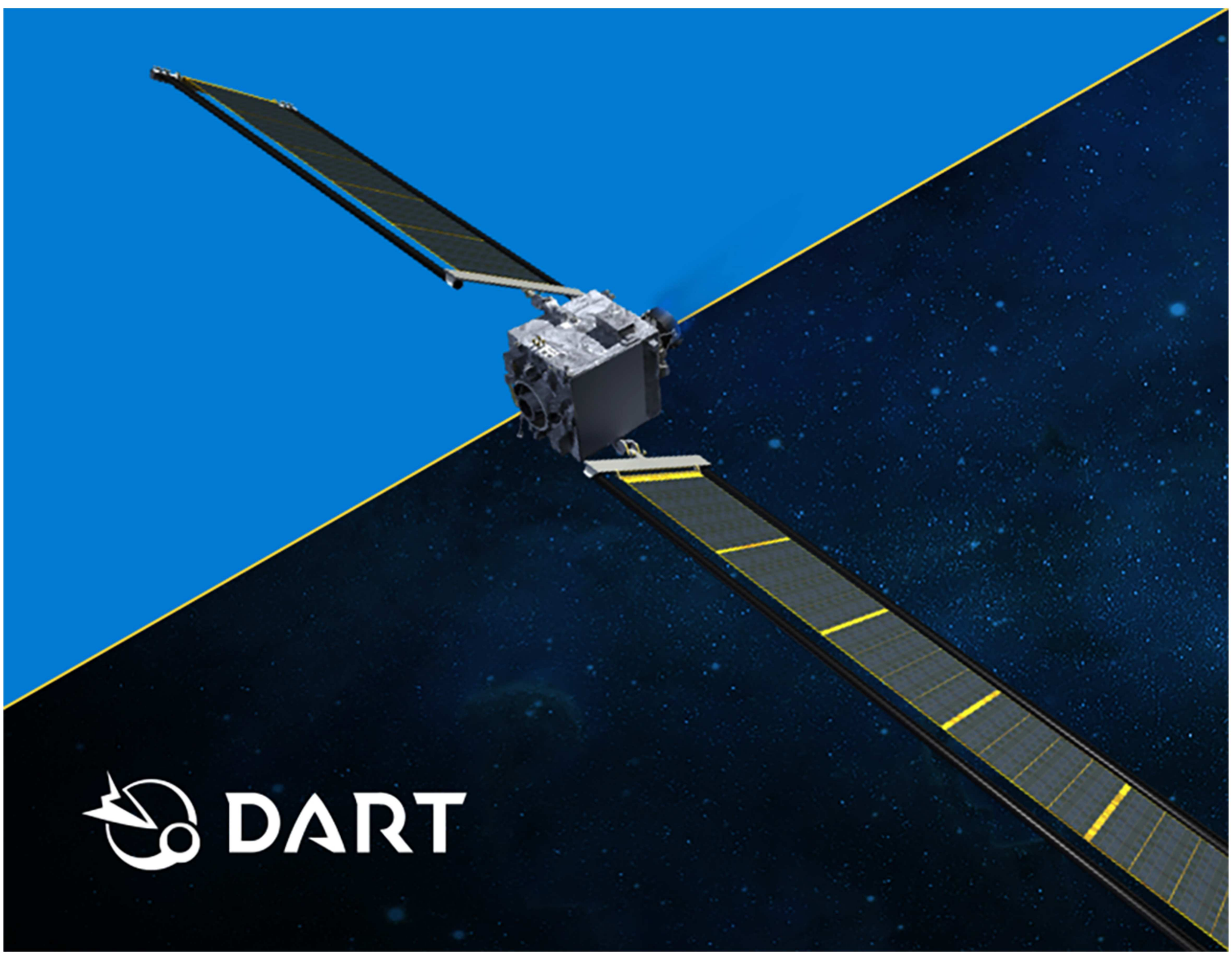
Didymos Reconnaissance and Asteroid Camera for OpNav (DRACO)
Uncalibrated/Calibrated Data Product
Software Interface Specification



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Revision Log

Version	Description of Change/Remarks	Date
1.0	Initial Release	2022-07-22
2.0	Complete review and edits to accompany second PDS delivery	2022-12-02

DRACO Keyword Cheat Sheet

Certain keywords in FITS header can help you find images that suit your needs. Other keywords flag images to avoid or pixels to be aware of. The following is a cheat sheet to those subsets of keywords.

Avoid images with these keyword values*.

Keyword	Values to look for	What these values mean
TSTPTTRN	STATHORZ, DYNAHORZ, TWOBOX, FLAT	These values indicate that the image is a test pattern.
BADIMAGE	TRUE	If BADIMAGE = 'TRUE', then the metadata and image contain invalid information. Do **not** use images with BADIMAGE=TRUE for any analyses.

*Look out for these in raw images. No calibrated images should have these keyword values.

Be cautious when analyzing images with these keyword values†.

Keyword	Values to look for	What these values mean
MISPXCNT	> 0	MISPXCNT >0 indicates a partial image. Missing pixels are set to the value indicated in MISPXVAL.
CALIB	ON	CALIB relates to an onboard calibration table used by SMART Nav. CALIB = ON indicates that on-board calibration was applied to the image. It does not mean that the image was calibrated by the SOC. Images calibrated by the SOC are located in the DRACO Calibrated Data Collection. See the Calibration Pipeline Description for details on how a calibrated image is created when on-board calibration is applied.
ATT_VAL	0	0 means that the attidue information in the FITS header is considered invalid.

†Assuming you've already removed any images users should avoid.

Use these keywords to identify images that meet your needs.

Keyword	Possible values	What these values mean
OBSTYPE	See Table 2 in SIS. Example values include TERMINAL, LIGHTCURVE, STAR_CLUSTER, BADIMAGE, PARTIAL_HDR, etc.	This keyword describes the type of observation during which a DRACO image was taken. Filter on this keyword if you want to hone in a particular set of images (e.g., lightcurve observations).
MPHASE	PRELAUNCH, COMMISIONNING, CRUISE, APPROACH, TERMINAL, FINAL	The DART mission is divided into phases; this keyword states the phase during which the image was acquired. Use this later in the mission to identify the high-resolution FINAL phase images.

Keyword	Possible values	What these values mean
IMGMOD	GLOBAL, ROLLING	Shutter mode used to acquire image. Rolling shutter has better sensitivity but introduces some distortion due to readout.
GAIN	1X, 2X, 10X, 30X	Detector gain setting. The bias, readnoise, etc. levels differ among gain states.
EXPTIME	Image integration time in seconds	Common values are 25, 50, and 90 ms; bias frames have an 87.467 µs EXPTIME.
WINDOWH	512; 1024	All DRACO image FITS files are 1024x1024. In some cases, the spacecraft sends down a 512x512 window, which the MOC correctly positions in the 1024x1024 frame. If WINDOWH = 512, then pixels outside of that window are set to the value in PXOUTWIN.
ACQ_UTC		The is the image time of validity—the time when the attidue information in the FITS header is valid. See Table 9 for additional detail on how this is calculated.
SMEARIN*	0 to 0.2	Smear in the X, Y, and Z directions, respectively. Images with larger values may look more smeared, though these inidicators are imperfect. See Table 9 and Section 4.3.2.1 for additional details, as well as for some additional keywords to look at if these keywords are blank for a particular image.

Be aware of pixels with these special values‡.

Keyword	Pixel value to look for	What the value(s) mean
MISPXVAL	-32768 (raw images) 1E10 (calibrated images)	This is the value assigned to missing pixels. You will encounter this value in partial images.
PXOUTWIN	32767 (raw images) -1E10 (calibrated images)	All of the pixels outside of the 512x512 window will be set to this value, in the case of a 512x512 image.
SATPXVAL	1E09 (calibrated images only)	Pixels with this value were saturated.
BADMASKV	-1E09 (calibrated images only)	Pixels with this value have a bad photoresponse and should be ignored.
OORADLUT	+1E08 (calibrated images only)	The DN value in this pixel was too large to be radiometrically calibrated, but the corresponding pixel in the raw image was not saturated.
IOVRFLAG	-1E08 (I/F calibrated images only)	The DN value in this pixel was negative before conversion to I/F.

‡An image with these values might look funny with an autostretch.

Full details on all keywords are in this SIS and the Calibration Pipeline Description.

CONTENTS

1. Purpose and Scope

This Software Interface Specification (SIS) describes the Didymos Reconnaissance and Asteroid Camera for OpNav (DRACO) uncalibrated and calibrated data products. The DART Science Operations Center (SOC) located at Johns Hopkins University Applied Physics Laboratory (APL) produces these products and distributes them to the DART Investigation Team (IT) and the Planetary Data System (PDS).

This document provides users with a detailed description of the data products, how they were generated, and how they are organized in the archive. The document is intended to provide sufficient information to enable users to read and understand the data products. The intended audience is the scientists who will analyze the data, including those associated with the DART mission and those in the general planetary science community.

2. Applicable Documents and Constraints

This DRACO data product SIS is consistent with the following Planetary Data System documents:

1. Planetary Data System Standards Reference, Version 1.14.0, May 22, 2020
2. PDS4 Data Dictionary, Abridged, Version 1.14.0.0, March 23, 2020
3. PDS4 Information Model Specification, Version 1.14.0.0, March 23, 2020

This DRACO data product SIS is responsive to the following DART documents:

1. DRACO Calibration Pipeline Description, December 2022
2. Dimorphos Coordinate System Description, December 2022

This DRACO data product SIS is consistent with the following documents:

1. Fletcher et al., 2022. Didymos Reconnaissance and Asteroid Camera for Opnav (DRACO): Design, Fabrication, Test and Operation, Proc. SPIE, Space Telescopes and Instrumentation 2022: Optical, Infrared, and Millimeter Wave, 121800E (29 August 2022), doi: 10.1117/12.2627873
2. Fletcher et al., Design of the Didymos Reconnaissance and Asteroid Camera for OpNav (DRACO) on the Double Asteroid Redirection Test (DART), Proc. SPIE 10698, Space Telescopes and Instrumentation 2018: Optical, Infrared, and Millimeter Wave, 106981X (6 July 2018), doi: 10.1117/12.2310136
3. Bekker, D., Smith, R., Tran, M. Q., 2021. Guiding DART to impact – the FPGA SoC design of the DRACO image processing pipeline. 2021 IEEE Space Computing Conference, 122–133. doi: 10.1109/SCC49971.2021.00020
4. Chen et al., Small-Body Maneuvering Autonomous Real-Time Navigation (SMART Nav): Guiding a Spacecraft to Didymos for NASA's Double Asteroid Redirection Test (DART), Proc. Advances in the Astronautical Sciences AAS/AIAA Guidance, Navigation and Control 2018, 164, AAS 18-063.

3. Relationships with Other Interfaces

Changes to the data products described in this SIS may affect the documents listed in Table 1. In the event of a conflict between the DRACO SIS and the DRACO Calibration Pipeline Description, the SIS takes precedence.

Table 1. Interface Relationships

Name	Type	Owner
DRACO Calibration Pipeline Description	Document	DART SOC

4. Data Product Characteristics and Environment

4.1. *Instrument Overview*

The Didymos Reconnaissance and Asteroid Camera for OpNav (DRACO) is a narrow field-of-view imager on NASA's Double Asteroid Redirection Test (DART) spacecraft (Figure 1). DRACO is designed to support optical navigation of the spacecraft and ensure impact with Dimorphos (the secondary member of the Didymos system), to refine system properties (e.g., orbit, rotation rate, pole), to characterize the surface characteristics and shape of Dimorphos during the Terminal and Final mission phases, and to constrain the location of the impact site. The latter observations will allow insight into target properties, presence or absence of blocks at the impact site, and impact angle, which will feed into the estimation of dynamical changes in the Didymos system resulting from the DART impact.

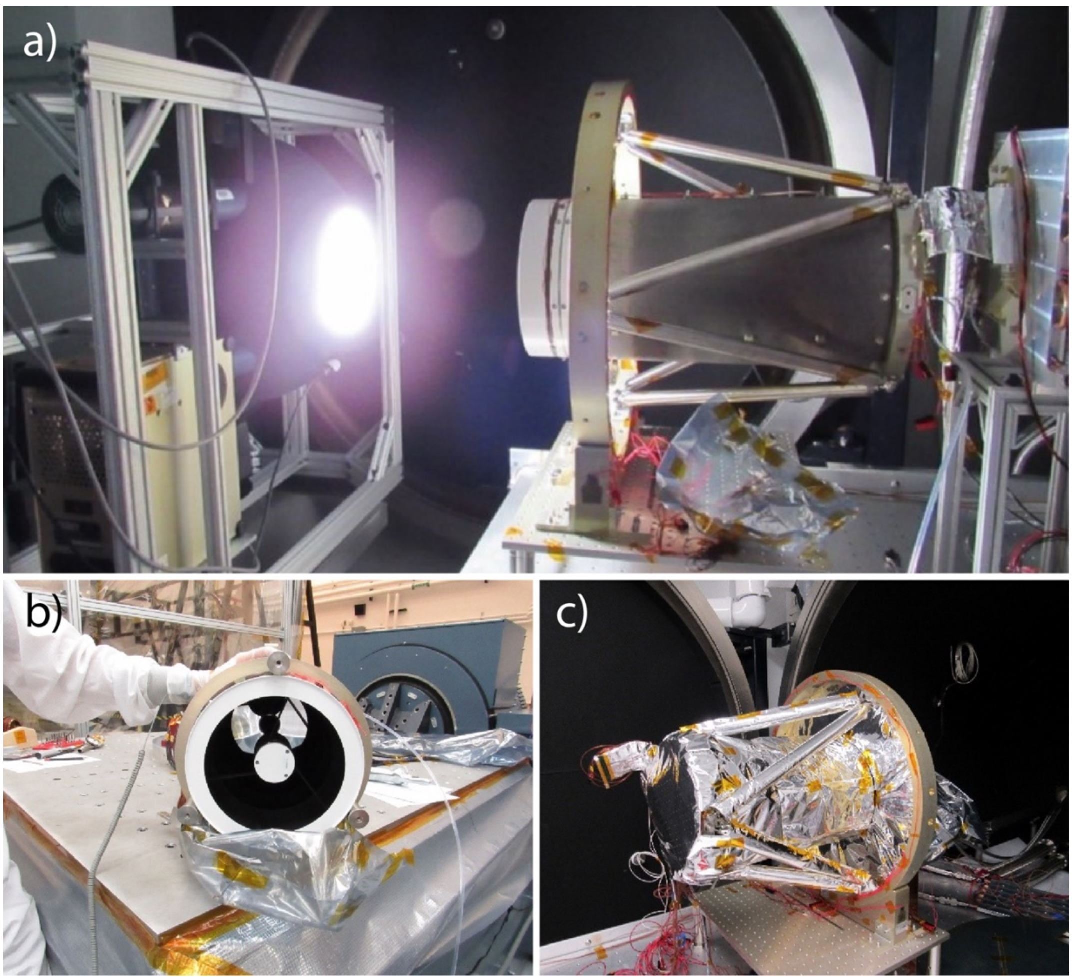

Figure 1. Photographs of DRACO during ground testing: a) throughput testing; b) before vibration testing; c) during setup of thermal testing.

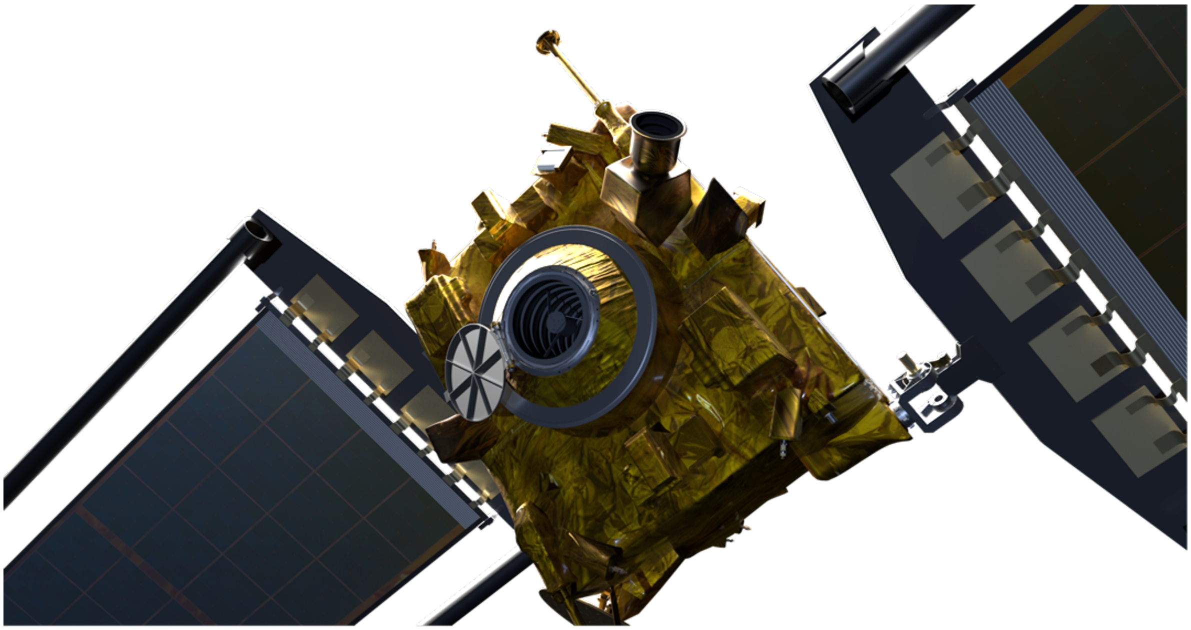

Figure 2. Location of DRACO on the DART spacecraft. The cover is shown in its open position.

DRACO is mounted on the –Z side of the spacecraft (Figure 2). Looking down the Z axis, DRACO's frame is rotated approximately -135° from the spacecraft frame (Figure 3; see DRACO frames kernel for more details). A set of twelve hydrazine thrusters provide spacecraft attitude control and precision pointing for DRACO. DRACO is thermally isolated and operated at -80ºC (telescope structure) to -20ºC (detector). A cover mounted to the spacecraft was closed during integration and test, launch, and early commissioning. It provided protection for DRACO by preventing direct sunlight from hitting the back mirror and providing thermal dissipation via the thermal strap.

DRACO is a narrow-angle, panchromatic, visible light imager consisting of an optical telescope assembly (OTA), a focal plane array with associated electronics, and image processing software. DRACO is derived from the Long Range Reconnaissance Imager (LORRI) on New Horizons (Cheng et al., 2008). DRACO has a Ritchey-Chrétien telescope with an aperture of 208 mm, operates at f/12.6, and has a field of view of 0.29°. The focal plane array is a 2560 × 2160 pixel, panchromatic, front-side illuminated complementary metal–oxide–semiconductor (CMOS) sensor with 6.5 µm pixels with digital output. The instantaneous field of view (IFOV) is 2.48 µrad unbinned, or 4.96 µrad binned. The detector is sensitive to light from 400–1000 nm (Figure 4).

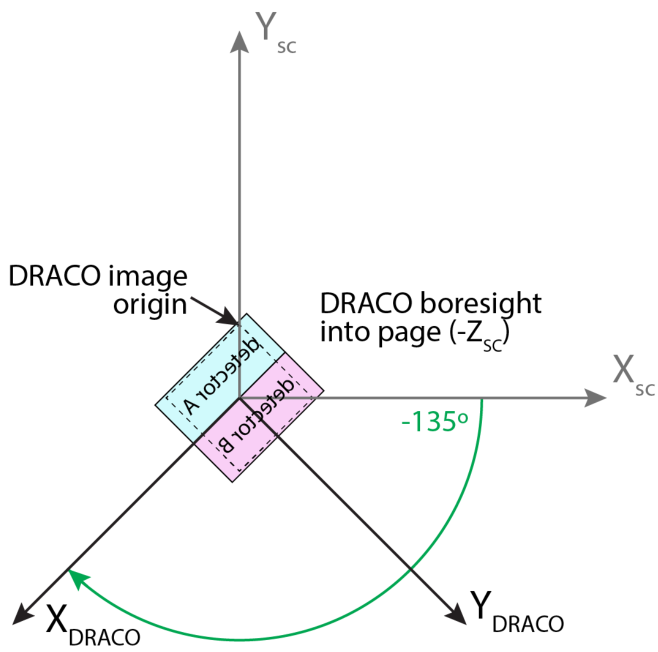

Figure 3. The DART spacecraft (DART_SPACECRAFT) and DRACO (DART_DRACO) frames oriented correctly with respect to one another. The origin of the DRACO frame is at the camera focal point. See the DART frames kernel and DART DRACO instrument kernel for more information. Detector A and B labels are purposefully backwards to illustrate that the view is looking out the DRACO boresight (i.e., looking through the back of the detector). The dashed box shows the location of Window 1.

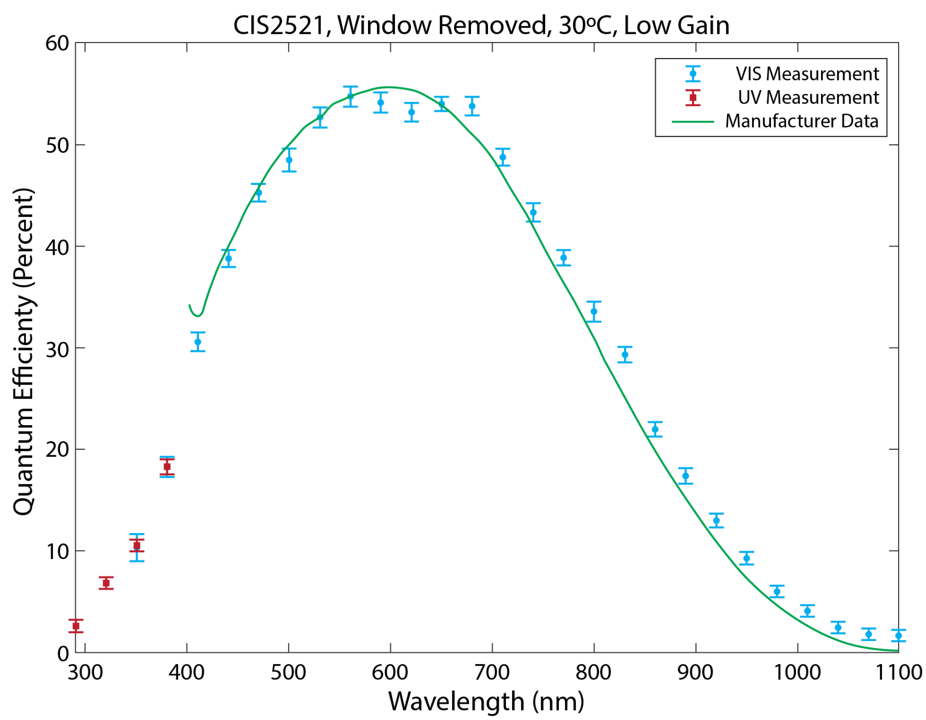

Figure 4. Quantum efficiency of the DRACO detector.

4.1.1. **Detector Layout**

The detector consists of two independent halves ("detector A" and "detector B"), each 2560 × 1080 pixels in size (Figure 5). The image is read out starting with the row along the centerline dividing the two detector halves. Readout starts with column 0 and proceeds along the row from left to right. Corresponding pixels from both halves are read out simultaneously. Subsequent rows are read out away from the centerline. The full image is assembled within the Focal Plane Electronics (FPE) and transferred to the Single Board Computer (SBC) Field Programmable Gate Array (FPGA) via a high-speed SERDES link. Section 4.1.4 describes the DRACO On-board Image Processing Pipeline.

