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CUBESAT BASED STUDY OF METEOROIDS AND THEIR IMPACT ON SPACECRAFT

Abstract

The space environment has long been known to cause deleterious effects on orbiting spacecraft. Meteoroids, which are particles ranging in size from 62 microns to 0.3 m that travel with speeds between 11 and 72 km/s, can cause both mechanical and electrical damage upon impacting a spacecraft. When a meteoroid impacts a satellite in space, both the meteoroid as well as a fraction of the target is vaporized and ionized, forming a dense plasma cloud [Close et al., 2010]. The expanding plasma cloud has been experimentally observed to emit an electromagnetic pulse over a broad frequency range, but with particle sizes that are orders of magnitude smaller than are present on-orbit [Close et al., 2013]. This RF emission is a plasma physics phenomenon that is not well characterized yet can have a detrimental effect on the health of the spacecraft. Ground based hypervelocity impact test facilities cannot fully reproduce the satellite conditions, background atmospheric and ionospheric conditions, and most importantly the mass-velocity combination of the meteoroid population. We hence propose MORGANA (Meteoroid On-orbit Research in Geopsace for Advancing Near-earth Awareness), a CubeSat mission to study the meteoroid population particularly in the low mass range (1 g - 1 ng) and to analyze the electrical effects of hypervelocity impacts from meteoroids and orbital debris in space.

We present a statistical analysis of electrical anomalies observed on spacecraft and their correlation with meteoroid flux as motivation for the proposed mission. We then describe the configuration of the CubeSat and the design and development of various sensors that form the science payload for the proposed mission. The 3U CubeSat will comprise optical, plasma and RF sensors to measure the mass, velocity and composition of the impacting particle. These sensors will also measure the properties of the plasma generated from the impact and the associated RF emission. Over the proposed 1 year duration of the experiment, we expect to measure the signal from more than 1000 sporadic meteoroids, in addition to the hits from stream meteoroids and orbital debris.

By understanding the physics behind the fundamental processes governing the hypervelocity impact phenomenon, one can understand the manner in which the plasma and RF emission generated by the impact can couple to electrical systems on satellites. This will eventually lead to the development of strategies and design guidelines for mitigation of electrical threats associated with hypervelocity impacts on spacecraft.