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Testing Telematic Antennas

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Introduction

There are an increasing number of antennas on mobile platforms such as trucks, tanks, armored personnel carriers, UAV's, small ships and boats. This has resulted from the military C^3I requirement to be able to communicate both tactical and strategic information in real time. Applications for such communication range from real time targeting to asset deployment. This on vehicle commutation capability to and from mobile platforms is referred to as telematics.

There are a number of unique test requirements for telematic antennas. Antenna manufacturers normally test their products as stand alone units. This data is usually inadequate for telematic applications since the antenna induces currents on the platform and all or part of the vehicle becomes part of the effective antenna. Hence, the effective antenna is much larger than the original antenna by itself. There can be significant changes in antenna pattern performance caused by the platform resulting in undesirable nulls that prevent coverage in several directions. A large amount of data must be taken to characterize the antenna over a hemisphere for ground and water vehicles and over a sphere for air vehicles. Often the antennas must operate over a wide frequency range since multiple RF systems may be using the same antenna. Another unique test requirement is that the pattern must be determined when it is in the presence of a ground plane. The ground plane is the earth's surface for land vehicles and the water surface for boats and ships. Conventional antenna measurement techniques employ designs to eliminate the ground reflections using absorber material or to minimize them by diffraction fences or height adjustment of the source antenna. In contrast, the pattern of telematic antennas needs to be determined in the presence of both the ground plane and the vehicle. MI Technologies has developed a technique to transform the near-field data taken in the presence of the ground plane into far-field patterns including the presence of the ground plane.

Test Range Configurations

The antenna range configurations that are useful for telematic antenna testing are (1) far-field ranges, (2) near-field ranges and (3) compact ranges. A far-field range has a transmitter connected to a source antenna at one end of the range and the antenna under test (AUT) is at the other end of the range. This range operates on the principal that when a source antenna is far enough away from the AUT then the wave front from the source antenna is essentially planar at the AUT. This leads to a minimum separation of $2D^2/\lambda$ where D is the diameter of the AUT and λ is the wavelength of operation. Indoor far-field ranges (see **Figure 1**) can be used when D is small and λ is large so that the needed separation can be achieved in a reasonably sized building. The size of the anechoic chamber in the building and hence the cost of the building and the cost of the absorber that lines the inside of the chamber (to make it anechoic) all increase as D increases. Eventually, the indoor far-field range becomes too expensive and an outdoor far-field range is required since the needed separation between the source antenna and the AUT can

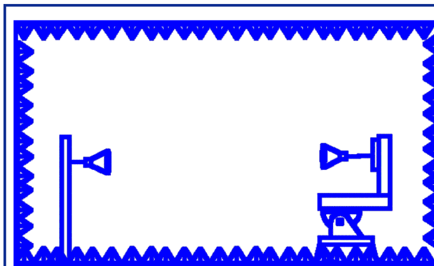
Figure 1: Rectangular Anechoic Chamber

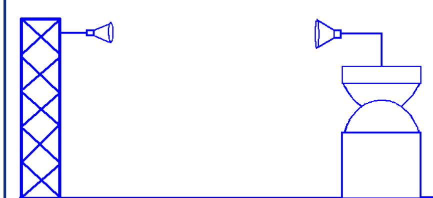
Figure 2: Outdoor Elevated Range

much more easily be achieved outdoors. The outdoor far-field antenna range (see **Figure 2**) has been a standard antenna test facility for many years, and range lengths from hundreds of feet to several miles have been utilized. The land transverse to the AUT to source antenna direction must be cleared of obstacles so that they do not contaminate the measurements. Thus a good deal of land may be required for an accurate outdoor far-field range. The cost of the requisite land for outdoor far-field ranges when located near an urban environment can be very high and beyond the reach of many companies. In addition, there is generally considerable RF contamination in urban areas that can interfere with the test and meas-