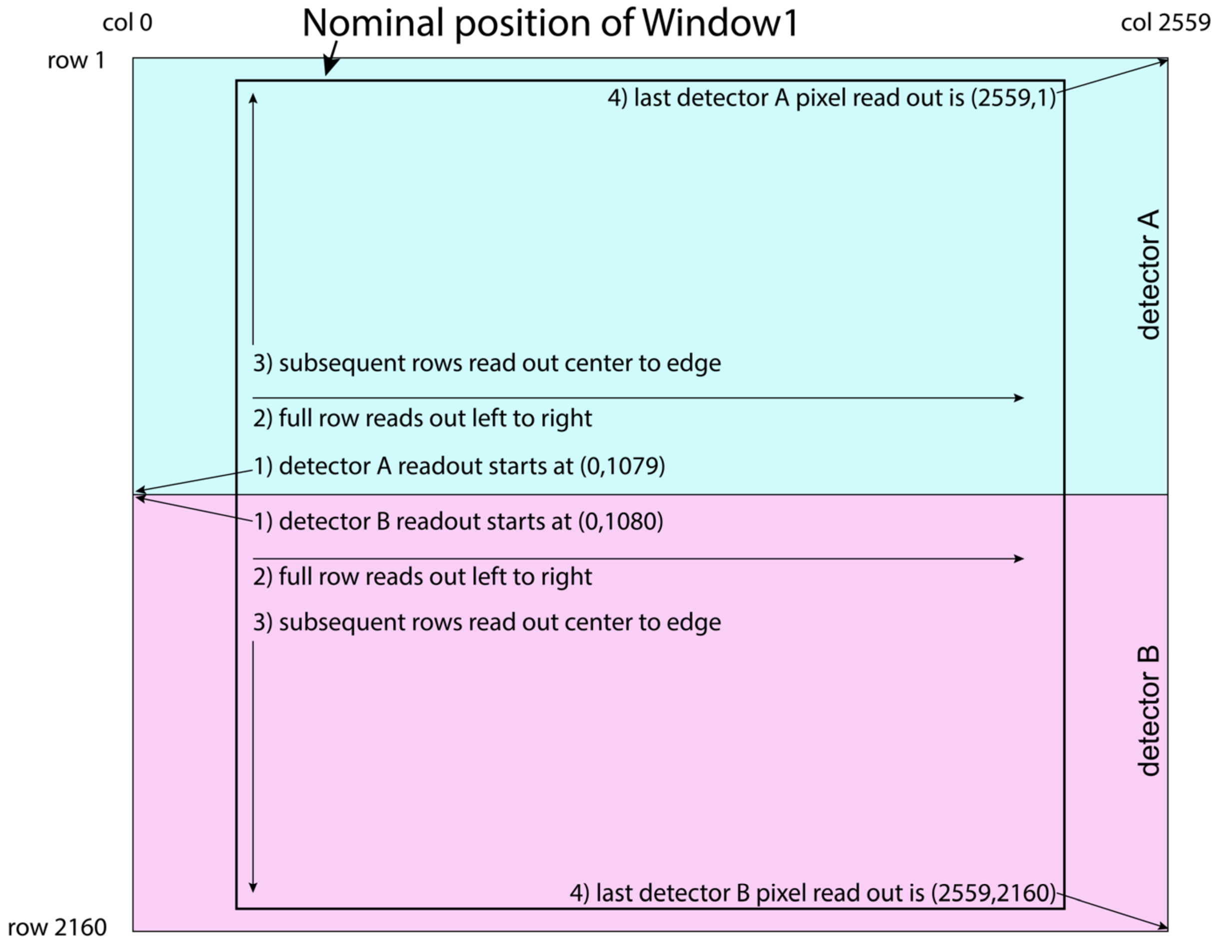

Figure 5. Diagram of the DRACO detector, indicating pixel numbering, readout direction, and the position of Window1 (see Section 4.1.4.1). Rows are numbered starting from 1 to account for the due to the header row (see Section 4.1.4). Corresponding pixels from both halves are read out simultaneously. Note, to show an image as an observer looking out the DRACO boresight would see, it has to be flipped vertically to place the origin at the lower left (see Section 4.1.6.2).

4.1.2. **Shutter Mode**

The DRACO detector runs in both global and rolling shutter readout modes. In global shutter readout mode the entire detector integrates over the same time period. Global shutter images will have higher noise relative to rolling shutter images, but no spatial distortion beyond that caused by the optics (≤0.2% (0.6 pixels) center to corner in a 1024×1024 binned image). In particular, global shutter images exhibit "popcorn noise" (see Figure 6) - single (unbinned) pixels that exhibit elevated DN values related to charge traps near the source follower amplifier that capture and emit charge that looks like signal coming from the sense node. Some of the popcorn noise is random telegraph signal (RTS) and is observed to transition rapidly (e.g., turning on and off in successive images one second apart). Some of the popcorn noise is flicker noise that transitions between multiple levels and not just on and off. The longest timeframe over which the RTS or flicker noise can remain hot is not known, but can persist for months. Global shutter mode can be used to minimize spatial distortion due to spacecraft jitter and drift. Global shutter mode requires the readout of a reset frame along with every data frame. The final image is created within the FPE by subtracting the reset frame from the data frame before it is transferred to the FPGA. Reset frames with no signal have a slightly larger signal average than the data frame with no signal. The image bottoms out at zero DN. As a result, the backgrounds of raw and calibrated global shutter images will contain many pixels with DN=0.

In rolling shutter mode each row of the detector integrates over the same amount of time, but the exact moment in time captured by each line is different (i.e., each line begins integrating one line time, 87.467 µs, after the previous line). For DRACO, each half of the detector is read out independently, from the centerline outwards (Figure 5). Rolling shutter images do not exhibit "popcorn noise". Rolling shutter images will have lower noise relative to global shutter images, but can cause apparent motion if the spacecraft is not stable over the course of image acquisition. DRACO typically employs rolling shutter mode to maximize the signal-to-noise ratio (SNR) when imaging faint sources (e.g., stars, early detection of Didymos). Because rolling shutter images do not have reset frames subtracted before transmission to the FPGA, the fixed pattern noise (the variable response of the detector halves and columns) can be seen in raw rolling shutter images (see Figure 6). This bias pattern is removed in the calibration step (see Section 4.3.2.2 and the DRACO Calibration Pipeline Description for more details).

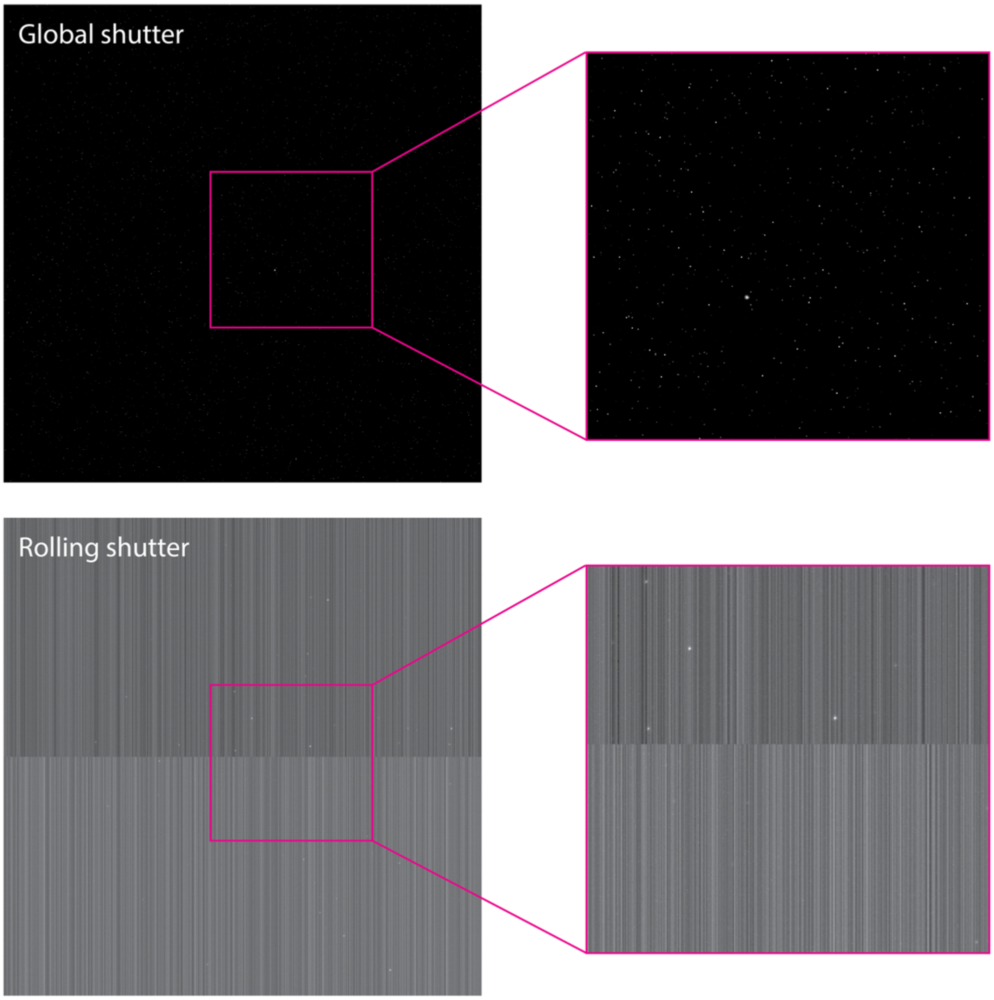

Figure 6. Examples of raw global and rolling shutter images. Top: Raw global shutter image of a star cluster. A reset frame was subtracted on board the spacecraft. In addition to a number of stars, single-pixel "popcorn" noise can be observed. Bottom: Raw rolling shutter image of a star cluster. The fixed-pattern noise is obvious because a bias frame has not yet been subtracted. Rolling shutter images do not exhibit popcorn noise. Images here are shown with the origin at the lower left to match the scene an observer looking out the DRACO boresight would see.

4.1.3. **Gain**

The DRACO detector has dual high and low gain output, although only one output can be recorded at a time. The gain of each amplifier can be selected to maximize the full-well capacity (low gain) or to maximize the SNR (by minimizing read noise; high gain). There are four possible gain settings: low gain amplification can be set to 1× or 2×; high gain amplification can be set to 10× or 30×. DRACO typically employs high gain, 30× when operating in rolling shutter mode to maximize the SNR, and low gain, 1× when operating in global mode during the Terminal and Final mission phases to prevent saturation and maximize the dynamic range of the images.

4.1.4. DRACO On-board Image Processing Pipeline

The on-board image processing pipeline receives data from the FPE over a SERDES link. This data stream includes both the image data (2560 × 2160) and one row of header data that comes in front of the image data. Effectively, the dimensions of the data received by the FPGA are 2560 × 2161. This "header row" is a separate packet from the image, but travels with the image through the on-board image processing pipeline until downlink and receipt at the MOC. The MOC ground software correlates the header row with the image data and uses the metadata in the header row to populate fits keywords for each image (see Section 4.3.3).

Figure 7 illustrates the two paths taken by images through the DRACO on-board image processing pipeline. The remainder of this section describes these steps in detail. Further detail on the DRACO on-board image processing pipeline can be found in Bekker et al. (2021). Additional processing steps are applied onboard the spacecraft to images of Didymos and Dimorphos taken during the Terminal and Final mission phases (see Section 4.1.6) to provide information to the on-board autonomous navigation software, which is called SMART Nav (Small-body Maneuvering Autonomous Real-Time Navigation; Chen et al., 2018). These "SMART Nav Data Path" steps are described Section 4.1.4.6 and produce information used to populate several keywords.

4.1.4.1. Windowing 1

Detector data from the FPE board comes into the SBC FPGA via a high-speed SERDES link. In the first windowing step, the 11-bit image data (no header row) is windowed from 2560 × 2160 pixels (format of detector) to 2048 × 2048 pixels. The WIN1SIZE keyword defines the size of Window 1. The location of Window 1 is at the center of the 2560 × 2160 detector. The keywords WIN1XSTA, WIN1XEND, WIN1YSTA, and WIN1YEND define the location of Window 1 with respect to the full 2560 × 2160 detector with header row and unbinned pixels. Because the position of Window 1 is fixed, WIN1XSTA=256, WIN1XEND=2303, WIN1YSTA=57, and WIN1YEND=2104 in all DRACO images. For all keywords describing Window 1, the image dimensions are effectively 2560 × 2161, where row 0 is the header row.

4.1.4.2. Binning

In order to improve the SNR and further reduce the data volume, each image is 2 × 2 binned (i.e., four adjacent pixels are added together). This operation reduces the overall number of pixels to 1024 × 1024, but grows the pixel bitwidth to 13 bits. In order to simplify downstream processing and packing, the data is truncated to 12 bits. All DRACO flight images were binned after windowing 1 step. The keyword BINNING indicates whether binning was on or off for a particular image. The keyword TRUNC indicates whether the most significant bits or least significant bits were kept.

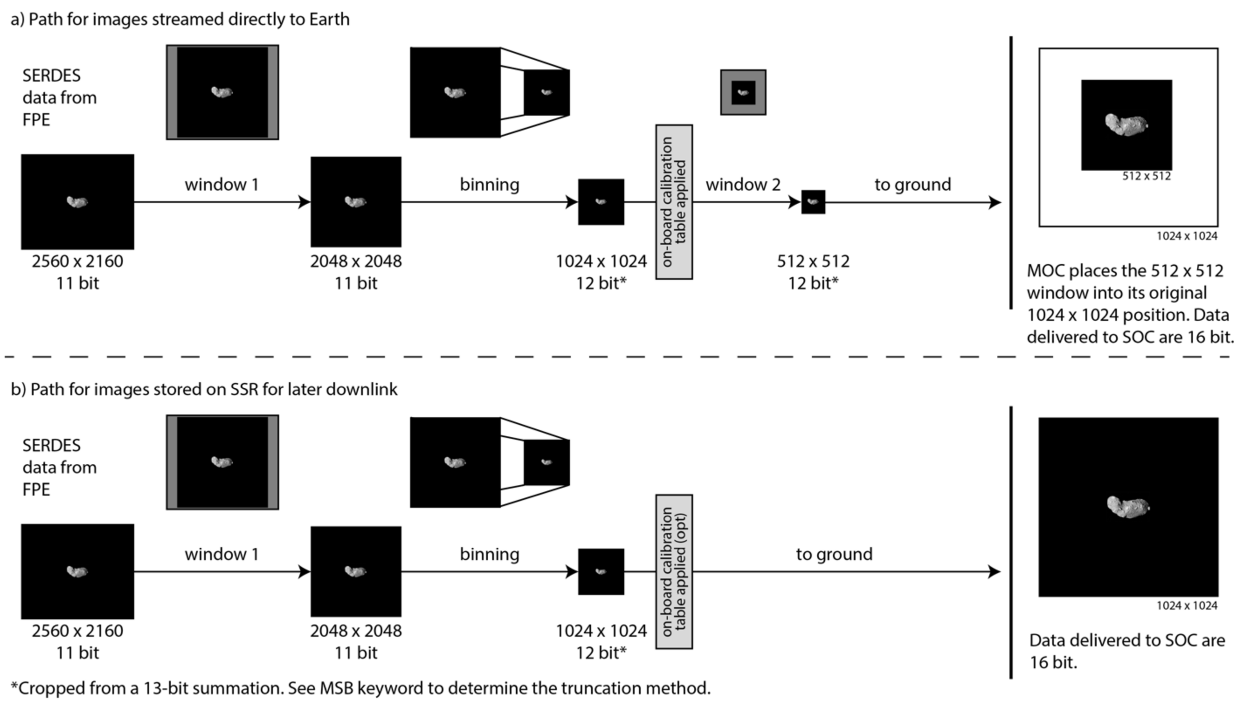

Figure 7. The path of an image through the DRACO on-board image processing pipeline for images sent to a) the radio for downlink to Earth (e.g., Terminal and Final phase images) and b) the SSR for downlink at a later time (e.g., OpNav, calibration, lightcurve images). See Table 4 for a full record of which types of images took which path.

4.1.4.3. **On-board Calibration**

A 1024 × 1024 (12-bit) calibration table can be subtracted from binned data (unsigned, floors at 0). This calibration table is stored onboard, and was updated once during flight (on 7 June 2022). This table also contains a map of bad pixels (1-bit per pixel). The calibration table subtraction is effectively a bias subtraction, and improves the performance of SMART Nav targeting. The on-board calibration table was subtracted from all images during the Terminal and Final phases of the mission and during SMART Nav tests (see Table 4 for a list of observation types that applied the calibration table). Section 5.2.3 provides further details on the structure of the on-board calibration table and bad pixel map as delivered to the PDS. See this same section to understand how the DRACO Calibration Pipeline reverses the on-board calibration table on the ground. The keyword CALIB indicates whether the on-board calibration step is on or off, and the CALFILE keyword lists the name of the file uploaded for the on-board calibration step. On the spacecraft, the calibration table and bad pixel map are combined into a single file, so only a single filename is listed in CALFILE. On the ground, these are represented in two separate files whose file naming conventions are detailed in Section 4.3.4, Table 8.

4.1.4.4. **Buffering in SRAM**

After the optional on-board calibration step, the image data is stored into Static Random-Access Memory (SRAM) in a triple-buffering scheme. From here, image data are either sent to the radio for downlink to Earth or are sent to non-volatile flash memory (solid state recorder, SSR) for storage. The keyword DATAMODE describes whether the images were directly downlinked or recorded and played back.

4.1.4.5. **Windowing 2**

In order to support real-time downlink of images at the 3 Mbps radio transmission rate, the data can be further windowed (Figure 7) to 512 × 512 pixels (12-bit). This reduced size allows for continuous image downlinking before impact during the Terminal and Final phases of the mission. This second windowing step can be bypassed. The keywords WIN2XSTA, WIN2XEND, WIN2YSTA, and WIN2YEND define the location of Window 2 with respect to a 1024 × 1024 image with header row following the Window 1 and/or binning process. The position of Window 2 is not fixed (see next paragraph). For these keywords, the image dimensions are effectively 1024 × 1025, where row 0 is the header row. These keywords are populated from information in the header row.

The location of Window 2 is centered on the region of interest (ROI; the unresolved Didymos system at first, switching to Dimorphos closer to impact) based upon centroid information from SMART Nav (see Section 4.1.4.6). Upon receipt at the MOC, each 512 × 512 image is placed back into its original location within the binned, 1024 × 1024 image display frame (now with no header row). The PXOUTWIN keyword defines the pixel value used by ground software to populate all pixels within the 1024 × 1024 image that are outside the 512 × 512 second window.

4.1.4.6. **SMART Nav Data Path**

The SMART Nav algorithm (Chen et al., 2018) is designed to autonomously navigate the spacecraft during its terminal approach to Dimorphos. It comprises image processing and guidance, navigation, and control (GNC) algorithms. Responsibility for navigation is handed over to the on-board SMART Nav algorithm 4 hours prior to impact. As part of this handoff, SMART Nav is initialized based on ground estimates of the current trajectory.

Images used by SMART Nav proceed through additional on-board processing steps performed on the FPGA (Bekker et al., 2021): thresholding, blobbing, and centroiding. Images enter the SMART Nav Data Path prior to the Window 2 step, still in their 1024 × 1024 plus header row form (after completing the binning step). Image processing results (centroids) are then used in the targeting module to identify and track the two asteroids; the targeting data is used in the GNC algorithms to autonomously keep the spacecraft on course.

In the thresholding step, each pixel is marked with a 1-bit flag (true/false) signifying whether the value is above a specified DN threshold value, defined by the FORETHRS keyword. This distinction is used to differentiate foreground pixels from background pixels, and is used in connected component analysis, known as blobbing and centroiding.

In the blobbing step, the thresholding flag of a pixel and its connected neighbors is checked to determine whether the pixel is part of the same "blob" as its neighbors, and an ID is assigned to the pixel. Pixels that belong to the same blob receive the same ID value. To reduce processing time downstream, very small blobs that are more likely to be the result of sensor noise than asteroids are discarded; the BLOBTHRS keyword states the maximum number of pixels for a blob to be discarded at this step (i.e., blobs that are smaller or equal to BLOBHRS are discarded; blobs that are larger are kept for further processing).

As the blobs are identified, feature data for each blob is computed. These data include the center coordinates (or centroid) of each blob (based on the information in the GCXSUM, GCYSUM, and GNPXLS keywords), along with the overall "intensity" of the blob (i.e., sum of all pixel values in the blob, the GINTSM keywords), and the bounding box of the blob (not captured in a keyword). This information is then passed on to SMART Nav targeting, which is able to search through the list of centroids to locate the center of Didymos (DID_X and DID_Y) and, later, Dimorphos (the DIM_X and DIM_Y keywords). The center-point of the 512 × 512 Window 2 (as described in Section 4.1.4.5 above) is set by SMART Nav based on the computed location of Dimorphos from the previous image. The SNGROI_C and SNGROI_R keywords are based on this information.

4.1.5. Image Processing Slot

DRACO image processing firmware has two configuration "slots" that define the image processing pipeline. These two configuration slots (A/B) alternate as image frames are received from the FPE over the SERDES link. For the FPE, the slots are differentiated only by integration time and are referred to as integration time 1, corresponding to slot-A, and integration time 2, corresponding to slot-B. Image-A goes through the processing pipeline configured from slot-A settings, and Image-B goes through the processing pipeline configured from slot-B settings. The option to alternate settings is only available for global-shutter images. Slot-A and slot-B settings matched for all DRACO flight images except for a small number of functional test images taken while the cover was closed during commissioning. The keyword IMGSLOT indicates which image processing mode slot was used to acquire a given image.

4.1.6. Observational Profile and Data Acquisition

The DART mission is divided into six main phases for the purpose of organizing DRACO data products: Pre-launch, Commissioning, Cruise, Approach, Terminal, and Final. The MPHASE keyword states the mission phase during which a given image was taken.

1. *Pre-launch phase*: The pre-launch mission phase refers to the period of software development and testing of the data processing pipeline, before launch. Data products generated during this phase include calibration files created during the ground testing of the instrument as well as data products created for peer review.
2. *Commissioning phase (2021-11-24 through 2021-12-21):* The commissioning phase lasted for 27 days after launch. Images acquired during this phase include calibrations and functional testing for DRACO to ensure proper operations.
3. *Cruise phase (2021-12-22 through 2022-08-26):* The cruise phase began after the commissioning phase and lasted until the beginning of the approach phase. Images acquired during this phase were acquired for several purposes, including for optical navigation (OpNav), testing of SMART Nav algorithms, characterization of star tracker noise, and star calibrations to characterize distortion, responsivity, and stray light.
4. *Approach phase (2022-08-27 through 2022-09-26T19:08:59 UTC)*: The approach phase began 30 days before impact, and extended until the Terminal phase begins. During this phase, DRACO acquired a long-range suite of observations where the Didymos system is mostly not resolvable to be used for OpNav and to extract light curves complementary to ground-based observations.

5. *Terminal phase (2022-09-26T19:09:00 through 2022-09-26T23:09:59 UTC)*: The terminal phase began with the initiation of DART's autonomous navigation, ~4 hours 5 minutes prior to impact, and extended until the final phase began. During this phase, the separation between Didymos and Dimorphos was resolved, and DRACO images supported both autonomous navigation (via Smart Nav algorithms) and characterization of Didymos and Dimorphos.
6. *Final phase (2022-09-26T23:10:00 UTC to impact)*: The final phase comprised the last ~4 min of the DART mission. The final image to contain Dimorphos and all of the sunlit terrain of Didymos was acquired just under 4 minutes before impact, at a pixel scale of ~4.88 m. Autonomous navigation ended ~2.5 minutes before impact. At 22 s prior to impact, DRACO achieved its requirement to image Dimorphos at a pixel scale of 66 cm. Higher-resolution images continued to be acquired in the final seconds of the DART spacecraft operations, which ended upon impact. The final complete image was acquired ~1.8 s before impact at a pixel scale of 5.5 cm. The final partial image returned was acquired ~0.9 s before impact at a pixel scale of 2.6 cm.

DRACO images support several activities. The OBSTYPE keyword states the observation type for each image, which can make it easier for a user to find identify images of interest. Details about the valid OBSTYPE values are given in Table 2.

