Paper ID: 31272
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SPACE EXPLORATION SYMPOSIUM (A3)
Small Bodies Missions and Technologies (4)

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DEPLOYMENT AND DYNAMICS OF SURFACE PACKAGES FOR SMALL BODY EXPLORATION

Abstract

The small body dynamical environment is well suited for the deployment of surface packages for exploration and scientific measurement purposes. This is mainly due to their meager gravity fields, which allow the delivery of complex instruments to the surface with impact speeds that are at most a meter per second — equivalent to dropping an object from less than a 5 cm height on Earth. Despite this seeming advantage, the delivery and mobility of such packages on the surface of a small body remains a challenging endeavor, and to date the delivery of surface packages to small bodies has had a mixed success rate. This paper will describe the results from a program of study devoted to this problem being carried out in the Celestial and Spaceflight Mechanics Lab at the University of Colorado. Work in this area has included the theoretical study of delivery trajectories, motion on the surface of a small body, and a program of laboratory experiments to determine relevant physical properties of interaction with an analog small body surface.

Challenges in this area arise from several different aspects of the problem. First is the design of delivery trajectories to the small body surface, accounting for the possible interactions of the probe with a rotating, non-spherical small body gravity field. The analysis includes delivery of packages to single bodies and to binary asteroids, with a focus on strategies that can guarantee the landing of a probe on the small body surface. Then, after first contact with the surface, it is paramount to understand the dynamics of a probe rebounding, rolling and in ballistic flight over the surface of a small body, accounting for the rigid body motion of a probe as it interacts with the possibly gravelly or rigid surface. The appropriate design of the delivery trajectory and of the probe must be optimized conjointly to ensure minimal surface travel of the deployed device. Methods for estimation of probe location and motion are also a fundamental aspect of the problem. Finally, once on the surface it is desirable for the probe to have mobility, which leads to the study of methods to mobilize and control the surface motion of a probe. Studies of all of these issues both theoretically and experimentally will be presented, along with proposed applications to achieve scientific goals on the surfaces of small bodies.