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◉ **Apophis T-4 Years**

TERP RAPTOR (Terrapin Engineered Rideshare Probe for Rapid-response Asteroid Apophis Profiling, Tracking, Observing, and Reconnaissance): Mission Concept Development

Adrienne Rudolph[a,1,*], Cameron Storey[a,2], Chinthan Prasad[a,3], Kruti Bhingradiya[a,1], Rahul Vishnoi[a,4], Ryan Mahon[a,2], Sean Philips[a,3], Brent W. Barbee[a,5], David A. Akin[a,6], Mary Bowden[a,7], Jarred Young[a,8], Paul Bernhardt[b,9], Mark Haynes[c], Yungshin Chen[d,10], Joe Huba[e,11]

[a] *The University of Maryland, Department of Aerospace Engineering, 3181 Glenn L. Martin Hall, College Park, Maryland, 20742, USA, (301) 405-2376*
[b] *The University of Alaska Fairbanks, 2156 Koyukuk Drive, Fairbanks, AK, 99775, USA, (907) 474-7558*
[c] *Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive Pasadena, CA, 91109, USA, (818) 354-4321*
[d] *U.S. Naval Research Laboratory, 4555 Overlook Ave SW, Washington, DC, 20375, USA, (202) 480-3746*
[e] *Syntek Technologies, 2751 Prosperity Avenue, Suite 460, Fairfax, VA, 22031, USA, (703) 522-1025*

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The ∼325-meter diameter Potentially Hazardous Asteroid (PHA) designated 99942 Apophis 2004 MN_4 will make a historic close approach of Earth on April 13th, 2029, passing within ∼31,634 km of Earth's surface, ∼4,152 km closer than our geosynchronous satellites. This is an extraordinarily unique opportunity for collecting data on a several hundred-meter size asteroid while it experiences the effects of close proximity to Earth's gravitational field. Current asteroid population models suggest that this is a 1 in 7500 years event. Apophis's Earth close encounter therefore provides a rare opportunity to observe planetary encounter effects on an asteroid.

Our Terrapin Engineered Rideshare Probe for Rapid-response asteroid Apophis Profiling, Tracking, Observing, and Reconnaissance (TERP-RAPTOR) is an Earth-orbiting mission concept in which a 12U CubeSat built by University of Maryland students would perform a flyby of Apophis, collecting data to address science questions regarding the asteroid's collisional and dynamical evolution, its surface and structural characteristics, and the effects of close proximity to Earth's gravitational field. This mission also supports planetary defense objectives by advancing our understanding of Apophis-sized objects and their potential Earth impact risks.

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*Corresponding author
Email addresses: rudolpa@umd.edu (Adrienne Rudolph), cjstorey@umd.edu (Cameron Storey), cprasad1@umd.edu (Chinthan Prasad), krutib26@umd.edu (Kruti Bhingradiya), rvishnoi@umd.edu (Rahul Vishnoi), rmahon1@umd.edu (Ryan Mahon), sphilip1@umd.edu (Sean Philips), bbarbee@umd.edu (Brent W. Barbee), dakin@ssl.umd.edu (David A. Akin), bowden@umd.edu (Mary Bowden), jyoung11@umd.edu (Jarred Young), pabernhardt@alaska.edu (Paul Bernhardt), mark.s.haynes@jpl.nasa.gov (Mark Haynes), yunghsin.chen.civ@us.navy.mil (Yungshin Chen), jdhuba@gmail.com (Joe Huba)
[1] PhD Student, Department of Aerospace Engineering
[2] M.S. Graduate Student, Department of Aerospace Engineering
[3] M.E. Graduate Student, Department of Aerospace Engineering
[4] M.S Graduate Student, Department of Computer Science
[5] Lecturer and Adjunct Member of the Graduate Faculty
[6] Professor of Aerospace Engineering and Director, Space Systems Laboratory
[7] Senior Lecturer
[8] Senior Lecturer
[9] Research Professor, Space Physics & Aeronomy Group
[10] Researcher, Plasma Physics Division
[11] Senior Research Scientist

The mission launches as a rideshare into an Apophis-intercepting orbit, an example of which is shown in Figure 1. We present several design reference mission cases, including an orbit potentially reachable from a typical Geosynchronous Orbit Transfer (GTO) rideshare launch, a high-inclination sub-geosynchronous altitude orbit with lower flyby speed and more benign radiation environment, and a retrograde orbit scenario minimizing flyby speed relative to Apophis but requiring advanced future launch rideshare systems, such as Blue Origin's Blue Ring.

