# Designing Ultrawideband High Precision Dual-polarized Antenna Probes for Unmanned Aerial Vehicle (UAV) Based Real-time Calibration of Digital Phased Array Radars for Defense and Meteorology Applications


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## Introduction

The antenna test ranges both indoor and outdoor, usually have a controlled environment for antenna testing and do not include the effects of the larger system, RF front-end, ground, pedestal and radome, etc., on the performance of antenna arrays. Moreover, environmental factors such as rain, snow, ice, temperature, and pollution can also adversely affect the performance of antenna arrays in terms of gain, side-lobe levels, polarization, and main beam direction. To cater these problems, outdoor in-situ characterization of the antenna arrays is desired especially in the case of weather radars, to have a reliable measured data considering a real operational environment. Several outdoor measurement techniques were used in the past such as using tethered balloons and aircraft or heli-born equipment. Such techniques are costly, time consuming, and tedious. With the advent of Unmanned Aerial Vehicles (UAVs), in-situ characterization and measurement of radars can provide very precise data and offer extra freedom by its operation in the hover, planar, cylindrical, and spherical modes.

Fig. Cylindrical Polarimetric Phased Array Radar (CPPAR) system mounted on the rooftop of the ARRC, and the UAV-based system during a mission.

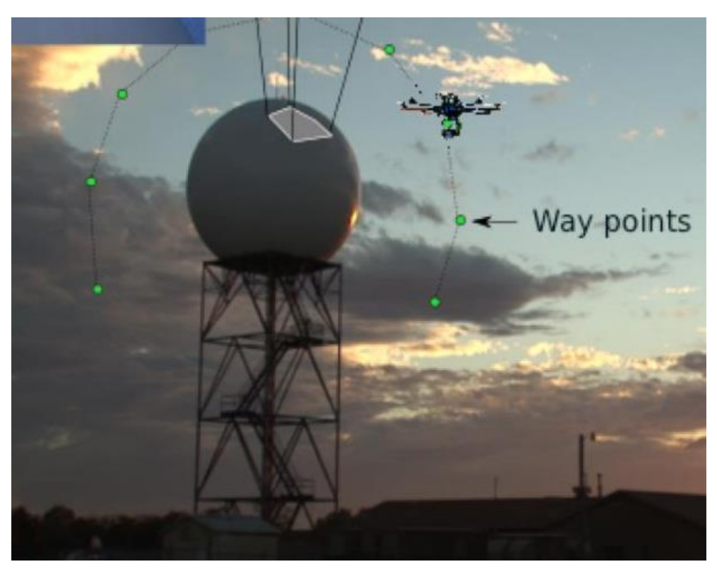


Fig. A UAV in the spherical scanning mode.

