Double Asteroid Redirection Test (DART) Mission Dictionary

NASA Planetary Data System

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USER GUIDE

The Double Asteroid Redireciton Test (DART) planetary defense mission flew to the (65803) Didymos system and impacted Dimorphos, the moon in that system, to attempt to modify the moon's orbit. The LICIACube cubesat flew along with the DART primary spacecraft until shortly before impact, at which point it detached to observe the impact and survive the encounter. The successful impact of the DART spacecraft occured on 26 September 2022. The DART spacecraft carreed the DRACO (Didymos Reconnaissance and Asteroid Camera for Optical Navigation) instrument on board. The LICIACube satellite carries two imagers: LICIACube Explorer Imaging for Asteroid (LEIA), and panchromatic camera; and LICIACube Unit Key Explorer (LUKE), a wide-field RGB camera.

CHAPTER

ONE

INTRODUCTION

This *User's Guide* provides a brief overview of the Double Asteroid Redirection Test (DART) mission namespace for those working with data from this mission.

Note *that the data production from the DART mission is ongoing. There will likely be modifications made to this namespace as that effort continues.*

This guide present the major features of the namespace.

CHAPTER

TWO

OVERVIEW OF THE DART MISSION DICTIONARY

The Double Asteroid Redireciton Test (DART) planetary defense mission flew to the (65803) Didymos system and impacted Dimorphos, the moon in that system, to attempt to modify the moon's orbit. The LICIACube cubesat flew along with the DART primary spacecraft until shortly before impact, at which point it detached to observe the impact and survive the encounter. The successful impact of the DART spacecraft occured on 26 September 2022. The DART spacecraft carreed the DRACO (Didymos Reconnaissance and Asteroid Camera for Optical Navigation) instrument on board. The LICIACube satellite carries two imagers: LICIACube Explorer Imaging for Asteroid (LEIA), and panchromatic camera; and LICIACube Unit Key Explorer (LUKE), a wide-field RGB camera.

- **Steward:** Ray Espiritu, APL and Anne Raugh (@acraugh on GitHub), SBN
- **Dictionary Repo:** https://github.com/pds-data-dictionaries/ldd-dart
- **Namespace Prefix:** dart:

Corrections, changes, and additions should be submitted directly to the stewards.

CHAPTER

THREE

ORGANIZATION OF CLASSES AND ATTRIBUTES

The DART dictioanry has a single top-level class that must be used to access any of the DART metadata classes. This class contains the mission phase identifier, a *<dart:Time>* class for overall timing information, and subclasses that are included as needed depending on the instrument that produced the data product.

3.1 Top-Level Class: <dart:DART_Parameters>

The *<dart:DART_Parameters>* class acts as a wrapper for all other DART classes. It contains one required attribute, *<dart:mission_phase>* for the mission phase identification, and five optional classes used as appropriate for the specific data product.

The major subclasses of the *<dart:DART_Parameters>* class are:

- *<dart:Time>*
- *<dart:DRACO_Instrument_Attributes>*
- *<dart:LEIA_Instrument_Attributes>*
- *<dart:LUKE_Instrument_Attribute>*
- *<dart:DRACO_Data_Processing_Information>*

You can see a complete outline of the namespace under the *DART Mission Namespace Outline* topic. Details of class and attribute definitions are provided as alphabetical lists in *Alphabetical List of Classes in the DART Mission Dictionary* and *Alphabetical List of Attributes in the DART Mission Dictionary*, respectively.

3.2 Subclass: <dart:Time>

This class contains attributes the provide timing information for the observation.

Attributes:

- acquisition_time - *Optional*
- soc_acquisition_time - *Optional*
- liciacube_sclk_image_time - *Optional*
- correct_image_time - *Optional*

3.3 Subclass: <dart:DRACO_Instrument_Attributes>

This class contains attributes that provide details about the DRACO instrument settings and observation parameters. It is used for observations made with the DRACO instrument aboard the DART spacecraft.

Attributes:

- imaging_mode - *REQUIRED*
- gain - *REQUIRED*
- bad_image - *Optional*
- observation_type - *Optional*
- lineread - *Optional*
- pix_delay - *Optional*
- exposure_time - *Optional*
- test_pattern - *Optional*
- binning - *Optional*
- window2_x_start - *Optional*
- window2_y_start - *Optional*
- window2_x_end - *Optional*
- window2_y_end - *Optional*
- onboard_cal - *Optional*
- calibration_file - *Optional*
- badpix_invalidation_mode - *Optional*
- detector1_temp - *Optional*
- detector2_temp - *Optional*
- fpe_temp - *Optional*
- current_18vd_supply - *Optional*
- current_33va_supply - *Optional*
- current_33vd_supply - *Optional*
- current_analog_reset_supply - *Optional*
- test_temp - *Optional*

3.4 Subclasses: <dart:LEIA_Instrument_Attributes> and <dart:LUKE_Instrument_Attributes>

The LEIA and LUKE instruments were flown aboard the LICIACube companion satellite for the mission. The class name is different, but the attribute content is the same irrespective of which instrument obtained the data.

