TESTING LARGE WIRELESS DEVICES IN SMALL ANECHOIC CHAMBERS

James D. Huff
Carl W. Sirles

The Howland Company, Inc.
4540 Atwater Court, Suite 107
Buford, Georgia 30518 USA

Abstract

Historically, testing a wireless device typically meant testing a cell phone or notebook computer. Small chambers ranging in size from 3 to 5 meters per side were adequate for both passive antenna efficiency measurements and active measurements of Total Radiated Power (TRP) and Total Isotropic Sensitivity (TIS). However, wireless technology is increasingly being added to appliances, teller machines, utility meters, medical devices, and other devices too numerous to list. Because many of the devices themselves are much larger and heavier than a handset or notebook computer, classical antenna range design would indicate the need for much larger chambers. On the other hand, the radiating element is a small, nominally isotropic antenna that happens to be on a large device. This paper reports on measurements made on a large wireless device in a relatively small wireless test chamber. Measurement uncertainty contributions are estimated, and possible data correction schemes are presented.

Keywords: **OTA, TIS, TRP, wireless, CTIA**

1. Introduction

Over the last 20 years hundreds of test chambers have been built to support the design and production of wireless devices. Since most wireless devices were small, the chambers were designed with 12 inch test zones and range lengths of between 1.2 meters and 5 meters. However, the current trend is to add wireless technology into larger devices such as appliances, teller machines, utility meters, parking meters and patient monitoring devices. Classical antenna range design would indicate the need for much larger chambers to test these devices. On the other hand, the radiating element is a small, nominally isotropic antenna that happens to be on a large device. This paper examines the possibility of using the existing base of wireless test chambers to make measurements on such devices.

2. Test Zone Parameters

The key parameters of the test zone of a wireless test chamber are phase taper, amplitude taper and the extraneous signal level. The phase taper is determined by the range length and is typically less than 22.5 degrees over the 12 inch test zone. This is the commonly accepted far-field criteria. When we increase the size of the device under test (DUT), we potentially violate the far-field criteria. However, since we do not know how much of the physical device contributes to the radiation pattern, we do not know the extent to which we may be violating the far-field criteria. The amplitude taper across the test zone is a similar situation. The wireless test chambers were designed with amplitude tapers of typically less than 0.5dB over a 12 inch quiet zone. However, the amplitude taper across a large DUT can be much higher. The extraneous signal level is also an unknown. The extraneous signal level in a wireless test chamber is typically evaluated over the 12 inch test zone, and little is known regarding the extraneous signal level outside the 12 inch test zone. The size of the 12 inch test zone imposes another constraint. Ideally one would like to position the radiating element at the center of the test zone. With a large DUT, this may not be possible.

3. Data Correction

Some of the measurement uncertainty introduced by the size of the DUT can be removed through fairly simple data correction. In many cases the size of the DUT will make it impossible to place the antenna at the center of the measurement coordinate system. If this is the case, then three errors are introduced. First, the range length will vary as a function of the direction to the measurement antenna. This introduces a change in the path loss between the measurement antenna and the DUT as a function of DUT position. For a spherical coordinate system the correction for range length is then

$$L_{corrected} = L_{measured} + 10LOG(R'/R)\ dB$$

Where R is the distance from the origin of the coordinate system to the measurement antenna (the range length) and R’ is the distance from the actual DUT position to the measurement antenna.

The second error introduced is due to the gain pattern of the measurement antenna. If the wireless antenna is not at the origin of the coordinate system, then the gain of the measurement antenna in the direction of the DUT is constantly changing. If the offset is large, this change in gain can introduce a significant error. However, if the pattern of the measurement antenna is known, this error can be backed out of the measurement.

The third error introduced is due to parallax, the difference in the direction to the measurement antenna reported by the measurement system and the actual direction from the DUT to the measurement antenna. This error can also be corrected if the position of the wireless antenna is known. Figure 1 below shows a graphical representation of these three elements.

