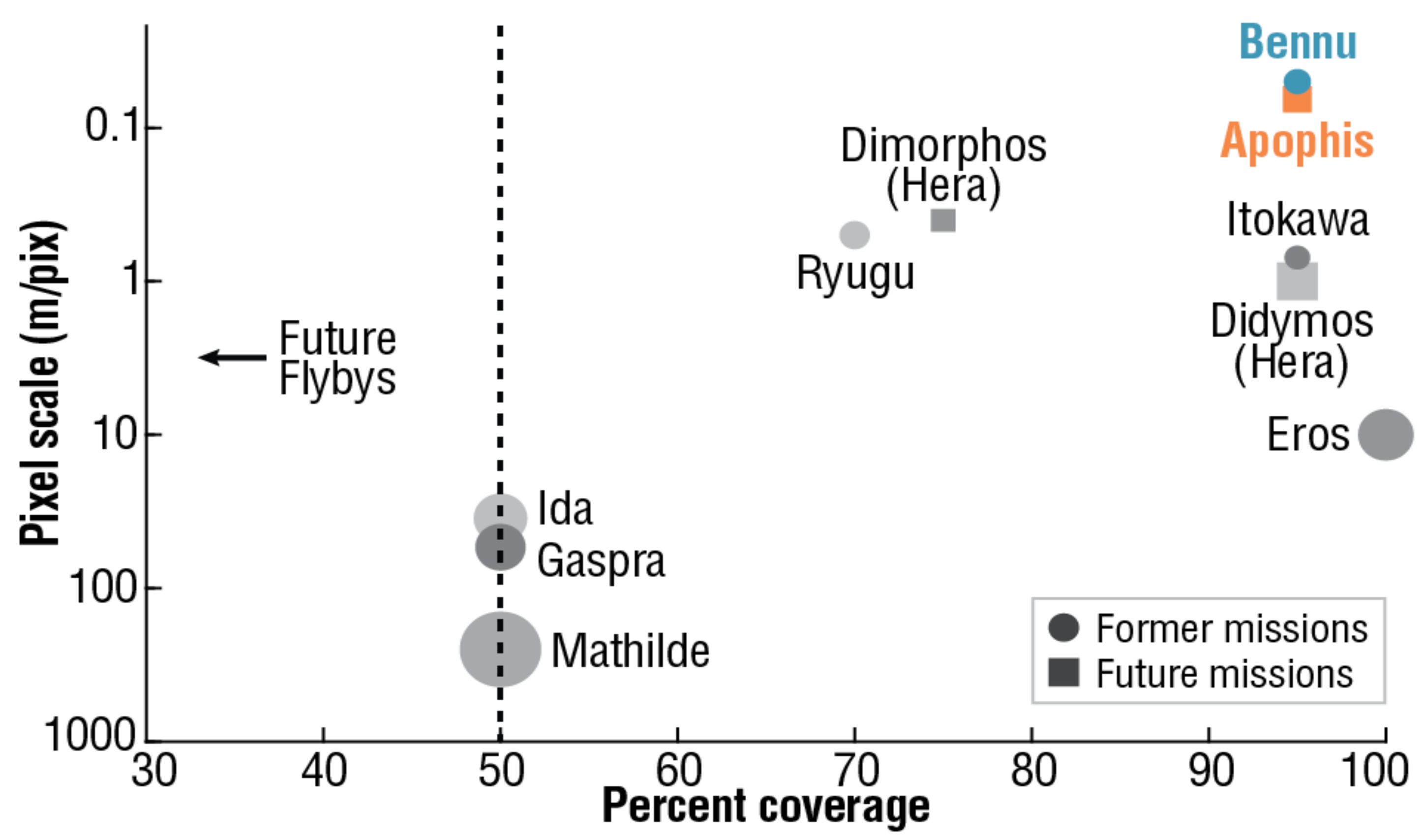
OSIRIS-APEX: AN OSIRIS-REX EXTENDED MISSION TO APOPHIS.

