STATUS OF ESA's "RAPID APOPHIS MISSION FOR SECURITY AND SAFETY" (RAMSES) CONCEPT

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Introduction: The Apophis close flyby of earth provides a unique opportunity to investigate the properties of a Near-Earth Asteroid from its reaction to tidal forces. The 2029 Earth encounter is predicted to have the following effects [1]:

(a) The orbit will be significantly changed. The semi-major axis will change from 0.92 au to 1.10 au.

(b) Apophis is in a state of Non-Principle Axis (tumbling) rotation, with a retrograde rotation period of 264 hours and a precession period of 27.4 hours. Simulations assuming a simple elongated ellipsoid show that the post-flyby rotation may be 0.5 to 2.0 times the pre-flyby value. The rotation pole is likely to shift by ~10 degrees.

(c) The approach is too distant to create tidal deformation of the asteroid if it is a single body. However stress changes of ~0.5 Pa are likely to occur. Assuming an object with low cohesiveness, this will likely result in small scale shifts in regolith material on the surface of the asteroid, and internally assuming a rubble-pile structure. Radar images indicate a bilobed shape. If Apophis is a contact binary, an adjustment of the relative positions of the components could occur.

ESA is studying mission concepts to rendezvous with Apophis before closest approach to Earth, to detect and measure possible changes to the asteroid during the encounter.

Mission Goals: A rendezvous mission arriving at Apophis before closest encounter with earth will allow to detect any surface changes or modifications of the interior structure imposed by the tidal forces of earth. Such a mission would be complementary to OSIRIS-APEX. While OSIRIS-APEX will likely provide the highest resolution data of Apophis after the flyby, such a mission would deliver the state before the flyby and look for changes during the encounter. Therefore we are studying concepts for an Apophis encounter before its flyby of earth.

Mission Concepts: Three concepts are currently being studied in phase A:

Satis: Satis is a self-standing 12U Cubesat that will rendezvous Apophis and is the topic of a separate presentation in this meeting.

Rapid Apophis Mission for Security and Safety (RAMSES): RAMSES is exploring two implementation approaches in parallel: 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 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.

References:

[1] Dotson, J. L., et al. 2022. Apophis Specific Action Team Report, draft, 6 November 2022.

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