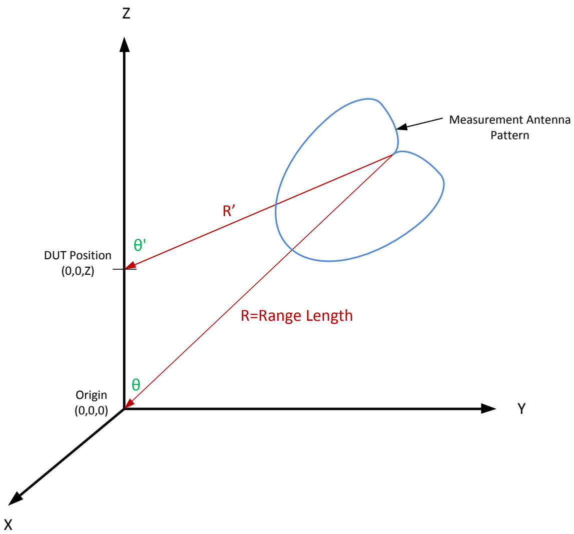

Figure 1

Data Correction Elements

4. Dipole Measurements

In order to determine the effectiveness of the data correction algorithms, pattern measurements were made at 1880 MHz on a coaxial dipole centered at the origin and offset from the origin by relatively large amounts. A distributed axis measurement system was used where motion in phi is supplied by an azimuth rotator on the floor of the chamber and motion is theta is supplied by an elevation boom whose axis intersects the phi axis at the center of the test zone. The dipole was offset along the z-axis (the phi axis) and measurements were taken at (x,y,z) positions (0,0,0), (0,0,12) and (0,0,18). The dipole measurement setup is shown in figure 2.

The uncorrected patterns and the corrected patterns are shown in figures 4 and 5. Whereas the uncorrected data show three distinct patterns, the patterns for the corrected data show only small variances.

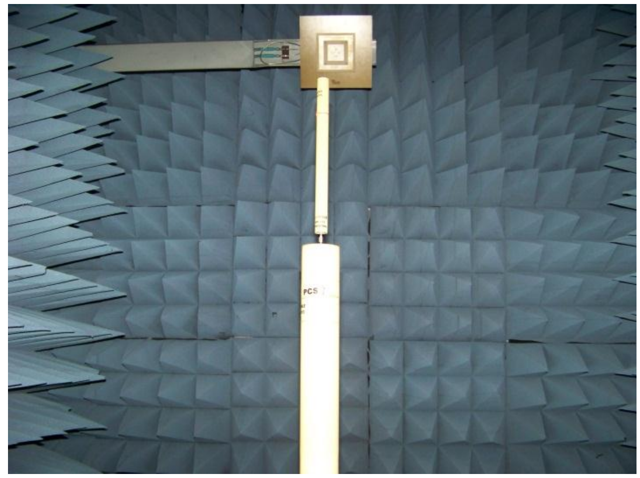

Figure 2

Dipole Measurement Setup

5. A Large Wireless Device

Not having ready access to a large wireless device, we decided to fabricate our own. We took a 30 gallon oil drum, turned it upside down, and mounted a small monopole antenna in the bottom, thus creating the world’s first wireless drum. The drum is 34 inches tall and 23 inches in diameter. This gave us a test object significantly bigger than the 12 inch test zone of our range. A picture of the wireless drum is shown in figure 3.

Figure 3

The Wireless Drum

6. DUT Measurements

In order to make pattern measurements on our wireless drum, we built a DUT support that allowed us to position the drum along the z-axis of the range. The range of travel was 18 inches with the starting point being the point (0,0,0) and the end point being (0,0,18). A total of 19 theta patterns were made at 1880 MHz with the drum positioned at 1 inch increments along the phi axis. At any given theta angle we have 19 data points. From these data points we can calculate from the maximum and minimum values a corrected pattern for the wireless drum. A block diagram of the measurement setup for the wireless drum is shown in figure 6.