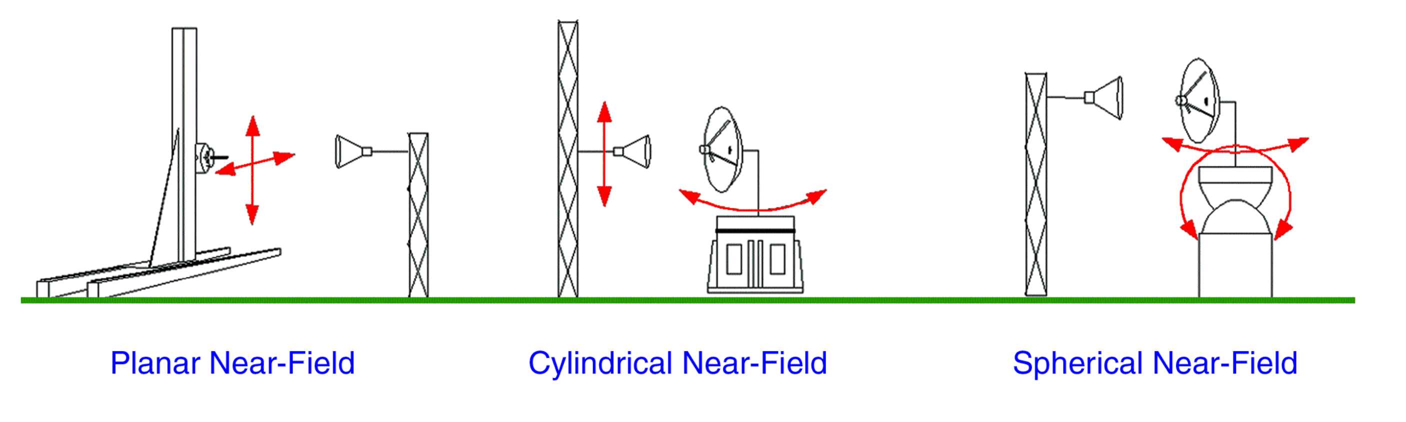

Figure 3

urement task. An indoor near-field range is then selected to avoid the cost and operational difficulties of an outdoor far-field range.

The principal of operation of a near-field range is that the tangential electromagnetic field is measured on a surface that completely surrounds the AUT. The field outside this surface can be computed exactly from the fields on the surface. A major advantage of the near-field technique is that the AUT pattern can be determined from measurements made in a relatively small indoor chamber. The three measurement surfaces for which the mathematical transformations have been developed and proven are planar, cylindrical, and spherical (see **Figure 3**). Each of these near-field measurement geometries works best for particular antenna types.

A planar near-field system employs a mechanical positioning system (referred to as a scanner) that precisely moves a probe antenna over a planar surface in front of the AUT. The vertical and horizontal components of the near field from the AUT are measured in amplitude and phase at equally spaced locations in x (horizontal) and y (vertical) over the measurement plane. The measured data is corrected to remove distortions produced by the probe and then transformed using FFT (Fast Fourier Transform) algorithms to arrive at the far-field pattern. This measurement system is intended for high gain antennas when only the pattern near the main beam of the antenna is of interest. Spillover and back lobes from the antenna cannot be measured with a PNF system.

A cylindrical near-field (CNF) scanner moves a probe over a right circular cylinder that encloses the AUT. A CNF system is a better choice when far-out sidelobes and backlobes are of interest. Backlobes and far-out sidelobes can be determined in the horizontal plane since the CNF measures the near field of the AUT over 360º in azimuth. Patterns in the elevation plane can be determined out to ±45º or ±60º from the horizon.

A spherical near-field (SNF) range can determine the pattern in all directions about the AUT since the near-fields are measured over a sphere that completely surrounds the AUT. A two- axis positioning system can move the entire AUT if it is lightweight. However, for most vehicles it is preferable to use an azimuth positioner to rotate the vehicle in azimuth only. A probe is moved in elevation on an arch or a gantry to provide the second spherical angle of motion. The gantry provides adequate accuracy at lower frequencies and can be used indoors and outdoors. The mechanically fixed arch provides better

Figure 5: MI-2097 Automatic Antenna Measurement System

accuracy and therefore, can be used at higher frequencies.

The compact range is another measurement technique for making antenna measurements at much less than the far-field spacing (see **Figure 4**). A small feed horn is placed at the focal point of a parabolic or Cassegrain reflector. Energy radiated by the horn is bounced off of the reflector system and leaves the last reflector as a collimated plane wave. This is just the type of wavefront that is produced at the AUT in a far-field range. Both indoor and outdoor compact ranges can be used, but the indoor version is much more common. An anechoic chamber is built around the compact range to prevent reflections from the chamber walls from perturbing the measurements. The compact range has the advantage over the near-field systems in that it measures the pattern of the AUT directly at each point in space. In contrast the near-field systems must collect all data on the measurement surface and then transform the information before the pattern can be seen. The compact range has the advantage over a far-field range since it is able to measure electrically larger antennas in a much smaller space. However, the cost of the compact range measurement system will be more than an indoor far-field range due to the addition of the precision compact range reflector.

