OSIRIS-APEX: AN OSIRIS-REX EXTENDED MISSION TO APOPHIS. M. C. Nolan[1], D. R. Golish[1], Scott Guzewich[2], M. Moreau[2], A. T. Polit[1], A. A. Simon[2] and D. DellaGiustina[1]. [1]Lunar and Planetary Laboratory, University of Arizona, Tucson AZ, USA, (mcn1@arizona.edu). [2]NASA Goddard Space Flight Center, Greenbelt, MD, USA.

Introduction: The OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer) mission characterized and collected a sample from asteroid (101955) Bennu. After the capsule containing the sample is released to Earth in 2023, the spacecraft (S/C) will divert into an orbit around the Sun, allowing for subsequent close Earth flybys. On this trajectory, the S/C will approach Earth alongside asteroid (99942) Apophis in 2029, enabling a second mission with the same unique capabilities that led to OSIRIS-REx's groundbreaking scientific results: OSIRIS—APEX (Apophis Explorer), or "APEX" for short.

Mission Concept: APEX will begin observations of Apophis as a point source on April 2, 2029, at a distance of 5 million km; orbital mechanics prohibit an earlier rendezvous. APEX will observe Apophis from 50,000 km during its close encounter and capture the evolution of its spin state in real time, revealing the consequences of a near-Earth object undergoing tidal disturbance by a planet. APEX will enter a 1.4-km Apophis orbit four months after their joint close Earth approach. Orbital observations will uncover any signs of mass wasting that the tidal encounter triggered, revealing centimeter-scale topography via lidar and millimeter-scale morphology via images.

Chronicling the tidal encounter is only the beginning of APEX's journey with Apophis. Having already challenged our fundamental understanding of "carbonaceous" (C-complex) asteroids during its exploration of Bennu, the S/C instrument suite will provide first-of-its-kind high-resolution data of a "stony" (S-complex) asteroid—dramatically advancing our knowledge of this asteroid class and its connection to the meteorite collection. Global spectral mapping at meter scales and across a wide range of wavelengths (0.4–100 μm) will determine the composition of Apophis and identify any volatiles on its surface. Optical and radiometric tracking data will reveal Apophis' mass and structure. We will also search for signatures of mass shedding, whether due to the tidal encounter or an episodic process like that observed at Bennu. After 15 months of orbital operations, APEX will perform a maneuver called Spacecraft Thruster Investigation of Regolith (STIR, Fig. 1) to mobilize surface material, as demonstrated at Bennu. Observations during and after excavation will provide otherwise inaccessible insights into space weathering and the surface strength of stony asteroids.

Although scientific discovery is APEX's prime motivator, Apophis' bulk structure and surface strength have critical implications for planetary defense. As an S-complex object, Apophis represents the most common class of potentially hazardous asteroids, and knowledge of its properties can inform mitigation strategies. Monitoring Apophis after Earth approach provides the first opportunity to witness a change in Yarkovsky force—a nongravitational effect that influences an asteroid's likelihood of striking Earth.

Figure 1. *The STIR maneuver shown in this cartoon will use the spacecraft's thrusters to mobilize surface material, providing insight into the near-surface properties of Apophis.*

Ground based Observations and Space Truth: APEX does not require any specific ground-based observations for operations, however, combining results from reconnaissance and ground-based observations is likely to provide improved understanding of Apophis—as a source of meteorites, as a remnant of early Solar System history, and as a potential hazard to Earth. In some cases, APEX can provide "space truth" that resolves ambiguities in ground-based observations and puts them in geologic context.

We welcome community input on possible additions or changes that might maximize the scientific output when combined with other ground-based observations or spacecraft missions. Discussions about possible coordinated observations through approximately early 2024 (the Apophis T-5 conference) would allow them to be included in mission planning with flexible constraints.

Acknowledgement: This work was supported by the NASA contract number NNM10AA11C and the University of Arizona Space Institute.