Table 2. Information about the valid OBSTYPE keyword values

OBSTYPE	Purpose
TERMINAL	Taken in the Terminal and Final mission phases
LIGHTCURVE	Taken to derive a lightcurve
STAR_CLUSTER	Images of stars taken for calibration purposes (e.g., geometric, radiometric, stray light)
STREAMING	Continuous stream of images transmitted directly to Earth for testing purposes
SMARTNAV_TEST	SMART Nav testing
OPNAV	Optical navigation
DARK	Dark calibration
BIAS	Bias calibration
FUNCTIONAL_TEST	DRACO checkout
OTHER	Various
PARTIAL_HDR	Identifies images that are missing keywords in their fits headers (see Section 4.1.6.1 for more information)
BAD_IMAGE	Identifies images whose image data and FPE metadata are not reliable and should not be used for analysis (see Section 4.1.6.1 for more information)
LIGHTCURVE_REHEARSAL	Mission rehearsal of spacecraft operations; not a real lightcurve
OPNAV_REHEARSAL	Mission rehearsal of spacecraft operations; not a real opnav
TERMINAL_REHEARSAL	Mission rehearsal of spacecraft operations; not real terminal observations

The TARGET and SECTAR keywords can be used to identify images that contain a particular target of interest to the user (e.g., Didymos, Dimorphos, the M 34 star cluster, etc.). Details about the valid TARGET values are given in Table 3. There are nine keywords that relate to the body designated in the TARGET keyword. Four of these keywords (PHDIST, PSCRNG, PSPHASE, PSELON) are calculated only for TARGET=Didymos, Dimorphos, Jupiter, Elara, and Himalia. Five of these keywords (PPPCLK, PSUBLAT, PSUBLON, PSSOLLAT, PSSOLLON) are only calculated for TARGET=Didymos, Dimorphos, and Jupiter. The SECTAR keyword only applies to Dimorphos when both Didymos and Dimorphos are in the DRACO field of view. Didymos remains the TARGET when both bodies are in the field of view. Dimorphos becomes the TARGET once Didymos completely leaves the field of view of the 512x512 images (i.e., in the final 65 images, starting with image dart_0401929979_29237_01). Further information about these keywords can be found in Table 9.

Table 3. Information about the valid TARGET keyword values

TARGET	Notes
65803 Didymos	Didymos
65803 Didymos I (Dimorphos)	Dimorphos; TARGET for final 65 returned images
Jupiter	SMART Nav Test Target
Elara	OpNav Test Target
Himalia	OpNav Test Target
M 34	Star Cluster; Calibration Target
M 38	Star Cluster; Calibration Target
NGC 3766	Star Cluster; Calibration Target
HD205905	Solar-like star; Calibration Target
alf Lyr	Alpha Lyra (or Vega); Calibration Target
gam Cnc	Gamma Cancri (or Asellus Borealis); Mission Rehearsal Target
Tet Vir	Theta Virginis; Mission Rehearsal Target
iSco	Star; SMART Nav Test Target
Cover	DRACO Cover
Test Pattern 2	DRACO Test Pattern

The imaging sequences acquired by DRACO over the course of the DART mission are detailed in Appendix 7.4.

4.1.6.1. Image Acquisition

DRACO images are acquired at a 1.04 Hz rate (0.962 seconds per image). The shutter mode (Section 4.1.2), gain (Section 4.1.3) and exposure time are defined for every imaging sequence. All DRACO images start out 2560 × 2160 pixels, are windowed to 2048 × 2048 pixels, and are 2 × 2 binned to 1024 × 1024 pixels (see also Sections 4.1.4.1 and 4.1.4.2). Table 4 lists the seven valid configurations for DRACO image processing to set the application of the on-board calibration table (Section 0), window 2 step (Section 4.1.4.5), and data playback (Section 4.1.4.4).

Table 4. Valid Configuration for DRACO Image Processing During Stream/Record

Image Type*	On-board Calibration Table	Window 2	Data Collection Mode	Final Image Size
TERMINAL, STREAMING, TERMINAL_REHEARSAL, SMARTNAV_TEST, OTHER	On	512 × 512	Radio	512 × 512
SMARTNAV_TEST, STREAMING, OTHER	Off	512 × 512	Radio	512 × 512
OTHER	Off	512 × 512	SSR	512 × 512
STREAMING	On	Bypass	Radio	1024 × 1024
LIGHTCURVE, BIAS, OPNAV_REHEARSAL, LIGHTCURVE_REHEARSAL, STREAMING, SMARTNAV_TEST, OTHER	Off	Bypass	Radio	1024 × 1024
SMARTNAV_TEST, OTHER	On	Bypass	SSR	1024 × 1024
OPNAV, STAR_CLUSTER, DARK, BIAS, OPNAV_REHEARSAL, OTHER	Off	Bypass	SSR	1024 × 1024

*All listed configurations were used during functional testing

Dropped images: Real-time downlink of 512 × 512 images (e.g., those from the Terminal and Final phases) occurs at ~0.90 Hz (1.107 seconds per image). Approximately 7 out of 8 (~87%) such images will make it to the ground as a result of the mismatch between this downlink rate and the 1.04 Hz imaging rate. The buffering scheme means that the latest image will always be downlinked. Real-time downlink of 1024 × 1024 images (e.g., lightcurve images) occurs at ~0.22 Hz (4.448 seconds per image). Approximately 1 out of five (~22%) such images will make it to the ground as a result of the mismatch between this downlink rate and the 1.04 Hz imaging rate. There is no *a priori* way to know which images will be lost and which will be downlinked. No images are dropped when they are recorded to the SSR and played back at a later time.

Patrial images: When DRACO is in streaming mode, the radio must be continually fed with either actual DRACO image data frames or idle frames. In idle mode, no image or data processing occurs. When the command is executed to begin or stop streaming DRACO images directly to the radio, it occurs mid-idle frame and results in a partial image. A keyword value MISPXCNT >0 (missing pixel count) indicates a partial image. Missing pixels are set to -32768 in raw images and 1E32 in calibrated images.

- The first image in a direct-to-radio (streamed) sequence will be missing the beginning portion of the data, including the DRACO header row (see Section 4.1.4), so fits keywords populated using this information are empty. Such an image will be labeled as OBSTYPE=PARTIAL_HDR and designated as BADIMAGE=TRUE. Such images should not be used for any analyses. Example: dart_0376599992_26784_02_raw.fits.

- The last image in a streamed sequence will be missing the end portion of the data. The header information will be present, so fits keywords can be populated and this image can be used for analysis. Example: dart_0380603034_08537_02_raw.fits.

Bad images: There are a few scenarios that result in DRACO images that should not be used for analysis. These images are identified using the keyword value BADIMAGE=TRUE in the fits header to alert users to the fact that the image data and FPE metadata are not reliable for that image. **Users should NOT use images with BADIMAGE=TRUE for any analyses.** The scenarios that result in a keyword value BADIMAGE=TRUE are:

- DRACO reconfiguration: For some imaging sequences, the DRACO detector is reconfigured during the observation to use a different imaging mode, gain setting, or exposure time. The first image or two acquired after the DRACO detector is reconfigured will have inaccurate image data and FPE metadata (e.g., the IMGMOD, GAIN, EXPTIME, and TRUNC keyword values will not match what was commanded). Example: dart_0376162040_16925_02_raw.fits. Lightcurve, terminal, and final images are not affected as DRACO is not reconfigured during these imaging sequences.
- DRACO misconfiguration: DRACO was misconfigured while acquiring images dart_0376147120_43856_02_raw.fits through dart_0376161226_45633_02_raw.fits on the first day of data acquisition (2021-12-02).
- Partial header: Images labeled with OBSTYPE=PARTIAL_HDR are missing the DRACO header row, so fits keywords populated using this information are empty. See "Partial images" description earlier in this section for more information and an example image name.
- Test pattern: The test pattern overwrites the DRACO header row (see Section 4.1.4), so fits keywords populated using this information are unreliable. Example: dart_0376146984_05334_02_raw.fits.

4.1.6.2. Image Flip

Different software may label the origin as (0,0) or (1,1). Different fits viewers may place the origin in a different position (e.g., upper left corner vs lower left corner). A DRACO image appears as it would if you were looking out the DRACO boresight when viewed with a fits viewer that places the origin at the lower left. SAO DS9 is an example of a program with this convention. Opening a DRACO image with a program where the origin is at the upper left (e.g., ImageJ, GraphicConverter) will flip the image vertically. The browse pngs included in the DRACO archive can be used to verify the correct orientation of a corresponding DRACO fits image. Software that utilizes the PDS4 XML to open and display the image will automatically display the image in the proper orientation due to the PDS4 Display dictionary keywords. Figure 8 illustrates the relationship of the DRACO and spacecraft frames with respect to the scene an observer looking out the DRACO boresight would see, and how the image looks when displayed with software that places the image origin at the upper left (Figure 8b, mirror flipped with respect to reality) or lower left (Figure 8c, correctly oriented with respect to reality). The browse PNG files delivered as a part of the DRACO raw image (Section 4.3.2.1) and calibrated image

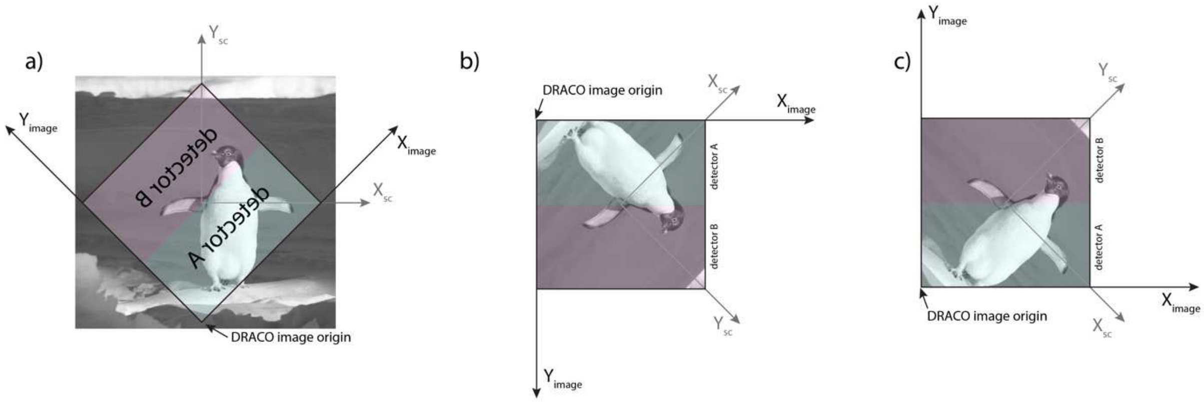

Figure 8. a) An example of a scene an observer looking out the DRACO boresight would see. The spacecraft and DRACO frames shown here are each oriented with respect to the scene, and not with respect to one another (see Figure 3 for their mutual orientation). Detector A and B labels are purposefully backwards to illustrate that the view is looking out the DRACO boresight (i.e., looking through the back of the detector). The square image here corresponds to the central 2048x2048 pixels of the detector (Window 1, see Figure 5). B) The scene as it appears on the DRACO detector, or in the image when viewed with software that places the image origin at the upper left corner. The image is mirror flipped across the x axis from reality. C) The scene as it appears when viewed with software that places the image origin at the lower left corner. This view matches reality.

(Section 4.3.2.2) collections can be used to verify the image display. The difference in response between the two halves of the detector in rolling shutter raw images can also be used to confirm the flip is correct (e.g., Figure 6).

4.2. Data Product Overview

This SIS describes the uncalibrated and calibrated image data acquired by DRACO. All DRACO images and their associated calibration files are 1024 × 1024 arrays formatted natively as binary Flexible Transport Image System (fits) files with a single header data unit (HDU), with the exception of the radiometric lookup tables, which are comma separated value (csv) ASCII files. Metadata are captured in the headers (see Section 5.2 for a description of these metadata).

The specific DRACO data products described by this SIS are:

1. DRACO Raw Image Data – Images that have been reassembled from downlinked telemetry with complete image metadata including instrument settings, in units of DN. These images are stored as 32-bit fits files. See Section 5.2.1 for more details.
2. DRACO Calibrated Image Data – Images that have been corrected for bias, dark current, and flat field, and calibrated into physical units (that depend on whether the image contains a point source or extended source) by the DRACO calibration pipeline. These images are stored as 32-bit fits files. See Section 5.2.2 for more details.
3. DRACO Calibration Files – Files needed to process image data. These files are: on-board calibration table; bad pixel map; bias frames; dark current frames; flat field; radiometric

lookup tables. These files are stored as 1024 × 1024, 32-bit fits files, except for the radiometric lookup tables, which are ASCII csv files. See Section 5.2.3 for more details.

4. DRACO Image Backplanes – Image cubes that include location, illumination, and geometric values for each pixel. These files are stored as 32-bit, 16-plane fits files. See Section 5.2.4 for more details.

4.3. Data Processing

All DRACO data processing is performed at the DART SOC. This section provides general information about data product content, format, size, and production rate. Specifics of the data processing pipeline can be found in Section 4.3.3 and data formats in Section 5.

4.3.1. Data Processing Level

Table 5 describes PDS4 data processing level of the DRACO data products covered by this SIS. The relationship to NASA and Committee on Data Management and Computation (CODMAC) data processing levels and definitions for both conventions are given in Appendix 7.3.

Table 5. DRACO Data Processing Levels

DRACO Data Product	NASA Product Level	PDS4 Data Processing Level	Unit	Description
Raw Images	Level-0	Raw	DN	Images reassembled from downlinked telemetry with complete image metadata including instrument settings, states, and geometry.
Calibrated Image	Level-1B	Calibrated	$W\ m^{-2}\ nm^{-1}\ sr^{-1}$ or unitless I/F	Images calibrated to physical units. The data are represented in radiance when keyword IOVERF = “SKIP” and in reflectance when IOVERF = “PERFORM”.
Calibration Files	Level-4	Calibrated	various	Files needed to process image data. In this archive the calibration files are co-located with the Calibrated Data.
Image Backplanes	Level-4	Derived	various	Backplanes containing additional per-pixel information. See Table 6 for a list and description of the image backplanes.

4.3.2. **Data Product Generation**

4.3.2.1. **Raw Images**

DRACO image and housekeeping telemetry are received by the MOC from the DSN. The MOC reconstructs images from the raw telemetry and populates a suite of fits keywords, which includes information on DRACO mode, spacecraft attitude, SMART Nav threshold estimates of centroids, and records of any windowing, binning, and calibration done via the on-board image processing pipeline. The MOC stores the image in the fits file in 16-bit integer format and delivers it to the SOC. The SOC then converts the fits file such that the images are stored as 32-bit floats. This conversion is done to standardize the DRACO data products. The SOC also adds additional information, such as TARGET, MPHASE (mission phase), and OBSTYPE (observation type) to the fits header. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored. See the DRACO Calibration Pipeline Description for additional details. The resultant fits header is defined in Section 5.2.1. Keyword values are directly derived from DRACO telemetry (including the DRACO header row), the GNC correlation packet, and some other spacecraft telemetry packets to which the MOC has direct access. Ground software requires that the GNC packets be time-stamped with the same image capture time as an image in order to correlate. However, the GNC correlation packet is generated at a 1 Hz rate, which is slightly slower than the DRACO 1.04 Hz imaging rate. Once every ~25 seconds, two images will be captured during the same second, but only one correlation packet will be generated in that second. Therefore, one in every ~26 images will not correlate with a GNC packet. When the packet is not available, the keywords derived from the GNC correlation packet will be left blank (see Section 5.2.1).

Smear and quaternion values are calculated independently onboard the spacecraft (ESTSC_Q*, SMEARIN*) and on the ground by the SOC (SOCQUAT*, SMERSIN*) so that this information is available even for images that do not correlate on the spacecraft (and therefore have blank values for ESTSC_Q* and SMEARIN*). The values of keywords calculated onboard the spacecraft and by the SOC will differ because the ESTSC_Q* and SMEARIN* keywords are computed from high-rate GNC data onboard the spacecraft, whereas SOCQUAT* and SMERSIN* are based on reconstructed SPICE kernels, which have a slower sample rate than the onboard GNC software. The smear-related keywords (SMEARIN*, SMERSIN*) are useful for identifying images most affected by smear, but they do not perfectly correlate with the magnitude of smear in the image.

Each final Level-0 raw PDS4 data product will consist of:

- A 32-bit fits file with one Header Data Unit (HDU) containing the metadata header fields and the data unit of the windowed array (1024 pixels x 1024 pixels). The data are represented as DN.
- A browse PNG created from the raw fits file. Pixel values indicating "outside of window" or "missing data" will be set to zero in the browse PNG. Note, the browse PNG files are oriented as the scene would appear to an observer looking out the DRACO boresight.

4.3.2.2. **Calibrated Images**

DRACO calibrated images have gone through the calibration pipeline at the SOC, as described in the DRACO Calibration Pipeline Description. The calibration pipeline appends keywords to the fits header keywords of the raw images (defined in Section 5.2.2). Some raw images will not be turned into calibrated images: in-flight bias and dark current images; test patterns; images identified as BADIMAGE=TRUE (images taken around detector reconfigurations; images with images taken with a misconfigured instrument; partial headers; test patterns). Additional data needed to interpret the calibrated images, such as bias frames, dark current frames, and flat field, are included as part of the DRACO Calibrated Data Collection (see also Section 5.2.3).

Each final Level-2 calibrated PDS4 data product will consist of:

- A 32-bit fits file with a single HDU containing header metadata records and a data unit of the radiometrically calibrated windowed array (1024 pixels x 1024 pixels). The data are represented in radiance (W m^{-2} nm^{-1} sr^{-1}) when keyword IOVERF = "SKIP". The data are represented in reflectance (I/F, unitless) when keyword IOVERF = "PERFORM". Additional fits keywords are added by the SOC to capture metadata relevant to the calibrated image, such as calibration files used.
- A browse PNG created from the calibrated fits file. Pixel values indicating "outside of window" or "missing data" will be set to zero in the browse PNG. Note, the browse PNG files are oriented as the scene would appear to an observer looking out the DRACO boresight.

Calibrated images whose processing ends with a conversion to radiance will have "rad" added to their filename. Calibrated images whose processing ends with a conversion to I/F will have "iof" added to their filename. See the DRACO Calibration Pipeline Description Sections 4.4.6 and 4.4.7 for more information. Neither this document nor the DRACO Calibration Pipeline Description discuss at length calibration activities or results. Instrument design and ground calibration topics are discussed in Fletcher et al. (2022). A publication by Ernst et al. will be submitted in 2023 and describe in detail the inflight performance and calibration of DRACO. Keywords in the calibrated image fits header (e.g., SATPXVAL, BADMASKV, OORADLUT, and IOVRFLAG) identify pixels to be cautious about when analyzing images (see Table 9, Table 10, and the DRACO Cheat Sheet at the beginning of this document).

4.3.2.3. **Calibration Files**

The following calibration files will be developed from in-flight and/or ground calibration data: on-board calibration table; bad pixel map; bias frames, dark frames; flat field; radiometric lookup tables. Calibration files will be saved in fits file format with the exception of the radiometric lookup tables, which are in ASCII csv format.

A detailed description of the calibration files and the calibration process is found in the DRACO Calibration Pipeline Description document (see Section 2).

The calibration files will be included in the DRACO Calibrated Data collection.

4.3.2.4. **Image Backplanes**

Backplanes are generated only for images collected during the Final phase. A number of location, illumination, and geometric parameters have been calculated at each DRACO pixel center that intersects either Didymos or Dimorphos using spacecraft position and observational geometry derived from the respective highest-resolution Didymos and Dimorphos shape models that are archived with the PDS as part of the DART Shape Model Collection (to be delivered in Jan–Mar 2023) and described in the DART Derived Data Product Software Interface Specification document. The intersection of the shape model with a ray originating at the spacecraft in the pixel direction is found. That facet determines the plane for the backplane calculation. For images that contain both Didymos and Dimorphos, backplanes are calculated for each body independently: if the pixel intersects Didymos the backplane values are calculated in the Didymos body fixed frame; if the pixel intersects Dimorphos, they are in the Dimorphos body fixed frame.

Each of the DRACO backplane files is a 16-plane image cube in fits format. The planes of the cube contain the information detailed in Table 6, calculated at the center of each pixel:

Table 6. Description of image backplanes

Plane Number	Plane Name	Description	Units
1	Pixel value	Pixel values of the calibrated image	I/F
2	X coordinate	X coordinate of the intercept with the surface of an asteroid in body-fixed reference frame	km
3	Y coordinate	Y coordinate of the intercept with the surface of an asteroid in body-fixed reference frame	km
4	Z coordinate	Z coordinate of the intercept with the surface of an asteroid in body-fixed reference frame	km
5	Latitude	Planetocentric latitude	degrees
6	Longitude	Planetocentric longitude	degrees east (0–360)
7	Radial distance	Radial distance from the asteroid center of figure	km
8	Solar incidence angle	Solar incidence angle	degrees
9	Emission angle	Emission angle	degrees
10	Solar phase angle	Solar phase angle	degrees
11	Horizontal pixel scale	Horizontal pixel scale measured from range to surface and shape	m
12	Vertical pixel scale	Vertical pixel scale measured from range to surface and shape	m

13	Surface slope	Average surface slope relative to gravity*	degrees
14	Elevation	Average elevation relative to gravity*	m
15	Gravitational acceleration	Average gravitational acceleration*	m s^{-2}
16	Gravitational potential	Average gravitational potential*	J kg^{-1}

* The calculations for a given body take the gravitational pull of the other body into account.

The values used to populate Planes 13–16 were calculated using the method described by Werner and Scheeres (1997), using a constant density for Didymos of 2400 kg/m^3 and a rotation rate of 7.7227E-4 rad/s (rotation period 2.2600 hr) and for Dimorphos of 2400 kg/m^3 and a rotation rate of 1.46400233E-4 rad/s (rotation period 11.9216289 hr). These values were the best available at the time the products were generated. The gravitational potential was computed via integration. A reference gravitational potential equivalent to a "geoid" on Earth was obtained from the area-averaged root-mean-square of the gravitational potential. This reference potential provides the elevation on the surface of the asteroid once divided by the local magnitude of the gravitational acceleration. The density and rotation also provide via integration the magnitude and direction of the gravitational acceleration at the surface. The slope given is obtained by taking the inverse cosine of the dot product of the normal to each plate model facet with the vector describing the direction of the gravitational acceleration at the center of each plate model facet. For more information on these calculations, see the DART Derived Data Product Software Interface Specification document.

Each final Level-4 image backplane file is:

- A single HDU, 16-plane, 1024 (sample) × 1024 (line), 32-bit floating point fits file. The first plane of the fits file contains the calibrated image for which the backplanes are derived. The contents of the 16 planes are detailed in Table 6. More details about these files can be found in Section 5.2.4.

These image backplane files may be read into the U.S. Geological Survey's Integrated Software for Imagers and Spectrometers (ISIS, version 3) using the command 'fits2isis' on the fits file. This command will generate an ISIS cube file that can be displayed using the 'qview' routine. To open one of the backplane fits files in an image analysis package such as ENVI, set the header offset to the value stored in the XML label under <Header><object_length unit="byte">.

A planetocentric coordinate system is employed, which is body-centered, using the center of figure as the origin. A complete discussion of the coordinate systems and how they are deployed in the mission can be found in the DART Coordinate System for Didymos document.

4.3.3. **Data Flow**

The MOC reconstructs DRACO images from the raw telemetry and populates a suite of fits keywords. Additional fits headers are then added by the SOC (see also Section 4.3.2.1). Calibrated images are created by the DRACO Calibration Pipeline (see also Section 4.3.2.2). Derived products (image backplanes) are generated by the SOC (see also Section 4.3.2.4). If data reprocessing leads to more than one version of a raw, calibrated, or derived data product (due to, e.g., updated SCLK information, updated calibration files, shape models), re-processed images can be identified by the two-digit version number in the file name (see Section 4.3.4; Table 7). Raw, calibrated, and derived data products are stored at the SOC. These products, with the calibration files and associated documentation, are combined to form the DRACO collections within the DART Spacecraft Bundle, which is delivered to the Small Bodies Node (SBN) of the PDS. The full list of collections described in this SIS is: DRACO Raw Data Collection, DRACO Calibrated Data Collection, DRACO Derived Data Collection, and the Documentation collection specifically for the DRACO documentation. This archive provides one public access point to the DRACO data. The DRACO raw, calibrated, and derived data products will be available in the Small Body Mapping Tool (SBMT; https://sbmt.jhuapl.edu) in late 2023, which includes image search, 3D visualization, and download capabilities.