M. C. Nolan[1], D. R. Golish[1], Scott Guzewich[2], M. Moreau[2], A. T. Polit[1], E. G. Rivera-Valentín[3], A. A. Simon[2] and D. DellaGiustina[1]. [1]Lunar and Planetary Laboratory, University of Arizona (mcn1@arizona.edu). [2]NASA Goddard Space Flight Center. [3]Johns Hopkins University Applied Physics Laboratory.

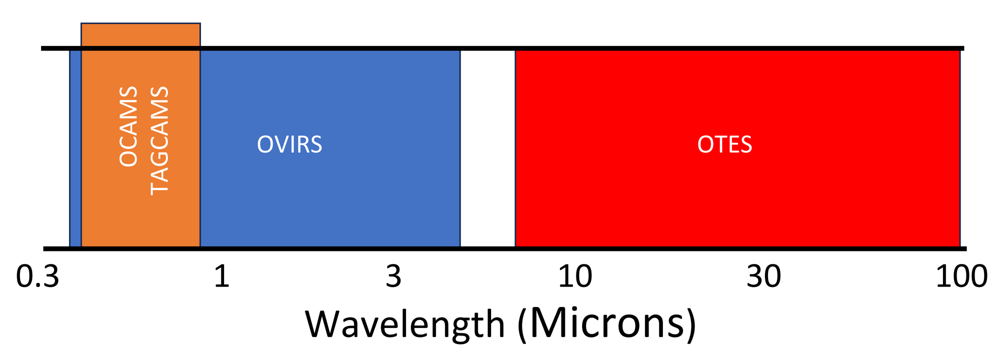
APEX Goals

- **Goal 1:** Establish the processes that drive the evolution of small asteroids, including tidal effects from close encounters with terrestrial planets.
- **Goal 2:** Determine the characteristics of an S-complex object to establish the link with its parent-asteroid family and its dynamical evolution from main belt through multiple Earth encounters.
- **Goal 3:** Examine the properties of an S-complex, potentially hazardous asteroid (PHA) as an analog for other PHAs and to defend the planet.

