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NANO-SATELLITE SECONDARY SPACECRAFT ON DEEP SPACE MISSIONS

Abstract

Nano-satellite technology has opened Earth orbit to extremely low-cost science missions through a common interface that provides greater launch accessibility. They have also been used on interplanetary missions, including Minerva (Hayabusa), Huygens (Cassini), and DCAM (Ikaros), but these missions have used one-off components and architectures so that the return on investment is limited. The recent widespread availability of nano-satellite parts and expertise (made common through the CubeSat movement) has now made low-cost secondary LEO missions achievable. A natural question is the role that nano-satellites could play to increase the science return of deep space missions. We do not consider single instrument nano-satellites as likely to complete entire Discovery-class missions alone, but believe that nano-satellites can augment larger missions to significantly increase science return. The key advantages offered by these mini-spacecraft over previous planetary probes is the common availability of advanced subsystems that open the door to a large variety of science experiments, including new guidance, navigation and control capabilities. Science applications may include low-altitude, high-risk reconnaissance mapping (e.g., to select landing or sampling sites); measurement of high-order field harmonics (gravity, magnetism; and probing of the fields, particles, and dust environment close to the surface (e.g., jets at comets and Enceladus). These assets enable the achievement of science in potentially high-risk environments, but at a relatively low cost. Nano-satellites also appear very relevant to the program that aims to prepare for human exploration through the reconnaissance of the surface environment of Near-Earth Objects and could be used, for example, for high-resolution mapping of the surface composition and morphology over a broad range of scales, for characterization of electric charging and levitated dust, and for searching for in-situ resources (especially volatiles).

However, significant challenges and questions remain as obstacles to the use of nano-satellites in deep space missions. Questions include mitigation of risk to the primary spacecraft, nano-satellite deployment and disposal, communications / power strategies, umbilical or coupling needs, assessment and modeling of the impact of these elements on mission design (cost, risk, mission design), finding relevant scientific missions for secondary satellites and identifying the correct form-factor for reuse. In this paper we discuss some of the possibilities and challenges for the use of nano-satellites on interplanetary missions and provide some thoughts on a development roadmap.

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