Figure 9 shows the DRACO data flow from raw telemetry to derived data products, and how the data are shared with the public.

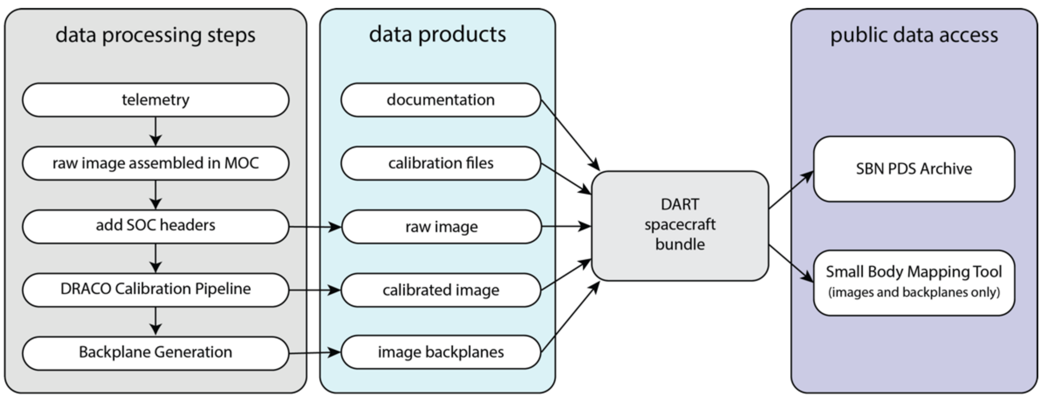

Figure 9. DRACO data processing flow diagram.

4.3.4. Labeling and identification

All DRACO data products are labeled with PDS4 compliant detached XML labels. These labels describe the content and format of the associated data product. Labels and products are associated by file name with the label having the same name as the data product except that the label file has an .xml extension.

Additional information regarding the XML labels and PDS4 data product specification can be found in the PDS documents referenced in Section 2.

DRACO uncalibrated and calibrated data products are identified with file names in the format of:

dart_SSSSSSSSSS_sssss_##_<product type>.<extension>

The file name sections are described in Table 7.

Table 7. Definition of DRACO filename

File name section	Description

SSSSSSSSSS	10-digit value of IMGTMSEC (see Section 5.2.1 for keyword description)
sssss	5-digit value of IMGTMSUB (see Section 5.2.1 for keyword description)
##	two digit version number, e.g., “01”
<product type>	defines product as one of the following types: • raw • rad (calibrated image converted to radiance, see Section 4.3.2.2) • iof (calibrated image converted to I/F, see Section 4.3.2.2) • geo (backplanes)
<extension>	the file extension. “.fits” for fits file format, “.png” for PNG files.

The naming convention for the DRACO calibration files is shown in Table 8. For more information about these files, refer to the DRACO Calibration Pipeline Description Document.

Table 8. File formats and naming conventions of calibration inputs

Pipeline input	File format	File naming scheme
On-board calibration table	1024x1024 32-bit floating point fits (2x2 binned from 2048x2048 window1)	draco_onboardcaltable_date-of-creation.fits (e.g., draco_onboardcaltable_20200910.fits)
Bad pixel map	1024x1024 32-bit floating point fits (2x2 binned from 2048x2048 window1)	draco_bad_pixels_date-of-creation.fits (e.g., draco_bad_pixels_20200910.fits)
Bias frames	1024x1024 32-bit floating point fits (2x2 binned from 2048x2048 window1)	draco_bias_mode_gain_temperature_date-of-delivery.fits (e.g., draco_bias_global_1x_n20c_20210225.fits) (An “n” indicates a negative temperature value.)
Dark current frames (if able to be measured)	1024x1024 32-bit floating point fits (2x2 binned from 2048x2048)	draco_dark_mode_gain_temperature_date-of-delivery.fits (e.g., draco_dark_global_1x_10int_n20c_20210225.fits) (An “n” indicates a negative temperature value.)
Flat fields	1024x1024 32-bit floating point fits (2x2 binned from 2048x2048)	draco_flat_date-of-delivery.fits (e.g., draco_flat_20210225.fits)
Radiometric look-up tables	.csv	draco_lookup_mode_gain_date-of-delivery.csv (e.g., draco_lookup_global_1x_20210225.csv)

4.4. *Standards used in Generating Data Products*

4.4.1. **PDS Standards**

All data products described in this SIS conform to PDS4 standards as described in the PDS Standards document noted in the Applicable Documents section of this SIS. Prior to public release, all data products will have passed both a data product format PDS peer review and a data product production pipeline PDS peer review to ensure compliance with applicable standards.

4.4.2. **Time Standards**

Time standards used by the DART mission conform to PDS time standards. All DRACO data products contain both the spacecraft clock time at the start of data acquisition and a conversion to UTC at the start of the data acquisition to facilitate comparison of data products.

4.4.3. **Coordinate Systems**

All coordinate systems used by the DART mission conform to IAU standards. A complete discussion of the coordinate systems and how they are deployed in the mission can be found in the DART Coordinate System for Didymos document.

4.4.4. **Data Storage Conventions**

All DRACO data products with the exception of the radiometric lookup tables are stored natively as binary fits files and conform to the fits 3.0 standard. The radiometric lookup tables are stored as ASCII csv files.

4.5. *Data Validation*

Data validation falls into two types, validation of the science data and validation of the compliance of the archive with PDS archiving and distribution requirements. The first type of validation will be carried out by the SOC and the Investigation Team, and the second will be overseen by the PDS, in coordination with the SOC.

The formal validation of data content, adequacy of documentation, and adherence to PDS archiving and distribution standards is subject to an external peer review. The peer review will be scheduled and coordinated by the PDS. The peer review process may result in "liens," actions recommended by the reviewers or by PDS personnel to correct the archive. All liens must be resolved by the SOC. Once the liens are cleared, PDS will do a final validation prior to packaging and delivery. When data are prepared for submission to PDS, the SOC will use PDS-provided validation tools to ensure conformance to PDS standards.

Continuous validation of the data products will be performed throughout the mission, as the Project will be utilizing the PDS4 data products as they are generated and the data do not exist in any form other than PDS4 data products.

5. Detailed Data Product Specifications

The following sections provide detailed data product specifications for the DRACO uncalibrated and calibrated data products.

5.1. *Data Product Structure and Organization*

The DRACO data archive is organized by processing level and then by mission phase. Mission phases are defined in Section 4.1.6.

All image data are stored as fits files with a detached PDS label. The detached PDS labels are PDS4 compliant XML labels that describe the contents of the image file and record the significant portions of the fits header for data processing and interpretation. See the Label Example sub-directory in the DRACO document collection for example labels for each type of DRACO data product. "DRACO Documentation" refers to the documentation used to describe the DRACO products. This includes, but is not limited to, the DRACO SIS, calibration pipeline description, and published papers.

The DRACO collection directory structure within the DART Spacecraft Bundle is as follows. The root directory of the bundle is "dart". The folder containing the DRACO data collections is named "data_draco<processing level>".

The "data_dracoraw" folder contains the data in the DRACO Raw Data Collection: raw fits file, browse PNG, and associated XML label.

The "data_dracocal" folder contains the data in the DRACO Calibrated Data Collection: calibrated fits file, browse PNG, and associated label. This collection also includes the calibration files and their associated labels.

The "data_dracoddp" folder contains the data in the DRACO Derived Data Collection: backplanes fits file and associated label.

There is also a "document_draco" folder to separate DRACO specific documentation from that of other upcoming collections, e.g., the Shape Model Collection.

```
/root
    /data_dracoraw/
    /data_dracocal/
    /data_dracoddp/
    /document_draco/
```

5.2. *Data Format Descriptions*

DRACO images are stored in the fits file format. These follow the fits Standard as referenced by Section 4.4.4. Pointing information and other ancillary information will be parsed from the fits header and stored in the PDS4 label associated with the fits file.

5.2.1. **Raw Image Data**

The Level-0 raw DRACO image format is a single HDU, 1024 (sample) × 1024 (line), 32-bit floating point fits file, 2×2 binned from the original 2048 × 2048 window1, in units of DN. Metadata contained in the fits header and mapping to class and attribute in the PDS4 .xml label structure is listed in Table 9. The Class.Attribute Name column is left blank for fits keywords not mapped to the .xml label.

Table 9. DRACO Level-0 Raw Image Metadata

Class.Attribute Name	Keyword and example	Description	Range of values
	SIMPLE = T / file conforms to FITS standard	Required in FITS standard.	T
Element_Array. data_type	BITPIX = -32 / number of bits per data pixel	DRACO images delivered to the SOC will always be 32 bit. Raw images are converted from the original 11- or 12-bit integer data. Calibrated images are the result of applying the calibration files, themselves in 32-bit floating point, to the raw images. Backplanes images include additional geometry data calculated as single-precision floats. All are stored in big-endian as per the FITS standard.	-32
	NAXIS = 2 / number of data axes	Number of axes; all DRACO images have 2 axes.	2
Axis_Array. sequence_number	NAXIS1 = 1024 / length of data axis 1	Number of rows, all DRACO images have 1024 rows.	1024
Axis_Array. sequence_number	NAXIS2 = 1024 / length of data axis 2	Number of columns, all DRACO images have 1024 columns.	1024
	EXTEND = T / FITS dataset may contain extensions	By default, set to T so that we can add extensions if needed.	T
Modification_History. modification_date	DATE = '2018-08-25T09:23:89' / FITS header creation date YYYY-MM-DDTHH:MM:SS	Time fits file was created by the SOC. For raw it is the time fits is transformed to 32-bit float and keywords added. For calibrated and derived it is the creation time of the product	YYYY-MM-DDTHH:MM:SS
Investigation_Area. name	MISSION = 'DART' / Mission: DART	Name of mission.	DART
Observing_System. name	HOSTNAME= 'DART' / spacecraft name	DRACO is on the spacecraft called DART.	DART
Observing_System_Component. name	INSTRUME= 'DRACO' / Instrument name	Name of instrument. Only one instrument, so always DRACO.	DRACO
	APID= '333' / Application ID of science data	Application ID of science image data: the images themselves	333
	MISPXCNT= '0' / The number of missing pixels.	Ground software will provide the number of missing pixels, not including areas that were not downlinked because of windowing.	0 to 1048576.
Special_Constants. missing_constant	MISPXVAL = '-32768' / the value assigned to missing pixels	Ground software would use this pixel value to populate all pixels within a 1024x1024 image that are missing.	-32768

Class.Attribute Name	Keyword and example	Description	Range of values
Special_Constants. not_applicable_constant	PXOUTWIN= ‘32767’/ Value assigned to pixels outside window2	Ground software would use this pixel value to populate all pixels within a 1024x1024 image that are outside of the 512x512 second window (see WIN2X* and WIN2Y*).	32767
	IMGTMSEC= ‘298271898’ / [sec] image time	Time the first bit of the image was read into the FPGA on the SBC, in spacecraft clock notation, as reported by GNC. This is also called the image capture time. Number is in integer seconds.	Time since t=0, as defined in the SCLK kernel. Left blank when not available.
	IMGTMSUB= ‘21314’ / [subsec] image time, 16-bit subseconds	Time the first bit of the image was read into the FPGA on the SBC, in spacecraft clock notation, as reported by GNC. This is also called the image capture time. Number is subsecond clock ticks, where each tick represents 20 microseconds (1/50,000). In some images, the comments for IMGTMSEC and IMGTMSUB will differ slightly from what is listed here. This is because the value for this keyword can come from either the image data packet (if no GNC packet), or the GNC packet (overrides what was in the image data packet). The different comments make it obvious what the source of the value is. The value itself would be the same in either case, so the effect on the end user is negligible.	0 to 49999. Left blank when not available.
	CORTMSEC= ‘298271898’ / [sec] correlation time	Time when the first bit of the image was read into the FPGA on the SBC, in spacecraft clock notation. Number is in integer seconds. This correlation time is used by the MOC to correlate the image and housekeeping data.	Time since t=0, as defined in the SCLK kernel. Left blank when not available.

Class.Attribute Name	Keyword and example	Description	Range of values
	CORTMSUB= ‘123’ / [subsec] 8-bit subseconds	Subsecond when the first bit of the image was read into the FPGA on the SBC, in spacecraft clock notation. This correlation time is used by the MOC to correlate the image and housekeeping data. This subsecond tick represents 1/256 sec. Subsecond resolution is part of the DART-standard secondary header and is enough to uniquely identify and correlate the image and housekeeping data.	0 to 255. Left blank when not available.
	SN_SEC= ‘298271898’ / [sec] SMART Nav time	Time when the image data is processed by SMART Nav, in spacecraft clock notation. Number is in integer seconds.	Time since t=0, as defined in the SCLK kernel. Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	SN_SUB= ‘21314’ / [subsec] SMART Nav time 16-bit subseconds	Subsecond when the image data is processed by SMART Nav, in spacecraft clock notation. Number is subsecond clock ticks, where each tick represents 20 microseconds (1/50,000).	0 to 49999. Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.

Class.Attribute Name	Keyword and example	Description	Range of values
	FPE_SEC= ‘323548618’ /[sec] MET first pixel arrives at SBC	32-bit MET seconds of when first pixel arrives at SBC as recorded in DRACO metadata. Should be consistent with IMGTMSEC.	Time since t=0, as defined in the SCLK kernel.
	FPE_SBSS= ‘25000’ /[subsec] MET 16bit subsec first pxl arr. at SBC	16-bit MET subseconds of when first pixel arrives at SBC as recorded in DRACO metadata. Should be consistent with IMGTMSUB.	0 to 49999.
	FPE_EBSS=‘128’ / [subsec] MET 8bit subsec first pxl arr. at SBC	8-bit MET subseconds of when first pixel arrives at SBC; LSB = 1/256 s, derived from 16-bit version (MSB-justified, 4-bits unused in pix 411). Should be consistent with CORTMSUB.	0 to 255.
	ESTAQSEC = ‘298271898’ / [sec] est. latch time	Estimated Image Time of Validity, in integer seconds, computed *before* the image is actually acquired. Time at which GNC information is latched.	Time since t=0, as defined in the SCLK kernel. Left blank when not available.
	ESTAQSUB= ‘1234’ / [subsec] est. latch time, 16-bit subseconds	Subsecond Estimated Image Time of Validity computed *before* the image is actually acquired. Time at which GNC information is latched. This subsecond tick represents 1/50000 sec.	0 to 49999. Left blank when not available.
dart:acquisition_time	ACQTMSEC= ‘298271898’ / [sec] image TOV	Image time of validity (TOV) in integer seconds, in spacecraft clock notation. This is the time for which the GNC attitude data is valid. In global imaging mode, this time is defined as the midpoint of the integration period, given by image capture time ([IMGTMSEC and IMGTMSUB]-[96.2 ms]-[EXPTIME/2]). In rolling imaging mode, this time is given by image capture time ([IMGTMSEC and IMGTMSUB]-[48.1 ms]-[EXPTIME/2]).	Time since t=0, as defined in the SCLK kernel. Left blank when not available.
	ACQTMSUB= ‘2345’ / [subsec] image TOV	Image time of validity (TOV) subseconds, in spacecraft clock notation. Number is subsecond clock ticks, where each tick represents 20 microseconds (1/50,000).	0 to 49999. Left blank when not available.

Class.Attribute Name	Keyword and example	Description	Range of values
	SNG_SEC= '298271898' / [sec] SNG state update time	The time at which the SMART Nav guidance (SNG) filter states were last updated, in integer seconds.	Time since t=0, as defined in the SCLK kernel. Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	SNG_SUB= '123' / [subsec] SNG state update time	The time at which the SMART Nav guidance (SNG) filter states were last updated, in subsecond clock ticks, where each tick represents 1/50,000 seconds.	0 to 49999. Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	IMGMOD= 'ROLLING' / Imaging mode	Shutter mode used to acquire image.	"ROLLING" or "GLOBAL".
dart:exposure_time	EXPTIME = '9.0440878E-0002' / [sec] Exposure time	Image exposure time in seconds.	0 to 0.094 for global shutter mode. 0 to 10.15129 for rolling shutter mode.
	VIRTROWS = '20' / number of virtual rows	Virtual rows are added to the image to increase the exposure time beyond that implied by the number of lines in the detector. 20 is the default.	20 to 1080 for global shutter mode; 20 to 115000 for rolling shutter mode.

Class.Attribute Name	Keyword and example	Description	Range of values
	GAIN= ‘1X’ /Gain setting	Detector gain setting.	“1X”, “2X”, “10X”, or “30X”.
	IMGSLOT= ‘A’ /Processing slot used	Image processing mode slot used. The detector ping-pongs between A and B, alternating with every image.	“A” or “B”.
	DATAMODE=‘RECORD’ / Data collection mode	Describes whether the images were directly downlinked or recorded and played back.	“DOWNLINK” or “RECORD”.
dart:test_pattern	TSTPTTRN = ‘dis’ /Test pattern mode	‘dis’ if the image is not a test pattern. Otherwise, the value corresponds to the test pattern used. STATHORZ is a static horizontal gradient, DYNAHORZ is a dynamic horizontal gradient (i.e., it changes from image to image), TWOBOX is a two-box pattern, and FLAT is a uniform gray image.	“dis”, “STATHORZ”, “DYNAHORZ”, “TWOBOX”, “FLAT”
dart:binning	BINNING=‘ON’ /Binning status	If binning is on or not.	“ON” or “OFF”.
	WIN1XSTA = ‘0’ / X origin of window 1	Column where first window starts. Window1 coordinates are with respect to a 2560 x 2161 image plus header row (the 2560 x 2160 image plus 2560 x 1 header row) and unbinned pixels. The first pixel of the image plus header row is coordinate 0,0.	0 to 511.
	WIN1XEND= ‘2047’ / X end of window 1	Column where first window ends. Window1 coordinates are with respect to a 2560 x 2161 image plus header row (the 2560 x 2160 image plus 2560 x 1 header row) and unbinned pixels. The first pixel of the image plus header row is coordinate 0,0.	2047 to 2559.
	WIN1YSTA = ‘1’/ Y origin of window 1	Row where first window starts. Window1 coordinates are with respect to a 2560 x 2161 image plus header row (the 2560 x 2160 image plus 2560 x 1 header row) and unbinned pixels. The first pixel of the image plus header row is coordinate 0,0.	1 to 113.

Class.Attribute Name	Keyword and example	Description	Range of values
	WIN1YEND= '2048' / Y end of window 1	Row where first window ends. Window1 coordinates are with respect to a 2560 x 2161 image plus header row (the 2560 x 2160 image plus 2560 x 1 header row) and unbinned pixels. The first pixel of the image plus header row is coordinate 0,0.	2048 to 2160.
	WINDOWH = '512'/ Height of the image	Height of the downlinked image. Will equal height of second window, when image is smaller than NAXIS1.	512 or 1024.
	WINDOWW = '512'/ Width of the image.	Width of the downlinked image. Will equal second window width, when image is smaller than NAXIS2.	512 or 1024.
	WINDOWX = '1' / X origin of image	Column where downlinked image starts. The first pixel of the image plus header row is coordinate 0,0. Greater than 0 when window2 is applied.	0 to 512.
	WINDOWY= '5' / Y origin of image	Row where downlinked image starts. The first pixel of the image plus header row is coordinate 0,0. Greater than 0 when window2 is applied.	0 to 512.
	SNGROI_C = '123' / pixel col start	Pixel column of the first pixel of the 512x512 image subwindow whose center corresponds to the S/C relative velocity to asteroid vector	0 to 512. Left blank when SMART Nav is not operating.
	SNGROI_R = '496' / pixel row start	Pixel row of the first pixel of the 512x512 image subwindow whose center corresponds to the S/C relative velocity to asteroid vector	0 to 512. Left blank when SMART Nav is not operating.
dart:window2_x_start	WIN2XSTA = '256' / X origin of window 2	Column where second window starts. Window 2 coordinates are with respect to a 1024 x 1025 image plus header row (the 1024 x 1024 image plus 1024 x 1 header row) following the window1 and/or binning process. The first pixel of the image plus header row is coordinate 0,0. Value should be same as WINDOWX but derived from different source. This keyword is populated but not meaningful when WINDOWH=1024.	0 to 512.

Class.Attribute Name	Keyword and example	Description	Range of values
dart:window2_y_start	WIN2YSTA = '257'/ Y origin of window 2	Row where second window starts. Window 2 coordinates are with respect to a 1024 x 1025 image plus header row (the 1024 x 1024 image plus 1024 x 1 header row) following the window1 and/or binning process. The first pixel of the image plus header row is coordinate 0,0. Value should be (WINDOWY+1) but derived from different source. This keyword is populated but not meaningful when WINDOWH=1024.	1 to 513.
	TRUNC= 'MSB' / Truncation mode	Defines whether the data are truncated using MSB or LSB. When binning is enabled, the truncation mode is MSB. When binning is disabled, the truncation mode is LSB.	"MSB" or "LSB".
dart:onboard_cal	CALIB= 'OFF' /Calibration status	Status of the on-board calibration table application.	"ON" or "OFF".
dart:badpix_invalidation_mode	BADPIXMD= 'BYPASS' /Bad pixel invalidation mode	When BADPIXMD=USE, pixels identified by the bad pixel map are invalidated. When BADPIXMD=BYPASS, the bad pixel map is not used.	"USE" or "BYPASS".
Special_Constants. invalid_constant	SNAVFLAG= '4095' /Value SMART Nav uses to flag to bad pixels	Value assigned to bad pixels for SMART Nav purposes.	'4095'. Hardcoded.
	TARSTATE = 'PRECISIONLOCKED' / Targeting State	Current state of the targeting state machine.	"INITIAL", "LOCKING", "LOCKED", "PRECISION LOCKED". Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.

Class.Attribute Name	Keyword and example	Description	Range of values
	DIDATRK = ‘1’ /Didymos track ID	This is the track ID discriminated as Didymos in each iteration.	0 – 65535. Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	DIMOTK1 = ‘1’ / Dimorphos Track ID 1	This is the track ID discriminated as Dimorphos in each iteration. In the Precision Locked Targeting state, Targeting could combine multiple tracks into its estimate of Dimorphos. If that happens, the track ID discriminated as Dimorphos with the highest total intensity is output here.	0 – 65535. Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	DIMOTK2 = ‘1’ / Dimorphos Track ID 2		
	DIMOTK3 = ‘1’ / Dimorphos Track ID 3		
	DIMOTK4 = ‘1’ / Dimorphos Track ID 4		
	DIMOTK5 = ‘1’ / Dimorphos Track ID 5		
	DIMOTK6 = ‘1’ / Dimorphos Track ID 6		
	DIMOTK7 = ‘1’ / Dimorphos Track ID 7		
	DIMOTK8 = ‘1’ / Dimorphos Track ID 8		
	DIMOTK9 = ‘1’ / Dimorphos Track ID 9		
	DIMOTK10 = ‘1’ / Dimorphos Track ID 10		
	DIMOTK11 = ‘1’ / Dimorphos Track ID 11		
	DIMOTK12 = ‘1’ / Dimorphos Track ID 12		
	DIMOTK13 = ‘1’ / Dimorphos Track ID 13		
	DIMOTK14 = ‘1’ / Dimorphos Track ID 14		
	DIMOTK15 = ‘1’ / Dimorphos Track ID 15		
	DIMOTK16 = ‘1’ / Dimorphos Track ID 16		
	DID_X = ‘780.22’ / Est. col. position of Didymos centroid		0 to 1023.