Attributes:

- gain - *REQUIRED*

- readout_time - *REQUIRED*
- test_pattern - *Optional*
- binning - *Optional*
- detector_temp - *Optional*
- liciacube_calibration_file - *Optional*
- window_x_start - *Optional*
- window_y_start - *Optional*
- window_x_end - *Optional*
- window_y_end - *Optional*

3.5 Subclass: <dart:DRACO_Data_Processing_Information>

The attributes of this class signal which data reduction steps have been applied to the product in hand.

Attributes:

- undo_onboard_cal - *REQUIRED*
- bias_subtraction - *REQUIRED*
- dark_subtraction - *REQUIRED*
- flatfield - *REQUIRED*
- radiance_conversion - *REQUIRED*
- ioverf_conversion - *REQUIRED*

CHAPTER

FOUR

DART MISSION NAMESPACE OUTLINE

<dart:DART_Parameters> is the top-level entry point to the DART mission namespace. This class contains all other DART classes and must be included to gain access to them. Below is a summary outline of all classes and attributes currently available in the DART mission dictionary, in the order in which they would appear in a label if every single one was used.

Note that there are no real cases in which every single mission class and attribute would appear in a single label. The point of this outline is primarily to catalog what is present and show the required ordering within classes when they are included in a label.

```
<dart:DART_Parameters>
    <dart:mission_phase>

    <dart:Time>
        <dart:acquisition_time>
        <dart:soc_acquisition_time>
        <dart:liciacube_sclk_image_time>
        <dart:correct_image_time>

    <dart:DRACO_Instrument_Attributes>
        <dart:image_mode>
        <dart:gain>
        <dart:bad_image>
        <dart:observation_type>
        <dart:lineread>
        <dart:pix_delay>
        <dart:exposure_time>
        <dart:test_pattern>
        <dart:binning>
        <dart:window2_x_start>
        <dart:window2_y_start>
        <dart:window2_x_end>
        <dart:window2_y_end>
        <dart:onboard_cal>
        <dart:calibration_file>
        <dart:badpix_invalidation_mode>
        <dart:detector1_temp>
        <dart:detector2_temp>
        <dart:fpe_temp>
        <dart:current_18vd_supply>
        <dart:current_33va_supply>
        <dart:current_33vd_supply>
```

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```
        <dart:test_temp>

    <dart:LEIA_Instrument_Attributes>
        <dart:gain>
        <dart:readout_time>
        <dart:test_pattern>
        <dart:binning>
        <dart:detector_temp>
        <dart:liciacube_calibration_file>
        <dart:window_x_start>
        <dart:window_y_start>
        <dart:window_x_end>
        <dart:window_y_end>

    <dart:LUKE_Instrument_Attributes>
        <dart:gain>
        <dart:readout_time>
        <dart:test_pattern>
        <dart:binning>
        <dart:detector_temp>
        <dart:liciacube_calibration_file>
        <dart:window_x_start>
        <dart:window_y_start>
        <dart:window_x_end>
        <dart:window_y_end>

