NFT Global Safety Map Algorithm Description Document

Overview

NFT provides layers of Component Level Fault Protection by estimating the time and location of touch on the surface of Bennu. In addition, the time of touch estimate is also used to define a time window where the sampling mechanisms are armed. If time of touch is not detected within this window, a backaway burn will be initiated to ensure spacecraft safety.

This data product supports the Safety Map requirement SM. ALG.11 "SPOC shall generate a global gravity input map of Bennu. The global scale gravity map will provide a measure of the error present in the asteroid surface gravitational acceleration." This safety map algorithm provides a rough measure of how accurately NFT will be able to predict the time, position and velocity at touch by assessing the altitude of each point on the surface as a potential TAG site. Specifically, the altitude of each site is compared to the gravity model Brillouin Sphere. The Brillouin Sphere radius is provided by the spherical harmonic gravity model products produced by the Flight Dynamics team. This sphere encompasses the asteroid and intersects the surface at only one point. The gravity field is valid outside of this sphere. Inside the sphere, the gravity model breaks down. The model degrades the further below the Brillouin sphere the spacecraft goes. For this reason, NFT is less and less able to accurately predict the time of touch as the TAG site altitude falls farther and farther below the Brillouin sphere.

The output of this safety map algorithm will result in the Bennu surface being ranked in terms of how well NFT is expected to perform the time of touch calculation.

Inputs

- Global 75cm or 35 cm Shape Model
- Spherical harmonic gravity model reference radius (Brillouin Sphere Radius)

Outputs

- NFT global safety map

Algorithm

For each TAG site of configurable radius across the surface of Bennu, perform the following calculation:

1) Compute the TAG site mean (TBR, may choose max) radius from the center of the gravity field coordinate system (should be center of mass)
2) Compute the how far below the Brillouin sphere the mean (TBR) TAG site radius falls
3) If the distance below the Brillouin Sphere radius is greater than 44 m, rank this TAG site as "poor" and in need of further analysis by the NFT team. This threshold is chosen because NFT has not been verified for TAG site altitudes this low. The lowest altitude TAG site tested during verification was X m corresponding to a modeled site at -45 deg lat, 45 deg longitude.
4) If the distance below the Brillouin Sphere radius is 19 m or less, rank this TAG site as "favorable"
5) TAG sites that have mean (TBR) radius in-between the "poor" and "favorable" thresholds above should be ranked on a relative scale with respect to those thresholds