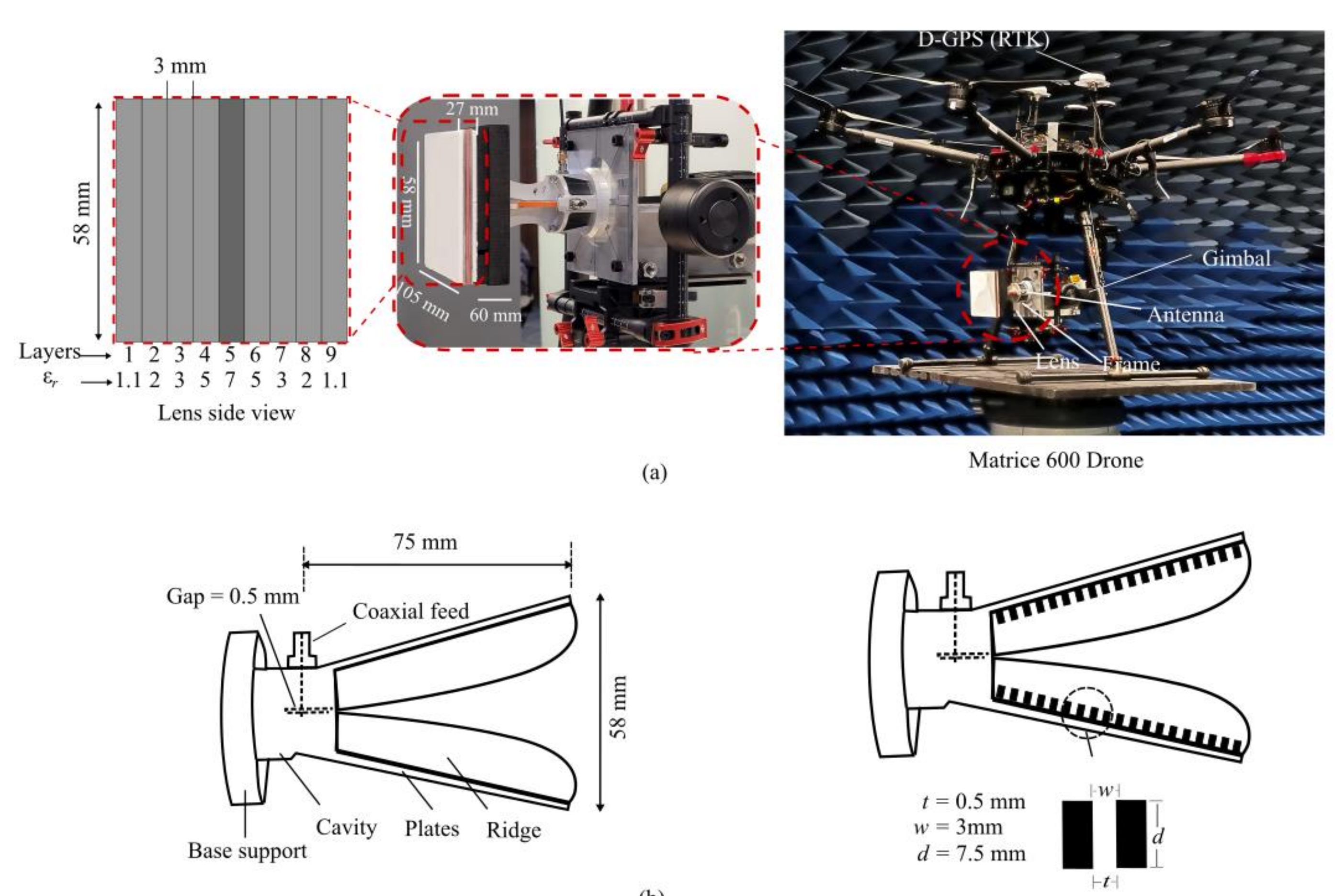


Fig. Description of the DJI Matrice 600 drone carrying the ridged horn antenna (a) prototype of the lens integrated ridged horn antenna mounted on the drone (b) description and dimensions of the standard and corrugated horn antennas.

## Analysis: The Need for Narrow Beamwidth at Low Frequencies

A typical horn antenna is bulky and thus not recommended for UAV based measurements. Moreover, it is also narrowband, which makes the measurements difficult, time consuming, and costly by removing and installing various probes for each band of operation. However, ridged horn antennas are famous for their reduced size, low weight, and wideband operation and can be found suitable for UAV based in-situ measurements. The wideband performance of the ridged horn antenna eliminates the need for using multiple probes and re-calibration of the system. But, the main limitation of the commercially available ridged horn antenna is, it suffers from wider H-plane beamwidth performance at low frequencies. Below measurement analysis using a commercial SH2000 probe mounted on the drone, exhorts the need for narrow beamwidth at low frequencies for UAV based measurements.

