CONFORMAL ANTENNAS ON A JOINED-WING AIRCRAFT

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This paper presents the results of investigating antenna arrays that are structurally integrated into the wings of a joined-wing aircraft. The joined-wing aircraft has a large rear wing swept forward to join with the trailing edge of the front wing, thus creating a diamond shape when looking down on the aircraft from above. These antennas conform to the airfoil shape on the top and bottom surfaces of the wing. One antenna ensemble is placed in each wing of the diamond shape, thereby giving the aircraft a 360^o field of view. These antennas are operating in the Ultra High Frequency (UHF) range (400-450 MHz). This paper focuses on the antenna analysis performed in this joined-wing study; the structural integration of the antennas will also be discussed briefly.

A simplified finite element model (FEM) of a conformal, load-bearing antenna is created. This model consists of an electromagnetically transparent top layer, a honeycomb core section, a load-bearing graphite epoxy layer, another honeycomb core section, and a second graphite epoxy layer. This layered material is then used in the full FEM of the joined-wing aircraft, replacing the aluminum skin material in the four sections of the wing surface where the antenna arrays are located. This process allows the antennas to become part of the optimized aircraft design.

Once the antennas are placed in the aircraft model, the antenna performance is investigated. To manage the scope of this research, half-wavelength, horizontally polarized dipole antenna elements with constant and cosine current distributions are used instead of the actual conformal, load-bearing antennas mentioned earlier. These dipoles have the same polarization as the actual antenna elements, and an analytical model can be developed and analyzed. The analytical model is then verified using a commercial Method of Moments software package. Two different cases are considered: an undeformed wing configuration, where the wings are rigidly trimmed, and a deformed wing configuration, where aerodynamic loads are applied to trim and deflect the wings.

For the case considering the undeformed wing, coordinate locations of the center points of each element in a chordwise array are read into a MATLAB routine. This code calculates the inter-element spacing and performs a far field sum of the electric field of each dipole. An array factor is then applied to this chordwise summation to create a rectangular array of 5 chordwise by 40 spanwise elements, and then polar plots are generated of the magnitude of the E-field off the leading edge of the wing.

For the deformed wing case, analysis similar to that of the previous case is performed except that an array factor cannot be used due to the rotation of the elements with respect to one another out the span of the wing. A central difference formula is used to approximate the curvature of the deformed wing, thus allowing tangents to be found at each of the element locations. These tangents define the direction of the dipoles. A second summation of the electric field is then performed to account for this rotation, and the magnitude of the E-field is once again plotted in polar form. The results of this deformed case are then compared to those of the undeformed case to quantify the effect that wing deformation has on the antenna performance.