THE DROID MISSION CONCEPT TO CHARACTERIZE APOPHIS THROUGH ITS 2029 EARTH CLOSEST APPROACH. C. A. Raymond[1], R. B. Amini[1], P. C. Adell[1], R. Anderson[1], S. Bandyopadhyay[1], S. Bhaskaran[1], P. Bousquet[2], B. J. R. Davidsson[1], F. Esteve[2], L. Fesq[1], M. S. Haynes[1], A. Herique[3], R. Karimi[1], J.T. Keane[1], N. Mastrodemos[1], P. Michel[4], R. Miller[1], C. Virmontois[2]. [1]Jet Propulsion Laboratory/California Institute of Technology (4800 Oak Grove Dr. M/S 321-625, Pasadena, CA 91109. carol.a.raymond@jpl.nasa.gov), [2]Centre National D'Etudes Spatiales, [3]Univ. Grenoble Alpes, CNRS, CNES, IPAG, Grenoble, France, [4]Univ. Côte d'Azur, Obs. Côte d'Azur, CNRS, Nice, France.

Introduction: 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, to inform the design of potential deflection and disruption attempts. As will be discussed, this is best accomplished by multi-static, low frequency radar [2].

DROID Concept: 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. The 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.

A possible flyby of asteroid 2004 GU9 on the way would demonstrate rapid flyby reconnaissance. While this flyby would delay arrival there would still be 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 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 characterized sufficiently the Mothership deploys both CubeSats, which each

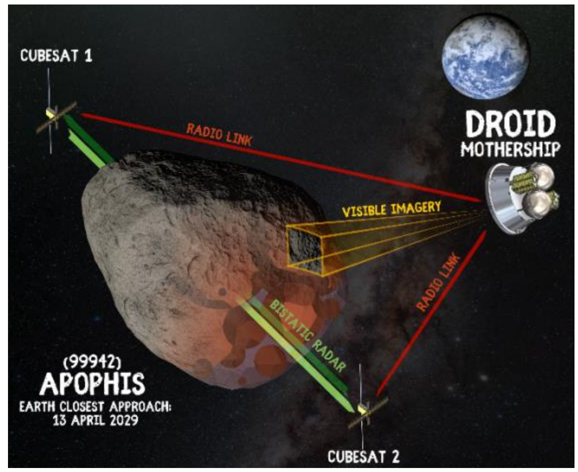

Figure 1. The DROID Mission Concept.

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.

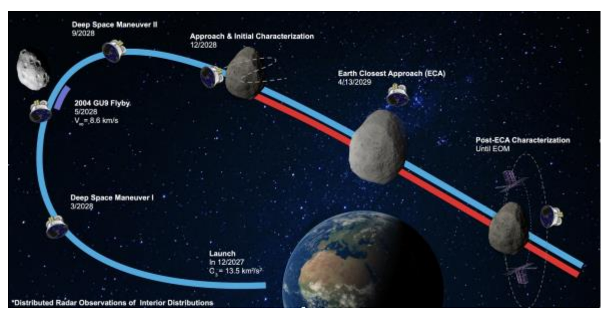

Figure 2. DROID Mission Architecture.

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References: [1] Herique, A. et al (2022) EPSC2022-474. [2] Haynes, M. et al (2022) LPSC #1295. [3] Herique, A. et al (2022) EPSC2022-487.