    <dart:DRACO_Processing_Information>
        <dart:undo_onboard_cal>
        <dart:bias_subtraction>
        <dart:dark_subtraction>
        <dart:flatfield>
        <dart:radiance_conversion>
        <dart:ioverf_conversion>
```

CHAPTER

FIVE

ALPHABETICAL LIST OF CLASSES IN THE DART MISSION DICTIONARY

Following is an alphabetical list of the classes in the DART mission dictionary. Within the listing, attributes and subclasses are listed in label order. See the Alphabetical List of Attributes for attribute definitions.

5.1 DART_Parameters

Included from: ***<pds:Mission_Area>*** Required for DART mission data products.

Atributes:

- dart:mission_phase - *Optional*

Subclasses:

- Time - *Optional*
- DRACO_Instrument_Attributes - *Optional*
- LEIA_Instrument_Attributes - *Optional*
- LUKE_Instrument_Attribtues - *Optional*
- DRACO_Data_Processing_Information - *Optional*

The <*dart:DART_Parameters*> class is the superclass containing all DART mission data dictionary classes.

5.2 DRACO_Data_Processing_Information

Included from: <*dart:DART_Parameters*>

Attributes:

- undo_onboard_cal - *REQUIRED*
- bias_subtraction - *REQUIRED*
- dark_subtraction - *REQUIRED*
- flatfield - *REQUIRED*
- radiance_conversion - *REQUIRED*
- ioverf_conversion - *REQUIRED*

Subclasses:

- None

The *<dart:DRACO_Data_Processing_Information>* class contains metadata describing the processing steps performed on the image. The processing steps are listed in the same order executed by the data processing pipeline.

5.3 DRACO_Instrument_Attributes

Included from: *<dart:DART_Parameters>*

Attributes:

- imaging_mode - *REQUIRED*
- gain - *REQUIRED*
- bad_image - *Optional*
- observation_type - *Optional*
- lineread - *Optional*
- pix_delay - *Optional*
- exposure_time - *Optional*
- test_pattern - *Optional*
- binning - *Optional*
- window2_x_start - *Optional*
- window2_y_start - *Optional*
- window2_x_end - *Optional*
- window2_y_end - *Optional*
- onboard_cal - *Optional*
- calibration_file - *Optional*
- badpix_invalidation_mode - *Optional*
- detector1_temp - *Optional*
- detector2_temp - *Optional*
- fpe_temp - *Optional*
- current_18vd_supply - *Optional*
- current_33va_supply - *Optional*
- current_33vd_supply - *Optional*
- current_analog_reset_supply - *Optional*
- test_temp - *Optional*

Subclasses:

- None

The *<dart:DRACO_Instrument_Attributes>* class contains metadata associated with the DRACO Instrument.

5.4 LEIA_Instrument_Attributes

Included from: <*dart:DART_Attributes*>

Attributes:

- gain - *REQUIRED*
- readout_time - *REQUIRED*
- test_pattern - *Optional*
- binning - *Optional*
- detector_temp - *Optional*
- liciacube_calibration_file - *Optional*
- window_x_start - *Optional*
- window_y_start - *Optional*
- window_x_end - *Optional*
- window_y_end - *Optional*

Subclasses:

- None

The <*dart:LEIA_Instrument_Attributes*> class contains metadata associated with the LEIA Instrument on the LICIACube spacecraft.

5.5 LUKE_Instrument_Attributes

Included from: <*dart:DART_Attributes*>

Attributes:

- gain - *REQUIRED*
- readout_time - *REQUIRED*
- test_pattern - *Optional*
- binning - *Optional*
- detector_temp - *Optional*
- liciacube_calibration_file - *Optional*
- window_x_start - *Optional*
- window_y_start - *Optional*
- window_x_end - *Optional*
- window_y_end - *Optional*

Subclasses:

- None

The <*dart:LUKE_Instrument_Attributes*> class contains metadata associated with the LUKE Instrument on the LICIACube spacecraft.

5.6 Time

Included from: <*dart:DART_Parameters*>

Attributes:

- acquisition_time - *Optional*
- soc_acquisition_time - *Optional*
- liciacube_sclk_image_time - *Optional*
- correct_image_time - *Optional*

Subclasses:

The <*dart:Time*> class contains metadata describing different time components associated with the DART mission.

CHAPTER

SIX

ALPHABETICAL LIST OF ATTRIBUTES IN THE DART MISSION DICTIONARY

Following is an alphabetical list of the attributes in the DART mission dictionary. See the Alphabetical List of Classes for attribute definitions.

6.1 acquisition_time

Data Type: String **Unit:** Seconds **Note:** Nillable

DRACO image time of validity (TOV) in integer seconds, in spacecraft clock notation. This is the time for which the GNC attitude data is valid. See the DRACO SIS for calculation of this value.

6.2 bad_image

Data Type: Enumerated **Values:** *true*, *false*

"True" identifies image whose image data and FPE metadata are not reliable and should not be used for analysis.

6.3 badpix_invalidation_mode

Data Type: Enumerated **Values:** *USE*, *BYPASS* **Unit:**

lags whether bad pixels identified by the on-board bad pixel map are invalidated by SMARTNAV. When invalidated the pixels in the raw image are set to the SNAVFLAG value in the raw fits header.

