

RAMSES – ESA’S STUDY FOR A SMALL MISSION TO APOPHIS. P. Martino¹, P. Michel², M. Kueppers³, and I. Carnelli⁴, ¹ESA (ESTEC) – European Space Agency, Keplerlaan 1, 2201 AZ, Noordwijk (The Netherlands), paolo.martino@esa.int, ²Université Côte d’Azur, Observatoire de la Côte d’Azur, CNRS, Laboratoire Lagrange, Nice, (France), michelp@oca.eu, ³ESA (ESAC) – European Space Agency, Villafranca del Castillo, Madrid (Spain), michael.kueppers@esa.int, ⁴ESA (ESTEC) – European Space Agency, Keplerlaan 1, 2201 AZ, Noordwijk (The Netherlands), ian.carnelli@esa.int

The objective: 99942 Apophis is a potentially hazardous asteroid with a diameter of about 370 metres that on April 13, 2029 will approach Earth’s surface at distance that is closer than orbiting geosynchronous satellites. Significant tidal torques will be exerted on the body of Apophis, with consequences that might include alterations of its rotation state, internal structural alterations, measurable seismic waves and real-time surface disturbances.

This very close Earth flyby therefore presents an unprecedented planetary defense and science opportunity. A mission to Apophis could allow transforming our understanding of the internal structure of potentially dangerous asteroids.

The mission: several parallel studies for small missions to Apophis have been launched by ESA.

The first is “Satis”, a study within the ESA S2P Programme based on a 12U CubeSat; in parallel a small-satellite study (“RAMSES”, Rapid Apophis Mission for SEcurity and Safety) is exploring two implementation approaches: an adaptation of the Hera spacecraft design, and an open concept small-satellite mission.

To rendezvous with the asteroid before April 2029, the RAMSES spacecraft needs to launch in April 2027 followed by an Earth flyby in April 2028 or launch for a direct 11-months transfer in April 2028 if 1530m/s ΔV can be accommodated in the spacecraft.

RAMSES will rendezvous with Apophis two months before its close encounter with Earth and will perform a detailed characterization campaign of the Asteroid (including global imaging at 10cm resolution). This will be performed both before (“PREP- PRE-encounter Phase”) and after (“POSP – POST-encounter Phase”) the close encounter with Earth on April 13th, 2029.

In addition, during the close encounter (“CEP-Close Encounter Phase”), characterization of Apophis with high temporal resolution will be performed to observe in detail the abovementioned physical and dynamical alterations of the asteroid.

RAMSES will embark as a minimum two visible cameras (possibly based on Hera’s AFC) and two 6U-XL CubeSats which will be released in proximity of Apophis before the close encounter and will operate

independently, using RAMSES as relay satellite. Additional payloads will be accommodated either on RAMSES or on the CubeSats on the basis of available on-board resources. These might include e.g. a Thermal Infrared Imager, a Laser Altimeter, a Low Frequency Radar, Dust Detectors, Seismometers, Penetrators, Microscopes, Radiometers, Laser Retro Reflectors and others.

The RAMSES studies aim at defining a mission architecture and spacecraft design based on maximum reuse of existing equipment and proven system/subsystem architectures (“heritage building blocks”).

The studies will be instrumental to make an informed decision at ESA’s Council at Ministerial Level in 2025 as part of the S2P/planetary defense roadmap, both on the most effective technical solution as well as implementation approach to reduce mission costs and allow fast implementation.