DART test Shape model collection review

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Overview

- **These collections contain a number of shape models and derived physical properties of these shape models along with the adequate documentation**
- **The documentation is provided as PDF files whereas the shape models are provided as OBJ and FITS files. There are two kinds of FITS files:**
  - **Image Cubes**
  - **Binary Tables -also called Ancillary files**
- **Image Cubes should contain all the information of the Binary Tables as different layers that can be overlayed in the shape model**

Opening Remarks

- **Only the data and documentation in accordance to NAIF's area of expertise have been reviewed. This mainly excludes the validation of the test/verify physical properties from the FITS Image Cubes and/or Binary Table (is test data anyhow.)**

- **Items that are considered liens, and therefore required to be addressed to pass the review from NAIF side are marked with [LIEN], the other items are --strong-- suggestions.**

PDS Validate Tool

Navigation and Ancillary Information Facility

- **PDS Validate tool has not been run on the collections, context products are missing.**
  - **Context Products should be provided for PDS4 reviews.**
- **Running the validate tool yelds to 6 errors and 1 warning**

```
$./validate -v 1 -t ~/dart/shape_review/dart --skip-context-validation \
          -R pds4.bundle -x PDS4_PDS_1E00.xsd -S PDS4_PDS_1E00.sch \
          -r dart_shapemodel.validate_report
```

- **Validation report is included in the review material**

PDS Validate Tool

Navigation and Ancillary Information Facility

- dart_coordinate_system_for_didymos_and_dimorphos_v1.pdf is incorrect, the PDF/A version must be corrected. [LIEN]
- Missing label for g_08440mm_spc_dtm_dimo_0000n00000_v002.fits [LIEN]
- Number of fields for binary tables in the following labels are incorrect:
  - g_08440mm_spc_nvf_dimo_0000n00000_v002.xml
  - l_08575mm_spc_nvf_dimo_1325s10722_v002.xml
  - g_08440mm_spc_grv_dimo_0000n00000_v002.xml
  - l_08575mm_spc_grv_dimo_1325s10722_v002.xml

  In the label:

  ```
  <Record_Binary>
      <fields>6</fields>
  ```

  but then there are 10 fields. [LIEN]
- There is a wrong offset in an entry in the table of:
  - l_08575mm_spc_obj_dimo_1325s10722_v002.fits [LIEN]

Documents

- **dart_coordinate_system_for_didymos_and_dimorphos_v1.pdf**
  - **Incorrect PDF/A type as reported by validate tool otherwise OK**
  - **Also given that no other document is versioned in the collections, I would drop "v1" from the name**
- **dart_shapemodel_sis.pdf [LIEN]**
  - **Several internal reference errors noted**
  - **Incorrect Section referenced**
  - **SPICE Kernels are mentioned as if they were present in the archive but they are not.**