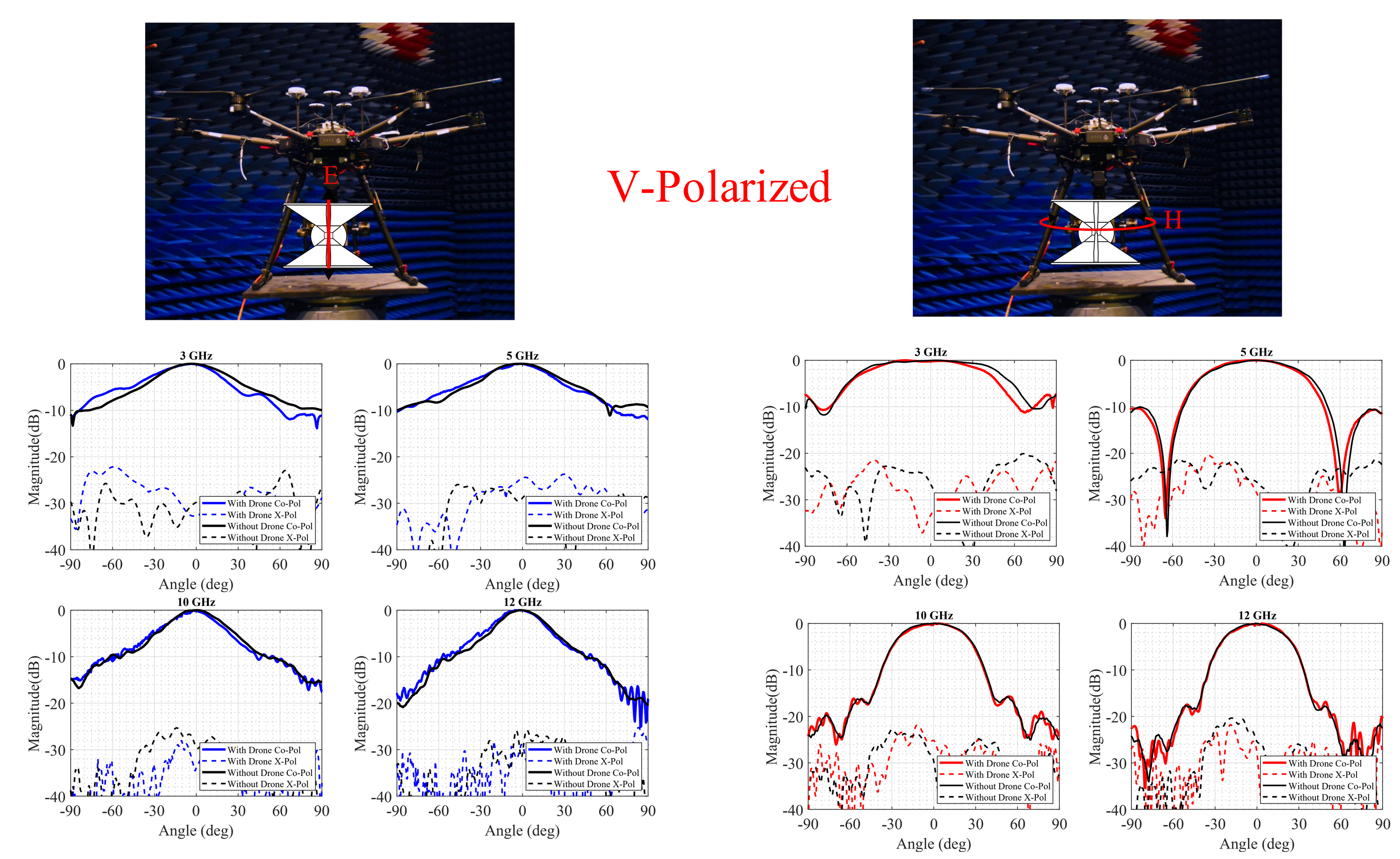


Fig. V-polarized measured radiation patterns for drone and without drone cases.

