MRD 124- Center of Figure

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Data Product Overview

The location of the center of figure of Bennu relative to Bennu's center of mass. The shape model provided in MRD-123, as well as the local maps in MRD-115 will all be produced relative to the center of mass. These products are the result of using navigation solutions for the OSIRIS-REx spacecraft relative to Bennu's center of mass which will be tracked by the Flight Dynamics team after Preliminary Survey Phase. An initial solution of any offset between the center of mass and center of figure will be determined after the preliminary survey phase, at which point spacecraft navigation will be relative to Bennu's center of mass. This offset is improved as the mission proceeds, and better gravity and a better shape model for Bennu are determined.

Overview

Simple text file describing the Dx,Dy,Dz location of the center of figure of Bennu relative to its center of mass. This is achieved in a straightforward manner by computing the asteroid's spatial centroid through a volumetric integration. This will be made with any shape model produced by ALTWG including those generated by SPC. These data will also be part of the header of any global OBJ file provided by the ALTWG as shown in red below.

Comment area of OBJ file:

#Model of the surface of Bennu. File consists of vertices and facets. Facets are triangular and

#connected by the right hand rule. The x, y, and z components of the vertices precede the

#letter ‘v’ in the first part of the file. The number of each vertex is defined by the position

#of the vertex in the list defined by the letter ’v’, where the first line in this list is the first vertex.

#In the second half of the file, the three numbers following the letter ‘f’ are the vertex numbers

#that make up each facet.

#PRODVERS = 1.0.0 \ Product version number

#MISSION = OSIRIS-REx

#TARGET = 101955 BENNU

#ORIGIN = OREXSPOC

#MPHASE = preflight ground test

#DATASRC = TRUTH

#DATASRCV = BENNUV3.7

#DATASRCD = 2015-09-12T17:02:03Z

#DATEPRD = 2015-11-09T08:24:56Z

#PRODNAME = g_1278cm_tru_obj_99900s-63900_v100.fits

#PRODVERS = 1.0.0 \ Product version number

#DATASRCV = BENNUV3.7

#CREATOR = Barnouin

#CLON = -999.0 \ [deg] longitude at center of image

#CLAT = -999.0 \ [deg] latitude at center of image

#Number of Plates = 12288

#Number of Vertices = 6534

#Number of Edges = 18432

#Euler Polyhedron Formula = 390

#Surface Area = 0.8090023859015390 km^2

#Plate Area Mean = 6.583678270683086e-05 km^2

#Plate Area Min = 3.998804125133503e-05 km^2

#Plate Area Standard Dev = 1.019094101334709e-05 km^2

#Edge Length Mean = 0.01278014956259093 km

#Edge Length Max = 0.02069469922150901 km

#Edge Length Variance = 4.850112744396241e-06 km^2

#Surface Closed? = Yes

#Volume = 0.06272496564911250 km^3

#Centroid:

[9.636659810963896E-4, -2.9035454395760866E-4, -6.436673871849306E-4] km

#Moment of Inertia Tensor Relative To Origin:

[0.0014745808961473246, -1.3105159233112575E-5, -4.491049522943029E-6]

[-1.3105159233112575E-5, 0.0015008758395474594, -6.626885868098366E-6]

[-4.491049522943029E-6, -6.626885868098366E-6, 0.001652418910218759]

#Moment of Inertia Tensor Relative To Centroid:

[0.0014745496206347648, -1.3122709979359531E-5, -4.529956587478493E-6]

[-1.3122709979359531E-5, 0.0015007916024383518, -6.615163089457709 5E-6]

[-4.529956587478493E-6, -6.615163089457709 5E-6, 0.0016523553724702611]

#Extent:

X: [-0.2697600126266 4795, 0.27915000915527344] km

Y: [-0.26078999042510986, 0.262800008058548] km

Z: [-0.2510699927806854, 0.25655999779701233] km

#Warning: The polyhedron is closed, but the Euler polyhedron formula, V-E+F,

#(see https://en.wikipedia.org/wiki/Euler_characteristic)

#does not equal 2, as would be expected. This is usually caused by duplicate

#vertices in the shape model. Please contact the creator of

#the shape model to see if this can be corrected.

The only data required to compute this center of figure is a shape model of the asteroid.

Data Product Structure and Organization

A simple ASCII file of three numbers: Dx,Dy,Dz of the asteroid center of figure in km relative to Bennu's center of mass.

Data Format Descriptions

An attached XML label file describing the vintage of the shape model, and what other AL or SPC data were used to make the shape model in the first place.

Detailed Description of data format

Data Type – ASCII file with three numbers.

