# TESTING REQUIREMENTS FOR TELEMATICS ANTENNAS

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## 1. Introduction

An antenna placed on an automobile excites currents on the vehicle that in turn modify the pattern of the isolated antenna. Measuring the pattern of the effective antenna (isolated antenna plus automobile) has become more challenging since patterns are now needed at high elevation angles due to the presence of satellite radio, GPS, satellite TV and other services coming into the vehicle. Ripples and nulls may be produced in the pattern by the interaction of the vehicle with the isolated antenna that can cause dropouts in coverage. The designer must select the proper antenna and the proper location for this antenna in order to eliminate dropouts. There are several options available when selecting a telematic antenna measurement system including:

a. Far-field versus quasi far-field near-field ranges
b. Outdoor versus indoor ranges
c. Conducting versus absorber ground plane

Effects on the measurements due to the selection of these various measurement options are covered in this paper.

## 2. Far-Field Testing

Typical outdoor far-field antenna ranges are configured as elevated, ground reflection, or slant ranges. The ground reflection range is the most practical for testing terrestrial based communication systems such as AM, FM and cellular at low-elevation angles. In this measurement geometry the vehicle is placed on an azimuth turntable and a source antenna is placed on a tower down range to simulate the testing terrestrial communication system.

Far-field telematic measurements can be made both indoors and outdoors. Indoor measurements require the construction of an anechoic chamber. The cost of the host building, the chamber and the absorber to cover the chamber make the indoor measurements system more expensive. However, it can be used without concern about weather or interference. An outdoor far-field facility is less expensive since it does not require a host building, chamber or absorber. However, the antenna measurement positioners must be able to provide the required accuracy under weather loads and interference to and from other systems operating at or near the same frequency can be a major problem.

An arch or gantry over azimuth turntable geometry is more appropriate for measuring patterns at high elevation angles that occur in satellite communication systems. However, the radius of the arch or gantry is limited by practical physical considerations. Hence, the measurements are often made at less than the far-field distance resulting in quasi far-field measurements.

## 3. Quasi Far-Field Measurements

Proper far-field antenna testing requires that the measurements be made in the far field (see Figure 1) of the effective antenna which is given by $R = 2D^2/\lambda$ where D is the diameter of the effective antenna (i.e. the antenna and automobile) and $\lambda$ is the wavelength of operation. The measured pattern at shorter distances will be distorted as shown in Figure 2 where it is seen that that the nulls in the true pattern are filled in and that the sidelobes levels are changed at 0.25 of the far field distance. At distance of 0.075 of the far-field distance, the main beam has been significantly distorted, as is the overall shape of the pattern.

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In addition to distortion of the measured pattern shape, significant errors in the measured gain of the antenna occur when testing at distance of 0.25 of the far-field distance as shown in Figure 3. Gain errors of 10 dB or more can occur when measuring at 0.075 of the far-field distance.

Some users measure what they consider to be satisfactory patterns using a gantry in a quasi far-field mode, i.e. at separations less than the far-field distance. These measurements are valid only if the antenna when mounted on the vehicle does not excite currents over large areas of the vehicle. In this case the effective antenna (antenna plus automobile) is much smaller than the size of the automobile and so that the far-field distance is shorter. However, the accuracy of the quasi far-field measurements must be validated by comparing them with valid far-field or near-field measurements. The antennas encountered in telematics applications usually have low-gain, broad-beam patterns as shown in Figure 4, which eases the measurement requirements except for pattern dropouts.

## 4. Near-Field Measurements

Near-field measurements are an alternate testing technique for telematic antennas. It provides higher accuracy in many cases, requires little space and provides excellent polarization measurements. Its major disadvantages are that data must be collect over an entire sphere before calculating any patterns, higher accuracy positioners are required, and phase and amplitude of both polarizations must be measured. Typically the near-field probe is moved in elevation by a gantry that straddles an azimuth turntable as shown in Figure 5. These two positioners provide Theta (elevation) and Phi (azimuth) spherical movement of the probe around the vehicle.

The basic spherical measurements procedure is as follows. First the probe pattern and polarization must be characterized either by measurement or calculation. Next, the phase and amplitude of two polarization components of the AUT are measured on a regular grid over a sphere using the probe. A 2D Fourier transform of the probe corrected AUT data is then performed to obtain the far-field pattern of the AUT. The frequency range of operation of a typical spherical near-field system is shown in Figure 6 and is determined by the size of the positioners and their accuracy.

## 5. Ground Plane Effects

Spherical near-field measurements require data over a complete sphere surrounding the antenna under test. Ground plane simulation software must be utilized in telematic measurement systems since the position cannot operate below the ground plane. The ground can be represented as either a perfect conductor if metal covers the ground surrounding the vehicle or as a perfect absorber if the ground is cover by absorber. Ground reflection multipath effects are included in the measured pattern by using a metal ground plane. An absorber ground plane eliminates ground reflections from the measured data, and these reflections (that are present in actual vehicle use) must be mathematically introduced into the measured pattern by the user. MI Technologies has implemented software for both absorber and conducting ground planes.

## 6. Conclusions

Traditional telematics antenna test systems rely on outdoor far-field antenna ranges with the vehicle on an azimuth turntable and the source antenna in the far field of the effective antenna. This geometry is satisfactory for terrestrial based communication such as AM, FM and cellular since the antenna only needs to be tested at low elevation angles. High elevation angle testing of antennas on automobiles is driven by satellite, GPS and other communications services on board the automobile. Arch or gantries over an azimuth turntable positioning systems are required to measure the pattern in these cases. Quasi far-field measurements may provide adequate pattern data but only if a small portion of the vehicle is excited by the antenna. Spherical near-field measurements can measure the effect of the influence of the entire vehicle and is the only technique that can provide the true antenna pattern.