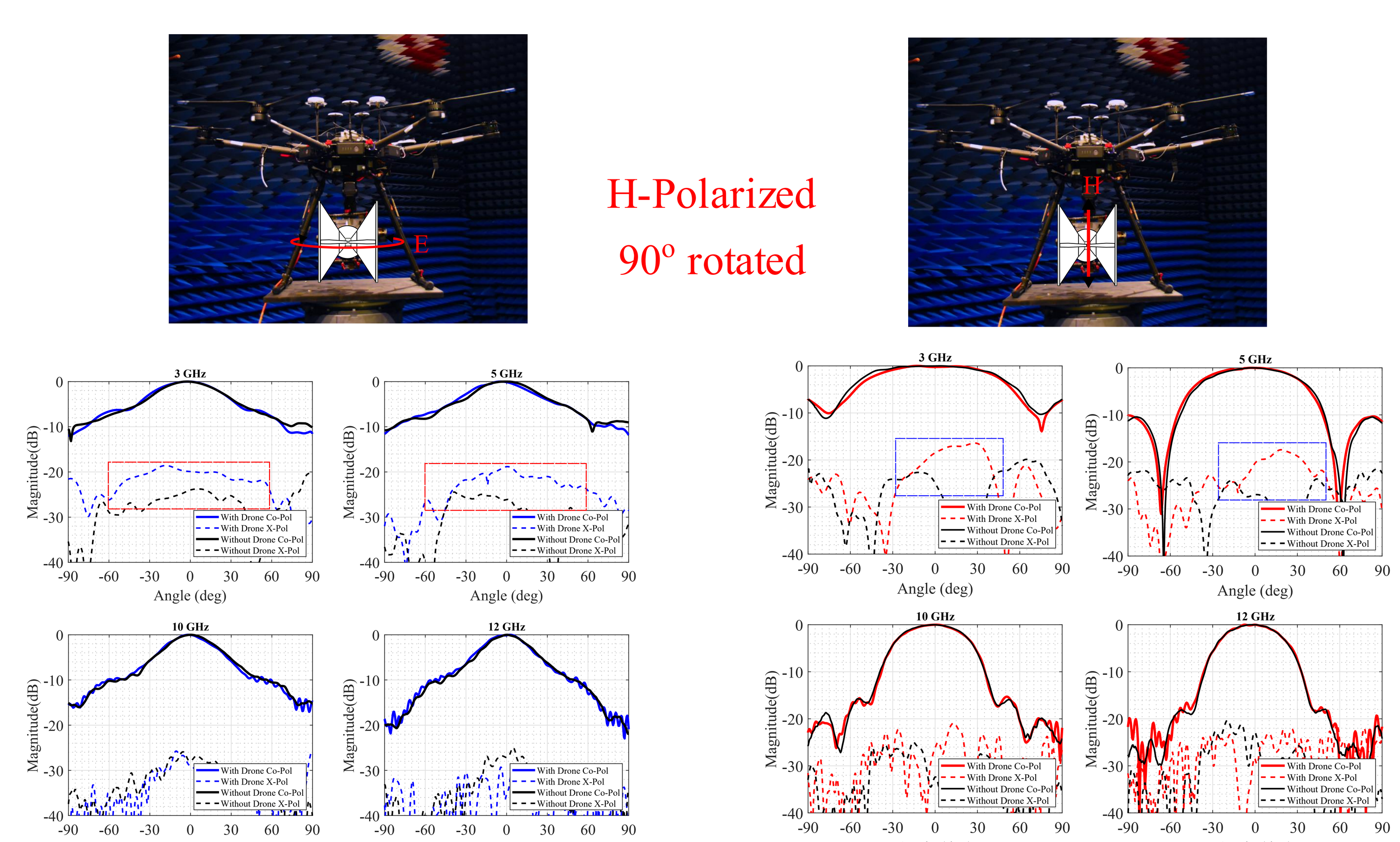


Fig. H-polarized measured radiation patterns for drone and without drone cases.

## Proposed Solution and Results

We have proposed and analyzed two techniques to reduce the H-plane beamwidth by almost 70% in the lower band and to achieve beam constancy as well as symmetry in the patterns. The first technique is based on integrating a multi-layer dielectric lens structure while the second technique involves using corrugations in the plates of the ridged horn antenna. Both techniques exhibit similar performance in the entire band of operation from 2- 12 GHz.