7. Measurement Results

The measured theta patterns of the wireless drum are shown in figure 7. The corrections described in section 3 were applied to this data, and the corrected patterns are shown in figure 8. Although the improvement is not as dramatic as in the case of the dipole, the corrected data fits in a much tighter envelope. A "true" pattern was calculated from the maximum and minimum points at each theta angle and is plotted on the same graph.

The same peak to peak values were then used to calculate an equivalent stray signal level for both the uncorrected data and the corrected data.[3] Equivalent Stray Signal is an analysis tool that allows one to compare the differences in patterns made on the same antenna under slightly different conditions. The differences in the patterns are converted into the extraneous signal level that would have caused the same variation. Figure 9 shows the plots of the equivalent stray signal level for both the corrected and uncorrected data.

8. Summary & Conclusions

It is obvious that the dipole pattern data is much more accurate than the wireless drum pattern data. However, the drum was measured at a range length of 5 feet in a chamber that is a 14 foot cube. If one had used the normal range design parameters, the range length would have been 30 feet and the chamber would have been 60 feet high and 40 feet long. This would be an expensive chamber to construct. Thus the question is one of cost versus measurement uncertainty.

We feel that the results are encouraging, but many questions remain to be answered. What is the most cost effective way of decreasing the measurement uncertainty of large wireless devices? Is the only answer a larger chamber, or are there other ways of improving the measurement uncertainty? The most commonly used metrics for wireless devices are total radiated power (TRP) and total isotropic sensitivity (TIS). What is the measurement uncertainty for these integrated measurements?

However, the conclusions we can draw from the measurements presented here are:

1. It is possible to make measurements on a large wireless device in a small chamber if one corrects for the offset of the wireless antenna from the origin of the measurement coordinate system.
2. Although the measurement errors are higher than for a small device, the results may well be acceptable for devices such as parking meters, utility meters, or appliances.

9. References

[1] Test Plan for Mobile Station Over The Air Performance, Revision 2.2, CTIA Certification Program, November 2006

[2] Microwave Antenna Measurements, Second Edition; Lyon, Hollis, Clayton; Scientific-Atlanta, Inc.; 1970

[3] HISTORICAL BACKGROUND ON THE USE OF EQIVALENT STRAY SIGNAL IN COMPARISON OF ANTENNA PATTERNS, D.W. Hess, Proceedings of the 5th European Conference on Antennas and Propagation (EUCAP), April 2011

