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ASTEROID PROBE EXPERIMENT: MISSION TO APOPHIS

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ABSTRACT

The objective of the Asteroid Probe Experiment (APEX) mission is to characterize the internal structure, rotational dynamics and surface morphology of the ~400 m asteroid (99942) Apophis and to determine the extent to which those characteristics change as a result of tidal forces during its close encounter with the Earth in 2029. Apophis' Earth encounter provides a unique opportunity for a detailed study of a Near-Earth Asteroid (NEA) to understand its structure and implications as a planetary hazard.

Apophis makes a close approach to Earth on April 13, 2029 passing within geosynchronous orbit at 36700 ± 9000 km (3σ). That distance is such that tidal forces would not be expected to disaggregate a body, but close enough to change the rotational state and produce solid-body deformation.

Two spacecraft concepts and mission scenarios were considered, a small scale PSDS small sat mission and a larger Discovery class mission. Four Level 1 Science Objectives are defined: 1) Determine the rotational state and bulk properties; 2) Determine the interior structure; 3) Determine the geology and geologic history; and 4) Determine the tidal effects on surface morphology, interior structure, and rotation. Both concepts use a launch date of 11/11/2025 with an arrival at Apophis of 3/22/2028. The encounter allows for an investigation of Apophis with a small spacecraft as observations would be made at 1 AU and near the Earth, minimizing spacecraft requirements.

The PSDS-class mission spacecraft has a total dry mass of 164 kg (including margin) and 101 kg of propellant and spacecraft measures ~0.7 x 0.7 x 0.8 m. Propulsion is provided by a Busek Hall thruster (BHT-600) with Xenon as the fuel. Four 3.6 N cold gas thrusters provide for high thrust maneuvers. Communications are conducted with the APL X-Band Frontier Radio with a radial line slot array antenna. 700 W of power is produced at 1 AU from seven solar panels that are

unfolded after launch. The payload consists of two instruments, a narrow-angle broadband camera and a deployable seismometer.

The Discovery-class mission has the same science goals, but employs a more diverse payload and a larger spacecraft. This second design has a dry mass of 850 kg and 513 kg of propellant. Power is provided by body mounted solar arrays. The payload includes narrow and wide angle cameras, thermal imager, laser altimeter, and multiple deployable seismometers and explosive packages. Propulsion is provided by a briprop monomethylhydrazine and nitrogen tetroxide system. The main engine provides 470 N and the monoprop thrusters 4 N.

Upon arrival at Apophis, the body will be mapped to understand the geology, shape, and rotational parameters. The seismometers will be emplaced around the body. A passive component of the seismology will involve monitoring thermal stress noise and impacts; the active component will involve deployment of explosive sources on the surface to probe the interior. After encounter with the Earth, the Apophis will be reimaged to understand changes in surface morphology, topography and rotational parameters.

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