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# NEXT GENERATION OF MASCOT NANO-LANDERS FOR THE MULTIPLE NEO RENDEZVOUS MISSION: A SELF- TRANSFERRING LANDER FOR THE 'SOUSVEILLANCE' OF NEOS FOR SPACE EXPLORATION, PLANETARY DEFENCE OR RESOURCE UTILISATION

**Abstract**

This is an exciting time for Near-Earth Object (NEO) Exploration as we get closer to finding answers to many important questions on how the Solar System was formed, how life arrived on Earth and how the vastly unknown Small Solar System Bodies (SSSBs) behave. In the next three years we will see the return of asteroid samples by the Hayabusa2 and the Osiris-Rex missions and the launch of the NEA-Scout, Psyche, Lucy, DART and HERA missions. Yet the NEA classifications are not exhaustive and each new asteroid provides its unique challenges. Thus, an on-site study via nano- landers has multi-fold advantages as they can provide a detailed scientific analysis and can lay the foundation for In-situ Resource Utilisation (ISRU) missions by the selection and geo-spatial mapping of the target site and by the testing of the relevant technology demonstration. Until now nano- landers have been deployed from an altitude of 40-100 meters. This paper aims to exploit the high vantage point of small spacecraft technology to study micro-gravity bodies by proposing a self- transferring, highly integrated nano-lander that can be deployed at ten to hundred-fold higher altitudes than before. It is a successor of MASCOT – the DLR-CNES nano-lander aboard Hayabusa2 that successfully operated on Ryugu in 2018.

An exciting prospect for future MASCOTs is a Multiple-NEO Rendezvous mission by a Solar- Sailing spacecraft. A previous GOSSAMER based study proves the feasibility of a ten-year mission that could deploy five MASCOTs to five asteroids in hundred days. This paper goes one step further and equips the nano-landers with minimalistic self-transfer GNC and Propulsion systems thereby enhancing the multiple target mission returns while conforming to the nano-spacecraft's system design constraints. Additionally, a software-in-the-loop mission design and a Monte Carlo sensitivity analysis have been done to prove its capability to land on the moon of binary asteroid systems that are critical target bodies for the development of planetary defence technology. The proposed MASCOT-variant can have a customised payload for individual target bodies. This system can hence pave way to a new generation of intelligent yet simple landers that can help in all the fields of NEO studies such as reconnaissance missions preceding human exploration or asteroid mining missions. Looking at how many extra miles a self-transfer MASCOT could scout ahead, the mission parameters are outlined for an added in-situ exploration capability which is simultaneously relaxing the requirements on and de-risking the operations of its main spacecraft.