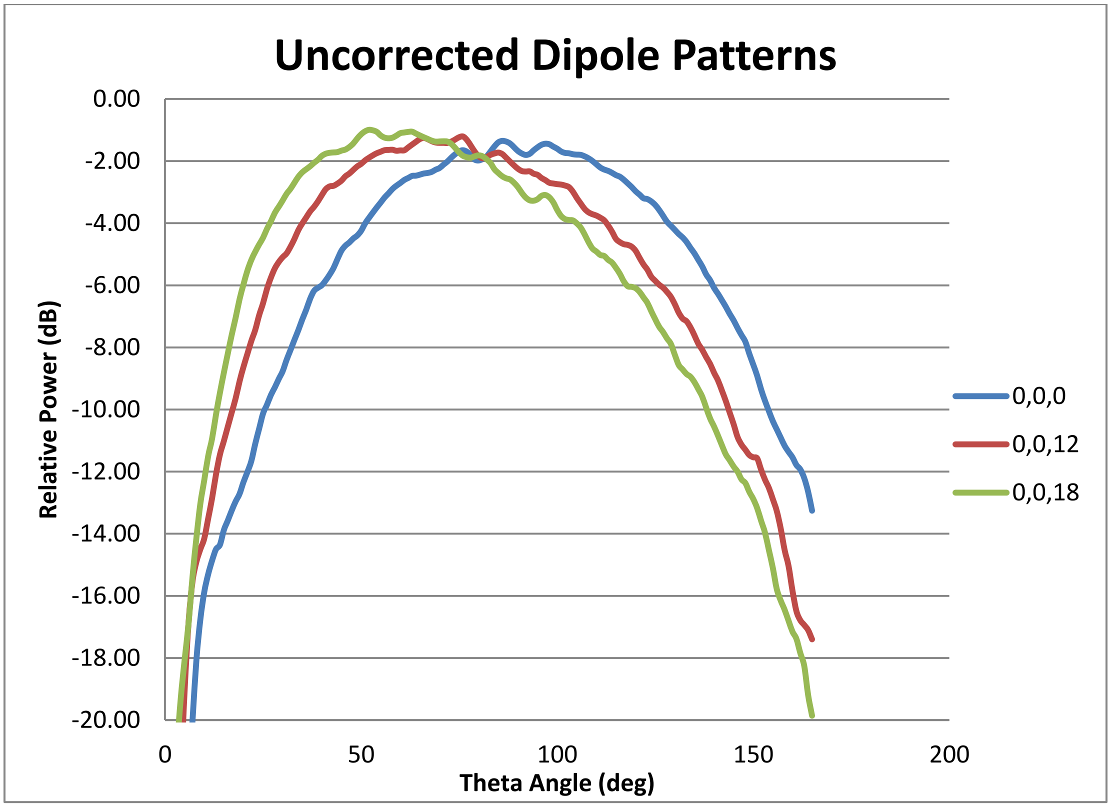

Figure 4

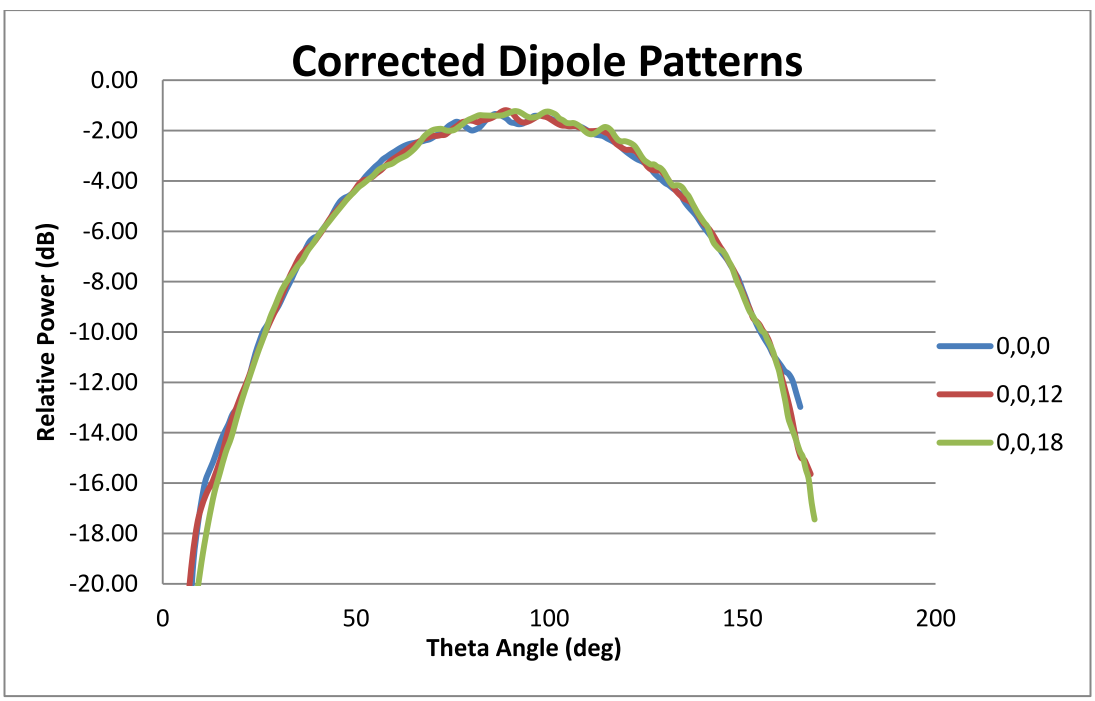