Capabilities at Apophis

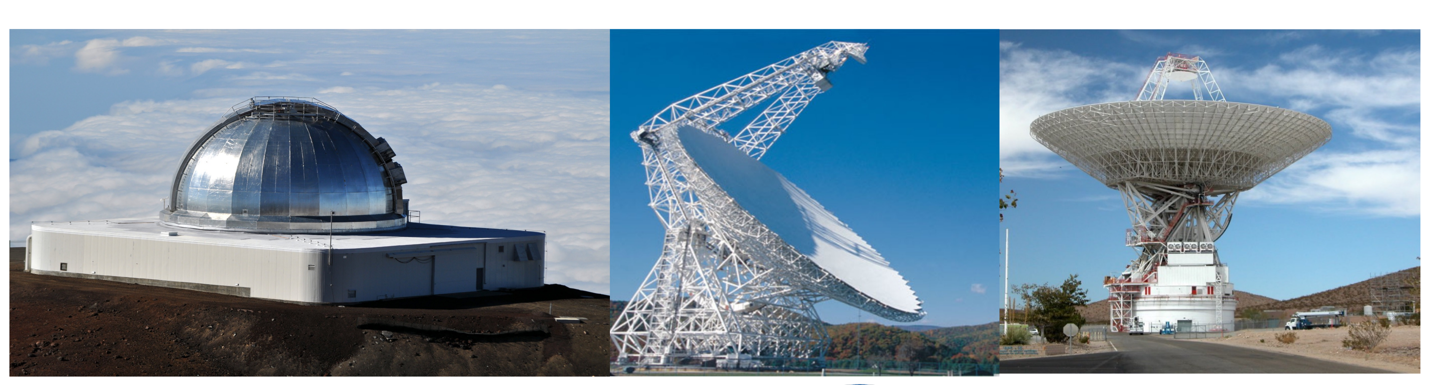


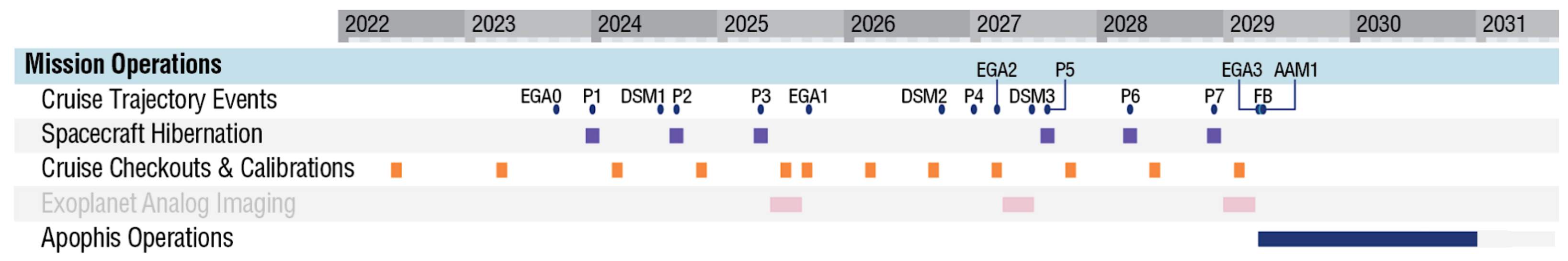
The OREx spacecraft and payloads were specifically designed to globally survey small bodies at exceptionally high spatial resolution (above) and broad spectral coverage (below).



"Space-truth" ground-based observations

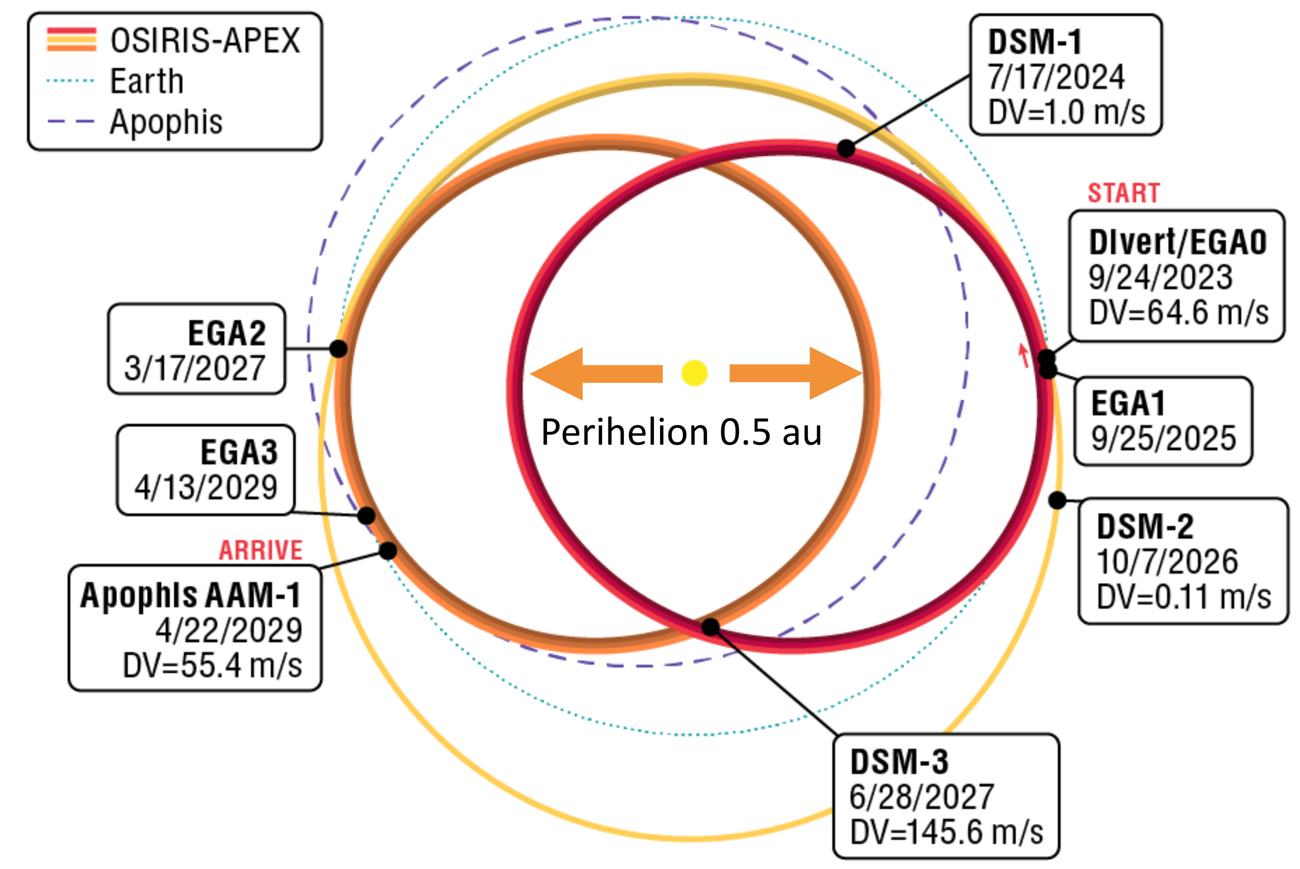
- Close-encounter provides excellent viewing conditions for many ground-based facilities
- Conditions quickly degrade only hours after close approach as Apophis passes within 20° of the Sun
- APEX can provide space-truthing for ground observations
  - Can also help resolve ambiguities (e.g., radar)
- Suggestions for coordinated spacecraft observations are relatively easy to incorporate through 2024.





