Compact Antenna Test Ranges: The Use of Simulation and Post-Processing Techniques in Support of 5G OTA Testing

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***Abstract*—The Compact Antenna Test Range (CATR) is a long established, general purpose, wide-band, test methodology for acquiring far-field radiation characteristics within comparatively small test volumes [1]. By projecting an image of the CATR feed at infinity through field collimation, typically achieved by means of reflection, the CATR synthesizes the type of wave-front that would be incident on the antenna under test (AUT) if it were instead located at a position very much further away from the feed than is actually the case. By recording the coupling of this collimated pseudo plane-wave into the AUT for different orientations, we may obtain the classical measured "far-field" radiation pattern in real-time. Thus, the quality of the CATR pattern measurement is primarily determined by the uniformity and purity of the phase and amplitude of the pseudo plane-wave [2, 3, 4]. Thus, the performance of the range is largely, but not completely, crystallized at the time that the reflector and feed are fabricated and installed with scope for *a posteriori* performance improvements being relatively limited. However, even here, uses of advanced post-processing techniques have recently been shown to provide worthwhile benefits to the facility-level uncertainly budget and crucially, these too can be verified and developed in conjunction with electromagnetic simulation [1].**

Thus, the successful development and deployment of CATRs has, necessarily, been predicated upon a corresponding development in the speed, accuracy and sophistication of the attendant CATR electromagnetic simulation software. Recent developments in CATR simulations have enabled the design and realization of increasingly complex and ever more efficient CATR assemblies that span progressively wider frequency ranges. These end-to-end simulations, which increasingly harness and rely upon parallel processing architectures, can now be used to determine the impact of the precise CATR design on over-the-air (OTA) communications system parameters. This therefore paves the way for the design and development of CATRs that are fully optimized for the test, calibration and OTA measurement of demanding mm-wave massive multiple input, multiple output (MIMO) backhaul antenna systems. This is particularly important as interest has largely shifted away from traditional antenna performance metrics and instead is focusing on communication system figures of merit [5, 6]. Similarly, sophisticated post processing techniques now enable communication system level parameters such as far-field error vector magnitude (EVM), bit error rate (BER), signal-to-interference-plus-noise-ratio (SINR), *etc.* to be derived conveniently and efficiently from conventional ranges without the need for additional, expensive, specialist RF instrumentation.

This paper presents an introduction to the CATR, the simulation and data post-processing highlighting some of the more significant developments while focusing on those aspects that are most pertinent to modern communication systems which are essential for the successful roll-out of 5G.

***Index Terms*—CATR, 5G, Massive MIMO, mm-Wave, OTA, CATR, EVM, EM Simulation.**

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