Class.Attribute Name	Keyword and example	Description	Range of values
	DID_Y = '780.22' / Est. row position of Didymos centroid	Image coordinates of Didymos. This is the estimated column (DID_X) and row (DID_Y) positions of Didymos with respect to the 1024x1024 image.	Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	DIM_X= '780.22' / Est. col. position of Dimorphos centroid	Image coordinates of Dimorphos. This is the estimated column (DIM_X) and row (DIM_Y) position of Dimorphos, with respect to the 1024x1024 image.	0 to 1023. Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	DIM_Y= '780.22' / Est. row position of Dimorphos centroid		
	GCXSUM1 = '1280' / Centroid 1 col sum	Centroid column sum. This is the sum of the column coordinate of each pixel in the centroid. The units are pixels. A value of 0 means there was no centroid in this slot during this iteration. This is because fewer than 16 centroids were identified in the image during this iteration.	0 to 536,346,624 Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	GCXSUM2 = '1280' / Centroid 2 col sum		
	GCXSUM3 = '1280' / Centroid 3 col sum		
	GCXSUM4 = '1280' / Centroid 4 col sum		
	GCXSUM5 = '1280' / Centroid 5 col sum		
	GCXSUM6 = '1280' / Centroid 6 col sum		
	GCXSUM7 = '1280' / Centroid 7 col sum		
	GCXSUM8 = '1280' / Centroid 8 col sum		
	GCXSUM9 = '1280' / Centroid 9 col sum		
	GCXSUM10 = '1280' / Centroid 10 col sum		

Class.Attribute Name	Keyword and example	Description	Range of values
	GCXSUM11 = '1280' / Centroid 11 col sum		
	GCXSUM12 = '1280' / Centroid 12 col sum		
	GCXSUM13 = '1280' / Centroid 13 col sum		
	GCXSUM14 = '1280' / Centroid 14 col sum		
	GCXSUM15 = '1280' / Centroid 15 col sum		
	GCXSUM16 = '1280' / Centroid 16 col sum		
	GCYSUM1 = '1280' / Centroid 1 row sum	Centroid row sum. This is the sum of the row coordinate of each pixel in the centroid. The units are pixels. A value of 0 means there was no centroid in this slot during this iteration. This is because fewer than 16 centroids were identified in the image during this iteration.	0 to 536,346,624 Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	GCYSUM2 = '1280' / Centroid 2 row sum		
	GCYSUM3 = '1280' / Centroid 3 row sum		
	GCYSUM4 = '1280' / Centroid 4 row sum		
	GCYSUM5 = '1280' / Centroid 5 row sum		
	GCYSUM6 = '1280' / Centroid 6 row sum		
	GCYSUM7 = '1280' / Centroid 7 row sum		
	GCYSUM8 = '1280' / Centroid 8 row sum		
	GCYSUM9 = '1280' / Centroid 9 row sum		
	GCYSUM10 = '1280' / Centroid 10 row sum		
	GCYSUM11 = '1280' / Centroid 11 row sum		
	GCYSUM12 = '1280' / Centroid 12 row sum		
	GCYSUM13 = '1280' / Centroid 13 row sum		
	GCYSUM14 = '1280' / Centroid 14 row sum		
	GCYSUM15 = '1280' / Centroid 15 row sum		
	GCYSUM16 = '1280' / Centroid 16 row sum		
	GINTSM1 = '1280' / Centroid 1 intensity	Centroid intensity. The units are DN. A value of 0 means there was no centroid in this slot during this iteration. This is because fewer than 16 centroids were identified	0 to 4,294,967,295 Left blank when not available.
	GINTSM2 = '1280' / Centroid 2 intensity		
	GINTSM3 = '1280' / Centroid 3 intensity		
	GINTSM4 = '1280' / Centroid 4 intensity		

Class.Attribute Name	Keyword and example	Description	Range of values
	GINTSM5 = '1280' / Centroid 5 intensity	in the image during this iteration.	If OBSTYPE is not TERMINAL or SMARTNAV_ TEST, all SMART-Nav-related keywords should be ignored.
	GINTSM6 = '1280' / Centroid 6 intensity		
	GINTSM7 = '1280' / Centroid 7 intensity		
	GINTSM8 = '1280' / Centroid 8 intensity		
	GINTSM9 = '1280' / Centroid 9 intensity		
	GINTSM10 = '1280' / Centroid 10 intensity		
	GINTSM11 = '1280' / Centroid 11 intensity		
	GINTSM12 = '1280' / Centroid 12 intensity		
	GINTSM13 = '1280' / Centroid 13 intensity		
	GINTSM14 = '1280' / Centroid 14 intensity		
	GINTSM15 = '1280' / Centroid 15 intensity		
	GINTSM16 = '1280' / Centroid 16 intensity		
	GNPXLS1 = '1280' / Centroid 1 num. pixels	Number of pixels in centroid. The units are pixels. A value of 0 means there was no centroid in this slot during this iteration. This is because fewer than 16 centroids were identified in the image during this iteration.	0 to 1,048,576 Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_ TEST, all SMART-Nav-related keywords should be ignored.
	GNPXLS2 = '1280' / Centroid 2 num. pixels		
	GNPXLS3 = '1280' / Centroid 3 num. pixels		
	GNPXLS4 = '1280' / Centroid 4 num. pixels		
	GNPXLS5 = '1280' / Centroid 5 num. pixels		
	GNPXLS6 = '1280' / Centroid 6 num. pixels		
	GNPXLS7 = '1280' / Centroid 7 num. pixels		
	GNPXLS8 = '1280' / Centroid 8 num. pixels		
	GNPXLS9 = '1280' / Centroid 9 num. pixels		
	GNPXLS10 = '1280' / Centroid 10 num. pixels		
	GNPXLS11 = '1280' / Centroid 11 num. pixels		
	GNPXLS12 = '1280' / Centroid 12 num. pixels		
	GNPXLS13 = '1280' / Centroid 13 num. pixels		
	GNPXLS14 = '1280' / Centroid 14 num. pixels		

Class.Attribute Name	Keyword and example	Description	Range of values
	GNPXLS15 = ‘1280’ / Centroid 15 num. pixels		
	GNPXLS16 = ‘1280’ / Centroid 16 num. pixels		
	CNTKID1 = ‘1’ / Centroid 1 track ID	Centroid Track ID. A list denoting the unique track ID associated with the 16 slots available for centroids. A value of 0 means there is no track at this centroid for this iteration. This is a mapping from the 16 centroid slots in memory to track IDs.	0 to 65535 Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	CNTKID2 = ‘1’ / Centroid 2 track ID		
	CNTKID3 = ‘1’ / Centroid 3 track ID		
	CNTKID4 = ‘1’ / Centroid 4 track ID		
	CNTKID5 = ‘1’ / Centroid 5 track ID		
	CNTKID6 = ‘1’ / Centroid 6 track ID		
	CNTKID7 = ‘1’ / Centroid 7 track ID		
	CNTKID8 = ‘1’ / Centroid 8 track ID		
	CNTKID9 = ‘1’ / Centroid 9 track ID		
	CNTKID10 = ‘1’ / Centroid 10 track ID		
	CNTKID11 = ‘1’ / Centroid 11 track ID		
	CNTKID12 = ‘1’ / Centroid 12 track ID		
	CNTKID13 = ‘1’ / Centroid 13 track ID		
	CNTKID14 = ‘1’ / Centroid 14 track ID		
	CNTKID15 = ‘1’ / Centroid 15 track ID		
	CNTKID16 = ‘1’ / Centroid 16 track ID		
	HYDRMSS = ‘8.6’ / [kg] Remaining hydrazine mass	Hydrazine mass remaining in propellant tank.	0 to 50. Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.

Class.Attribute Name	Keyword and example	Description	Range of values
	SNTIAMAT = ‘TRUE’ / Targeting attitude matched	SMART Nav Targeting image attitude successfully matched. True/false flag that is true when an image has been matched to an attitude measurement successfully.	“TRUE” or “FALSE” Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	SNGDMAT = ‘TRUE’ / Guidance attitude matched	SMART Nav Guidance image attitude successfully matched. True/false flag that is true when an image has been matched to delta-V measurement successfully.	“TRUE” or “FALSE” Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.

Class.Attribute Name	Keyword and example	Description	Range of values
	TDVEST_X = '2.9' / [m/s] Terminal X deltaV est.	Terminal inertial DeltaV estimate in X direction.	Full datatype range; 32-bit double (single precision) Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	TDVEST_Y = '2.9' / [m/s] Terminal Y deltaV est.	Terminal inertial DeltaV estimate in Y direction.	Full datatype range; 32-bit double (single precision) Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.

Class.Attribute Name	Keyword and example	Description	Range of values
	TDVEST_Z = '2.9' / [m/s] Terminal Z deltaV est.	Terminal inertial DeltaV estimate in Z direction.	Full datatype range; 32-bit double (single precision) Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	SNFTEXE = 'TRUE' / SMART Nav guidance filter executing	SMART Nav Guidance filter executing. True/false flag that indicates whether the SMART Nav Guidance Filter is being executed.	"TRUE" or "FALSE" Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	SNGSTAT = '0' /SN Guidance status flags in 8-bit LSB word	SMART Nav Guidance (SNG) status word with individual bits defining the following status: bit0 (LSB) – runFilterOff: if 1 then runFilter flag is True bit1 – imgTimeLTOEToLastImg: if 1 then image time is less than or equal to last image time bit2 – imgTimeOlderThanTol: if 1 then image time is older than tolerance bit3 – imgTimeGTOEToSCLK: if 1 then image time is greater than or equal to SCLK	0 to 255. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.

Class.Attribute Name	Keyword and example	Description	Range of values
	BLOBTHRS = ‘5’ / Minimum number of pixels used for a blob	Minimum number of pixels per blob threshold employed to compute centroid.	0 to (2^{19} – 1).
	FORETHRS = ‘1’ / DN Foreground threshold	Foreground threshold employed to compute centroid.	0 to (2^{19} – 1).
	ESTSC_QA = ‘0.108080037674849’ / SC quaternion in J2000 (q0)	Raw quaternion from S/C associated with ESTAQSEC and ESTAQSUB.	Left blank when not available.
	ESTSC_QX = ‘-0.674302095900066’ / SC quaternion in J2000 (q1)	Raw quaternion from S/C associated with ESTAQSEC and ESTAQSUB.	Left blank when not available.
	ESTSC_QY = ‘-0.32453616895850’ / SC quaternion in J2000 (q2)	Raw quaternion from S/C associated with predicted ESTAQSEC and ESTAQSUB.	Left blank when not available.
	ESTSC_QZ = ‘0.65445524213556’ / SC quaternion in J2000 (q3)	Raw quaternion from S/C associated with predicted ESTAQSEC and ESTAQSUB.	Left blank when not available.
	SMEARINX = ‘1.56559E-05’ / [rad/sec] Angular rate about SC +X axis	Smear indicator. Windowed average angular rate about +X direction. Window duration is image integration time.	0 to 0.2. Left blank when not available.
	SMEARINY = ‘1.56559E-05’/ [rad/sec] Angular rate about SC +Y axis	Smear indicator. Windowed average angular rate about +Y direction. Window duration is image integration time.	0 to 0.2. Left blank when not available.
	SMEARINZ = ‘1.56559E-05’/ [rad/sec] Angular rate about SC +Z axis	Smear indicator. Windowed average angular rate about +Z direction. Window duration is image integration time.	0 to 0.2. Left blank when not available.
	ATT_VAL =‘1’/Attitude flag	Flag indicating if the estimated attitude is considered valid. 1 = attitude valid; 0 = attitude not valid.	0 or 1. Left blank when not available.
	FRM_ID = ‘2’ /Frame ID	Frame ID. The units are count.	0 to 4294967295. Left blank when not available.
dart:detector1_temp	DETTEMP1 = ‘18.333’ / [degC] Detector temperature sensor 1	Detector 1 temperature.	
dart:detector2_temp	DETTEMP2 = ‘18.333’ / [degC] Detector temperature sensor 2	Detector 2 temperature.	
dart:fpe_temp	FPETEMP = ‘21.111’ / [degC] FPE board temperature	Temperature of FPE.	

Class.Attribute Name	Keyword and example	Description	Range of values
dart:current_33va_supply	CURR33VA = '12.1' / [mA] Current for detector 3.3VA supply	Current for detector 3.3VA supply.	
dart:current_18vd_supply	CURR18VD = '7.14' / [mA] Current for detector 1.8VA supply	Current for detector 1.8VD supply.	
dart:current_33vd_supply	CURR33VD = '1.68' / [mA] Current for detector 3.3VD supply	Current for detector 3.3VD supply.	
	CURR33VP = '0.1' / [mA] Current for detector 3.3V pixel supply	Current for detector 3.3V pixel supply.	
dart:analog_reset_supply	ANRSTCUR = '7.01' / [mA] Current for detector analog reset supply	Current for detector analog reset supply.	
	REL_A_X= '0.123'/ X SC Relative Inertial Position of Didymos	Position of Didymos relative to the spacecraft in the Vehicle Inertial Frame (VIF)	Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	REL_A_Y= '0.123'/ Y SC Relative Inertial Position of Didymos		
	REL_A_Z= '0.123'/ Z SC Relative Inertial Position of Didymos		
	REL_B_X= '0.123'/ X SC Relative Inertial Position of Dimorphos	Position of Dimorphos relative to the spacecraft in the VIF	Left blank when not available. If OBSTYPE is not TERMINAL or SMARTNAV_TEST, all SMART-Nav-related keywords should be ignored.
	REL_B_Y= '0.123' /Y SC Relative Inertial Position of Dimorphos		
	REL_B_Z= '0.123'/ SC Relative Z Inertial Position of Dimorphos		
	FSWNAM= 'DART_ONBOARD' /name of flight software	Name of onboard flight software.	Defined by FSW team
	FSWVER= '1.1.2' /flight software version tag	Version of flight software employed.	"X.X.X"

Class.Attribute Name	Keyword and example	Description	Range of values
Target_Identification	TARGET = 'DIDYMOS' / Primary target object	Primary target object.	"65803 Didymos", "65803 Didymos I (Dimorphos)", "JUPITER", "M11", "SKY", etc.
	SECTAR = 'NA' / Secondary target object	Secondary target object.	"65803 Didymos I (Dimorphos)", "NA", etc.
dart:mission_phase	MPHASE = 'TERMINAL' / phase of the mission	The DART mission is divided into phases; this keyword states the phase during which the image was acquired.	"PRELAUNCH", "COMMISIONNING", 'CRUISE', "APPROACH", "TERMINAL", "FINAL".
	COR_UTC='2018-08-25 12:34:56.000' / Est UTC (YYYY-MM-DD HH:MM:SS.000)	Estimated UTC, to second precision only, of the CORTMSEC and CORTMSUB using the SPICE SCLK kernel at the time of image receipt.	Time since t=0, as defined in the SCLK kernel. Left blank when not available.
	SCLKPATI='1' / SCLK partition	SCLK time partition.	
	SCLKNAME='DART_SCLK_0000.TSC' /SCLK file used for COR_UTC	Name of SCLK file used to compute COR_UTC.	
	ACQTM = '298271898:2345' / [sec:subsec] image TOV	Image time of validity (TOV) in integer seconds:subseconds. This concatenates the information in ACQTMSEC and ACQTMSUB, with a colon between the two.	Left blank when not available.
	ACQTM_ET = '717892158.7820001' / [sec] image TOV as ephemeris time	Image time of validity (TOV) as ephemeris time based on ACQTM.	Left blank when not available.

Class.Attribute Name	Keyword and example	Description	Range of values
dart:soc_acquisition_time	ACQTMSOC = ‘298271898: 2345’ / [sec:subsec] SOC-calculated TOV	Image time of validity (TOV) calculated by the Science Operations Center (SOC). The value before the colon is integer seconds in spacecraft clock notation. The value after the colon is subsecond clock ticks, where each tick represents 20 microseconds (1/50,000). This is the time for which the GNC attitude data is valid. In global imaging mode, this time is defined as the midpoint of the integration period, given by image capture time ([FPE_SEC and FPE_SBSS]-[96.2 ms]-[EXPTIME/2]). In rolling imaging mode, this time is given by image capture time ([FPE_SEC and FPE_SBSS]-[48.1 ms]-[EXPTIME/2]). The math is identical to the math for AQCTMSEC and ACQTMSUB. However, the SOC calculates the image TOV based on FPE_SEC and FPE_SBSS, rather than IMGTMSEC and IMGSTMSUB. FPE_SEC and IMGTMSEC should be identical. IMGTMSUB and FPE_SBSS should be identical. However, using FPE_SEC and FPE_SBSS allows the SOC to calculate image TOV even when an image does not correlate to information provided by the GNC system.	Time since t=0, as defined in the SCLK kernel.
	ACQTMSET = ‘717892158.7820001’ / [sec] ephemeris time from ACQTMSOC	Image time of validity (TOV) as ephemeris time based on ACQTMSOC	
	ACQ_UTC = ‘2022 OCT 01 10:28:09.600’ / Image TOV in UTC from ACQTMSOC	Image time of validity (TOV) in UTC based on ACQTMSOC	
	ACQ_JDAT = ‘2459853.93702294’ / Image TOV in Julian Ephemeris Date, ACQTMSOC	Image time of validity (TOV) in Julian Ephemeris Date based on ACQTMSOC	
dart:lineread	LINEREAD = ‘87.46666’ / Readout time in microsec/line	Each line is read out at a 87.46666 microsecond clock rate.	87.46666

Class.Attribute Name	Keyword and example	Description	Range of values
dart:pix_delay	PIXDELAY = '33.3' / Delay between sequential pixels in line in ns	Each pixel is read out sequentially at a 33.3 ns clock rate.	33.3
dart:window2_x_end	WIN2XEND= '767' / X end of window 2	Column where second window ends. Window 2 coordinates are with respect to a 1024 x 1025 image plus header row (the 1024 x 1024 image plus 1024 x 1 header row) following the window1 and/or binning process. The first pixel of the image plus header row is coordinate 0,0. -1 if second windowing not applied.	-1 or 511 to 1023.
dart:window2_y_end	WIN2YEND= '768' / Y end of window 2	Row where second window ends. Window 2 coordinates are with respect to a 1024 x 1025 image plus header row (the 1024 x 1024 image plus 1024 x 1 header row) following the window1 and/or binning process. The first pixel of the image plus header row is coordinate 0,0.-1 if second windowing not applied.	-1 or 512 to 1024.
	CALFILE= 'DRACO_calibration_20210106.mat' / calibration file	Name of file provided by SMART Nav to the spacecraft for use when CALIB=ON.	DRACO_calibration_YYYYMMDD.mat
	SOCQUATA = '0.108080037674849' / SC quaternion in J2000 (q0) using ACQTMSOC	Spacecraft quaternion computed by the SOC using SPICE and ACQTMSOC.	
	SOCQUATX = '-0.674302095900066' / SC quaternion in J2000 (q1) using ACQTMSOC		
	SOCQUATY = '-0.32453616895850' / SC quaternion in J2000 (q2) using ACQTMSOC		
	SOCQUATZ = '0.65445524213556' / SC quaternion in J2000 (q3) using ACQTMSOC		
	SMERSINX = '1.56559E-05' / [rad/sec] Angular rate about SC +X axis	Smear indicator. Windowed average angular rate about +X direction. Window duration is image integration time. Computed by SOC, rather than GNC.	0 to 0.2. Left blank when not available.

Class.Attribute Name	Keyword and example	Description	Range of values
	SMERSINY = '1.56559E-05' / [rad/sec] Angular rate about SC +Y axis	Smear indicator. Windowed average angular rate about +Y direction. Window duration is image integration time. Computed by SOC, rather than GNC.	0 to 0.2. Left blank when not available.
	SMERSINZ = '1.56559E-05'/ [rad/sec] Angular rate about SC +Z axis	Smear indicator. Windowed average angular rate about +Z direction. Window duration is image integration time. Computed by SOC, rather than GNC.	0 to 0.2. Left blank when not available.
	BORERA = '326.459994' / [deg] Boresight right ascension	Boresight right ascension	0 to 360 degrees.
	BOREDEC = '-38.093559' / [deg] Boresight declination	Boresight declination	-90 to 90 degrees
	CELN_CLK = '28.16' / [deg] Celestial north clock angle	Celestial north clock angle	0 to 360 degrees.
	ECLN_CLK = '49.30' / [deg] Ecliptic north clock angle	Ecliptic north clock angle	0 to 360 degrees.
	SUN_CLK = '318.40' / [deg] Sun clock angle	Sunward direction clock angle	0 to 360 degrees.
	PXARCS = '1.02' / [arcsec] Pixel scale	Pixel scale in arcsec	Either 1.02 arcsec if BINNING = ON or 0.512 arcsec if BINNING = OFF.
	PXMRAD = '4.96' / [microradians] Pixel scale	Instantaneous field of view of a pixel, in microradians. If BINNING = ON, this value is reported for a 2x2 binned pixel.	Either 4.96 urad if BINNING = ON or 2.48 urad if BINNING = OFF.
	PHDIST = '1.04' / [AU] Heliocentric distance - Primary	Distance between the sun and the primary target, in AU	Calculated for selected TARGET values only (65803 Didymos, 65803 Didymos I (Dimorphos), Jupiter, Elara, Himalia), otherwise set to -1E32.

Class.Attribute Name	Keyword and example	Description	Range of values
	PSCRNG = ‘4.2622E+02’ / [km] Spacecraft range - Primary	Distance between the spacecraft and the primary target center, in km	Calculated for selected TARGET values only (65803 Didymos, 65803 Didymos I (Dimorphos), Jupiter, Elara, Himalia), otherwise set to -1E32.
	PSPHASE = ‘55.98’ / [deg] Solar phase angle - Primary	Angle between the sunward direction and the direction to the spacecraft, as observed from the primary target.	0 to 180 degrees. Calculated for selected TARGET values only (65803 Didymos, 65803 Didymos I (Dimorphos), Jupiter, Elara, Himalia), otherwise set to -1E32.
	PSELON = ‘73.49’ / [deg] Solar elongation - Primary	Angle between the sunward direction and the direction to the primary target, as observed from the spacecraft.	0 to 180 degrees. Calculated for selected TARGET values only (65803 Didymos, 65803 Didymos I (Dimorphos), Jupiter, Elara, Himalia), otherwise set to -1E32.

Class.Attribute Name	Keyword and example	Description	Range of values
	PPPCLK = ‘228.64’ / [deg] Positive pole clock angle - Primary	Positive pole clock angle of the primary target	0 to 360 degrees. Calculated for selected TARGET values only (65803 Didymos, 65803 Didymos I (Dimorphos), Jupiter), otherwise set to -1E32.
	PSUBLAT = ‘38.04’ / [deg] Sub-observer latitude - Primary	Sub-observer latitude of the primary target	-90 to 90 degrees. Calculated for selected TARGET values only (65803 Didymos, 65803 Didymos I (Dimorphos), Jupiter), otherwise set to -1E32.
	PSUBLON = ‘146.65’ / [deg] Sub-observer longitude - Primary	Sub-observer east longitude of the primary target	0 to 360 degrees. Calculated for selected TARGET values only (65803 Didymos, 65803 Didymos I (Dimorphos), Jupiter), otherwise set to -1E32.

Class.Attribute Name	Keyword and example	Description	Range of values
	PSSOLLAT = ‘-1.07’ / [deg] Sub-solar latitude - Primary	Sub-solar latitude of the primary target	-90 to 90 degrees. Calculated for selected TARGET values only (65803 Didymos, 65803 Didymos I (Dimorphos), Jupiter), otherwise set to -1E32.
	PSSOLLON = ‘190.18’ / [deg] Sub-solar longitude - Primary	Sub-solar east longitude of the primary target	0 to 360 degrees. Calculated for selected TARGET values only (65803 Didymos, 65803 Didymos I (Dimorphos), Jupiter), otherwise set to -1E32.
	SHDIST = ‘1.04’ / [AU] Heliocentric distance - Secondary	Distance between the sun and the secondary target, in AU	Calculated for selected SECTAR values only (65803 Didymos I (Dimorphos)), otherwise set to -1E32.
	SSCRNG = ‘4.2623E+02’ / [km] Spacecraft range - Secondary	Distance between the spacecraft and the secondary target center, in km	Calculated for selected SECTAR values only (65803 Didymos I (Dimorphos)), otherwise set to -1E32.

