Advanced Computational Tools for the Multidisciplinary Design Optimization of Airborne Radomes

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A radome (**rad**ar d**ome**) is a structural, weatherproof enclosure that protects a radar system or antenna from its physical environment with minimal impact to the electrical performance of the antenna (L. Griffiths, Microwave Product Digest, May 2008). In aerospace applications, radomes often double as a nose-cone and thus have a significant impact on the aerodynamics of the aircraft. As such, an airborne radome must satisfy the structural and aerodynamic requirements in addition to being transparent to the RF signal. This paper demonstrates a complete design process starting from the antenna design, characterizing the radome wall material for RF transparency, to a full nose-cone radome analysis for electromagnetic, structural, aerodynamic, and bird strike performance using commercially available simulation tools (https://altairhyperworks.com/solvers-optimizaton).
A composite radome constructed from fiberglass plies and a foam core is designed to protect an X-band slotted waveguide array of a nose-cone weather radar. The transparency of the radome wall configuration is analyzed using the planar Green's function approach and a nose-cone radome is designed using this layered configuration. The full sized radome is then analyzed for boresight error and increase in sidelobe levels using the Ray-Launching Geometric Optics (RL-GO) method, which is computationally very efficient for electrically large models. The radome is then analyzed for structural damage from a "bird-strike" using an explicit structural Finite Element Method (FEM) solver. Multiple physics models (electromagnetics, structural and bird strike impact) are simulated for multiple composite layup design and are then approximated as a mathematical response surface via a self-selecting regression technique, Fit Automatically Selected by Training (F.A.S.T). These mathematical response surfaces are combined to perform a Multidisciplinary Design Optimization (MDO) to minimize weight and cost of the radome. The resulting design is 45% lighter than the original radome and satisfies the design requirements structurally and electromagnetically. A detailed MDO process for nose-cone composite radome to improve performance and reduce design time will be presented.

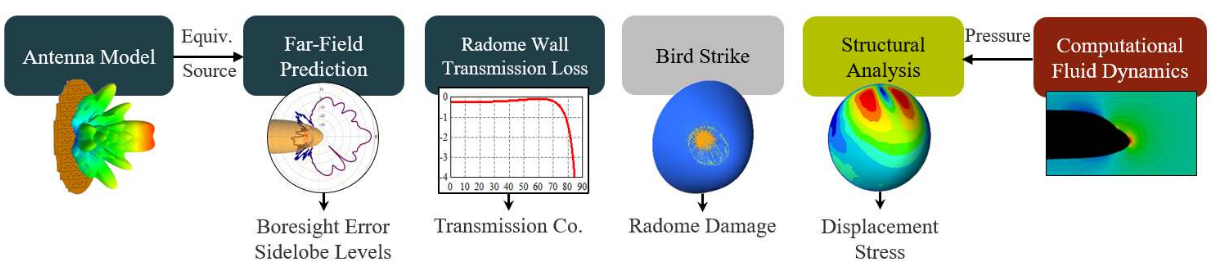

Figure 1. Multidisciplinary design optimization of a nose-cone radome.