Material Enhancement Strategies and CFD Analysis of an Aerodynamically Functionalized Antenna

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Unmanned aerial vehicles (UAVs) have become increasingly widespread in many modern military applications where mobile readily deployable communication systems are required. The typical applications include short range reconnaissance missions or in forming distributed networks of mobile wireless access points in remote areas. Conventional UAV designs simply mount the antenna structure to the aerodynamic surface which effectively separates the aerodynamic and antenna structures. A newer approach is to integrate the electromagnetic and aerodynamic structures into one monolithic superstructure that combines the capabilities of the constituent components.

This work expands on concepts for an aerodynamically functionalized wideband antenna with material enhancement strategies. The focus is on a detailed aerodynamic analysis and assessment of material enhancement for aerodynamic and electromagnetic co-design. The antenna under study is a stripline-fed radial dipole which is constructed using two circular sheets of Rohacell foam and three conductive layers. Aerodynamic functionalization is enabled and controlled using an electrically driven propeller and servo actuated flaps. The goal of the material enhancement strategies is to achieve a stronger substrate material with lower weight cost and higher dielectric loading. The chosen method for achieving this is to apply a thin coating of foam embedded with rutile and fiberglass nanoparticles to the entire substrate. The effective properties will be analyzed using various mixing rules including the Maxwell Garnett mixing rule and the rule of mixtures. The properties of interest include effective dielectric constant, composite density, tensile strength, Young's modulus, and compressive strength. The effects of this new material on the electromagnetic and aerodynamic performance will be examined. A computational fluid dynamic (CFD) analysis will be performed to examine the effects of the new material on the lift and drag characteristics of the plane body.