Field:

X-coordinate of centroid (center of figure) relative to center of mass (km),

Y-coordinate of centroid (center of figure) relative to center of mass (km),

Z-coordinate of centroid (center of figure) relative to center of mass (km)

Data Product Generation

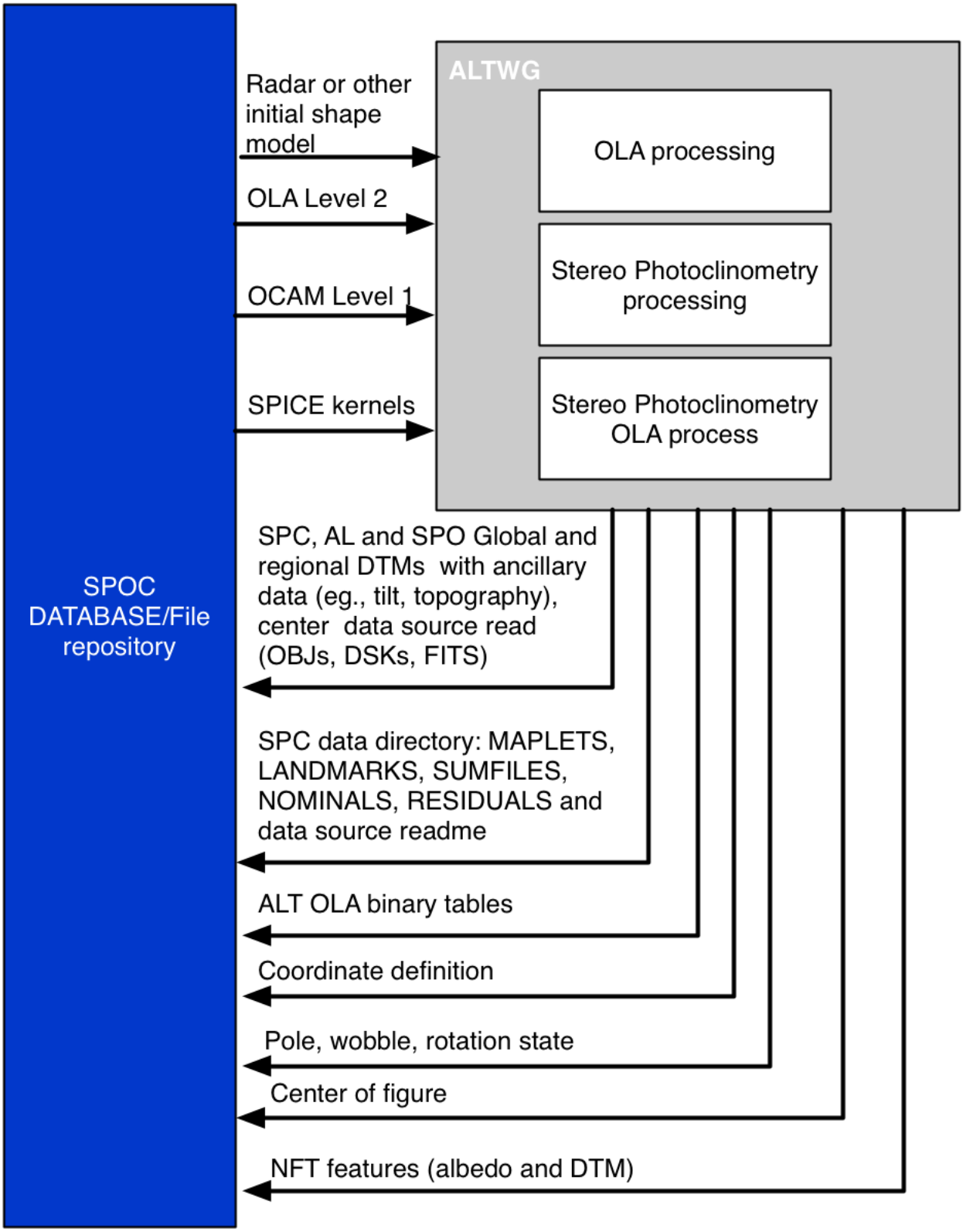
This product is generated after each shape model is produced by the ALTWG. This information will be output automatically in the header of each shape model produced. The spatial requirement of MRD-124 are achieved with a shape model made with OLA data produced in orbital phase-B, and with OLA and SPC data in the detailed survey phase. It is achieved with SPC following the Preliminary survey.

Data Product Validation

SPC and OLA process has been validated by using imagery and altimetry data from past mission such Dawn, Hayabusa and MESSENGER, and simulated OSIRIS-REx imagery and altimetry. These latter data were generated during SPC/OLA thread tests. The algorithms employed have heritage from Dawn, Hayabusa and MESSENGER.

Data Flow

For SPC, imagery, spacecraft attitude and trajectories are combined to determine through stereo and photoclinometry the shape of celestial object. This is achieved via a least squares inversion approach, where the topography at each pixel is modeled to match observations. When using OLA data, OLA level 2 data, where the x, y, z position of each return has been derived from OLA ranges, and spacecraft attitude and trajectory are combined together and minimized via least square to make the asteroid shape model, and regional high resolution terrain maps smooth and continuous. The following schematic provides the overall flow of this process.


SPOC DATABASE/File repository
Radar or other initial shape model
OLA Level 2
OCAM Level 1
SPICE kernels
ALTWG
OLA processing
Stereo Photoclinometry processing
Stereo Photoclinometry OLA process
SPC, AL and SPO Global and regional DTMs with ancillary data (eg., tilt, topography), center data source read (OBJs, DSKs, FITS)
SPC data directory: MAPLETS, LANDMARKS, SUMFILES, NOMINALS, RESIDUALS and data source readme
ALT OLA binary tables
Coordinate definition
Pole, wobble, rotation state
Center of figure
NFT features (albedo and DTM)