Figure 5

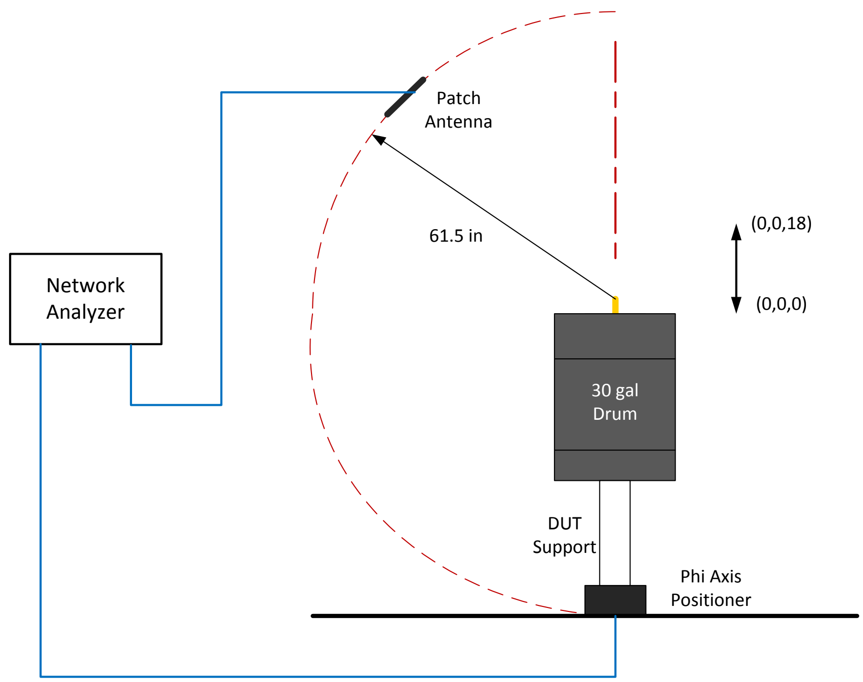

Figure 6