6.4 bais_subtraction

Data Type: Enumerated **Values:** *PERFORM*, *SKIP*

Indicates whether bias subtraction step was done. If performed, then refer to the REFBIAS keyword in the fits header for the name of the bias file used. This file is also archived in the DRACO Calibrated Data Collection.

6.5 binning

Data Type: Enumerated **Values:** *ON*, *OFF*

Identifies whether pixel binning was applied to generate the image.

6.6 calibration_file

Data Type: ASCII_File_Name

Name of calibration table file provided by SMART Nav to the spacecraft for use when onboard calibration is applied. Data values from this file are added back to the downloaded image if applied to the image on board. The file is stored on-board as a .mat file, but the same data values are archived in the DRACO Calibrated Data Collection as a .fits file. The archived filename is the same as the base filename shown here with the '.fits' extension.

6.7 correct_image_time

Data Type: ASCII_String

UTC Time at mid exposure used to define attitude and representative geometric attributes.

6.8 current_18vd_supply

Data Type: ASCII_Real **Units of:** Current

Current for detector 1.8VD supply.

6.9 current_33va_supply

Data Type: ASCII_Real **Units of:** Current

Current for detector 3.3VA supply.

6.10 current_33vd_supply

Data Type: ASCII_Real **Units of:** Current

Current for detector 3.3VD supply.

6.11 current_analog_reset_supply

Data Type: ASCII_Real **Units of:** Current

Current for detector analog reset supply.

6.12 dark_subtraction

Data Type: Enumerated **Values:** *PERFORM*, *SKIP*

Indicates whether dark subtraction step was done. If performed then refer to the REFDARK1 and REFDARK2 keywords in the fits header for the names of the dark files used. These files are also archived in the DRACO Calibrated Data Collection. Also refer to the DRACO calibration pipeline description document to see how the two files are utilized to interpolate temperature dependent dark currents.

6.13 detector1_temp

Data Type: ASCII_Real **Units of:** Temperature

DRACO detector temperature sensor 1.

6.14 detector2_temp

Data Type: ASCII_Real **Unit:** Temperature

DRACO detector temperature sensor 2.

6.15 detector_temp

Data Type: ASCII_Real **Units of:** Temperature

Instrument detector temperature for LICIACube. The container class identifies whether it is for LUKE or LEIA.

6.16 exposure_time

Data Type: ASCII_Real **Unit:** Seconds

Image exposure time in seconds.

6.17 flatfield

Data Type: Enumerated **Values:** *PERFORM*, *SKIP*

Indicates whether flat field was applied. If performed then refer to the REFFLAT keyword in the fits header for the names of the flat field files used. This file is also archived in the DRACO Calibrated Data Collection.

6.18 fpe_temp

Data Type: ASCII_Real **Units of:** Temperature

DRACO FPE board temperature

6.19 gain

Data Type: Enumerated **Values:** *1X*, *2X*, *10X*, *30X*

Defines the detector gain setting used. The container class identifies whether this is for the DRACO, LUKE, or LEIA detectors.

6.20 imaging_mode

Data Type: Enumerated **Values:** *GLOBAL*, *ROLLING*

The imaging_mode defines the shutter readout mode of the DRACO detector.

6.21 ioverf_conversion

Data Type: Enumerated **Values:** *PERFORM*, *SKIP*

Indicates whether conversion to I/F was applied. If performed then refer to the DRACO calibraiton pipeline description document for the steps performed to convert pixel values to I/F. The F_SUN622 keyword in the fits header contains the solar flux at 622nm (the DRACO pivot wavelength) as well as the PHDIST and SHDIST keywords for the heliocentric distance to the primary and secondary bodies respectively.

6.22 liciacube_calibration_file

Data Type: ASCII_File_Name

Name of calibration table file used by LICIACube calibration pipeline.

6.23 liciacube_sclk_image_time

Data Type: ASCII_String

Start of image capture time in spacecraft clock notation. Numeric number preceding the decimal point is integer seconds. Numeric number after the decimal point is subsecond clock ticks, where each tick represents TBD microseconds.

6.24 lineread

Data Type: ASCII_Real

Defines the time it takes to readout a single line of the detector in microsec/line.

6.25 mission_phase

Data Type: Enumerated **Values:** *prelaunch*, *commissioning*, *cruise*, *approach*, *terminal*, *final*

The mission_phase identifies the time period within the mission.

6.26 observation_type

Data Type: ASCII_String

Describes the purpose for which the image was taken.

6.27 onboard_cal

Data Type: Enumerated **Values:** *ON*, *OFF*

Defines whether calibration table was applied to the DRACO image onboard the DART spacecraft prior to downlink.

