Effect of Conductive Propellers on VHF UAV-based Antenna Measurements: Experimental Results

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Effect of Conductive Propellers on VHF UAV-based Antenna Measurements: Measured Results

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***Abstract*— Professional Unmanned Aerial Vehicles (UAVs) are generally equipped with carbon fiber propellers. Their conductivity and significant size can potentially increase both noise and systematics of UAV-based antenna measurement systems operating in the VHF band. A set of alternative fiberglass propellers has been manufactured and tested. This paper present measured results on the signal stability achieved with both fiberglass and carbon-fiber propellers at 175 MHz.**

***Keywords*— Unmanned Aerial Vehicles, Drones, Propellers, In–situ Antenna Measurement, Carbon Fiber**

I. Introduction

UAV-based antenna measurements are recently exploited for in-situ verification of RF systems [1]-[5], with particular refence to large arrays for radio-astronomy [6]-[10]. The need of long flight duration and lift capabilities (for more RF functionalities of the payload) lead to exploitation of more powerful UAVs with respect to small prototypes used in [9],[10]. The standard propeller material for heavy-lift UAVs is carbon fiber owing to its stiffness and low-weight. Unfortunately, its conductivity can affect the stability of transmitted/received signals with a statistic that is related to the four (or more) counter-rotating propellers.

The impact of conductive propellers has been studied in [11] and [12] for Radar Cross Section and UAV-ground communication channel modelling, respectively. The effect of conductive propellers in the framework of antenna measurements has been investigated in [13] with simulations only. Experimental results on two sets of conductive (carbon fiber) and non-conductive (glass fiber) propellers are reported in this work.

II. Experimental Results

The experimental setup consists of a UAV equipped with an RF synthesizer and a dipole [7]. The UAV is programmed to hover above a log-periodic antenna placed on the ground (pointed towards the zenith) at an altitude satisfying the far-field condition. The log-periodic is connected to a spectrum analyser configured to operate as a receiver i.e. span zero mode, sample detector, 1 MHz of both resolution and video bandwidths. The center frequency has been set to 175 MHz because it was expected to be a worst case [13]. At this frequency the dipole length is similar to the UAV frame one, therefore, directional resonance phenomena can occur [14].

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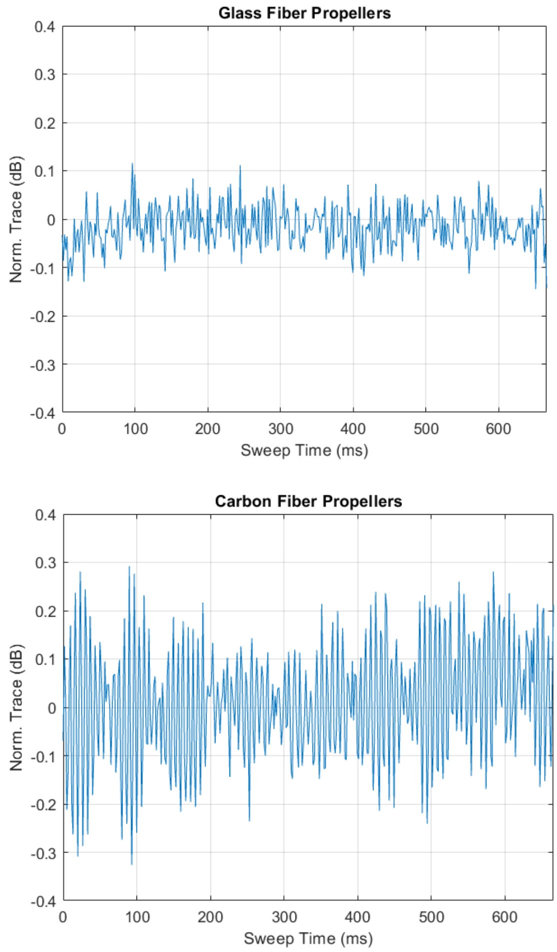

Figure 1. Received signal for Glass (top) and Carbon (bottom) Fiber propellers at 175 MHz.

Two hovering flights have been performed with custom-built glass-fiber propellers and commercial carbon-fiber ones, respectively. Two acquisitions of the received power (normalized) are shown in Fig. 1. The data with glass-fiber (top axes of Fig. 1) exhibits a variation which is consistent with trace noise of the instrument. On the contrary, a strong periodic behavior can be observed for the carbon-fiber ones (bottom of Fig. 1). The period of the signal is about 6 ms, this corresponds to a frequency of 167 Hz which is consistent to a propeller rotation speed of 10.000 RPM.

The peak-to-peak variation is in the order of 0.6 dB which is relevant for antenna measurement applications. In [13], the worst-case predicted ripple was in the order of +/- 2 dB. This can suggest that the simulation was too pessimistic, probably because the anisotropy of the carbon fiber propellers was not accounted for, their conductivity was not accurate or the predicted resonance effect were over estimated on the perfect conducting model of the UAV frame. However, it should be mentioned that the simulations in [13] were performed with the four propellers arranged in a symmetrical configuration to maximize their effect on the UAV radiation pattern. Such configurations are unlikely to happen in real experiments. Moreover, the sampling time for the data in Fig. 1 is about 1.66 ms (sweep time equal to 666 ms with 401 measurement points) which corresponds to a Nyquist frequency of 300 Hz i.e. 18.000 RPM. However, UAV motors can potentially go up to 40.000 RPM. Therefore, the discrepancy between simulation and measurements could be also due to under-sampling phenomena.

CONCLUSION

The effect of conductive propellers in the framework of VHF antenna measurements has been demonstrated with experimental results. The simulated data in [13] are more pessimistic than the measured ones. However, tests should be repeated with a higher sampling rate. The presented effect of conductive propellers does not totally impair the measurements (averaging could be exploited). However, it will be visible on digital back-ends with high data rate (such as the back-ends for low-frequency radioastronomy [6],[10]). Future studies are still required to determine the best trade-off between Carbon and Fiber Glass propellers.

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