## 7. References

1. R. C. Hansen, Microwave Scanning Antennas, Vol. I, Academic Press, New York, 1964.

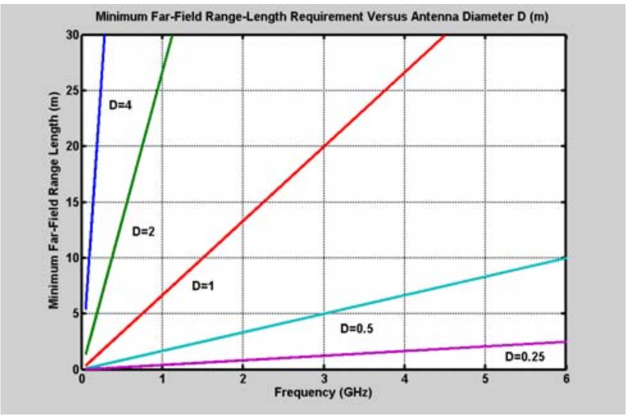

Figure 1. Far-field measurement distance of typical telematic systems

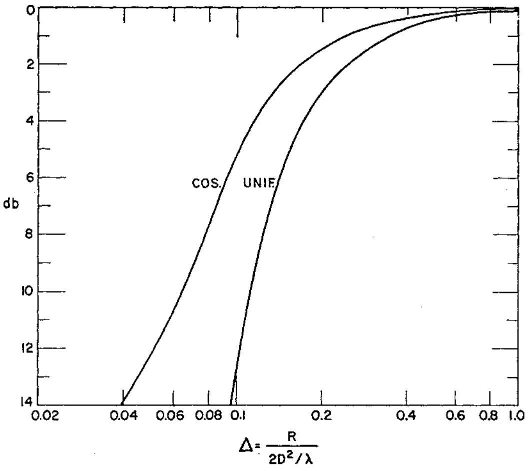

**Fig. 47.** Directivity reduction for square aperture.

Figure 3. Error in antenna directivity caused by measuring at less than the far-field distance.

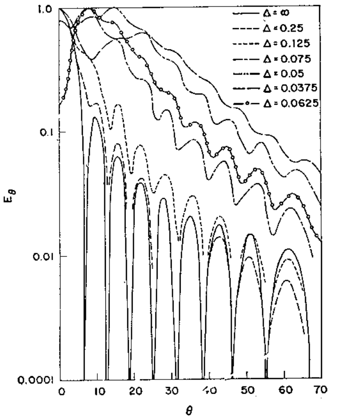

**Fig. 14.** Fresnel region elevation pattern for a uniform distribution, $D = 10\lambda$.

Figure 2 Pattern distortion caused by measuring at less than the far-field distance. Fresnel region elevation pattern for a uniform distribution, D = 10λ.

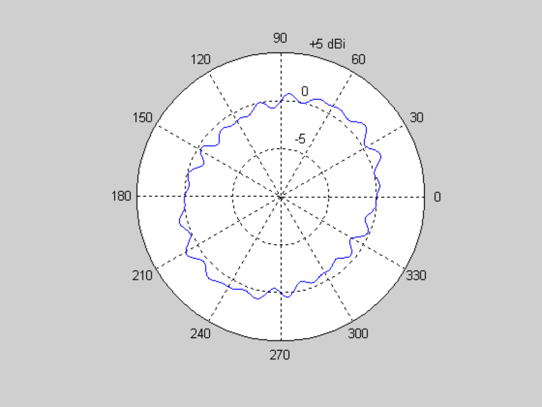

Figure 4. Typical output data.

**Test Configuration**

| | |
|---|---|
| **Antenna:** | **Slotted Patch** |
| **ID:** | **MX-19-4** |
| **Vehicle:** | **TY 450** |
| **Operator:** | **G. Burdell** |
| **Frequency:** | **827 MHz** |
| **Elevation:** | **0 degrees** |
| **Polarization:** | **Vertical** |
| **Date:** | **15 June 2004** |

Figure 5. Spherical near-field telematics measurement system

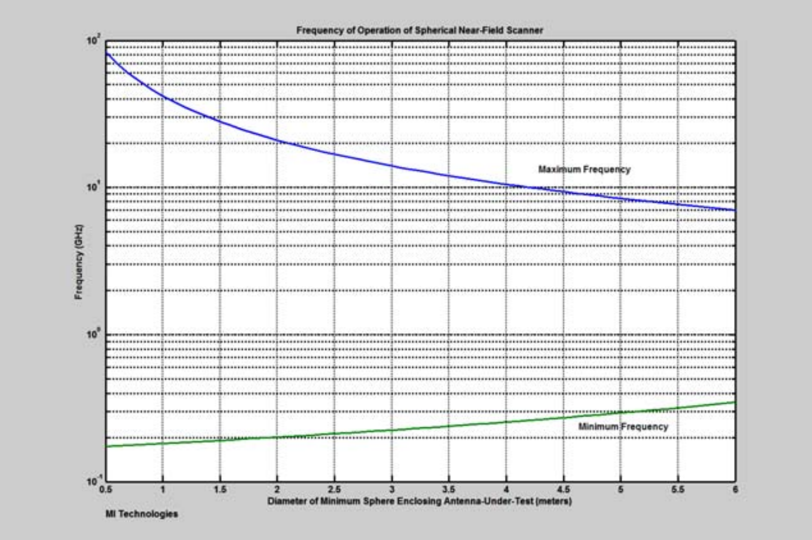

Figure 6. Estimated frequency range of operation for typical spherical near-field antenna measurement system.