

DROID: A MISSION CONCEPT TO ACCOMPANY AND CHARACTERIZE APOPHIS THROUGH ITS 2029 EARTH CLOSEST APPROACH

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ABSTRACT

The close approach of asteroid (99942) Apophis on April 13, 2029 presents a unique opportunity to achieve breakthrough science and strengthen planetary defense goals. As discussed in [1], low-frequency (VHF) radar observations can probe the interior structure of small bodies. Radar measurements can determine the distribution of monolithic objects and voids within the body at 10's of meter scale, which are critical for potential deflection and disruption attempts. This is best accomplished by multi-static, low frequency radar [2].

A mission concept to exploit the Apophis opportunity has been developed in a collaboration between NASA/JPL and CNES. The Distributed Radar Observations of Interior Distributions (DROID) mission would rendezvous with Apophis seven months prior to Earth closest approach (ECA) and escort it through the encounter. A possible asteroid flyby on the way would delay arrival but still provide ample time for pre-ECA characterization. DROID's measurements would determine the interior structure and properties, the body's shape, morphology and rotation and observe any resolvable changes. DROID provides unique high fidelity in situ data that complements and enhances Earth-based optical and radar observations of Apophis, as well as data collected by OSIRIS-APEX which is due to rendezvous with Apophis 8 days after ECA.

DROID's architecture calls for a dedicated launch of three spacecraft: an ESPA Grande-class Mothership and two 6U CubeSats. The Mothership carries the CubeSats to Apophis, achieves the rendezvous cruise trajectory, performs high resolution imaging with a narrow-angle camera, and acts as a Direct-to-Earth (DTE) node for the constellation. Once Apophis's physical characteristics (shape, spin, gravity field) are sufficiently characterized, the Mothership deploys both CubeSats, which each carry a wide-angle camera and low-frequency radar (60 MHz, based on JuRa [3]) and insert themselves into coordinated low orbits to perform monostatic and bistatic radar observations. Inter-Spacecraft Link (ISL) S-band transponders on all three spacecraft perform data transfer between CubeSats and Mothership, and synchronize the CubeSat clocks for accurate bistatic radar measurement. ISLs are also used with the Mothership's DTE link to map the gravity field.

The DROID mission has two primary goals: to understand the interior structure of a rubble pile asteroid and implications for its formation, evolution and response to a deflection attempt, and to understand how close planetary encounters affect asteroids. DROID will provide critical pre-ECA imagery of Apophis necessary for change detection.

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References: [1] Herique, A. et al (DROID Radar, this meeting). [2] Haynes, M. et al (2022) LPSC #1295. [3] Herique, A. et al (JuRa, this meeting).