Class.Attribute Name	Keyword and example	Description	Range of values
	SSPHASE = ‘56.14’ / [deg] Solar phase angle - Secondary	Angle between the sunward direction and the direction to the spacecraft as seen from the secondary target	0 to 180 degrees. Calculated for selected SECTAR values only (65803 Didymos I (Dimorphos)), otherwise set to -1E32.
	SSELON = ‘73.59’ / [deg] Solar elongation - Secondary	Angle between the sunward direction and the direction to the secondary target, as observed from the spacecraft.	0 to 180 degrees. Calculated for selected SECTAR values only (65803 Didymos I (Dimorphos)), otherwise set to -1E32.
	SPPCLK = ‘228.64’ / [deg] Positive pole clock angle - Secondary	Positive pole clock angle of the secondary target	0 to 360 degrees. Calculated for selected SECTAR values only (65803 Didymos I (Dimorphos)), otherwise set to -1E32.
	SSUBLAT = ‘38.09’ / [deg] Sub-observer latitude - Secondary	Sub-observer latitude of the secondary target	-90 to 90 degrees. Calculated for selected SECTAR values only (65803 Didymos I (Dimorphos)), otherwise set to -1E32.

Class.Attribute Name	Keyword and example	Description	Range of values
	SSUBLON = ‘146.46’ / [deg] Sub-observer longitude - Secondary	Sub-observer east longitude of the secondary target	0 to 360 degrees. Calculated for selected SECTAR values only (65803 Didymos I (Dimorphos)), otherwise set to -1E32.
	SSSOLLAT = ‘-1.07’ / [deg] Sub-solar latitude - Secondary	Sub-solar latitude of the secondary target	-90 to 90 degrees. Calculated for selected SECTAR values only (65803 Didymos I (Dimorphos)), otherwise set to -1E32.
	SSSOLON = ‘190.18’ / [deg] Sub-solar longitude - Secondary	Sub-solar east longitude of the secondary target	0 to 360 degrees. Calculated for selected SECTAR values only (65803 Didymos I (Dimorphos)), otherwise set to -1E32.
dart:bad_image	BADIMAGE = ‘FALSE’ / Bad image identifier	A flag describing whether an image should be analyzed by end data product users. If BADIMAGE = ‘FALSE’, then the image is valid and can be reliably used. If BADIMAGE = ‘TRUE’, then the metadata and image contain invalid information and should **not** be used in any analyses.	TRUE or FALSE See Section 4.1.6.1 for more details about this keyword.
dart:observation_type	OBSTYPE = ‘TERMINAL’ / Observation type	A keyword that describes the type of observation the DRACO image is associated with. This is a useful keyword for users to filter on to hone in on the specific images of interest.	See list in Table 2

Class.Attribute Name	Keyword and example	Description	Range of values
geom:SPICE_Kernel_Identification	METAKRNL = 'current_2022052T16.tm' / metakernel used to compute SOC keywords	Name of metakernel used to compute SOC added keywords. The XML label identify the specific SPICE kernels using geom:SPICE_Kernel_Identification	
	SRCFILE = 'dart_0380520950_01511_01.fits' / original MOC fits file	Name of the original fits file received from the MOC. Used by the pipeline to track provenance between the PDS Data Product file and MOC original file, as the MOC version numbering system is independent of the PDS version number.	

5.2.2. **Calibrated Image Data**

The Level-2 calibrated DRACO image format is a single HDU, 1024 (sample) × 1024 (line), 32-bit floating point fits file, 2×2 binned from the original 2048 × 2048 window1. These images have traveled through the DRACO Calibration Pipeline, which is described in detail in the DRACO Calibration Pipeline Description document. The data are represented in radiance (W m^{-2} nm^{-1} sr^{-1}) when keyword IOVERF = “SKIP”. The data are represented in reflectance (I/F, unitless) when keyword IOVERF = “PERFORM”. The conversion to I/F is performed for Final Phase images only. The metadata associated with these Level-2 calibrated images (Table 10) are appended as additional keywords to the fits header and XML label of the corresponding raw image. The Class.Attribute Name column is left blank for fits keywords not mapped to the .xml label.

Not all calibrated images will have all keywords listed below. If the DRACO Instrument Scientist determines that a particular step can be skipped, the pipeline does not add the names of the reference files that would be used in that step if it had been performed. Instead, the pipeline only shows the step as being skipped. For example, if the dark current correction step were not needed, then DARK_SUB = 'SKIP' and they keywords REFDARK1 and REFDARK2 would not be added to the fits header of the calibrated image.

Table 10. DRACO Level-2 Calibrated Image Appended Metadata

Class.Attribute Name	**Keyword and example**	**Description**	**Range of values**
dart:undo_onboard_cal	ONBRDCAL = ‘UNDONE’ / On-board cal table status	Indicates whether the on-board calibration table was removed (i.e., by adding it back) to the image. NA if the onboard cal table was not applied to the image.	UNDONE, NA
dart:bias_subtraction	BIAS_SUB = ‘PERFORM’ / Bias subtraction	Indicates whether the bias subtraction step was done	PERFORM, SKIP
dart:dark_subtraction	DARK_SUB = ‘PERFORM’ / Dark subtraction	Indicates whether the dark subtraction step was done	PERFORM, SKIP
dart:flatfield	FLATFIEL = ‘PERFORM’ / Flat fielding	Indicates whether the flat field was applied	PERFORM, SKIP
dart:radiance_conversion	RADIANCE = ‘PERFORM’ / Conversion to radiance	Indicates whether the conversion to radiance was applied	PERFORM, SKIP
dart:ioverf_conversion	IOVERF = ‘PERFORM’ / Conversion to I/F	Indicates whether the conversion to I/F was done	PERFORM, SKIP
	REFBADPX = ‘DRACO_bad_pixels_20200910.fits’ / bad pixel map file	Name of bad pixel map used to calibrate image.	Determined by file naming convention.
	BADMASKV = ‘-1E09’ / Value assigned to bad pixels	Pixel value assigned to bad pixels by the SOC	-1E09
	REFBIAS = ‘DRACO_bias_global_1x_n20C_20200910.fits’ / ref bias file	Name of bias file used.	Determined by file naming convention.
	REFDARK1 = ‘DRACO_dark_global_1x_n20C_20200910.fits’ / ref dark file	Name of first dark file used to interpolate temperature-dependent bias.	Determined by file naming convention.

	REFDARK2 = 'DRACO_dark_global_1x_n15C_20200910.fits' / ref dark file	Name of second dark file used to interpolate temperature-dependent bias.	Determined by file naming convention.
	REFFLAT = 'DRACO_flat_global_1x_20200910.fits)' / Flat field file	Name of flat field file used.	Determined by file naming convention.
	LUPTABLE = 'DRACO_lookup_global_1x_20200910.csv' / Look-up table	Name of look-up table used	Determined by file naming convention.
Special_Constants. not_applicable_constant	PXOUTWIN = '-1E10' / Value assigned to pixels outside window2	Keyword created by MOC; value updated by pipeline	-1E10
Special_Constants. missing_constant	MISPXVAL = '1E10' / Value assigned to missing pixels	Keyword created by MOC; value updated by pipeline	1E10
Special_Constants. high_instrument_saturation	SATPXVAL = '1E09' / Value assigned to saturated pixels	Pixel value assigned to saturated pixels by the SOC	1E09
	OORADLUT = '1E08' / Out of range of lookup table	Pixel value assigned to pixels that are not truly saturated but whose DN is too high to be reliably calibrated using the radiometric lookup tables	1E08
	IOVRFLAG = '-1E08' / negative before conversion to I/F	Pixel value assigned to pixels that are negative before conversion to I/F	-1E08
	PIVOTWL = '622' / pivot wavelength, nm	DRACO pivot wavelength	622
	RDIDYMOS = '4.11E8' / (e-/s)/[W/(m^2 nm sr)]	Photometric keyword. Fixed value to be updated once flight instrument is tested.	4.11E8 Value may be updated periodically based on in-flight data. Assume the value in the fits file is the most-up-to-date value.
	F_SUN622 = '1.6784' / solar flux at 1 AU at 622 nm, W/(m^2 nm)	Solar flux at 622 nm. Fixed value	1.6784

5.2.3. DRACO Calibration File Formats

DRACO has the following calibration files that will be developed from in-flight and/or ground calibration data: on-board calibration table; bad pixel map; bias; dark; flat field; radiometric lookup table. Calibration files will be saved in the formats listed in and described further in the DRACO Calibration Pipeline Description Document, which is included in the DRACO bundle document collection. In the event of a conflict between the DRACO SIS and the DRACO Calibration Pipeline Description, the pipeline description takes precedence.

The calibration pipeline inputs specified as fits files cover the same area as window1 on the DRACO detector and are 2×2 binned from 2048×2048 to 1024×1024 to match the DRACO images obtained in flight. The naming convention for the calibration input files is described in Table 8.

5.2.3.1. On-board Calibration Table and Bad Pixel Map

On-board Calibration Table – The on-board calibration table is used as part of Small-body Maneuvering Autonomous Real-Time Navigation (SMART Nav) algorithm. It is essentially a bias subtraction that improves algorithm performance.

This file is formatted as a single HDU, 1024 (sample) × 1024 (line), 32-bit floating point fits file, 2×2 binned from the original 2048 × 2048 window1, in units of DN. Metadata contained in the fits header for the on-board calibration table are listed in Table 11.

The on-board calibration table is not completely reversible because the calibration table subtraction bottoms out at zero. In every image that has had the onboard calibration table applied to it, ≤0.8% of pixels will be affected by the calibration table. This is an inherent property of the calibration table. The specific consequences of applying the calibration table depend on the content of the image to which the table is applied. In dark frame images, roughly 70% of the pixels affected by the calibration table (≤0.6% of all pixels in a dark frame image) may have DN = 0 after the on-board calibration table has been applied. In approximately 16% of such pixels (i.e., <0.1% of the total pixels in a dark frame image), adding back the calibration table will overcorrect the image by one or a few DN. For example, if the original value in a pixel were 3 DN, but the calibration table value was 5 DN, the pixel value after the calibration table was applied would be 0 DN, not -2 DN. So, when the ground calibration pipeline adds back the on-board calibration table, the pixel value in that pixel would be 5 DN, rather than the correct value of 3 DN. In illuminated images, fewer pixels will be overcorrected. For images where Dimorphos fills the frame, no pixels should be overcorrected.

One cannot identify which pixels have been overcorrected; however, one can hone in on the subset of pixels that might have been overcorrected by comparing the locations of pixels where DN = 0 in the SMART Nav image and where DN > 0 in the on-board calibration table.

The calibration table is built by identifying two kinds of pixels: “hot pixels”, here defined as having a high bias value that is consistent across a multi-frame dataset (50 frames for pre-launch data), and “popcorn pixels” which have an intermittent high bias value. For consistently hot pixels, the high bias value is entered into the calibration table. For intermittent, popcorn pixels, the minimum bias value seen for that pixel over the multi-frame dataset is entered into the calibration table to reduce the frequency and severity of overcorrections discussed in the previous paragraph. It is possible that actual popcorn pixels exist that fluctuate with a longer time constant than that used in testing (50 seconds for pre-launch data), leading to misidentification either as a hot pixel and overcorrection in the calibration table, or as a good pixel and under-correction. The fits header includes keywords relating to how these two types of pixels are distinguished: popcorn pixels are identified as those whose standard deviation, over the multi-frame dataset, is both larger than POPSTD in absolute terms and larger than POPFACTR times the value expected for a hot pixel due to electron shot noise. If a pixel does not meet the criteria for either a hot pixel or a popcorn pixel, then the on-board calibration table is set to 0 DN for those pixels.

Bad Pixel Map – To allow for the situation in which some pixels on the detector are deemed "bad" (i.e., responsivity abnormal enough to potentially affect SMART Nav performance), the pipeline contains an input file that specifies the locations of bad pixels. A value of 0 indicates that the pixel is good. A value of 1 means that the pixel was deemed bad. The header contains keywords that relate to determining how potential bad pixels are identified: pixels which, under dark frame conditions: have a very high bias value (larger than BADBIAS), or under illuminated conditions are much dimmer than surrounding pixels (have a relative photoresponse less than BADPR). For pre-launch testing, both dark and flat-field illuminated datasets are available, so the bad pixel map will be the union of the set of pixels with high bias and the sets of pixels with low photoresponse measured from each listed exposure time independently. For post-launch updates, flat-field illumination is not available, so any updates to the bad pixel map will be based only on the bias values from dark frames.

This file is formatted as a single HDU, 1024 (sample) × 1024 (line), 32-bit floating point fits file, 2×2 binned from the original 2048 × 2048 window1, and is unitless. Metadata contained in the fits header for the bad pixel map are listed in Table 11. The Class.Attribute Name column is left blank for fits keywords not mapped to the .xml label.

Table 11. DRACO File Metadata for On-board Calibration Table and Bad Pixel Map

Class.Attribute Name	Keyword and example	Description	Range of values
	SIMPLE = T / file conforms to FITS standard	Required in FITS standard.	T
Element_Array. data_type	BITPIX = -32 / number of bits per data pixel	Calibration inputs are always be 32-bit floating point files.	-32
	NAXIS = 2 / number of data axes	Number of axes; all DRACO images have 2 axes.	2
Axis_Array. sequence_number	NAXIS1 = 1024 / length of data axis 1	Number of rows, all DRACO images have 1024 rows.	1024
Axis_Array. sequence_number	NAXIS2 = 1024 / length of data axis 2	Number of columns, all DRACO images have 1024 columns.	1024
	EXTEND = T / FITS dataset may contain extensions	By default, set to T so that we can add extensions.	T
Modification_History. modification_date	DATE = '2018-08-25'/ file creation date YYYY-MM-DD	Date file was created.	YYYY-MM-DD
Investigation_Area. name	MISSION = 'DART' / mission: DART	Name of mission.	"DART"
Observing_System. name	HOSTNAME= 'DART ' / spacecraft name	DRACO is on the spacecraft called DART.	"DART"
Observing_System_Component.name	INSTRUME= 'DRACO ' / instrument name	Name of instrument.	"DRACO"

	ORIGIN = 'JHUAPL' / source of data product	Organization that created the file	"JHUAPL"
	CREATOR = 'CAROLYN SAWYER' / product author	Author of the file	The format is firstName lastName.
	DETECTOR = 'SN403' / detector name	Name of detector from which the images used to create the file were collected	"SN403"
	CALTYPE = 'CALTABLE' / calibration file type	Type of calibration file	"CALTABLE", "BADPIXEL MAP", "BIAS", "DARK", "FLATFIELD", "RADIOMETRIC"
dart:mission_phase	MPHASE = 'PRELAUNCH' / mission phase	Mission phase(s) during which the images used to create the input file were collected. A slash indicates data from multiple mission phases were used to create the file	"PRELAUNCH", "COMMISSIONING", "CRUISE", "APPROACH", "TERMINAL", "FINAL"
dart:imaging_mode	IMGMOD= 'GLOBAL' / imaging mode	Shutter mode of the images used to create the file	"GLOBAL". The calibration table and bad pixel map are only built from global shutter images, even though DRACO is capable of using both rolling and global shutter modes.
dart:gain	GAIN= '1X' /gain setting	Detector gain setting of the images used to create the file	"1X", "2X", "10X", or "30X"
dart:test_temp	TESTTEMP = -20 / [degC] nominal test temperature	Nominal temperature for the test sequence used to generate the calibration table	Unspecified
	SRCRTDIR = 'APLFSFRONTIER/PROJECT/AIDA/500 INSTRUMENT/DETECTOR/' / Top-level path	Top-level directory location of source images used to create the file	Unspecified

	DATASRC = 'TESTING/SN403 PTC/-20C/20_09_14_10_28_44/' / Mid-level data path	Path to lowest-level folder containing both illuminated and dark data used to create the file, relative to SRCRTDIR	Unspecified
	DARKFRM = 'BIAS_FULL/GLOBAL/1X_BIAS_FULL/1' / Location of dark frames	Path to directory containing dark frames used to create the file, relative to DATASRC	Unspecified
	ILLUMFRM = 'FULL/GLOBAL/1X' / Location of illuminated frames	Path to directory containing illuminated frames used to create the file, relative to DATASRC	Unspecified
	LITTIMES = '100 500 1000' / [linetimes] exposure time for photoresponse	Exposure times of the illuminated images used to create the file, in units of linetime. This should be understood as a pointer to the datasets used within the ILLUMFRM folder – pre-launch testing included flat-field illuminated frames with a variety of integration times – rather than having direct significance. If N/A, no illuminated data were used.	1, 2, 4, 8, 16, 32, 64, 100, 150, 200, 250, 200, 250, 400, 450, 500, 550, 600 650, 700, 750, 800, 850, 900, 950, 1000, N/A
	GENVER = '4CEC7B2E' / Version of software used to create file	Comment used for internal version control	Unspecified
	BADBIAS = 2048 / Bias limit for bad pixels	Bias in DN above which pixels are declared bad and included in the bad pixel map. The value of 2048 is convenient because, at half-saturated, it implies only half of the pixel's range is available to respond to light, making the post-calibration pixel likely to have poor photoresponse.	0 to 4095
	POPFACTR = 1.5 / Popcorn shot noise criterion	Factor above the expected shot noise used to declare a popcorn pixel. The expected standard deviation due to shot noise is calculated from the mean bias of the pixel. Then the actual standard deviation of each pixel is compared to POPFACTR times the expected shot noise, and pixels with a standard deviation greater than this product are treated as popcorn pixels.	1 to Inf

	POPSTD = 1 / Popcorn standard deviation criterion	Floor on allowed std values for a popcorn pixel. Because of discretization, it is difficult to estimate shot noise for pixels with few- or sub-DN mean bias. To avoid spuriously marking a large number of popcorn pixels, pixels which meet the POPFACTR criterion, but have an absolute standard deviation below this floor, are not treated as popcorn pixels in the on-board calibration table.	0 to 4095
	BADPR = 0.5 / Photoresponse criterion	Photoresponse to mark a bad pixel. Pixels are considered bad if they are much less responsive to light than their neighbors, potentially leading to a distorted blob and incorrect centroid. A criterion of 0.5 marks pixels that are less than half as bright as their neighbors under flat-field illumination conditions.	0 to 1
	OFFSTCOL = 256 / Window 1 column offset	Window 1 offset from left edge of frame. Window1 coordinates are with respect to a 2560 x 2161 image plus header row (the 2560 x 2160 image plus 2560 x 1 header row) and unbinned pixels. The first pixel of the image plus header row is coordinate 0,0.	0 to 512
	OFFSTROW = 57 / Window 1 row offset	Window 1 offset from origin of frame, incl. header. Window1 coordinates are with respect to a 2560 x 2161 image plus header row (the 2560 x 2160 image plus 2560 x 1 header row) and unbinned pixels. The first pixel of the image plus header row is coordinate 0,0.	1 to 113
Time_Coordinates. start_date_time	CALSTART = '2022-03-10T00:00:00' / file start time YYYY-MM-DDThh:mm:ss	UTC start time at which the calibration file is used in the pipeline. For the on-board calibration table and the bad pixel map, hh:mm:ss always set to 00:00:00.	YYYY-MM-DDThh:mm:ss

5.2.3.2. Bias Frames, Dark Current Frames, and Flat Field

Bias Frames – Bias frames remove the electronic readout noise present for a zero-length exposure time. One file exists per combination of shutter mode and gain state used to calibrate flight data. This file is formatted as a single HDU, 1024 (sample) × 1024 (line), 32-bit floating point fits file, 2×2 binned from the original 2048 × 2048 window1, in units of DN. Metadata contained in the fits header for the bias frame files are listed in Table 12.

Dark Current Frames –Dark current frames correct for the accumulation of signal in a pixel in the absence of photons. One file exists per combination of shutter mode, gain state, and temperature used to calibrate flight data. This file is formatted as a single HDU, 1024 (sample) × 1024 (line), 32-bit floating point fits file, 2×2 binned from the original 2048 × 2048 window1, in units of DN/second. Metadata contained in the fits header for the dark current files are listed in Table 12.

Flat Field – The flat field frame is used to normalize responsivity variations across the detector. This file is formatted as a single HDU, 1024 (sample) × 1024 (line), 32-bit floating point fits file, 2×2 binned from the original 2048 × 2048 window1, and is unitless. Metadata contained in the fits header for the flat field files are listed in Table 12. The Class.Attribute Name column is left blank for fits keywords not mapped to the .xml label.

Table 12. DRACO File Metadata for Bias, Dark Current, and Flat Field Frames

Class.Attribute Name	Keyword and example	Description	Range of values
	SIMPLE = T / file conforms to FITS standard	Required in FITS standard.	T
Element_Array. data_type	BITPIX = -32 / number of bits per data pixel	Calibration inputs are always be 32-bit floating point files.	-32
	NAXIS = 2 / number of data axes	Number of axes; all DRACO images have 2 axes.	2
Axis_Array. sequence_number	NAXIS1 = 1024 / length of data axis 1	Number of rows, all DRACO images have 1024 rows.	1024
Axis_Array. sequence_number	NAXIS2 = 1024 / length of data axis 2	Number of columns, all DRACO images have 1024 columns.	1024
	EXTEND = T / FITS dataset may contain extensions	By default, set to T so that we can add extensions.	T
Modification_History. modification_date	DATE = '2018-08-25'/ file creation date YYYY-MM-DD	Date file was created.	YYYY-MM-DD
Investigation_Area. name	MISSION = 'DART' / mission: DART	Name of mission.	"DART"
Observing_System. name	HOSTNAME= 'DART ' / spacecraft name	DRACO is on the spacecraft called DART.	"DART"
Observing_System_Component.name	INSTRUME= 'DRACO ' / instrument name	Name of instrument.	"DRACO"
	ORIGIN = 'JHUAPL' / source of data product	Organization that created the file	"JHUAPL"
	CREATOR = 'SYAU-YUN HSIEH' / product author	Author of the file	The format is firstName lastName.
	DETECTOR = 'SN403' / Detector name	Name of detector used to create the file	"SN403"

Class.Attribute Name	Keyword and example	Description	Range of values
	CALTYPE = 'BIAS' / calibration file type	Type of calibration file	"CALTABLE", "BADPIXEL MAP", "BIAS", "DARK", "FLATFIELD", "RADIOMETRIC"
dart:mission_phase	MPHASE = 'PRELAUNCH' / mission phase	Mission phase(s) during which the images used to create the input file were collected. A slash indicates data from multiple mission phases were used to create the file	"PRELAUNCH", "COMMISSIONING", "CRUISE", "APPROACH", "TERMINAL", "FINAL"
dart:imaging_mode	IMGMOD= 'ROLLING' / imaging mode	Shutter mode of the images used to create the file	"GLOBAL" or "ROLLING"
dart:gain	GAIN= '1X' /gain setting	Detector gain setting of the images used to create the file	"1X", "2X", "10X", or "30X"
dart:test_temp	TESTTEMP = '-20' / [degC] nominal test temperature	Nominal temperature for the test sequence used to generate the file	Unspecified
	BASEDIR = 'APLFSFRONTIER/' /Base path	Base-level directory location of source images used to create the file.	Unspecified
	TOPDIR = 'PROJECT/AIDA/500 INSTRUMENT/DETECTOR/' / Top-level path	Top-level directory location of source images used to create the file. N/A indicates that the pixel values in this file were set to zero (no correction) based on test results to date.	Unspecified
	MIDDIR = 'TESTING/SN403 PTC/-20C/20_09_14_10_28_44/' / Mid-level path	Path to lowest-level folder containing both illuminated and dark data used to create the file, relative to TOPDIR. N/A indicates that the pixel values in this file were set to zero (no correction) based on test results to date.	Unspecified
	BOTDIR = 'BIAS_FULL/GLOBAL/1X_BIAS_FULL/1' / Bottom-level path	Path to directory containing dark frames used to create the file, relative to MIDDIR. N/A indicates that the pixel values in this file were set to zero (no correction) based on test results to date.	Unspecified

Class.Attribute Name	Keyword and example	Description	Range of values
	LITTIMES = '100 500 1000' / [linetime] exposure	Exposure of the images used to create the file, in units of linetime. A DRACO linetime is 87.467 us.	1 to 116059
	GENVER = '4CEC7B2E' / Version of software used to create file	Version of software used to create the calibration table or bad pixel map, in the form of a Git repository commit hash	8-character short version of Git commit hash
	OFFSTCOL = 256 / Window 1 column offset	Window 1 offset from left edge of frame. Window1 coordinates are with respect to a 2560 x 2161 image plus header row (the 2560 x 2160 image plus 2560 x 1 header row) and unbinned pixels. The first pixel of the image plus header row is coordinate 0,0.	0 to 512
	OFFSTROW = 57 / Window 1 row offset	Window 1 offset from origin of frame, incl. header. Window1 coordinates are with respect to a 2560 x 2161 image plus header row (the 2560 x 2160 image plus 2560 x 1 header row) and unbinned pixels. The first pixel of the image plus header row is coordinate 0,0.	1 to 113
Time_Coordinates. start_date_time	CALSTART = '2022-03-10T00:00:00'/ file start time YYYY-MM-DDThh:mm:ss	UTC start time at which the calibration file is used in the pipeline.	YYYY-MM-DDThh:mm:ss

5.2.3.3. Radiometric Look-up Tables

Radiometric Look-up Tables – The radiometric lookup table defines the conversion from DN to electrons. The detector is sufficiently nonlinear that a lookup table is used instead of a linear function. Separate conversions exist for the two halves of the detector. One lookup table exists for each combination of shutter mode and gain state that had adequate performance to generate a radiometric calibration. This file is formatted as CSV file. Each CSV line will consist of the following fields. The CSV file should be sorted by row start, then by DN.