Getting There

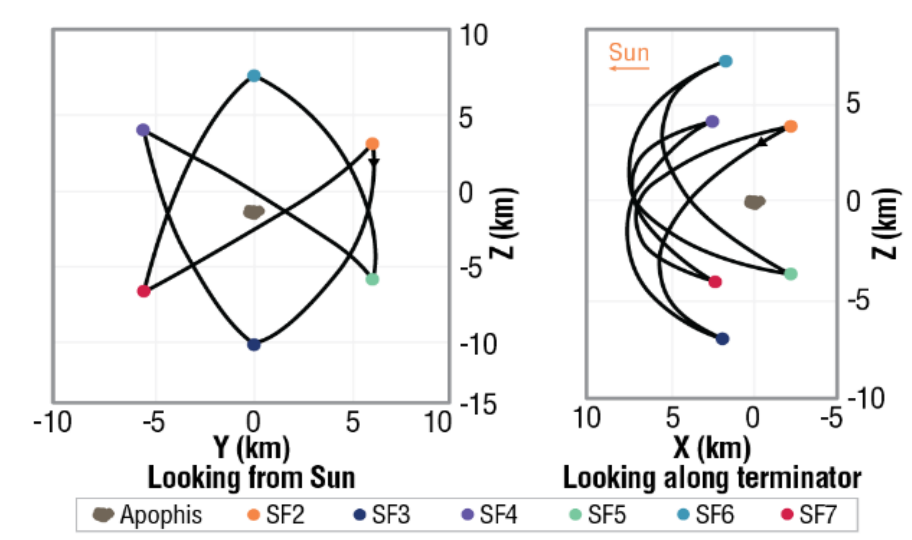
The APEX spacecraft uses three Earth Gravity Assists (far right) to arrive at Apophis in 2029, with the last assist about an hour after Apophis makes its own dramatic close approach. There is not sufficient remaining fuel to arrive before the Apophis approach. On the way, it gets within 0.5 au of the Sun. Image on the near right shows the spacecraft as viewed from the Sun in the "Fig Leaf Attitude" which protects vital spacecraft components.