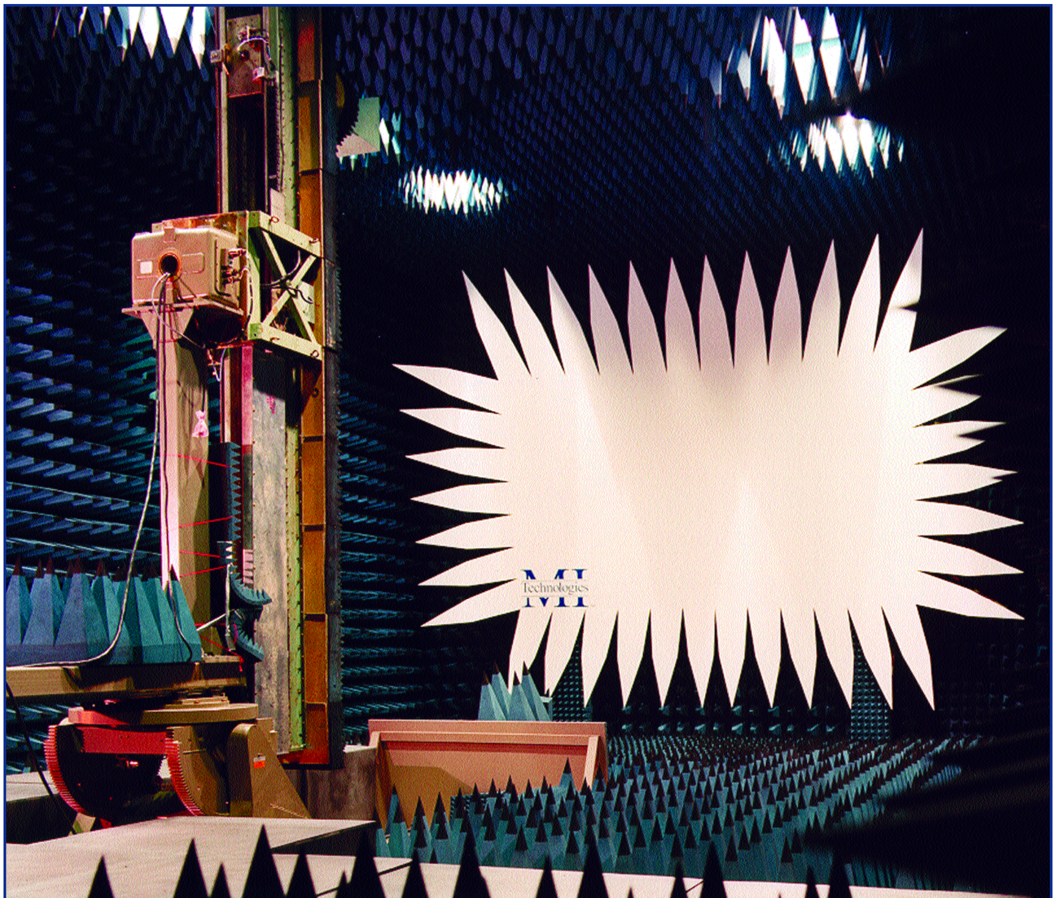

Figure 4: Compact Range

Instrumentation

Automated RF instrumentation is required for telematic antenna measurements. A large amount of data usually must be collected since multiple antennas, operating at a wide range of frequencies, multiple polarizations, and at several potential orientations must be measured over the full hemisphere. Hence automated instrumentation such as the MI-2097 Automatic Antenna Measurement system shown in **Figure 5** is required to make the data collection both efficient and reliable. Automation begins with the MI-3000 instrument control and data collection workstation shown in **Figure 5**. The MI-3000 is combined with a fast instrumentation quality receiver such as the MI-1797 that can collect 10,000 measurements per second. Matched with the receiver is the MI-3101 synthesized signal source that covers 10 MHz to 18 GHz. The positioning of the AUT and of the near-field scanners is handled by the MI-4190 family of position controllers.

Visualization tools are extremely important to reduce the large amount of data into an easily comprehensible form. Software packages are provided with the MI-3000 that (1) transform measured near-field data into far-field patterns, (2) plot data in a variety of formats including a single pattern plot, multiple patterns on a single plot, 3-D plots, contour plots, and pass-fail plots.

It is interesting to note that there is a similar interest from the automotive industry in telematics since commercial motor vehicles are becoming 'antenna farms.' Wireless RF capabilities that are on or will be on our personal vehicles include GPS, cell phone, automatic tolling, collision avoidance, traffic control, and TV.

