

Rotorcraft Scattered Field Effects on Communications for NASA's Dragonfly Mission

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NASA's Dragonfly mission, led by Johns Hopkins University Applied Physics Laboratory, will send a rotorcraft lander to the surface of one of Saturn's icy moons, Titan, to investigate its atmosphere, geology, and potential chemical biosignatures (<https://dragonfly.jhuapl.edu>). The lander has three antennas utilized for telecommunications back to Earth consisting of a choke ring horn Low Gain Antenna (LGA), a 1-axis gimbaled sectoral horn array as a Medium Gain Antenna (MGA), and a 2-axis gimbaled radial line slot array (RLSA) as a High Gain Antenna (HGA). All three of the lander antennas are designed to communicate from Titan's surface back to Earth via the Deep Space Network's (DSN) X-band uplink and downlink frequencies. Due to the size, weight, and cost of manufacturing a physical model lander vehicle for measurements in an antenna range, computational electromagnetic simulations provide the best prediction of risk against the antenna's communication link requirements. This presentation aims to cover the ongoing analysis of the effects of the lander body on the far field performance of the lander antennas.

The top deck surface of the lander serves as the mounting location for all three above mentioned antennas and is considered as an electrically large PEC boundary (about 2.5m by 0.75m area) using asymptotic EM simulations. Also included in models are the nose of the lander which houses instruments and a large Radioisotope Thermoelectric Generator (RTG) in the tail. The entire lander is covered in foam outside the metal structure for thermal protection. Measurements show that the foam is close to free space in permittivity and is neglected in the simulation. The eight rotors that give lift to the lander with their respective mounting arms are also considered in the model. The scattered fields from these complex shaped surfaces can contribute significantly to the far field patterns of these antennas. Composite E-glass fins around the RTG help to stabilize the lander during flight, but also act as a scatterer to the antennas when the Earth is at a low elevation angle in the sky and the fins are in the antenna field of view. The fins are made of one-inch thick, low relative permittivity, e-glass honeycomb core with a higher permittivity e-glass reinforced epoxy face sheets. These fins are modeled using Fresnel reflection and transmission coefficients extracted from periodic simulations of the layup. Simulations are verified using scattering parameter measurements of fin samples. Antenna requirement verification is performed by first measuring the volumetric radiation of the antennas in an antenna range. The measured radiation pattern is then placed in the lander scattered model and the results are compared against requirements.

To help bound uncertainties in the approximate scattering model of the entire lander, a perturbation analysis is performed. The total radiated fields are separated into incident field from the radiating antenna and the scattered field from the lander. A phase variation is added to each scattered field point and combined back with the incident field. The minimum gain over the field of view with the worst-case phase perturbation is used to bound the results from the model. Simulation models, results, and impact on the overall Dragonfly telecom system requirements will be presented at the conference.