

APOPHIS PATHFINDER: A SMALLSAT MISSION TO INVESTIGATE THE POTENTIALLY HAZARDOUS NEAR EARTH ASTEROID (99942) APOPHIS. J.F. Bell III¹ and L. Papsidero²,
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Introduction: The MILO Space Science Institute [1] (<http://miloinstitute.org>), a non-profit deep space mission collaboration between Arizona State University, Lockheed Martin, and GEOshare, is planning a mission called Apophis Pathfinder. The dedicated mission would focus specifically on performing the first-ever close flyby of the ≈ 370 meter diameter, potentially hazardous near Earth asteroid (99942) Apophis, launching well-before the 2029 flyby, and reaching the asteroid within approximately a year. Apophis occasionally comes extremely close to Earth. For example, on April 13, 2029, it will pass Earth's center of mass at a distance of approximately 31,000 km – roughly five Earth radii above the surface and well within Earth's geosynchronous satellite ring. This extremely close pass of such a relatively large object represents a once-in-a-millennium opportunity to study not only a relatively large potentially hazard object in general, but potentially also the internal structure of such a body because of the potential tidal effects that the Earth will have on it [2]. As such, we assume that one or more large-scale (perhaps Discovery class or larger) robotic missions will be formulated and flown by the world's major space agencies to study (99942) Apophis just before, during, and just after its 2029 close flyby.

To inform and influence planning of flyby or encounter missions around the time of the 2029 flyby, MILO's Apophis Pathfinder mission would conduct a precursor flyby investigation of the asteroid up to 3 to 5 years in advance. The mission would use a pair of small spacecraft (less than 50 kilograms each) to provide initial reconnaissance data designed to increase knowledge of the asteroid's orbit, to provide initial geologic and compositional information, and to estimate its mass and density [3]. This knowledge would be obtained using data from small and high-heritage payload elements like visible to near-IR and thermal imagers, near-IR point or imaging spectrometers, and a deep space radio communications system. Such flyby data would provide new scientific information on asteroids

like (99942) Apophis, a so-called "S type" asteroid, similar to the LL Chondrite meteorite class according to its visible to near-infrared spectrum (similar to more than 80% of the other known near-Earth asteroids) [4]. Mission data would not only enhance advance planning for future missions to (99942) Apophis but would also provide additional data needed to formulate future Planetary Defense strategies for this object as well as others like it.

The Apophis Pathfinder mission would allow for payload flight opportunities, spacecraft teaming opportunities, data processing and analytics training and development opportunities, and Principal Investigator training. Apophis Pathfinder would be conducted by a consortium of U.S. and international universities and space agencies that join the MILO Institute's membership-based model for deep space exploration.

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References: [1] See, for example, "The MILO Institute: A new model for deep space exploration," Space News, Dec. 21, 2018 and <http://miloinstitute.org>. [2] R.P. Binzel, 2019 IAA Planetary Defense Conf., [Abstract 19-03-01](#), 2019. [3] J.F. Bell III, 2019 IAA Planetary Defense Conf., [Abstract 19-03-09](#), 2019. [4] R.P. Binzel *et al.*, *Icarus*, 200, 480, 2009.