- rowStart – start row (with respect to the 1024×1024, 2×2 binned image) for which this line in the lookup table applies
- rowEnd – end row for which this line applies (with respect to the 1024×1024, 2×2 binned image) for which this line in the lookup table applies
- DN – the DN value to be looked up.
- e – the electron value to use given the DN value

Example:
0, 511, 1, 25.111
0, 511, 2, 50.222
0, 511, 3, 73.333

Metadata contained in the csv header for the radiometric look-up tables are listed in Table 13. The header rows in the CSV files are prefixed with "#" to distinguish them from the table data so the pipeline can parse the keywords and use them to fill out the .xml label. Hence the keywords in Table 13 start with “#”. The Class.Attribute Name column is left blank for keywords not mapped to the .xml label.

Table 13. DRACO File Metadata for Radiometric Look-up Tables

Class.Attribute Name	Keyword and example	Description	Range of values
Modification_History. modification_date	#DATE= ‘2018-08-25’/ file creation date YYYY-MM-DD	Date file was created.	YYYY-MM-DD
Investigation_Area. name	#MISSION = ‘DART’ / mission: DART	Name of mission.	“DART”
Observing_System. name	#HOSTNAME= ‘DART ‘ / spacecraft name	DRACO is on the spacecraft called DART.	“DART”
Observing_System_Component.name	#INSTRUME= ‘DRACO ‘ / instrument name	Name of instrument.	“DRACO”
	#ORIGIN = ‘JHUAPL’ / source of data product	Organization that created the data product	“JHUAPL”
	#CREATOR = ‘Andy Cheng’ / product author	Author of the file	The format is firstName lastName.
	#DETECTOR = ‘SN403’ / detector name	Name of detector used to create the file	“SN403”
	#CALTYPE = ‘RADIOMETRIC’ / calibration file type	Type of calibration file	“CALTABLE”, “BADPIXEL MAP”, “BIAS”, “DARK”, “FLATFIELD”, “RADIOMETRIC”
dart:mission_phase	#MPHASE = ‘PRELAUNCH’ / mission phase during which data used to create lookup table were collected	Mission phase(s) during which the images used to create the input file were collected. A slash indicates data from multiple mission phases were used to create the file	“PRELAUNCH”, “COMMISSIONING”, “CRUISE”, “APPROACH”, “TERMINAL”, “FINAL”
dart:imaging_mode	#IMGMOD= ‘GLOBAL’ / imaging mode	Shutter mode of the images used to create the file	“GLOBAL” or “ROLLING”
dart:gain	#GAIN= ‘1X’ /gain setting	Detector gain setting of the images used to create the file	“1X”, “2X”, “10X”, or “30X”
dart:test_temp	#TESTTEMP = 18.333 / [degC] nominal test temperature	Nominal temperature for the test sequence used to generate the file	Unspecified
	#DATASRC = ‘APLFSFRONTIER/PROJECT/AIDA/500	Complete path to data used to create the file	Unspecified

	INSTRUMENT/DETECTOR/' / path to lowest-level directory that still contains all data used to create the table		
	#LITTIMES = '16 32 64 100 150 200 250 200 250 400 450 500 550 600 650 700 750 800 850 900 950 1000' / [linetime], exposure	Exposure of the images used to create the file, in units of linetime. A DRACO linetime is 87.467 us.	1 to 116059
	#GENVER = 'DRACO_lookup_generator_v20201214.xlsx' / Version of software used to create file	Version of software used to create the radiometric look-up table, in the form of a file name	File name
	#OFFSTCOL = 256 / Window 1 column offset	Window 1 offset from left edge of frame. Window1 coordinates are with respect to a 2560 x 2161 image plus header row (the 2560 x 2160 image plus 2560 x 1 header row) and unbinned pixels. The first pixel of the image plus header row is coordinate 0,0.	0 to 512
	#OFFSTROW = 57 / Window 1 row offset	Window 1 offset from origin of frame, incl. header. Window1 coordinates are with respect to a 2560 x 2161 image plus header row (the 2560 x 2160 image plus 2560 x 1 header row) and unbinned pixels. The first pixel of the image plus header row is coordinate 0,0.	1 to 113
Time_Coordinates. start_date_time	#CALSTART = '2022-03-10T00:00:00'/ file start time YYYY-MM-DDThh:mm:ss	UTC start time at which the calibration file is used in the pipeline.	YYYY-MM-DDThh:mm:ss
	#Data structure	Alerts the user that the following header row contains the table column names	
	#rowStart, rowEnd, DN, electrons	Column names for the radiometric lookup table	

5.2.4. Derived Image Data with Geometry Backplanes

The Level-4 derived DRACO image with geometry backplanes format is a single HDU, 16-plane, 1024 (sample) × 1024 (line), 32-bit floating point fits file. The first plane of the fits file contains the calibrated image for which the backplanes are derived. These derived data products are generated only for Final phase images (those acquired in the final ~4 minutes before impact, see Section 4.1.6). Valid backplane values are generated only for pixels that intercept the surface of Dimorphos or Didymos. Pixels that intercept space are set to -999 (see GEOINVAL keyword). Pixels outside of the original 512 × 512 image (window 2) retain their PXOUTWIN = -1E32 values (see PXOUTWIN keyword in Table 10). The metadata associated with these Level-4 derived products (Table 14) are appended as additional keywords to the fits header and XML label of the corresponding calibrated image. The Class.Attribute Name column is left blank for fits keywords not mapped to the .xml label.

Table 14. DRACO Level-4 Derived Image with Geometry Backplanes Appended Metadata

Class.Attribute Name	Keyword and example	Description	Range of values
	GENVER = '2021-09-18T02:12:00' / Version of software used to create file	Version of software used to create the geometry backplanes. Format is YYYY-MM-DDTHH:MM:SS in UTC.	
	SHAPREF1 = 'g_06650mm_rdr_obj_dida_0000n00000_v001.obj ' / Used shape model	Shape model used to calculate the backplanes for pixels that intersect with Didymos	See DART derived products SIS for shape model naming scheme. Example: g_06650mm_rdr_obj_dida_0000n00000_v001.obj

Class.Attribute Name	Keyword and example	Description	Range of values
	SHAPREF2 = ‘g_06650mm_rdr_obj_didb_0000n00000_v001.obj ’ / Used shape model	Shape model used to calculate the backplanes for pixels that intersect with Dimorphos	See DART derived products SIS for shape model naming scheme. Example: g_06650mm_rdr_obj_didb_0000n00000_v001.obj
Special_Constants. invalid_constant	GEOINVAL = ‘-999’ / Value assigned to pixels without valid intercepts	Value assigned to pixels that do not have valid intercepts for computing backplanes	-999
Array_2D_Image. local_identifier = ioverf	PLANE01 = ‘Pixel value’ / [I/F]	Pixel values of the calibrated FITS image, in I/F	See calibrated data product
Array_2D_Image. local_identifier = xcoord	PLANE02 = ‘X coordinate of pixel center’ / [km]	X coordinate (km) of the intercept with the surface of the asteroid in body-fixed reference frame	0 to 1
Array_2D_Image. local_identifier = ycoord	PLANE03 = ‘Y coordinate of pixel center’ / [km]	Y coordinate (km) of the intercept with the surface of the asteroid in body-fixed reference frame	0 to 1
Array_2D_Image. local_identifier = zcoord	PLANE04 = ‘Z coordinate of pixel center’ / [km]	Z coordinate (km) of the intercept with the surface of the asteroid in body-fixed reference frame	0 to 1
Array_2D_Image. local_identifier = latitude	PLANE05 = ‘Planetocentric latitude of pixel center’ / [deg]	Planetocentric latitude (degrees) of pixel center	-90 to 90
Array_2D_Image. local_identifier = longitude	PLANE06 = ‘Planetocentric East longitude of pixel center’ / [deg]	Planetocentric longitude (degrees east) of pixel center	0 to 360
Array_2D_Image. local_identifier = radius	PLANE07 = ‘Radial distance from asteroid center to pixel center’ / [km]	Radial distance (km) from the asteroid center of figure to pixel center	0 to 1

Class.Attribute Name	Keyword and example	Description	Range of values
Array_2D_Image. local_identifier = incidence	PLANE08 = 'Solar incidence angle' / [deg]	Solar incidence angle (degrees)	0 to 180
Array_2D_Image. local_identifier = emission	PLANE09 = 'Emission angle' / [deg]	Emission angle (degrees)	0 to 180
Array_2D_Image. local_identifier = phase	PLANE10 = 'Solar phase angle' / [deg]	Solar phase angle (degrees)	0 to 180 degrees
Array_2D_Image. local_identifier = horizpixscale	PLANE11 = 'Horizontal pixel scale' / [m]	Horizontal pixel scale (meters) measured from range to surface and shape	0.1 to 100 m
Array_2D_Image. local_identifier = vertpixscale	PLANE12 = 'Vertical pixel scale' / [m]	Vertical pixel scale (meters) measured from range to surface and shape	0.1 to 100 m
Array_2D_Image. local_identifier = slope	PLANE13 = 'Slope ' / [deg]	Average surface slope relative to gravity (degrees)	0 to 180 degrees
Array_2D_Image. local_identifier = elevation	PLANE14 = 'Elevation' / [m]	Average elevation relative to gravity (meters)	-10 to 10 m
Array_2D_Image. local_identifier = gravacc	PLANE15 = 'Gravitational acceleration' / [m/s^2]	Average gravitational acceleration (meters/[s^2])	0 to 6.0E-5 m.s^2
Array_2D_Image. local_identifier = gravpot	PLANE16 = 'Gravitational potential' / [J/kg]	Average gravitational potential (J/kg)	0 to -0.01 J/kg

5.3. *Label and Header Descriptions*

All DRACO data products contain date and time information that can be used to sort and correlate data products. Data product labels are in XML format and are PDS4 compliant. Example labels can be found in the "draco" folder of the bundle document collection in a sub-directory named "example_labels". There are example labels for each type of DRACO data product.

5.3.1. **Image Time Keywords**

DRACO images contain several fits keywords that describe different times associated with the image. Table 9 in the DRACO SIS describes each time-related keyword individually. In some cases, keywords provide redundant information. This redundancy can occur for three reasons. First, in some cases different subsystems on the spacecraft report the time of the same event, and verifying that these times are consistent is a check on data quality. Second, in some cases the SOC computes keywords that provide time information in other formats for the convenience of the data user (e.g., ephemeris time and UTC, in addition to MET). Third, some images will not have certain time keywords populated because occasionally GNC telemetry and DRACO images fail to correlate. So, the SOC computes several redundant time-related keywords so that the key times are available for each image.

This section contains additional information about how the time keywords relate and which time keywords(s) are likely to be of interest to most end users of DRACO images. Most of the time keywords describe two events (Figure 10). The first event is the image time of validity, which is defined as the midpoint of the integration period. The second event is the image capture time, which is defined as the time that the first bit of the first pixel of an image arrives at the spacecraft SBC. The image time of validity is the time of interest to most end users of DRACO images. The attitude information in the fits header is correct at the image time of validity.

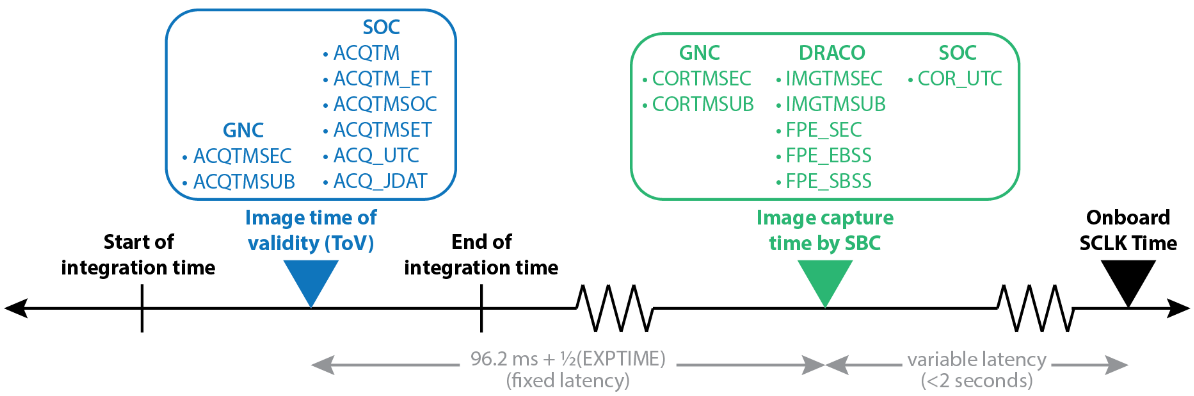

Figure 10. Keywords corresponding to the image time of validity (left box, in blue) and the image capture time (right box, in green) and the sources of each keyword. Some keywords come from GNC, some are calculated by the SOC, and others come from the DRACO FPE. The image time of validity is the time of interest to most end users of DRACO images.

Table 15 lists the keywords that provide the image time of validity. All of these keywords start with ACQTM. The various ACQTM* keywords report the time of validity in different formats or from different sources. Every DRACO image will have a valid value for ACQTMSOC and ACQTMSET. However, some images will lack values for ACQTMSEC, ACQTMSUB, ACQTM, and ACQTM_ET because GNC telemetry and DRACO images are generated at different rates.

Table 15. Image time of validity keywords.

Name	Source	Additional notes
ACQTMSEC	GNC	Computed by GNC onboard the spacecraft. Limited to images for which GNC and DRACO telemetry successfully correlate.
ACQTMSUB	GNC	
ACQTM	SOC	The SOC concatenates ACQTMSEC and ACQTMSUB and computes ACQTM_ET, when ACQTMSEC and ACQTMSUB are available, otherwise left blank.
ACQTM_ET	SOC	
ACQTMSOC	SOC	The SOC computes this using the same formula as GNC. Keyword available for all images.
ACQTMSET	SOC	

ACQ_UTC	SOC	The SOC computes this using SPICE based on ACQTMSOC. Keywords available for all images.
ACQ_JDAT	SOC	

Table 16 lists the keywords that record the time when the first pixel of a DRACO image arrives at the SBC. These times are recorded in different formats, to different precisions, or from different sources, depending on the keyword. These times are not likely to be of use to most end users of DRACO images.

Table 16. Image capture time keywords.

Name	Source	Additional notes
CORTMSEC	GNC	Computed by GNC onboard the spacecraft. Limited to images for which GNC and DRACO telemetry successfully correlate.
CORTMSUB	GNC	
IMGTMSEC	DRACO	Reported by the DRACO focal plane electronics. Limited to images for which GNC and DRACO telemetry successfully correlate.
IMGTMSUB	DRACO	
FPE_SEC	DRACO	These keywords values are also provided by the DRACO focal plane electronics; however, they are downlinked in a different packet from IMGTMSEC and IMGTMSUB such that these keywords are available with every image, rather than only for images in which GNC and DRACO telemetry successfully correlate.
FPE_EBSS	DRACO	
FPE_SBSS	DRACO	
COR_UTC	SOC	The SOC computes this using SPICE based on COR_UTC, whenever COR_UTC is available.

The following keywords record estimated times used to latch GNC telemetry to DRACO images on the spacecraft and should not be used by end users of the DRACO images. These estimated times are computed before the image is acquired:

- ESTAQSEC
- ESTAQSUB

The following keywords record times relevant to SMART Nav processing and should not be used by end users of the DRACO images:

- SN_SEC
- SN_SUB
- SNG_SEC
- SNG_SUB

6. Applicable Software

6.1. Utility Programs

At the current time the DART project has no plans to release any mission specific utility programs.

6.2. Applicable PDS Software Tools

Data products found in the DART archive can be viewed with any PDS4 compatible software utility. DRACO image data are formatted as fits data files which can be read by any fits compatible software viewer or fits library.

6.3. Software Distribution and Update Procedures

As no DART specific software will be released to the public, this section is not applicable.

7. Appendices

7.1. List of Acronyms and Abbreviations

Acronym or Abbreviation	Definition
APL	Applied Physics Laboratory
ASCII	American Standard Code for Information Interchange
CAD	Computer Aided Design
CDR	Calibrated Data Record
CMOS	Complementary Metal–Oxide–Semiconductor
CODMAC	Committee on Data Management and Computation
CSV	comma separated value
DAP	Derived Analysis Product
DART	Double Asteroid Redirection Test
DDP	Derived Data Product
DMAP	Data Management and Archive Plan
DN	Digital Numbers
DRACO	Didymos Reconnaissance and Asteroid Camera for OpNav
DSN	Deep Space Network
EDR	Experiment Data Record
FITS	Flexible Image Transport System
FPE	Focal Plane Electronics
FPGA	Field Programmable Gate Array
GNC	Guidance, Navigation, and Control
HDU	Header Data Unit
IAU	International Astronomical Union
IFOV	Instantaneous Field of View
IT	Investigation Team
LORRI	Long Range Reconnaissance Imager
MOC	Mission Operations Center
NASA	National Aeronautics and Space Administration
OpNav	Optical Navigation
OTA	optical telescope assembly
PDS	Planetary Data System
PLM	Product Lifecycle Management System
PNG	Portable Network Graphics
ROI	Region of Interest
RTS	Random Telegraph Signal
SBC	Single Board Computer
SBMT	Small Body Mapping Tool
SERDES	Serializer/Deserializer
SBN	Small Bodies Node
SIS	Software Interface Specification
SMART Nav	Small-Body Maneuvering Autonomous Real-Time Navigation

SNR	Signal to Noise
SOC	Science Operations Center
SRAM	Static Random-Access Memory
SSR	Solid State Recorder
TOV	Time of Validity
UTC	Coordinated Universal Time
XML	Extensible Markup Language

7.2. References

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7.3. *Definitions of Data Processing Levels*

Table 17 shows the comparison of DART, NASA and CODMAC data processing levels.

Table 17. Definition of data processing levels for science data (DART/DRACO, PDS4, NASA & CODMAC)

DRACO	PDS4	NASA	CODMAC	Description
	Packet Data	Packet Data	Raw Level 1	Telemetry data stream as received at the ground station, with science and engineering data embedded.
Raw Images	Raw Data	Level 0	Edited Level 2	Instrument science data (e.g., raw voltages, counts) at full resolution, time ordered, with duplicates and transmission errors removed. Prior to PDS4, referred to as Experiment Data Records (EDRs).
	Partially Processed Data	Level 1A	Calibrated Level 3	NASA Level 0 data that have been located in space and may have been transformed (e.g., calibrated, rearranged) in a reversible manner and packaged with needed ancillary and auxiliary data (e.g., radiances with the calibration equations applied). Prior to PDS4, referred to as Calibrated Data Records (CDRs) and in some cases Derived Data Products (DDPs).
Calibrated Images and Calibration Files	Calibrated Data	Level 1B	Resampled Level 4	Irreversibly transformed (e.g., resampled, remapped, calibrated) values of the instrument measurements (e.g., radiances, magnetic field strength). Prior to PDS4, referred to as either Derived Data Products (DDPs) or Derived Analysis Products (DAPs). Note that for this archive, the Calibration Files are co-located with the Calibrated Data in the Calibrated Data Collection even though they technically would be categorized as Level-4 NASA processed data.
		Level 2	Derived Level 5	Geophysical parameters, generally derived from NASA Level 1 (CODMAC level 3 and 4) data, and located in space and time commensurate with instrument location, pointing, and sampling. Prior to PDS4, referred to as Derived Analysis Products (DAPs).
	Derived Data	Level 3	Derived Level 5	Geophysical parameters mapped onto uniform space-time grids. Prior to PDS4, referred as derived analysis products (DAPs).
Image Backplanes		Level 4	Ancillary Data Level 6	Non-science data needed to generate calibrated or resampled data sets and consisting of instrument gains, and offsets, spacecraft positions, target information, pointing information for scan platforms, etc.

