Development of an Inflatable Antenna Prototype for Interplanetary CubeSats

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CubeSat and small spacecraft are a promising, low-cost approach to interplanetary exploration. Rapid advances in electronics have made miniaturization of satellites possible but major challenges remain in long distance communication and tracking. The challenges of long distance communication needs to be addressed to make miniature interplanetary spacecraft possible. One promising solution is using an inflatable antenna that can be deployed at low cost, mass and can be stowed in a CubeSat platform (Babuscia et al., 2012). Inflatable systems were used in space right from Project ECHO in 1960s and continue to the present, with the Mars Path finder mission, Mars Exploration Rover, and Hypersonic Inflatable Aerodynamic Decelerator (HIAD). These systems use nitrogen gas generators, that are solid state, enable rapid deployment in the order of few seconds, but at high pressure and temperature. However the requirements and challenges for inflatables antennas are unique. Inflatable antennas need to achieve a well-defined parabolic shape, be stowed in much smaller volumes and survive for long periods, under varying temperature and exposure to prolonged micrometeorite impacts. Use of sublimating powders (Babuscia et al., 2013) that can change from solid state to gaseous state without going through the liquid state or undergo combustion offers a promising solution to deploying an inflatable antenna. They offer the same advantages of these nitrogen generators but the reaction can be better controlled at much lower pressures and temperature. These compounds could in theory keep a system inflated for long durations even with micrometeorite impacts. Methods are being explored to use temperature/UV cured rigidizing membranes that can turn the inflatable membrane into hard shell after inflation. Other options to use self-healing materials that can plug holes from micrometeorite damage are also being explored. Our efforts focus on physically realizing a laboratory prototype, where a few gram of the sublimating powder would inflate a $0.165m^3$ antenna in space within 10s of seconds. An extended 3-6 hour temperature/UV curing process would result in a hardened shell. Experiments are being designed to identify suitable sublimating powders ranging from butyramide to benzoic acid that can accomplish this goal. Similarly, curable membranes are also being characterized with a focus on better understanding the practical challenges in realizing this inflatable system.

References

Babuscia, A.; Corbin, B.; Knapp, M.; Jensen-Clem, R.; Van de Loo, M.; Seager, S., "Inflatable antenna for cubesats: Motivation for development and antenna design," Acta Astronautica, Vol. 91, Oct. 2013, pp. 322-332