6.28 pix_delay

Data Type: ASCII_Real

Delay between sequential pixels in line in nanoseconds.

6.29 radiance_conversion

Data Type: Enumerated **Values:** *PERFORM*, *SKIP*

Indicates whether conversion to radiance was applied. If performed then refer to the the DRACO calibration pipeline description document for the steps performed to convert pixel values to electrons then from electrons to radiance. The lookup table used to convert pixel values to electrons is stored in the LUPTABLE keyword in the fits header along with the photometric keyword RDIDYMOS. The lookup table file is also archived in the DRACO Calibrated Data Collection.

6.30 readout_time

Data Type: ASCII_Real

Defines the time it takes to readout a single line of the detector in microsec/line.

6.31 soc_acquisition_time

Data Type: ASCII_String

DRACO image time of validity calculated by the SOC based on FPE_SEC and FPE_SBSS in the fits header. This way the SOC can calculate an estimated time of validity even when an image does not correlate to information provided by GNC. See the DRACO SIS for information on how this value is calculated.

6.32 test_pattern

Data Type: ASCII_String

Flag to show if image is a test pattern. If it is then the value corresponds to the test pattern used.

6.33 test_temp

Data Type: ASCII_Real **Units of:** Temperature

Nominal temperature for the test sequence used to generate the data product. Reported by the calibration files, i.e. flat fields, bias, and dark images.

6.34 undo_onboard_cal

Data Type: Enumerated **Values:** *UNDONE*, *NA*

Indicates whether on-board calibration table was undone, ie. by adding it back to the image. NA if onboard_cal table was not applied to the image.

6.35 window2_x_end

Data Type: ASCII_Integer **Range:** -1 to 1023

Ending column of windowed image data with respect to a 1024 x 1025 image array, where the top row of the array is the header row containing metadata associated with the image. Upper left hand corner is coordinate 0,0. Set to -1 if windowing is not applied.

6.36 window2_x_start

Data Type: ASCII_Integer **Range:** -1 to 512

Starting column of windowed image data with respect to a 1024 x 1025 image array, where the top row of the array is the header row containing metadata associated with the image. Upper left hand corner is coordinate 0,0. Set to -1 if windowing is not applied.

6.37 window2_y_end

Data Type: ASCII_Integer **Range:** -1 to 1024

Ending row of windowed image data with respect to a 1024 x 1025 image array, where the top row of the array is the header row containing metadata associated with the image. Upper left hand corner is coordinate 0,0. Set to -1 if windowing is not applied.

6.38 window2_y_start

Data Type: ASCII_Integer **Range:** -1 to 512

Starting row of windowed image data with respect to a 1024 x 1025 image array, where the top row of the array is the header row containing metadata associated with the image. Upper left hand corner is coordinate 0,0. Set to -1 if windowing is not applied.

6.39 window_x_end

Data Type: ASCII_Integer **Range:** -1 to 512

Column where window ends with respect to a LICIACUBE image array. The container identifies whether this is the LEIA or LUKE image array. The LEIA image array is 2048 x 2048, the LUKE image array is For LEIA this is a 2048 x 2048 image, for LUKE it is a 1088 x 2048 image. Upper left hand corner is coordinate 0,0. Set to -1 if windowing is not applied.

6.40 window_x_start

Data Type: ASCII_Integer **Range:** -1 to 512

Column where window starts with respect to a LICIACUBE image array. The container identifies whether this is the LEIA or LUKE image array. The LEIA image array is 2048 x 2048, the LUKE image array is For LEIA this is a 2048 x 2048 image, for LUKE it is a 1088 x 2048 image. Upper left hand corner is coordinate 0,0. Set to -1 if windowing is not applied.

6.41 window_y_end

Data Type: ASCII_Integer **Range:** -1 to 512

Row where window ends with respect to a LICIACUBE image array. The container identifies whether this is the LEIA or LUKE image array. The LEIA image array is 2048 x 2048, the LUKE image array is For LEIA this is a 2048 x 2048 image, for LUKE it is a 1088 x 2048 image. Upper left hand corner is coordinate 0,0. Set to -1 if windowing is not applied.

6.42 window_y_start

Data Type: ASCII_Integer **Range:** -1 to 512

Row where window starts with respect to a LICIACUBE image array. The container identifies whether this is the LEIA or LUKE image array. The LEIA image array is 2048 x 2048, the LUKE image array is For LEIA this is a 2048 x 2048 image, for LUKE it is a 1088 x 2048 image. Upper left hand corner is coordinate 0,0. Set to -1 if windowing is not applied.