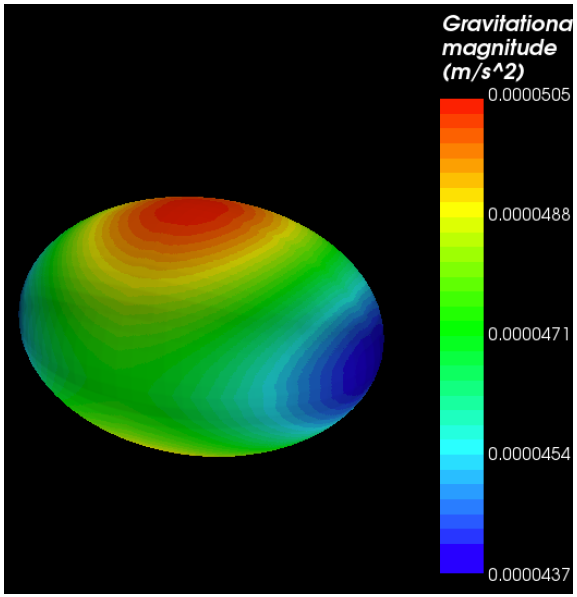
Shape Models

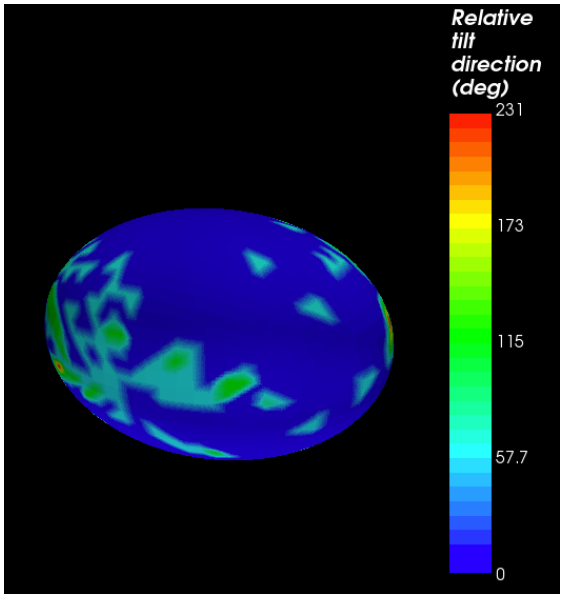
- **Only Dimorphos test shape models have been provided even though Didymos models already exist.**
- **overview.txt, its label and collection label**
  - **Several typos and errors, suggestions provided.**
- **model01 directory**
  - **Selected name is indicative of the shape model version, this nomenclature is not explained elsewhere recommend to include it in the overview file.**
- **All FITS and OBJ labels mention an UNKNOWN shape model. The shape model is known and included in the bundle the label fields affected are [LIEN]:**
  - **Identification_Area/title**
  - **File_Area_Observational/File/comment**
- **l_08575mm_spc_obj_dimo_1325s10722_v002 label requires a fix (validation tool)**

Shape Models

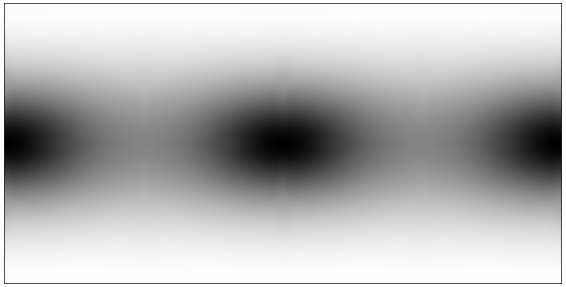
Navigation and Ancillary Information Facility

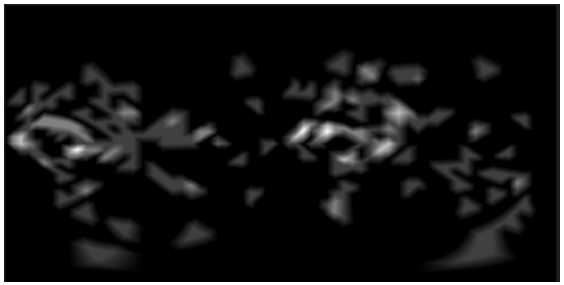
- **Image Cube FITS files have been tested with AstroImageJ, SAOImageDS9, and the Small Bodies Mapping tool**
- **OBJ files have been inspected**
  - **SBMT shape models overlayed with quantities**





  - **Quantities in a contour plot with SAImageDS9**





Shape Models

Navigation and Ancillary Information Facility

- **Header of the DTM file has been inspected.**
- **The Binary Table FITS files cannot be opened with the beforementioned SW but they have been read and inspected with PDS4 Viewer. Some values have been cross-checked.**

g_08440mm_spc_dtm_dimo_0000n00000_v002.fits

```
MAP_VER = '0.0.2    '           / Product version number.
MAP_TYPE= 'global   '           / Defines whether this is a global or local map
GSD     =                8440.0 / [mm] grid spacing in units/pixel
COMMENT summary spatial information
CLON    =                   0.0 / [deg] longitude at center of image
CLAT    =                   0.0 / [deg] latitude at center of image
LLCLNG  =                 180.0 / [deg]
LLCLAT  =                 -90.0 / [deg]
URCLNG  =                 180.0 / [deg]
URCLAT  =                  90.0 / [deg]
LRCLNG  =                 180.0 / [deg]
LRCLAT  =                 -90.0 / [deg]
ULCLNG  =                 180.0 / [deg]
ULCLAT  =                  90.0 / [deg]
COMMENT plane information
PLANE1  = 'Latitude of vertices' / [deg]
PLANE2  = 'Longitude of vertices' / [deg]
PLANE3  = 'Radius of vertices' / [km]
PLANE4  = 'X coordinate of vertices' / [km]
PLANE5  = 'Y coordinate of vertices' / [km]
PLANE6  = 'Z coordinate of vertices' / [km]
PLANE7  = 'Normal vector X'
PLANE8  = 'Normal vector Y'
PLANE9  = 'Normal vector Z'
PLANE10 = 'Gravity vector X'    / [m/s^2]
PLANE11 = 'Gravity vector Y'    / [m/s^2]
PLANE12 = 'Gravity vector Z'    / [m/s^2]
PLANE13 = 'Gravitational magnitude' / [m/s^2]
PLANE14 = 'Gravitational potential' / [J/kg]
PLANE15 = 'Elevation'           / [m]
PLANE16 = 'Slope    '           / [deg]
PLANE17 = 'Area     '           / [km^2]
PLANE18 = 'Facet tilt'          / [deg]
PLANE19 = 'Facet tilt direction' / [deg]
PLANE20 = 'Mean tilt'           / [deg]
PLANE21 = 'Tilt variation'      / [deg]
PLANE22 = 'Mean tilt direction' / [deg]
PLANE23 = 'Tilt direction variation' / [deg]
PLANE24 = 'Relative tilt'       / [deg]
PLANE25 = 'Relative tilt direction' / [deg]
PLANE26 = 'Max relative height' / [km]
COMMENT product specific
SIGMA   =                -999.0 / Global uncertainty of the data [m]
SIG_DEF = 'Uncertainty'         / SIGMA uncertainty metric
PXPERDEG=                  2.0 / [pixel per degree] grid spacing of global map.
DENSITY =               2170.0 / [kgm^-3] density of body
ROT_RATE=     1.54567447948E-4 / [rad/sec] rotation rate of body
REF_POT = -0.00411002566691244 / [J/kg] reference potential of body
TILT_MAJ=                  1.5 / [m] semi-major axis of ellipse for tilt calcs
TILT_MIN=                  1.5 / [m] semi-minor axis of ellipse for tilt calcs
TILT_PA =                  0.0 / [deg] position angle of ellipse for tilt calcs
END
```

