APEX: APOPHIS PROBE EXPERIMENT MISSION

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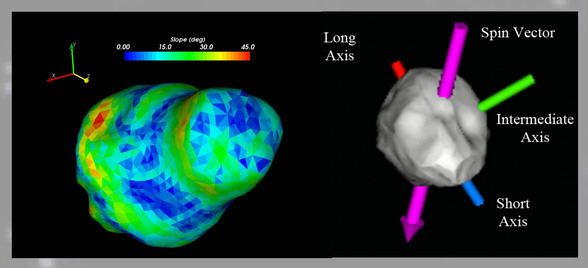
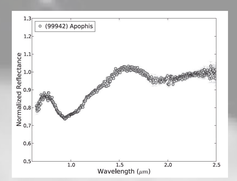
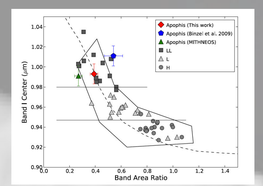






Apophis is a S-type Near Earth Asteroid with dimensions of about 260 x 300 x 430 m diameter, a rotational period of 27.38 hr and an orbital period of 323.6 days.

The asteroid will have a close encounter with the Earth on Friday the 13th April 2029 at a distance of 36,700±9000 km (Geosyn orbit 42,164 km). The encounter distance is insufficient to break up the body but may cause tidally induced resurfacing.

This encounter provides a once-in-a-lifetime opportunity to observe tidal interactions of a small body with a planet and to conduct a mission close to the Earth facilitating the study of the internal structure of Apophis. Defining the interior structure is critical to understanding the history of the body and its potential as an Earth impact hazard.

Tidal interactions with the Earth will deform Apophis and change the rotation rate and pole orientation. While the deformation will be too small to observe visually, it may induce surface movements that can be observed, visually and spectrally. Deformation during encounter will also produce seismic signals that APEX plans to probe to understand the interior structure of the asteroid.

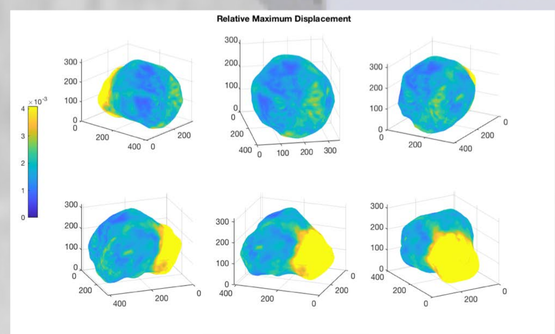
APEX Science Objectives

Level 1 objectives

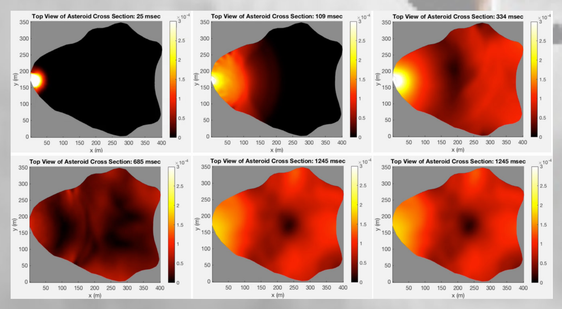
- Rotational state / bulk properties
- Interior structure
- Geology / geologic history
- Tidal effects

Level 2 objectives

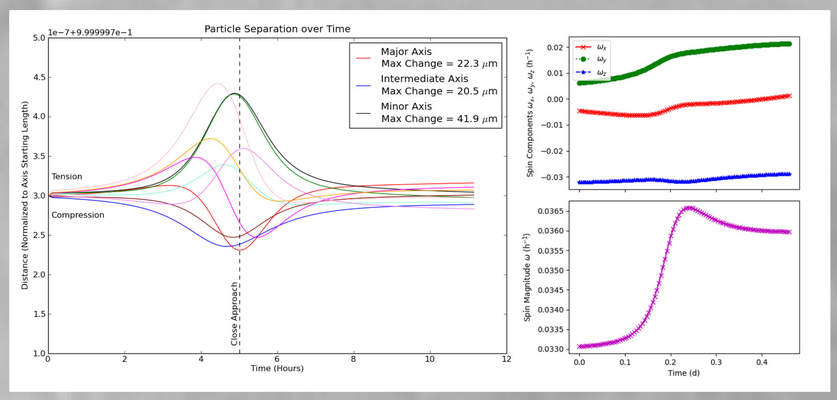
- Rotation period and orientation
- Shape and volume
- Topography
- Mass and density
- Internal tectonic stress seismicity
- Surface thermal stress seismicity
- Impact induced seismicity
- Geologic history
- Surface morphology
- Physical properties
- Calibration of remote sensing data



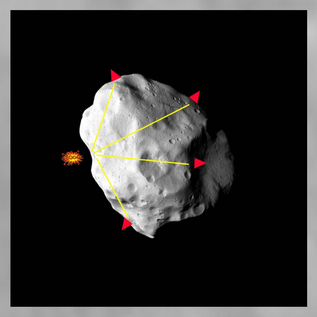
Peak ground motion (displacement) for a source situated at the surface of Apophis [0,150,150]. The source is located at the tip of the model in the lower right.



3-D simulation of seismic waves propagating within Apophis for a 5 N source at the surface. Each panel is a snapshot of the evolution within the asteroid for ground motion in m/s^2 . Note the antipodal focusing.



