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3D wave field synthesis testbed for Over-the-Air testing of advanced GNSS antenna designs

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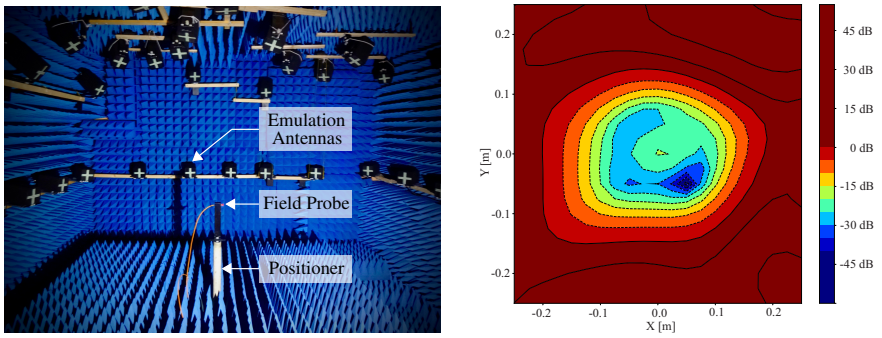
Generally, Over-the-Air (OTA) testing is an alternative to testing through cabled connections. However, if the directivity of the antennas of the Device-under-Test (DuT) is important for device functionality or the antennas are integrated into the device, i.e. no cabled RF connections can be made, OTA testing is the sole option. In testing advanced Global Navigation Satellite Systems (GNSS) receivers, both of these criteria simultaneously apply. Such receivers utilise adaptive antenna arrays for combating jamming or spoofing attacks on the positioning integrity by null-steering and/or beam-steering. We present a testbed design for thoroughly OTA testing of so-called Controlled Reception Pattern Antenna (CPRA) arrays for pattern accuracy and agility, by 3-D wave field synthesis (WFS).

The 3D WFS testbed is built in an anechoic chamber equipped with multiple dual-polarized emulation antennas distributed on a hemisphere, see Figure 1a. WFS is a process of coherently superposing waves from multiple sources, following Huygens-Fresnel [1]. In principal, arbitrary wave forms can be synthesised, but for satellite signals, plane waves will used and for jammer/spoofers, optionally spherical wavefronts with wavefront curvature dependent on the distance of jammer/spoofer. Also polarisations can be chosen arbitrarily. The feasibility of WFS in 2D has already been shown in [2], here we show the extension to 3D. Inherent to WFS techniques is the limited area/volume over which sufficient (synthesised) field quality can be achieved, the so-called sweet spot as apparent from simulations (Figure 1b). For current CRPA arrays, the 20 to 25 cm across we achieve, suffices.



(a) **(b)**

Figure 1. (a) Set-up in anechoic chamber during calibration; (b) Simulated field quality in EVM across sweet spot

The DuT is mounted on a X,Y,Z-positioner for translations in the respective directions and rotations around the z-axis. For calibration purposes, also a small EM-field probe can be mounted on the positioner for measuring the complex values of the three field components of each of the respective synthesising sources over the volume of the sweet spot. From these measurement data, the optimal superposition for the synthesis can be computed [1]. However, maintaining phase-exact repeatability from calibration to actual measurements is a challenge.

During the presentation, we will expand on the calibration procedure and its accuracy and stability. We will also demonstrate the actually achieved field quality and the size of the sweet spot. In an realistic end-to-end check, a professional geodetic GNSS antenna (*NavXperience 3G+C*, by Fraunhofer IIS) connected to a *Septentrio* reference receiver will be put to the test, similar to [2].

References

[1] C. Schirmer, "Over-The-Air Testing using Wave-Field Synthesis", *PhD thesis*, 2018, TU Ilmenau, Germany.

[2] A. Rügamer et al., "Setup and verification of a multi-GNSS over-the-air wave field synthesis testbed", *PLANS 2016*, pp. 863–873, doi:10.1109/PLANS.2016.7479782.