Exploration of Near-Earth Asteroids (4)
Exploration of Near-Earth Asteroids (1) (1)

Author: Ms. Suditi Chand
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institute of Space Systems, Germany, suditi.chand@dlr.de

Mr. Jan Thimo Grundmann
DLR (German Aerospace Center), Germany, jan.grundmann@dlr.de
Dr. Caroline Lange
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany, caroline.lange@dlr.de
Mr. Eugen Ksenik
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany, eugen.ksenik@dlr.de
Dr. Tra-Mi Ho
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany, Tra-Mi.Ho@dlr.de

EXPLORING NEAR-EARTH ASTEROIDS BY 'SOUSVEILLANCE' WITH THE NEXT GENERATION OF MASCOT NANO-LANDERS

Abstract

Asteroid exploration began with flybys by planetary missions (Galileo observing Gaspra in 1991), followed by soft landings (NEAR-Shoemaker on Eros in 1996). The turn of the millennium saw the first sample return mission, Hayabusa to the Near-Earth asteroid, Itokawa, in 2003, marking the onset of dedicated orbiter or orbiter-rover missions to NEAs. Then in October, 2018 the first European nano-lander, MASCOT, arrived on another NEA, Ryugu. MASCOT ('Mobile Asteroid Surface Scout') is a 18 U, 10 kg nano-lander that flew aboard the Japanese spacecraft, Hayabusa2, and successfully operated for 17 hours. It occupied the compartment for a single instrument on Hayabusa2 yet helped in in-situ exploration via four payload instruments on a scale unobservable by the latter. Until now the orbiters have deployed their rovers from a small height of 40-100 m above the surface. The next logical step would be landers that can be deployed from larger distances to de-risk the main mission. This would give rise to many possibilities such as a multiple NEA rendezvous spacecraft that deploys a nano-lander to each of its targets, thus ensuring a high scientific return. Such nano-landers can also help explore unstable micro-gravity environments or active asteroids where a touchdown by the orbiter is too precarious. They also enable orbiters with new modes of asteroid studies such as tomography of the interior by bistatic low-frequency radar.

This paper offers a MASCOT-derivative with enhanced guidance, navigation, control and propulsion capabilities for a remote deployment to asteroids. A preliminary mission study, conducted for a binary asteroid system, Didymos, helped in its design and analysis to demonstrate its high success rate. Current state-of-the-art commercial-off-the-shelf (COTS) equipment, that have flown to space, has been selected for the GNC and propulsion systems to reduce risks as well as minimise the follow-on system requirements. The unique advantages of MASCOT are its modular and customisable design and independent functioning. Consequently, its highly integrable architecture has been used with an adaptable, hybrid small spacecraft topology in its successor's design to ensure a high payload-to-mass ratio (above 30%). This implies that there is no clear demarcation between the spacecraft subsystems and the same instrument has been used as both a GNC sensor as well as a payload. Therefore, the mass and volume of the upgraded lander remain very similar to its predecessor, thereby imposing no additional requirements on its carrier spacecraft and yet providing a significant advantage to future NEA missions.