Statement of Objective

Measure the Yarkovsky effect on a potentially hazardous asteroid and constrain the asteroid properties that contribute to this effect

Overview

Bennu is a potential Earth impactor. The highest individual impact probability is 9.5E-5 in 2196, and the cumulative impact probability is 3.7E-4. The primary source of uncertainty is the dynamical model of its orbital evolution.

The main non-gravitational orbit perturbation expected over a time span of centuries is due to the Yarkovsky effect, which results from the way the asteroid rotation affects the surface temperature distribution and therefore the anisotropic thermal re-emission (Chesley et al. 2003). When thermal forces align with orbital vectors, the Yarkovsky effect can cause a steady drift in semi-major axis. OSIRIS-REx dramatically extends the time horizon for reliable position predictions for Bennu, not only by measuring spin state, surface area, albedo distribution, and thermal emission, but also by directly measuring the Yarkovsky acceleration.

A close approach of Bennu to Earth in September 2011 permitted the OSIRIS-REx team to use the Arecibo Planetary Radar System to acquire radar astrometry and detect the Yarkovsky effect. The signal-to-noise ratio in this detection was >3, sufficient to measure the range to within one asteroid diameter. During encounter, precision tracking of the OSIRIS-REx S/C, in combination with modeling of the S/C motion relative to Bennu, will improve the signal-to-noise ratio by at least a factor of 10, providing the most accurate determination of the Yarkovsky effect. This increase in position knowledge leads to better understanding of the possible threat, allowing ample time for policy makers to approve appropriate mitigation efforts.

Continued study of the Bennu trajectory is a significant element of the OSIRIS-REx science investigation. In particular, the characterization of the Yarkovsky effect is planned to be conducted on two tracks. On one track, Earth-based radio tracking of the spacecraft and optical navigation images of the asteroid from the spacecraft would be used to derive high-precision asteroid position measurements. These position updates would afford refined estimates of the non-gravitational accelerations that the asteroid experiences.

On the other track, science observations by the OSIRIS-REx spacecraft would allow the development of a complete thermophysical model of the asteroid, yielding a precise estimate of the thermal recoil acceleration, as well as direct and reflected solar radiation pressure acting on the body. A comparison of the acceleration prole from these two independent approaches will provide signicant insight into the quality of current thermophysical models, and, for example, the extent to which surface roughness affects the net thermal recoil acceleration (Rozitis and Green 2012).

Level-1 Requirements

1.14 – Constrain the properties of Bennu that contribute to the Yarkovsky effect and measure the magnitude of the Yarkovsky effect

Required Inputs

Spectral Data

Imaging Data

Asteroid Position

Level-2 Requirements