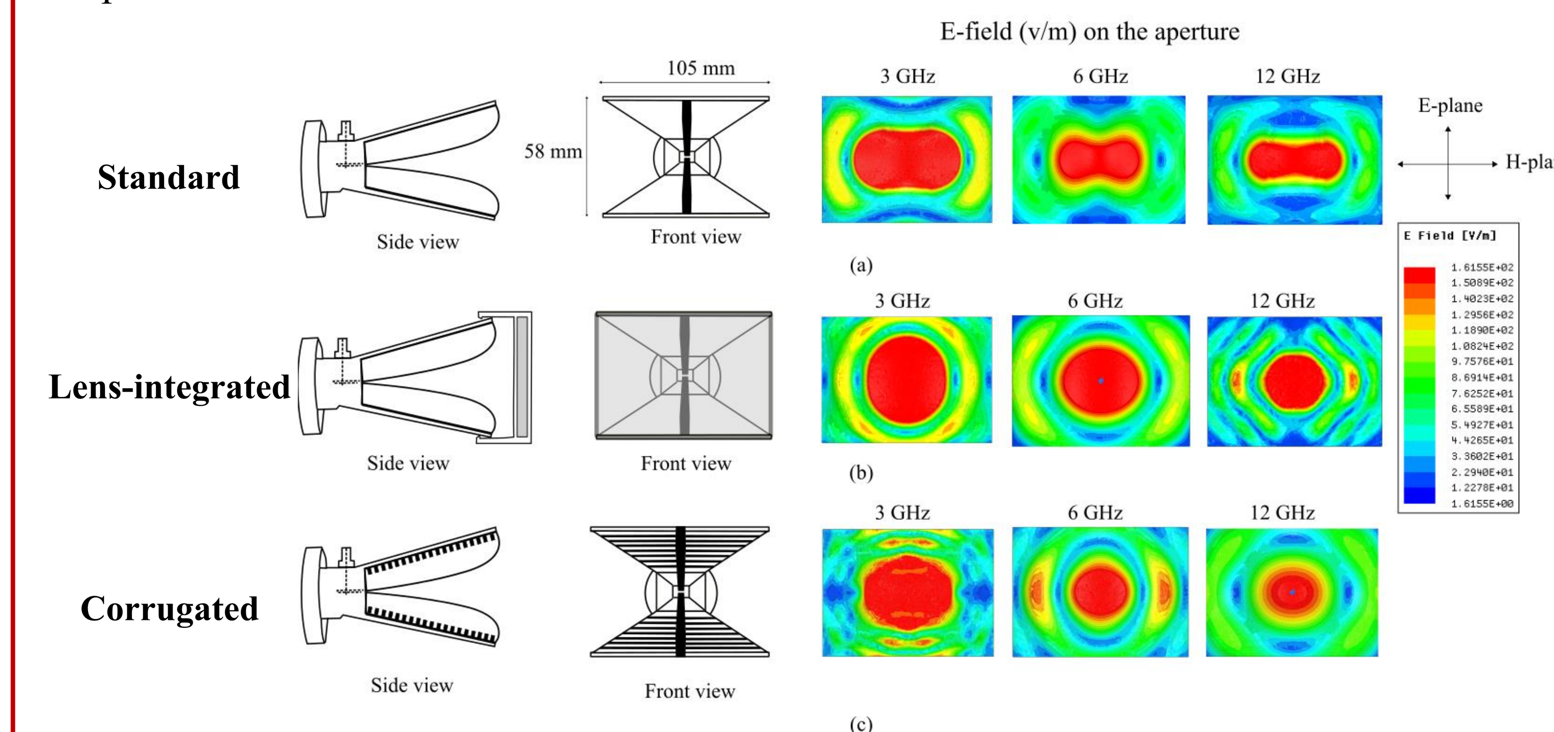


Fig. Antenna geometry models and E-field distribution on the antenna aperture for the 3 cases.

