Global Tilt Map Algorithm Description Document

Overview

This data product supports the Safety Map requirement SM. ALG.01: "*SPOC shall generate a global tilt input map of Bennu. The global tilt scale map will provide the average tilt of the expected sampling area (nominally 50m diameter) for each facet within the GSM. The assigned location for the tilt will be the geometric center of the facet.*" The tilt at the scale of the sampling ellipse defines the spacecraft attitude during the final approach to surface contact. This map calculates which candidate TAG sampling sites on the global shape model satisfy the mission requirement for continuous communications coverage during TAG final approach to surface contact.

Inputs

- Global Shape Model (GSM)
    - Nominally 1m resolution
- Acceptable angle between TAG vector and Earth vector as a function of date
- Global Deliverability Map (GDM)
- Sampling site radius (circular)
- G_comm – parameter for acceptable facet tilt angle
- R_comm – parameter for unacceptable facet tilt angle

Outputs

- Global Tilt Safety Map
    - Referenced to the GSM

Algorithm

The 'sampling area' centered about each facet in the GSM is defined by the Global Deliverability Map (GDM). Since the GDM is not at the same resolution as the GSM, the size of the sampling area is defined by the semimajor and semiminor axes of the nearest-latitude GDM site. If there are multiple GDM sites with the same latitude, then the nearest longitude GDM site is selected from the remaining options. The semimajor and semiminor axes of the sampling area should be converted 3-sigma values, assuming a Gaussian error distribution (the GDM input is currently 1-sigma). Alternatively, the user can input a single scalar for the sampling site area radius instead of the GDM. The sampling area in this case for every facet is a circle with the specified radius.

For each facet within a sampling area:

1. Calculate unit surface normal (ACF) for each facet
2. Calculate radial vector from the asteroid center to the geometric center facet - **F**
3. Search for other plates within given radius 'r' of current plate center. A plate is considered within the given radius if any one of its vertices is within the ellipsoid defined by the sampling area from the GDM.
4. Calculate average unit vector for all facets within the sampling area, using the following formula

$$Y^j = \sum_{i=1}^{N} x_i^j * A_i * W_i$$

Where: Y^j is the j^{th} component of the average tilt vector
x_i is j^{th} component of the vector normal to the i^{th} facet
A_i is the area of the i^{th} facet
W_i is the optional weighting factor for the facet and is given by the following formula:

$$W_i = B * \exp\left[-\frac{r_i^2}{2 * \sigma^2}\right]$$

Where r_i is the distance from the center of the facet to the center of the sampling area and 'B' and σ are input parameters.
The weighting scheme is currently TBD. It is possible the final chosen weighting scheme will be a function of radius or other parameters.

The resultant vector **Y** should be normalized to a value of one and represents the ACF normal vector for the sampling area on Bennu.

Repeat steps 1-4 above for a sampling area centered on each facet in the shape model to generate ACF normal vectors of the average TAG site tilt centered on every facet in the GSM.

The ACF normal vector needs to be compared to the Earth vector at the time of touch to ensure that communications is possible during TAG. This angle and a color-coded safety rating will be output for each facet as part of the Global Tilt Map. The following criteria should be used to color code each facet:

a. The angle between Y and the Earth is less than G_comm, the facet will be colored Green
b. The angle between Y and the Earth is greater than R_comm, the facet will be colored Red
c. Else the facet is colored Yellow

The values for G_comm and R_comm will be supplied.