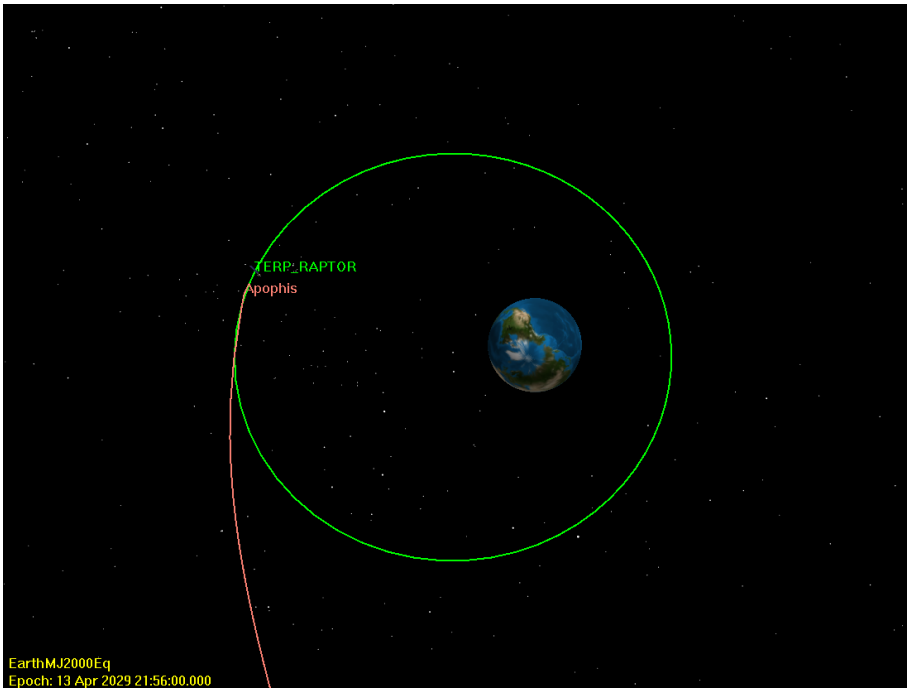

Figure 1: Exemplar TERP-RAPTOR orbit for Apophis flyby.

After launch and separation, TERP-RAPTOR performs on-orbit commissioning, loiters, and then maneuvers to fly by Apophis at its perigee. Data is collected by two cameras: a high-resolution RGB imager for wide-field analysis of asteroid size, shape, spectral weathering signatures, and crater distribution; and a multi-spectral imager with customizable bands (up to near-infrared) to detect fine-scale surface changes. TERP-RAPTOR will also carry an antenna instrument provided by the High-frequency Active Auroral Research Program (HAARP) and collect HAARP's bi-static radar signals reflected by Apophis, in collaboration with the Owens Valley Radio Observatory. Those data help characterize portions of Apophis's interior. Image data and HAARP data will be stored onboard and down-linked to ground stations.

The spacecraft may then perform extended missions. As the spacecraft nears the end of its operational lifetime, it will conduct End-of-Life operations adhering to NASA Procedural Requirements for Limiting Orbital Debris.

TERP-RAPTOR is an innovative design for a small, affordable University-built spacecraft capable of providing a higher ratio of scientific return to mission cost than any previous mission to an asteroid or comet. Apophis will be naked-eye visible in the night sky in parts of Europe and Africa, capturing the attention of everyone around the world. As people's eyes and imaginations gaze upwards, TERP-RAPTOR will be our eyes in space, alongside any other spacecraft that the nations of the world might dispatch to study this extraordinary natural event.

Comments: *Oral presentation slot preferred. Apophis T-4 Years session preferred, but Space Mission & Campaign Design is a potential alternate.*