Orbital Dust Impact Experiment (ODIE) – a passive dust collector designed to address the dust flux data gap

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ABSTRACT

Monitoring dust particle populations in the vicinity of the Earth is vital to understand and mitigate against the hazards they pose to spacecraft, driving design of effective spacecraft shielding and optimum operational protocols. The flux of particles > few mm orbiting Earth has been investigated remotely using radar and optical telescopes [e.g. 1, 2], revealing that objects in this size range have increased in abundance rapidly since the dawn of the space age. Despite their diminutive size, objects smaller than the radar detection limit are still capable of significant damage to spacecraft. Such particles are expected to be far more numerous, with estimates in the trillions for the total number of particles >100 µm in size [3]. The degree of damage caused by these dust particles is heavily dependent on characteristics such as their relative velocity, impact angle, shape and composition, which vary as a function of origin (e.g. orbital debris originating from human activities in space have relative velocities that are typically slower than for natural micrometeoroids originating from comets and asteroids). It is therefore important to be able to distinguish between these two dust populations, to fully understand the threat posed by these particles.

Previous flux measurements for smaller dust populations have largely been based on passive collection surfaces retrieved from dedicated missions, such as the long duration exposure facility (LDEF) [e.g. 4, 5], and opportunistic analyses of returned surfaces, such as solar cells and radiator panel from the Hubble Space Telescope [e.g. 6-9]. For many impact features it has been very time consuming, difficult or even impossible to give unambiguous attribution of particle origin due to the nature of the collection surface. Consequently, we lack significant and important information for both populations, but especially orbital debris, where there is currently a gap in our knowledge of the particle population between approximately 200 µm and 2 mm.

The Orbital Dust Impact Experiment (ODIE) is a dedicated, passive dust collector that we have designed to verify and understand the flux and origins of these smaller particles. By exposing in low Earth orbit for a period of at least 1 year and returning to Earth for analysis, it will enable the unambiguous identification of both micrometeoroid and orbital debris particles over size ranges from 200 µm to 2 mm. This paper will introduce our design and potential deployment options, as well as details of the analyses that would need to be performed upon its return.

REFERENCES: [1] Goldstein et al., 1998 Radar observations of space debris. Planetary and Space Science, 46:1007-1013. [2] Stokely et al., 2006. Debris flux comparisons from the Goldstone radar, Haystack radar, and Hax radar prior, during, and after the last solar maximum. In Proceedings of the 36th Scientific Assembly of COSPAR, Beijing; China. [3] Bauer et al., 2014. Development of in-situ space debris detector. Advances in Space Research 54:1858 -1869. [4] Love and Brownlee, 1993. A direct measurement of the terrestrial mass accretion rate of cosmic dust. Science, 262:550-553. [5] McDonnell et al., 1997. Microparticle populations at LEO altitudes: recent spacecraft measurements. Icarus 127:55-64. [6] Drolshagen, 1995 [7] Moussi et al., 2005. Hypervelocity impacts on HST solar arrays and the debris population. Advances in Space Research, 35:1243-1253. [8] Kearsley et al., 2005. Impacts on Hubble Space Telescope solar arrays: discrimination between natural and man-made particles. Advances in Space Research, 35, 1254-1262. [9] Kearsley et al., 2017. Hypervelocity impact in low earth orbit: finding subtle impactor signatures on the Hubble Space Telescope. Procedia Engineering, 204:492-499.