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ACCURATE PENETRATOR FOR THE IN-SITU ASTROBIOLOGICAL EXPLORATION OF EUROPA

Abstract

This paper aims to first demonstrate the need for planetary penetrators with a higher landing accuracy than that offered by current penetrator designs, in particular for the astrobiological exploration of Jupiter's moon Europa. The paper will then investigate modifications to the penetrator landing operations and propulsion system. Finally, we will propose a Guidance, Navigation, Control (GNC) system that will be able to achieve the increased landing accuracy to reliably target astrobiologically interesting areas on Europa.

There are targets for penetrators in the solar system where the target location to be sampled lies in a concentrated area, and a certain shallow depth under the surface. Particularly in the case of Europa, there are various interesting geological characteristics that potentially represent the transport of material from the ocean to the surface. These interesting features range in size, from 10 km to under 1 km. Due to severe chemical degradation from the radiation environment, samples acquired from the very surface will not compositionally represent the ocean. Planetary penetrators would thus be ideal for subsurface sampling of these interesting areas. Penetrators proposed up to now however do not have adequate landing accuracy in order to reach the above mentioned interesting areas. In particular, the CLIPPER Europa ESA Penetrator (CLEP) concept prepared by ESA CDF after mutual interest was expressed for a potential contribution of ESA to the NASA Europa Multiple-Flyby Mission (EFSM, formerly known as Europa CLIPPER) would have a landing accuracy of only 300 km.

In this paper we investigate the accuracy requirements for a penetrator design able to reach these areas. Using the CLIPPER Europa ESA Penetrator (CLEP) concept as reference we investigate ways to increase penetrator accuracy: We first look into the benefits to accuracy we can obtain by modifying the CLEP system and operations (propulsion, stabilization method during manoeuvres, navigation sensors, etc). Inspired by recent developments in pinpoint planetary soft landing, we then investigate appropriate Guidance & Control laws as well as Navigation concepts. We also assess the potential of a Hazard Detection and Avoidance function. According to the results of the above studies we implement the selected GN&C concepts and simulate penetrator operations to verify the fulfillment of accuracy and reliability requirements. We finally propose a modified CLEP penetrator design that optimizes landing accuracy and reliability.