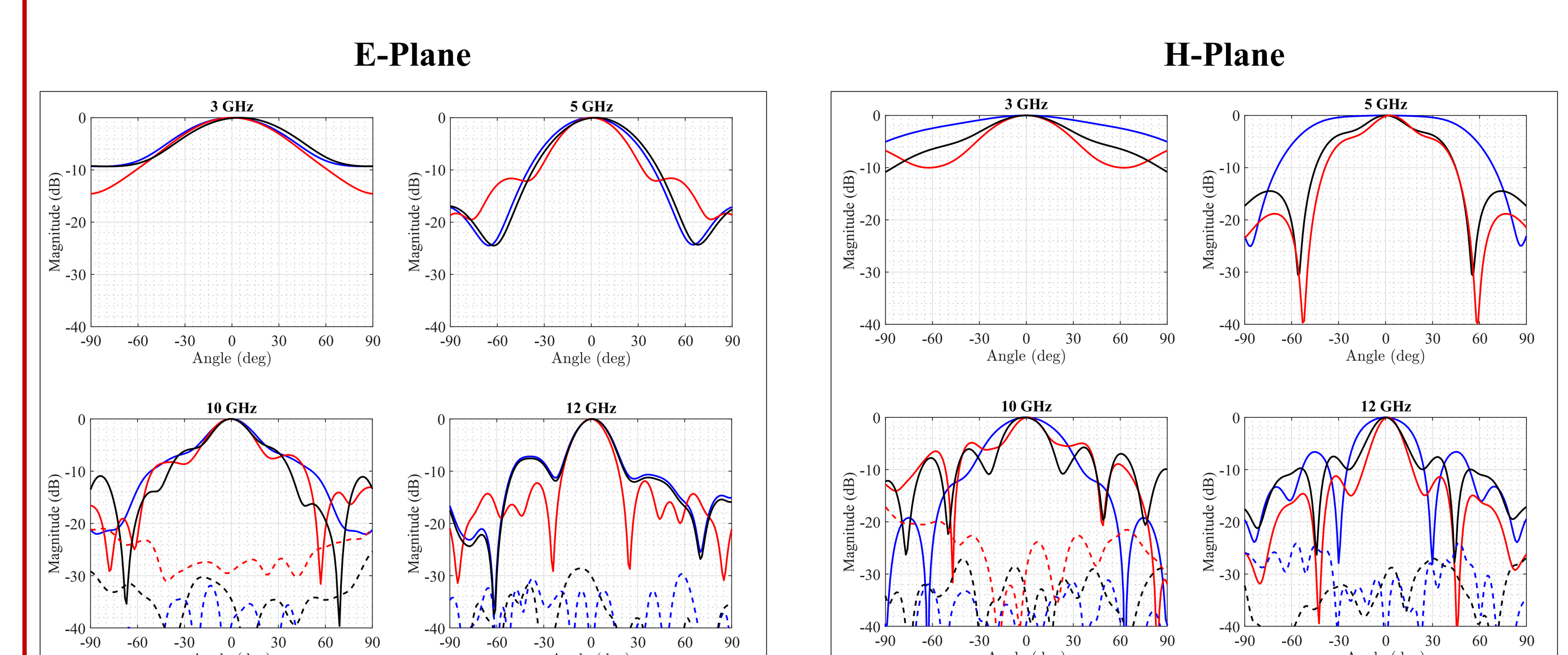


Fig. Comparison of the simulated patterns of the three antennas at different frequencies.

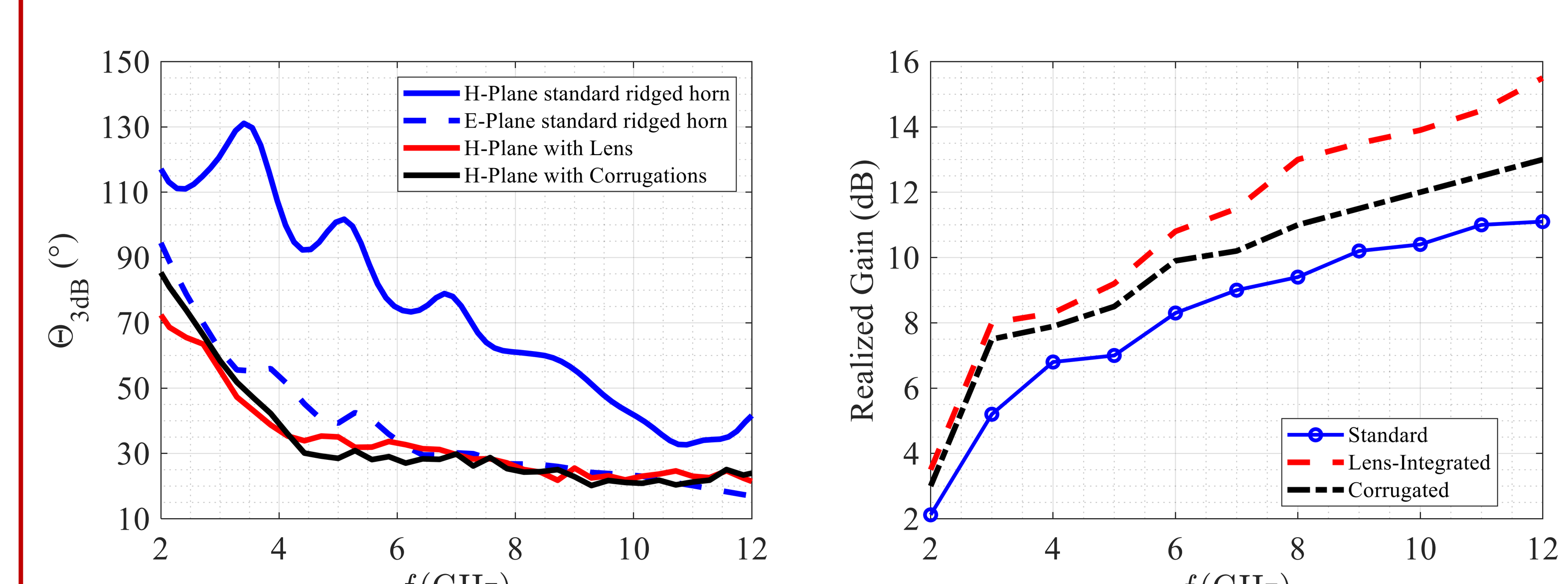


Fig. Comparison of the simulated 3dB beamwidths and gain for the three cases.


J. L. Salazar-Cerreno, S. S. Jehangir, N. Aboserwal, A. Segales and Z. Qamar, "An Ultrawideband UAV-Based Metrology Platform for In-situ EM Testing of Antennas, Radars, and Communication Systems," *2022 IEEE Radar Conference*.

J. L. Salazar-Cerreno, S. S. Jehangir, N. Aboserwal, A. Segales and Z. Qamar, "An UAV-Based Polarimetric Antenna Measurements for Radar and Communication Systems from 3 GHz to 32 GHz," *2021 IEEE Conference on Antenna Measurements & Applications (CAMA)*, 2021, pp. 55-60.