Conclusion

The need for communications with and between mobile platforms has always existed. Technologies such as satellite communications, GPS and cell phones now provide a feasible approach to accomplish this communication. Antennas are the gateway for this RF communication, but these antennas are characterized as stand-alone units by their manufacturers. Mobile platform providers need to insure that the on-vehicle performance of the antenna system will support the mission of their platform. The test range configurations discussed in this article can provide the needed coverage confirmation data. The high-speed RF instrumentation systems can perform the characterization in a reliable and timely fashion.

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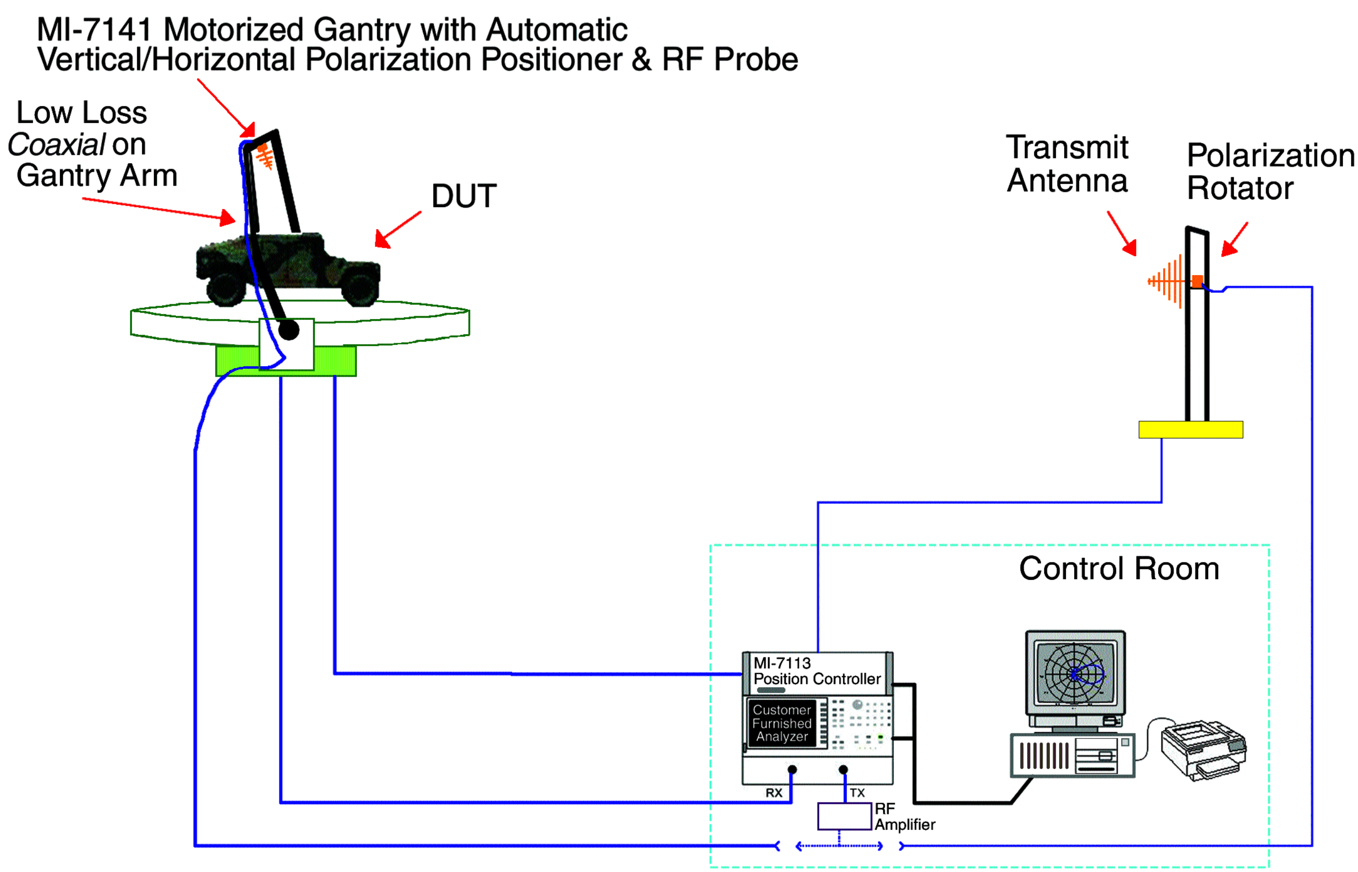

Figure 6: Telematics Range Configuration:
The drawing above is a representation of a combination spherical near-field test system (vehicle on turntable under gantry on left) with a far-field range (vehicle on turntable and transmit antenna on right.)
The range configuration can be used for testing vehicular mounted antennas in a wide variety of applications.