PDS4 Viewer - Data Structure Summary for '/Users/mcosta/dart/shape_review/dart/shapemodel/model01/g_08440mm_spc_grm_dim...

Index	Name	Type	Dimension	View
2	g_08440mm_spc_grm_dimo_0000n0...	Table_Binary	6 cols X 3072 rows	Label Table Plot

PDS4 Viewer - Table 'g_08440mm_spc_grm_di

Row #	FACET_NUM	LATITUDE	LONGITUDE	RADIUS	GRAVITATIONAL MA	SIGMA
0	0	33.6335	136.882	0.0804389	4.80032e-05	nan
1	1	33.4062	140.615	0.0812974	4.79027e-05	nan
2	2	35.869	142.515	0.080504	4.80961e-05	nan
3	3	35.3232	146.154	0.0814498	4.79725e-05	nan
4	4	37.7396	148.145	0.0805621	4.8175e-05	nan
5	5	36.8976	151.621	0.0815751	4.80316e-05	nan
6	6	39.2649	153.773	0.080607	4.8241e-05	nan
7	7	38.1548	157.035	0.0816784	4.80794e-05	nan
8	8	40.4652	159.407	0.0806437	4.82932e-05	nan

Shape Models

- **Although there are several FITS and OBJ files in reality two shape models are present: a test global model and a test local model. The Image cube FITS is missing for the local model [LIEN]:**
  - **l_08575mm_spc_dtm_dimo_1325s10722_v002.fits**
- **The label for the global image cube FITS is missing:**
  - **g_08440mm_spc_dtm_dimo_0000n00000_v002.xml**
- **The header of the global image cube is missing (or the documentation is wrong) [LIEN]:**
  - **HDRVERS (The version number of this FITS header)**
- **The header has an incorrect value for the target keyword (or the documentation is wrong) [LIEN]:**
  - **TARGET = 'DIMORPHOS' instead of '920065803 Dimorphos'**
- **There is a plane (ALBEDO) missing in the global image cube, that is present as an ancillary FITS file [LIEN]:**
  - **g_08440mm_spc_alb_dimo_0000n00000_v002.fits**
- **SIGMA values for most of binary tables are "nan", a value compliant with the format specified by the label: IEEE 754 MSB single precision floating point, could be used e.g.: -999**

Missing SPICE Kernels

- **SPICE kernels for shape models (DSKs) are missing in the collection. This is perfectly OK, and in fact is somehow documented in dart_shapemodel_sis.pdf There are two different approaches:**
  1. **Include the relevant SPICE Kernels for full exploitation of the shape model in the collection. The SPICE Kernels would be duplicated then in the SPICE Kernel Bundle**
  2. **Do not include the SPICE Kernels in the collection**
- **Whatever option is chosen it has to be ensured that there is a 1-to-1 correspondance in between OBJ files, DTM Image Cubes files, and DSKs (Digital Shape Kernels):**
  - **g_08440mm_spc_obj_dimo_0000n00000_v002.bds**
  - **l_08575mm_spc_obj_dimo_1325s10722_v002.bds**

  (dsk, or bds instead of obj)
- **In addition, there should be a PCK for the Didymos system, a SPK for both bodies, and maybe a CK for each body (in the case the rotation cannot be modeled by the PCK subsystem). These files are necessary to understand the rotation model and they should be referenced by this collections if they are not included.**

Conclusions

- **Validate Tool Run should result in no errors or warnings -including context products**
- **Documents might need corrections if that is possible**
- **There are missing data files in the shapemodel collection**
- **There is a total of 10 liens and several suggestions. Liens should be resolved.**

- **I would like to remark that I have not seen any hint of coordination with ESA's HERA project with respect to shape models.**