Measurement Block Diagram

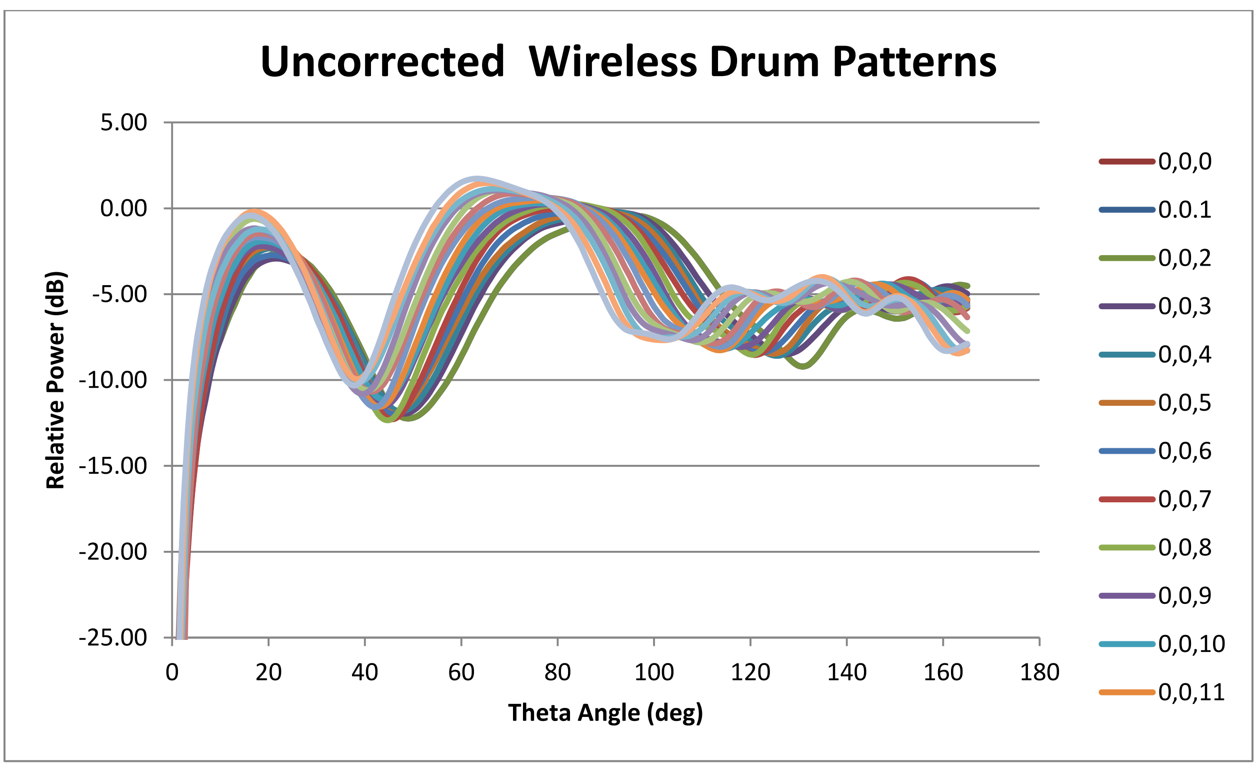

Figure 7

