by 3.0° to 4.2° (Max Error = sqrt (3^2 + 3^2) = 4.2°) resulting in errors up to 12X the published accuracy. The contractor or turf vendor would be using a tool that he believes is very accurate but, in reality, it is not. The Smart Aligner Tool accuracy is specified as absolute accuracy and, due to the extension of the GPS receiving antennas multi-path is eliminated. The Smart Aligner Tool can also be mounted in such a way that RF interference is mitigated.