In Situ Far-Field Measurement Antenna Patterns Using an Unmanned Air Vehicle

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Abstract

A novel technique to measure antenna patterns in their operational environment is presented. The proposed concept makes use of a customized octocopter that enables long flight time (45 minutes), large payload (7.2 lb) and precise position and sampling of the signals from the antenna under test (AUT). Several scanning modes are proposed according to the mission selected. Spherical, cylindrical, planar and other scanning modes can be customized to the AUT requirement and external enviromental conditions.

I. Introduction

Characterizing antenna patterns with a high degree of accuracy can be accomplished in either indoor or outdoor specialized anechoic chambers. Both techniques are used to characterize the intrinsic properties of the antenna patterns, excluding the reflections, diffractions and other external sources of contamination that may influence the performance. In both types of chambers, techniques are used to characterize the intrinsic properties of the antenna patterns, to exclude the reflections, diffractions and other external sources of contamination that may influence performance. In a real situation, the antenna interacts with other elements which can differ depending on the application. In most radar and communications systems, an antenna is mounted on a giant mechanical pedestal surrounded by other elements such as a radome, tower, lightning protection, RF equipment, and ground irregularities. The radar equipment and radome can be the same for each radar site in any operational radar network. However, there are external elements, geography, morphology, temperature and other environmental conditions, that are not equal for each site. These elements have the potential to affect the performance of the overall radar system, specifically in the antenna patterns, causing errors in the overall radar calibration.

Since summer 2015, the Phased Array Antenna Research and Development (PAARD) group at the University of Oklahoma has carried out few field experiments using few commercial UAV platforms. In order to prove the feasibility of both the antenna test and differential reflectivity radar calibration, the Phantom 3 platform was used. It has zero payload, a flight autonomy of only 15 minutes, and error positioning of 2 to 3 meters that significantly impact in antenna accurate measurements.
This paper will discuss the development of the UAVRF1200-1 platform to overcome those limitations and enhance the antenna characterization and radar calibration. The proposed UAVRF1200-1 is a customized octocopter of 1.2 m diameter that provides position accuracy of less than 4 cm and high stability, with capacity for up to a large, 7.2 lb payload. Improved accuracy, stability, and capacity over existing technologies, make this platform unique for accurate characterization of dual polarized 3D antenna patterns, including cross-polarization patterns. An S-band antenna probe array is optimized to minimize interference with the UAV platform and to improve the signal to noise ratio of the measurements. The probe is a dual-polarized antenna array with 45 dB cross-polarization in the principal planes. The gimbal is designed to have a position accuracy of 0.1 degrees in each axis. In addition, the transmitter has independent channels for H and V polarizations. This feature adds the flexibility of controlling the accuracy of the polarization orientation of the probe with respect to the antenna during the flight scan mode. The 3-D antenna pattern from the AUT antenna can be fully characterized using different scanning modes in Far-Field region. This concept was proved in X-band and S-band, however it can be used from a range of frequencies from 1 to 34 GHz.

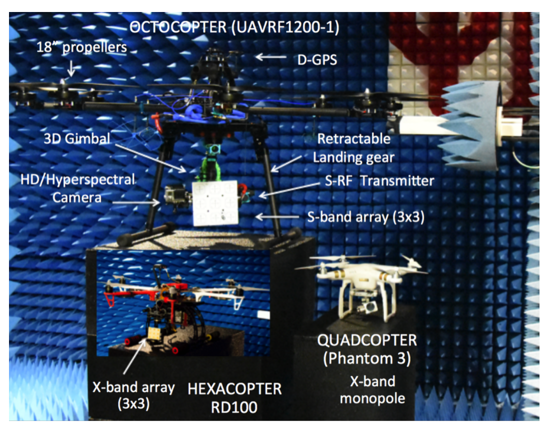

Fig. 1. UAV platforms under development by the PAARD UAV team. At the top, the UAVRF1250 with a S-band antenna array probe. At the bottom left, a hexacopter with a X-band antenna array probe. At the bottom right, the Phantom-3 with a X-band antenna probe