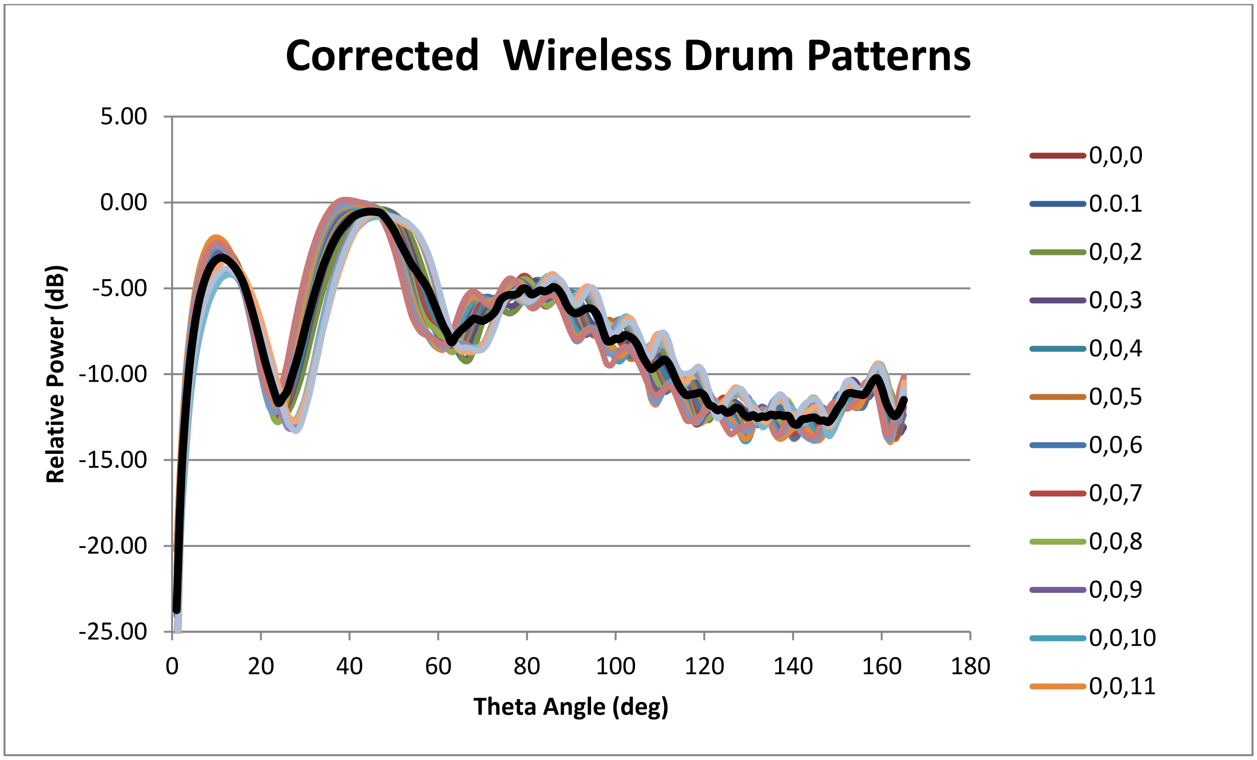

Figure 8

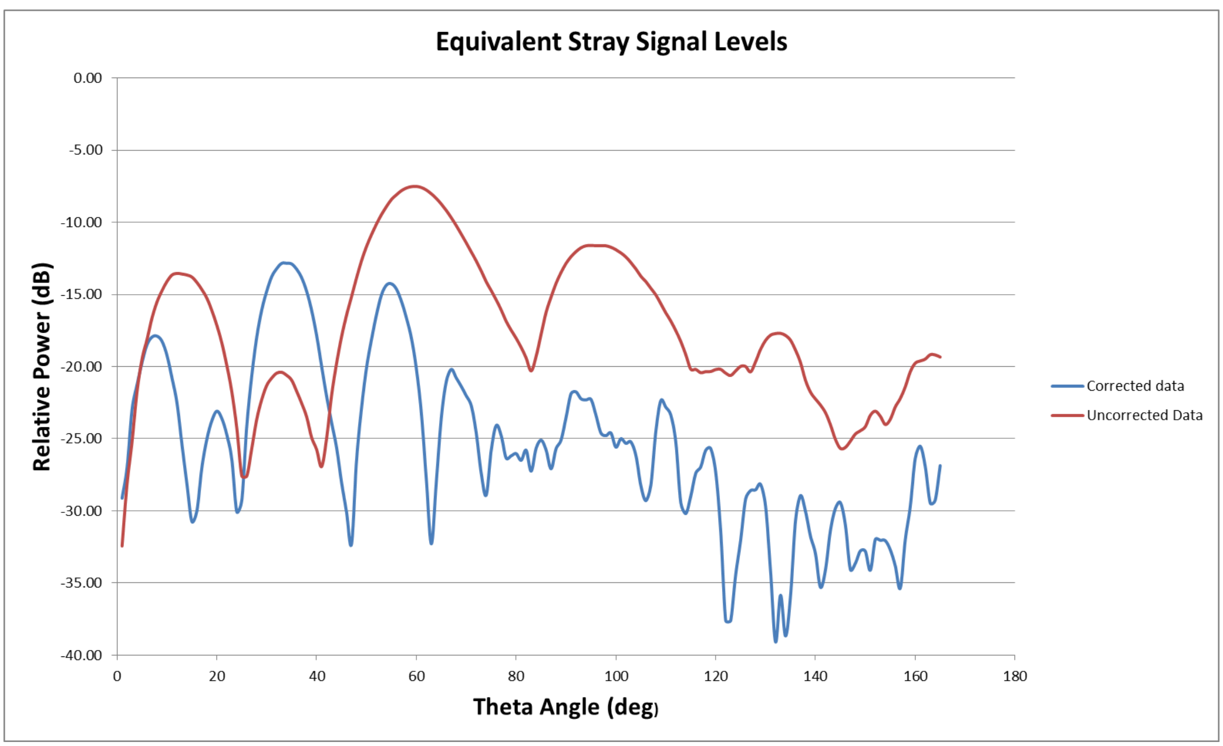

Figure 9