MRD 150- Planetary Encounters & Impact Hazard

Data Product Overview

This data product is responsive to MRD-150 (2.14.1) Measure the Yarkovsky acceleration of Bennu with a SNR ≥400.

This document discusses only the planetary encounter and impact hazard aspect of MDR-150. Other aspects are covered elsewhere, for example:

- Bennu ephemeris
- Bennu pseudo-ranging measurements
- Bennu Yarkovsky measurement

This data product consists of a tabulation of planetary encounters and associated uncertainties out to the predictability time horizon. Additionally an assessment of future impact hazard will take the form of a tabulation of dynamically unique routes to future potential impacts along with their impact probabilities.

This data product will be in the form of a journal article that describes the key result along with the input data and algorithms. **This data product is not a SPOC deliverable.**

Background

The future orbital evolution of Bennu will be calculated by inputting the available of Bennu into JPL's solar system dynamics orbital integration codes and tracking its orbit into the future. This will allow a tabulation of the nominal sequence of planetary encounters in the past and future, out to some time horizon beyond which encounters are statistical rather than deterministic.

Given the nominal trajectory and associated uncertainties, we can identify dynamical routes to potential future Earth impacts. Computing the measure of the impact solutions and the probability density allows us to compute the probability of Earth impact for potential impacts far beyond the deterministic prediction horizon.

As of 2013 we have identified a series of potential Earth impacts from 2175 through 2196. The cumulative impact probability is ~4x10^-4. Orbital updates obtained from the combination of optical navigation imagery and radio tracking of the spacecraft during proximity operations will allow us to refine these predictions and rule out many of the current potential impacts. A necessary byproduct of this process is that some current potential impacts may see an increased impact probability.

Tracking data from three sources will constrain the deviation of the asteroid orbit from a gravity only trajectory:

1. Ground-based optical astrometry

2. Ground-based radar astrometry (delay and Doppler)
3. Pseudo-ranging from a DSN tracking station to the asteroid center of mass

The generic approach is to fit all of the available observations, given their stated (or assumed) a priori uncertainties, in a least-squares fit that estimates the initial condition (osculating orbital elements) and relevant nongravitational parameters.

Inputs

The inputs required to compute the past and future trajectory include the same items used for the Yarkovsky measurement:

- Bennu shape model
- Bennu rotation model
- Bennu thermo-physical model
- Bennu pseudo-ranging measurements
- Ground-based optical and radar astrometry, which are obtained from the IAU Minor Planet Center(https://minorplanetcenter.net//iau/mpc.html) and the JPL Solar System Dynamics(https://ssd.jpl.nasa.gov/?radar)websites) respectively.

Data Product Structure and Organization

This data product consists of a tabulation of planetary encounters and associated uncertainties out to the predictability time horizon. The assessment of future impact hazard will take the form of a tabulation of dynamically unique routes to future potential impacts along with their impact probabilities.

Data Format Descriptions

The planetary encounter tabulation and impact hazard assessment will be described in a peer-reviewed journal article and online at NASA's Near-Earth Object Program website. (https://cneos.jpl.nasa.gov/)

Data Product Generation

This product development will be led by Co-I Steve Chesley. He will use existing codes that exist at the JPL Solar System Dynamics group. His work will be submitted to the OSIRIS-REx science team and peer review journals as a means to check his results.