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SCIENTIFICALLY STRENGTHENING AN ASTEROID MISSION WITH SMALL PROBES ON RAMSES AS USE CASE

Abstract

The close flyby of asteroid (99942) Apophis on 13 April 2029, when it will pass Earth within 38.000 km, presents a unique scientific and strategic opportunity for asteroid research and planetary defense in particular. This event has prompted NASA to revise its OSIRIS-APEX (OSIRIS-REx Extended Mission to Asteroid Apophis) mission to rendezvous Apophis after its closest approach, while ESA is currently studying the RAMSES mission for a rendezvous before Earth's closest approach. One of RAMSES main scientific objectives is to observe the tidal and magnetospheric effects on the Near-Earth Asteroid (NEA) during this close flyby, including possible surface changes. An in-situ science package/lander with a suite of instruments would provide important ground truth and thus improve our understanding of Apophis, especially in determining, for example, its internal structure, magnetic properties, surface features in the micrometer range and volatiles. In addition, returning asteroidal samples to Earth by taking advantage of the short duration of the sample return leg, which requires only a tiny extra boost, is an extremely attractive scenario. We present a lander concept, MASCOT3, based on the heritage of MASCOT flown on the Hayabusa2 mission and MASCOT2, studied for the AIM mission concept as well as a sampler concept, the APOphiS Surface saMpler (APOSSUM), which has undergone a concurrent engineering (CE) feasibility study. The RAMSES mission schedule foresees the rendezvous with the asteroid Apophis about 2 months before its closest approach with Earth in 2029. During this time, early March, the lander or sampling probe will be detached and self-delivered to the asteroid. After a controlled landing, surface operations such as in-situ observations or regolith sampling can be performed. The sampler, after completing its operation, will ascend from the surface of the asteroid and injected on a trajectory to re-enter Earth with a delta-v requirement of only a few tens of meters per second. This is orders of magnitude less than the speed requirement of sample-return missions to other targets, thanks to the very close Earth flyby of Apophis on 13 April 2029. The reentry capsule will return to Earth as the asteroid passes at a safe distance. The reentry capsule's entry velocity is about 12.6 km/s, compared to the asteroid's 7.4 km/s due to Earth's gravitational field. By entering the atmosphere in phase with the Earth's rotation, the entry velocity can be slightly reduced.