Apophis Proximity Operations

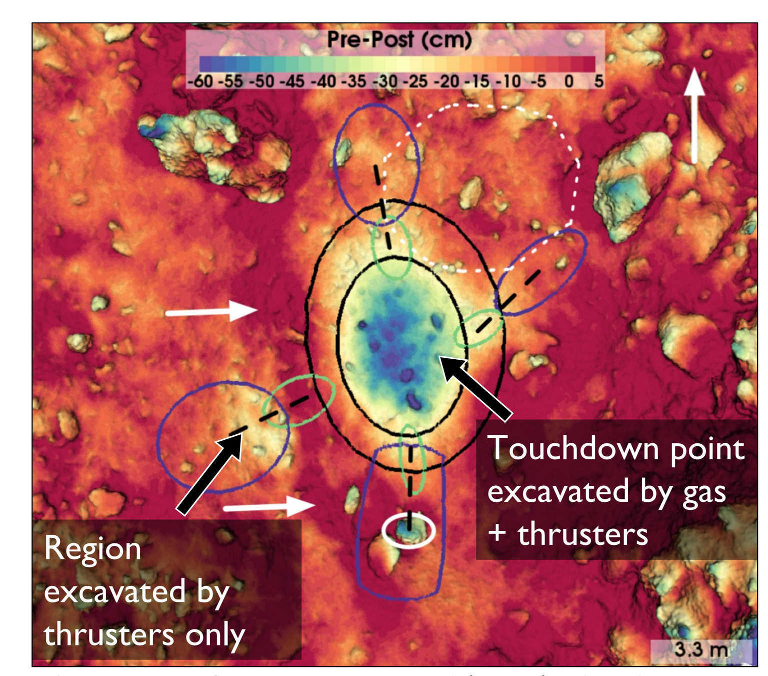
The APEX proximity operations plan is similar to the OSIRIS-REx plan in concept, but with changes to accommodate Apophis' higher albedo and slow, tumbling rotation state. The high-resolution imagery, lidar, and spectroscopic observations will use terminator and "quasi-terminator" orbits that provide multiple observing geometries. For the lower-resolution global surveys, we will use long slow arcs in a "starfish" pattern (right) that covers a wide range of observing geometries over a six-week cycle with more-or-less continuous observations.

After global surveys are complete, we will perform higher-resolution detailed surveys of sites of interest, ending with a "STIR" maneuver to excavate the surface, followed by detailed observations of the disturbed surface.

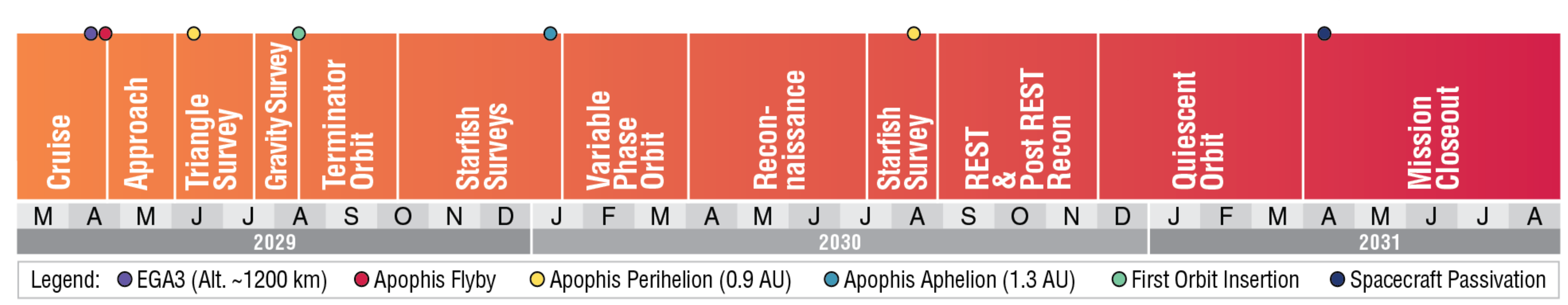


Graphical representation of the Starfish Survey trajectory (one set of six waypoints). The Sun is located along the +X axis.

The STIR maneuver shown in the cartoon to the left will use the spacecraft's thrusters to mobilize surface material, providing insight into the near-surface properties of Apophis. Examination of the scars left by the TAG maneuver at Bennu (right) show that the thrusters are able to excavate loose surface material. Figure adapted from Lauretta et al. (2022).



Above: Fig. 4 from Lauretta et al.(2022). The change in topography at Nightingale due to TAG. We highlight the thruster footprint (light green ellipse for start position and dark purple for final position), and indications of debris deposits (white arrows).



Mission Summary paper to appear in PSJ.