Changes in axial length and rotation rate of Apophis during Earth encounter. Changes in dimensions will likely be too small to be imaged, but imaging at high frequency will define changes in rotation rate.

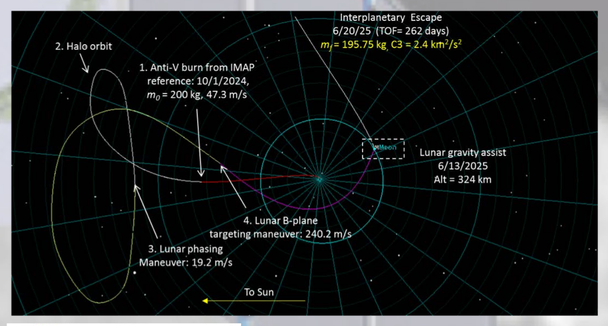


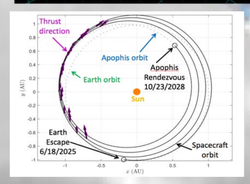
Using a number of stations and sources, an active seismic experiment could be conducted.

We have studied several mission concepts to understand the spacecraft requirement and science potentials of each. The payload is a function of the mission scale with a Discovery class providing the largest and most capable payload.

The primary instruments for each class of mission is a seismometer (deployed onto the surface) and panchromatic imagining.

With additional capability we would deploy multiple seismometers as well as energy sources to conduct both a passive and active experiment. Color imaging, multi/hyperspectral imaging, and X-ray / gamma ray spectrometers could be included.

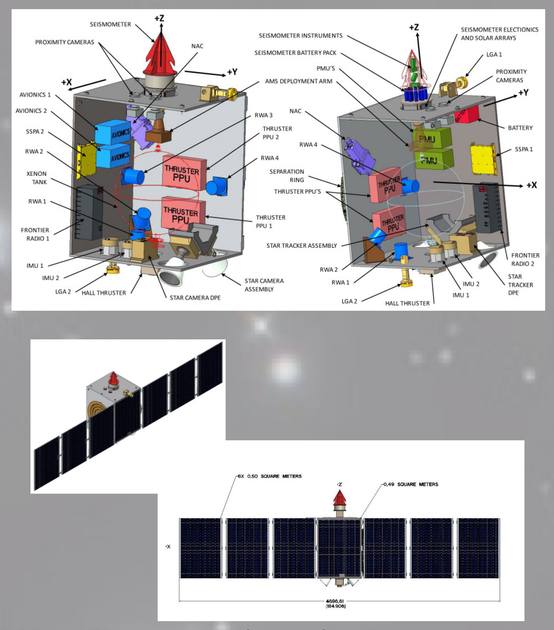




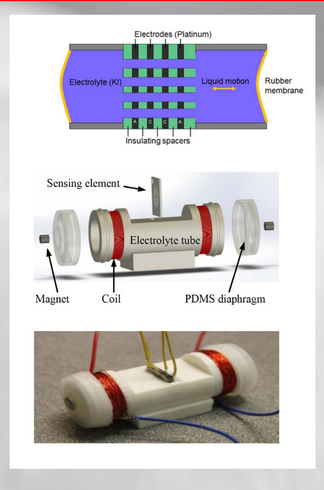
ΔV Budget	
Mission Phase	**m s^{-1}**
Early Ops through Earth Escape/Lunar Flyby	307
Heliocentric Cruise	3408
Station Keeping	50
Total	3765

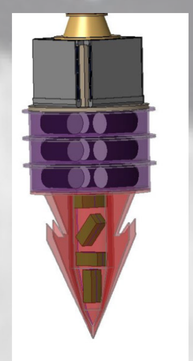
Launch date is flexible. APEX can loiter at L1 until 6/20/25 when it must depart the Earth-Moon system. Arrival is October 2028 allowing 6 months of observation and operations before Earth encounter.

Spacecraft Element Masses (kg)			
Element	**NIAC**	**PSDS**	**Discovery**
Structure	52	50	282
Propulsion	16	26	57
Avionics	11	6	28
Power	27	28	30
Attitude Control	12	13	58
Thermal	4	52	18
RF	4	12	59
Harness	11	10	42
Spacecraft Bus	***137***	***197***	***573***
Instruments	42	7	75
Dry Mass	***179***	***204***	***648***
Propellant	114	62	513
Total	***293***	***266***	***1162***

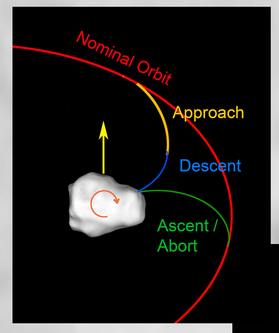


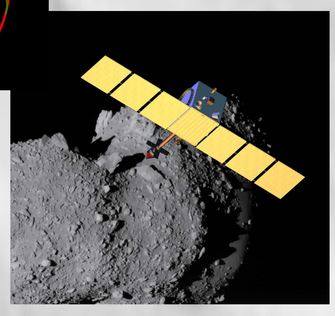
PSDS SEP spacecraft configuration.





Seismic sensor uses a fluid-filled membrane MEMs device to detect motion. Unit has no moving parts and is orientation-independent allow easy deployment. The sensor package must operate as an independent entity with its own computer, power, and comm.





Deployment scenario is similar to Hayabusa and OSIRIS REx: S/C would match rotational speed, descend to the surface and push the seismometer into the regolith to ensure coupling. This scheme also allows the spacecraft to back off without deploying the sensor if an anomaly occurs.

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