7.4. DRACO Imaging Sequences

Date (UTC)	Day of Year	Sequence Purpose	Images Acquired	Image Size	Of Interest	First Image Name Prefix	Last Image Name Prefix	First Image UTC	Data Quality Note
2-Dec-21	336	DRACO Functional Testing (test pattern)	517	512x512 & 1024x1024		dart_0376144597_01640	dart_0376146984_05334	2021-12-02T12:36:35.874	Test patterns overwrite some header info. Do not trust values
2-Dec-21	336	DRACO Functional Testing (detector)	349	512x512 & 1024x1024		dart_0376161307_39654	dart_0376161568_31622	2021-12-02T17:15:06.643	ACQTM* values have errors up to 200 ms
2-Dec-21	336	Darks with door closed	744	1024x1024	Taken in rolling & global shutter; 4 gain states; 3 exposure times	dart_0376162835_37980	dart_0376165300_35035	2021-12-02T17:40:34.610	ACQTM* values have errors up to 200 ms
2-Dec-21	336	Bias with door closed	248	1024x1024	Taken in rolling & global shutter; 4 gain states; 1-INT exposure time	dart_0376165355_43668	dart_0376165992_35718	2021-12-02T18:22:34.725	ACQTM* values have errors up to 200 ms
2-Dec-21	336	DRACO images taken under misconfiguration (detector functionals + dark/bias)	5026	512x512 & 1024x1024	DO NOT USE THESE IMAGES	dart_0376147120_43856	dart_0376161226_45633	2021-12-02T13:18:39.719	DO NOT USE THESE IMAGES
7-Dec-21	341	Door open check / first light	64	512x512 & 1024x1024	First light; stars (hard to see in global 1x images); DRACO was not yet thermally stable; psf will improve	dart_0376581511_26840	dart_0376581842_38108	2021-12-07T13:58:30.600	ACQTM* values have errors up to 200 ms
7-Dec-21	341	Real-time DRACO stream downlink test 1 / DRACO - star tracker calibration	12945	1024x1024	Taken in rolling; 30x gain; 90 ms exposure time	dart_0376582665_26505	dart_0376597108_23394	2021-12-07T14:17:44.594	ACQTM* values have errors up to 200 ms
7-Dec-21	341	Darks 1 with door open	744	1024x1024	Taken in rolling & global shutter; 4 gain states; 3 exposure times	dart_0376597454_26050	dart_0376599915_25330	2021-12-07T18:24:13.592	ACQTM* values have errors up to 200 ms
7-Dec-21	341	Bias 1 with door open	254	1024x1024	Taken in rolling & global shutter; 4 gain states; 1-INT exposure time	dart_0376599992_26784	dart_0376600795_13809	2021-12-07T19:06:31.608	ACQTM* values have errors up to 200 ms

Date (UTC)	Day of Year	Sequence Purpose	Images Acquired	Image Size	Of Interest	First Image Name Prefix	Last Image Name Prefix	First Image UTC	Data Quality Note
10-Dec-21	344	Star Cluster Cal A (M38) (geometric & radiometric cal)	4076	1024x1024	(1) Mosaic taken in global shutter at 13 positions to move the center of M38 around the FOV. At each location image with 4 gain/exposure time combinations. (2) Long series of rolling shutter images taken in 30x gain with 3 exposure times - all centered on M38.	dart_0376844404_15273	dart_0376848329_02856	2021-12-10T15:00:03.503	
10-Dec-21	344	Bias characterization	37	1024x1024	Taken in rolling; 30x gain; 1-INT exposure time	dart_0376848329_46228	dart_0376848364_05292	2021-12-10T16:05:29.124	
21-Dec-21	355	DRACO with high rate star tracker data streaming test (M34)	12905	512x512	Taken in rolling; 30x gain; 90 ms exposure time	dart_0377785801_14751	dart_0377800199_46780	2021-12-21T12:30:00.878	
21-Dec-21	355	Bias characterization	34	1024x1024	Taken in rolling; 30x gain; 1-INT exposure time	dart_0377800261_13512	dart_0377800407_31267	2021-12-21T16:31:00.906	
22-Jan-22	022	MR1: Lightcurve rehearsal	9436	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 90 ms exposure time; loose pointing to bright star Gamma Cancri (in real light curve, Didymos will not leave FOV)	dart_0380533439_15992	dart_0380581643_05072	2022-01-22T07:44:00.000	Gamma Cancri is saturated
22-Jan-22	022	MR1: Bias characterization	88	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 1-INT exposure time; tight pointing to bright star Gamma Cancri	dart_0380581647_16927	dart_0380582034_20462	2022-01-22T21:07:28.437	Gamma Cancri can be seen in stretched images
22-Jan-22	022	MR1: OpNav rehearsal (1/2)	270	1024x1024		dart_0380520839_15051	dart_0380522034_10674	2022-01-22T04:14:00.368	Gamma Cancri is saturated
22-Jan-22	022	MR1: OpNav rehearsal (2/2)	75	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to bright star Gamma Cancri	dart_0380583835_22233	dart_0380584150_15047	2022-01-22T21:43:56.544	Gamma Cancri is saturated
22-Jan-22	022	MR1: Ground streaming test rehearsal part 1	1607	512x512	Part of Mission Rehearsal #1; Taken in global; 1x gain; 90 ms exposure time; loose pointing to bright star Gamma Cancri	dart_0380582038_13034	dart_0380583833_49997	2022-01-22T21:13:59.359	
22-Jan-22	022	MR1: Ground streaming test rehearsal part 2	11784	512x512	Part of Mission Rehearsal #1; Taken in global; 1x gain; 90 ms exposure time; loose pointing to bright star Gamma Cancri	dart_0380585059_36266	dart_0380598297_08565	2022-01-22T22:04:20.825	
23-Jan-22	023	MR1: OpNav rehearsal (1/5)	270	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 90 ms	dart_0380601839_12878	dart_0380603034_08537	2022-01-23T02:44:00.366	Gamma Cancri is saturated

Date (UTC)	Day of Year	Sequence Purpose	Images Acquired	Image Size	Of Interest	First Image Name Prefix	Last Image Name Prefix	First Image UTC	Data Quality Note
					exposure time; tight pointing to bright star Gamma Cancri				
23-Jan-22	023	MR1: OpNav rehearsal (2/5)	270	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to bright star Gamma Cancri	dart_0380623439_17317	dart_0380624634_12933	2022-01-23T08:44:00.466	Gamma Cancri is saturated
23-Jan-22	023	MR1: OpNav rehearsal (3/5)	271	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to bright star Gamma Cancri	dart_0380646839_15646	dart_0380648039_01975	2022-01-23T15:14:00.444	Gamma Cancri is saturated
23-Jan-22	023	MR1: OpNav rehearsal (4/5)	270	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to bright star Gamma Cancri	dart_0380659439_16576	dart_0380660634_12192	2022-01-23T18:44:00.469	Gamma Cancri is saturated
23-Jan-22	023	MR1: OpNav rehearsal (5/5)	271	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to bright star Gamma Cancri	dart_0380675639_15039	dart_0380676839_01373	2022-01-23T23:14:00.447	Gamma Cancri is saturated
23-Jan-22	023	MR1: Bias characterization (1/2)	34	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 1-INT exposure time; tight pointing to bright star Gamma Cancri	dart_0380648043_18644	dart_0380648190_34541	2022-01-23T15:34:04.505	Gamma Cancri can be seen in stretched images
23-Jan-22	023	MR1: Bias characterization (2/2)	34	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 1-INT exposure time; tight pointing to bright star Gamma Cancri	dart_0380676843_18041	dart_0380676990_33939	2022-01-23T23:34:04.507	Gamma Cancri can be seen in stretched images
24-Jan-22	024	MR1: OpNav rehearsal (1/4)	270	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to bright star Gamma Cancri	dart_0380691839_13499	dart_0380693034_09107	2022-01-24T03:44:00.424	Gamma Cancri is saturated
24-Jan-22	024	MR1: OpNav rehearsal (2/4)	270	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to bright star Gamma Cancri	dart_0380699039_13314	dart_0380700234_08928	2022-01-24T05:44:00.424	Gamma Cancri is saturated
24-Jan-22	024	MR1: OpNav rehearsal (3/4)	270	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to bright star Gamma Cancri	dart_0380706239_13177	dart_0380707434_08800	2022-01-24T07:44:00.425	Gamma Cancri is saturated
24-Jan-22	024	MR1: OpNav rehearsal (4/4)	271	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to bright star Gamma Cancri	dart_0380713439_13063	dart_0380714638_49400	2022-01-24T09:44:00.427	Gamma Cancri is saturated
24-Jan-22	024	MR1: Bias characterization	34	1024x1024	Part of Mission Rehearsal #1; Taken in rolling; 30x gain; 1-INT exposure time; tight pointing to bright star Gamma Cancri	dart_0380714643_16069	dart_0380714790_31967	2022-01-24T10:04:04.487	Gamma Cancri can be seen in stretched images

Date (UTC)	Day of Year	Sequence Purpose	Images Acquired	Image Size	Of Interest	First Image Name Prefix	Last Image Name Prefix	First Image UTC	Data Quality Note
24-Jan-22	024	MR1: Terminal rehearsal	1244	512x512	Part of Mission Rehearsal #1; Taken in global; 1x gain; 90 ms exposure time; tight pointing to bright star Gamma Cancri	dart_0380741450_28269	dart_0380742837_04441	2022-01-24T17:30:51.745	Window 2 fixed in center of detector (will move in real terminal)
04-Mar-22	063	TCM support	10000	512x512 & 1024x1024	Taken to support the trajectory correction maneuver (TCM)	dart_0384115798_13363	dart_0384127189_45327	2022-03-04T18:50:01.071	Images have high smear because acquired during TCM
04-Mar-22	063	Bias characterization	30	1024x1024		dart_0384127194_21614	dart_0384127345_30094	2022-03-04 21:59:57.334	
31-Mar-22	090	SMARTNav Testing	4836	512x512	Taken in rolling; 30x; 90 ms exposure time	dart_0386444696_13099	dart_0386450091_08956	2022-03-31 17:45:00.343	SMART-Nav-related keywords (see Table 9) for this dataset should be ignored. There was an issue with the population of these keywords during this test.
31-Mar-22	090	Bias characterization	37	1024x1024	Taken in rolling; 30x gain; 1-INT exposure time	dart_0386450092_21571	dart_0386450238_39326	2022-03-31 19:14:56.515	First four images in this sequence are 512x512
31-Mar-22	090	Bias characterization	34	1024x1024	Taken in global; 1x; 1-INT exposure time	dart_0386450243_20427	dart_0386450389_38179	2022-03-31 19:17:27.492	
31-Mar-22	090	SMARTNav Testing	34	1024x1024	Taken in global; 1x; 90 ms exposure time	dart_0386450394_19280	dart_0386450540_37033	2022-03-31 19:19:58.469	SMART-Nav-related keywords (see Table 8) for this dataset should be ignored. There was an issue with the population of these keywords during this test.
27-Apr-22	117	Star Tracker Terminal Sky Calibration 1	16259	512x512	Taken in rolling; 30x; 90 ms exposure time	dart_0388772995_13450	dart_0388788649_24947	2022-04-27 16:30:00.628	DETTEMP1 and. DETTEMP2 values are incorrect
27-Apr-22	117	Bias characterization	158	1024x1024	Taken in rolling; 30x; 1-INT exposure time	dart_0388789254_18537	dart_0388789405_27019	2022-04-27 21:00:59.783	DETTEMP1 and. DETTEMP2 values are incorrect
2-May-22	122	Star Tracker Terminal Sky Calibration 2	16259	512x512	Taken in rolling; 30x; 90 ms exposure time	dart_0389161795_14519	dart_0389177449_25742	2022-05-02T04:30:00.950	DETTEMP1 and. DETTEMP2 values are incorrect
2-May-22	122	Bias characterization	181	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0389178054_19322	dart_0389178227_35094	2022-05-02T09:01:00.055	DETTEMP1 and. DETTEMP2 values are incorrect
6-May-22	126	Star Tracker Terminal Sky Calibration 3	16259	512x512	Taken in rolling; 30x; 90 ms exposure time	dart_0389525395_12364	dart_0389541049_23517	2022-05-06T09:30:01.102	
6-May-22	126	Bias characterization	181	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0389541654_17091	dart_0389541827_32861	2022-05-06T14:01:00.205	
11-May-22	131	Star Tracker Terminal Sky Maneuvers 1	14933	512x512	Taken in rolling; 30x; 90 ms exposure time	dart_0389987094_16119	dart_0390001535_16918	2022-05-11T17:45:00.424	
11-May-22	131	Bias characterization	181	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0390002093_15911	dart_0390002266_31683	2022-05-11T21:54:59.428	

Date (UTC)	Day of Year	Sequence Purpose	Images Acquired	Image Size	Of Interest	First Image Name Prefix	Last Image Name Prefix	First Image UTC	Data Quality Note
24-May-22	144	SMARTNav Testing	2147	512x512	Taken in global; 1x; 90 ms exposure time	dart_0391114194_14331	dart_0391116587_48135	2022-05-24T18:50:00.992	
24-May-22	144	Bias characterization	38	1024x1024	Taken in global; 1x; 1-INT exposure time	dart_0391116589_49272	dart_0391116740_33657	2022-05-24T19:29:56.692	first four images in this sequence are 512x512 but are valid
27-May-22	147	Bright star calibration (Vega)	2775	1024x1024	Taken in rolling; Mosaic taken in at 13 positions to move Vega inside and outside of the FOV. At each out-of-FOV position image with 30x gain 90 ms exposure time. At each in-FOV position image image with 4 gain/exposure time combinations.	dart_0391362415_08133	dart_0391365169_07692	2022-05-27T15:47:02.001	Vega saturated in many images
27-May-22	147	Bias characterization (1/4)	32	1024x1024	Taken in rolling; 30x; 1-INT exposure time	dart_0391365169_46254	dart_0391365199_14601	2022-05-27T16:32:56.765	
27-May-22	147	Bias characterization (2/4)	29	1024x1024	Taken in rolling; 1x; 1-INT exposure time	dart_0391878318_46025	dart_0391365227_20415	2022-06-02T15:05:26.036	
27-May-22	147	Bias characterization (3/4)	27	1024x1024	Taken in rolling; 30x; 1-INT exposure time	dart_0391366554_11628	dart_0391366579_13349	2022-05-27T16:56:01.073	
27-May-22	147	Solar-like star calibration (HD205905)	1349	1024x1024	Taken in rolling and global; various gains; various exposure times	dart_0391366580_21153	dart_0391367869_40021	2022-05-27T16:56:27.264	
27-May-22	147	Bias characterization (4/4)	27	1024x1024	Taken in rolling; 30x; 1-INT exposure time	dart_0391367870_23735	dart_0391367895_25460	2022-05-27T17:17:57.316	
2-Jun-22	153	Star Cluster Cal B (NGC 3766) (geometric & radiometric cal)	4075	1024x1024	(1) Mosaic taken in global shutter at 13 positions to move the center of NGC 3766 around the FOV. At each location image with 4 gain/exposure time combinations. (2) Long series of rolling shutter images taken in 30x gain with 3 exposure times - all centered on NGC 3766.	dart_0391874393_15253	dart_0391878318_02653	2022-06-02T14:00:00.419	
2-Jun-22	153	Bias characterization	36	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0391878318_46025	dart_0391878352_06945	2022-06-02T15:05:26.036	
7-Jun-22	158	Darks 2 with door open	741	1024x1024	Taken in rolling & global shutter; 4 gain states; 3 exposure times	dart_0392315993_13404	dart_0392316708_19843	2022-06-07T16:40:00.619	
7-Jun-22	158	Bias 2 with door open	498	1024x1024	Taken in rolling & global shutter; 4 gain states; 1-INT exposure time	dart_0392316709_17986	dart_0392317188_00089	2022-06-07T16:51:56.712	
7-Jun-22	158	Navigation terminal sky calibration	2122	1024x1024	Taken in rolling shutter; 30X gain; 2 exposure times. Three	dart_0392317188_48272	dart_0392319231_05054	2022-06-07T16:59:56.317	

Date (UTC)	Day of Year	Sequence Purpose	Images Acquired	Image Size	Of Interest	First Image Name Prefix	Last Image Name Prefix	First Image UTC	Data Quality Note
					positions across the terminal sky field.				
7-Jun-22	158	New cal table test images	40	1024x1024	Taken in global shutter; 1X gain; 1-INT exposure time; alternating cal table on/off	dart_0392328967_47154	dart_0392329141_12906	2022-06-07T20:16:15.301	
29-Jun-22	180	Star Tracker IMU Thermal Test	14945	512x512	Taken in rolling shutter; 30X gain; 90 ms exposure time;slewed to position on doy178 to get to thermal equilibrium before imaging	dart_0394192792_12828	dart_0394207181_16313	2022-06-29T10:00:00.620	
29-Jun-22	180	Bias characterization	30	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0394207192_15175	dart_0394207220_11331	2022-06-29T14:00:00.675	
1-Jul-22	182	Targets of opportunity SMARTNav test 1 (Europa)	1858	1024x1024	Taken in global shutter; 1X gain; 12 ms exposure time; cal table on; targeting Jupiter to watch Europa coming out from behind it.	dart_0394396193_12478	dart_0394397981_14209	2022-07-01T18:30:01.723	
1-Jul-22	182	Bias characterization	120	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0394397993_11209	dart_0394398107_40239	2022-07-01T19:00:01.699	Images beginning with dart_0394397993–8013 and dart_0394398033–8034 have Jupiter in the FOV and should not be used as bias files.
1-Jul-22	182	OpNav Jovian Test - Himalia	617	1024x1024	Taken in rolling shutter; 30X; 90 ms exposure time	dart_0394398108_23953	dart_0394398701_30105	2022-07-01T19:01:56.954	
1-Jul-22	182	OpNav Jovian Test - Elara	508	1024x1024	Taken in rolling shutter; 30X; 90 ms exposure time	dart_0394398702_28248	dart_0394399190_36796	2022-07-01T19:11:51.040	
25-Jul-22	206	Star Tracker IMU Thermal Test	14945	512x512	Taken in rolling shutter; 30X gain; 90 ms exposure time;slewed to position on doy203 to get to thermal equilibrium before imaging	dart_0396431991_14766	dart_0396446380_17903	2022-07-25T08:00:00.872	
25-Jul-22	206	Bias characterization	30	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0396446391_16765	dart_0396446419_12920	2022-07-25T12:00:00.920	
27-Jul-22	208	Terminal Sky SMARTNav Test 2x2 mosaic	952	1024x1024	Taken in global shutter; 1X and 2X gain; 50 ms 70 ms and 90 ms exposure time	dart_0396633591_15348	dart_0396634580_08844	2022-07-27T16:00:00.993	
27-Jul-22	208	Terminal Sky SMARTNav Test Star	30	1024x1024	Taken in global shutter; 1X gain; 10 ms exposure time	dart_0396634591_12511	dart_0396634619_08660	2022-07-27T16:16:40.937	
27-Jul-22	208	OpNav	245	1024x1024	Taken in rolling shutter; 30X gain; 90 ms exposure time	dart_0396636291_13977	dart_0396636526_10894	2022-07-27T16:45:00.967	
27-Jul-22	208	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0396636526_49456	dart_0396636559_12234	2022-07-27T16:48:56.677	

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2-Aug-22	214	Targets of opportunity SMARTNav test 3 (Europa)	3612	1024x1024	Taken in global shutter; 1X gain; 12 ms exposure time; cal table on; targeting Jupiter to watch Europa coming out from behind it.	dart_0397157692_13935	dart_0397161169_08665	2022-08-02T17:35:02.249	
2-Aug-22	214	OpNav Jovian Test - Himalia	494	1024x1024	Taken in rolling shutter; 30X; 90 ms exposure time	dart_0397161411_16685	dart_0397161886_01241	2022-08-02T18:37:01.306	
2-Aug-22	214	Bias characterization	66	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0397161886_49424	dart_0397161949_04639	2022-08-02T18:44:56.961	
9-Aug-22	221	Star Cluster Cal C (NGC 3766) (geometric & radiometric cal + 1x global gain curve cal)	3966	1024x1024	(1) Mosaic taken in global and rolling shutter at 13 positions to move the center of NGC 3766 around the FOV. At each location image with different gain/exposure time combinations. Rolling shutter images taken in a subset of positions to save data volume. (2) Series of global shutter images taken in the central position of the mosaic in 1x gain with exposure times ranging from 1–94 ms. (3) Bias characterization images taken near the beginning and end of the mosaic sequence. Taken in rolling; 30x gain; 90 ms exposure time.	dart_0397749590_14846	dart_0397754493_39890	2022-08-09T14:00:00.489	Images on this doy were taken at a solar phase angle of ~82.7 degrees, which is within the 90-degree DRACO keep-out zone that was set to minimize scattered light. Images from the doy exhibit elevated scattered light. The OTA temperature increased tens of degrees during the observation and caused some temperature-induced defocus. The detector temperature stayed within limits for the duration of the test, but trim heater duty cycle increased over the test, indicating a different thermal environment and possibly affecting bias levels. Some images noted as BAD_IMAGE due to DRACO reconfiguration.
11-Aug-22	223	TR2: OpNav	245	1024x1024	Part of Terminal Rehearsal #2; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to Didymos	dart_0397950254_13337	dart_0397950489_10259	2022-08-11T21:44:24.667	
11-Aug-22	223	TR2: Bias characterization	35	1024x1024	Part of Terminal Rehearsal #2; Taken in rolling; 30x gain; 1-INT exposure time; tight pointing to Didymos	dart_0397950489_48821	dart_0397950522_11600	2022-08-11T21:48:20.377	
12-Aug-22	224	TR2: OpNav (1/5)	248	1024x1024	Part of Terminal Rehearsal #2; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to Didymos	dart_0397968254_15921	dart_0397968492_07283	2022-08-12T02:44:24.728	

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12-Aug-22	224	TR2: OpNav (2/5)	248	1024x1024	Part of Terminal Rehearsal #2; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to Didymos	dart_0397986254_13083_	dart_0397986492_04429	2022-08-12T07:44:24.681	
12-Aug-22	224	TR2: OpNav (3/5)	248	1024x1024	Part of Terminal Rehearsal #2; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to Didymos	dart_0398004254_14442	dart_0398004492_05784	2022-08-12T12:44:24.718	
12-Aug-22	224	TR2: Ground streaming test rehearsal	TBD	512x512	Part of Terminal Rehearsal #2; Taken in global; 1x gain; 90 ms exposure time; loose pointing to Didymos	dart_0398011454_13978	dart_0398016012_23473	2022-08-12T14:44:24.713	
12-Aug-22	224	TR2: OpNav (4/5)	248	1024x1024	Part of Terminal Rehearsal #2; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to Didymos	dart_0398022254_16176	dart_0398022492_07529	2022-08-12T17:44:24.763	
12-Aug-22	224	TR2: OpNav (5/5)	245	1024x1024	Part of Terminal Rehearsal #2; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to Didymos	dart_0398040254_12632	dart_0398040489_09542	2022-08-12T22:44:24.701	
12-Aug-22	224	TR2: Bias characterization	35	1024x1024	Part of Terminal Rehearsal #2; Taken in rolling; 30x gain; 1-INT exposure time; tight pointing to Didymos	dart_0398040489_48104	dart_0398040522_10882	2022-08-12T22:48:20.411	
13-Aug-22	225	TR2: OpNav (1/4)	248	1024x1024	Part of Terminal Rehearsal #2; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to Didymos	dart_0398058254_13770	dart_0398058492_05111	2022-08-13T03:44:24.734	
13-Aug-22	225	TR2: OpNav (2/4)	248	1024x1024	Part of Terminal Rehearsal #2; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to Didymos	dart_0398065454_13286	dart_0398065692_04627	2022-08-13T05:44:24.640	
13-Aug-22	225	TR2: OpNav (3/4)	248	1024x1024	Part of Terminal Rehearsal #2; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to Didymos	dart_0398072654_12816	dart_0398072892_04157	2022-08-13T07:44:24.728	
13-Aug-22	225	TR2: OpNav (4/4)	248	1024x1024	Part of Terminal Rehearsal #2; Taken in rolling; 30x gain; 90 ms exposure time; tight pointing to Didymos	dart_0398079854_12328	dart_0398080092_03668	2022-08-13T09:44:24.717	
13-Aug-22	225	TR2: T-6 hours pre-terminal rehearsal imaging	448	512x512	Part of Terminal Rehearsal #2; Taken in global; 1x gain; 12 ms exposure time; teriminal pointing to Didymos	dart_0398101448_27080	dart_0398102052_12823	2022-08-13T15:44:19.024	
13-Aug-22	225	TR2: Terminal rehearsal	1546	512x512	Part of Terminal Rehearsal #2; Taken in global; 1x gain; 12 ms	dart_0398107827_41529	dart_0398109551_17741	2022-08-13T17:30:38.316	

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					exposure time; terminal pointing to Didymos				
22-Aug-22	234	OpNav	245	1024x1024	Taken in rolling shutter; 30X; 90 ms exposure time	dart_0398869190_12830	dart_0398869425_09762	2022-08-22T13:00:01.155	
22-Aug-22	234	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0398869425_48323	dart_0398869458_11104	2022-08-22T13:03:56.865	
27-Aug-22	239	Approach Opnav 1	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399327230_13828	dart_0399327465_10760	2022-08-27T20:14:01.423	
27-Aug-22	239	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0399327465_49322	dart_0399327498_12103	2022-08-27T20:17:57.133	
28-Aug-22	240	Approach Opnav 2	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399345229_14197	dart_0399345464_11146	2022-08-28T01:14:00.440	
28-Aug-22	240	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0399345464_49708	dart_0399345497_12491	2022-08-28T01:17:56.151	
28-Aug-22	240	Approach Opnav 3	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399363229_13835	dart_0399363467_05222	2022-08-28T06:14:00.443	
28-Aug-22	240	Approach Opnav 4	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399381229_13875	dart_0399381467_05265	2022-08-28T11:14:00.453	
28-Aug-22	240	Approach Opnav 5	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399399229_13350	dart_0399399467_04729	2022-08-28T16:14:00.452	
28-Aug-22	240	Approach Opnav 6	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399417229_12879	dart_0399417467_04257	2022-08-28T21:14:00.453	
29-Aug-22	241	Approach Opnav 7	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399435229_12249	dart_0399435464_09205	2022-08-29T02:14:00.450	
29-Aug-22	241	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0399435464_47767	dart_0399435497_10551	2022-08-29T02:17:56.160	
29-Aug-22	241	Approach Opnav 8	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399453229_16305	dart_0399453467_07680	2022-08-29T07:14:00.541	
29-Aug-22	241	Approach Opnav 9	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399471229_15895	dart_0399471467_07277	2022-08-29T12:14:00.542	
29-Aug-22	241	Approach Opnav 10	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399489229_15110	dart_0399489467_06491	2022-08-29T17:14:00.536	
29-Aug-22	241	Approach Opnav 11	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399507229_14804	dart_0399507467_06191	2022-08-29T22:14:00.540	
30-Aug-22	242	Approach Opnav 12	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399525229_14786	dart_0399525464_11741	2022-08-30T03:14:00.550	
30-Aug-22	242	Bias characterization	34	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0399525465_19546	dart_0399525497_08274	2022-08-30T03:17:56.645	

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30-Aug-22	242	Approach Opnav 13	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399543229_14080	dart_0399543467_05460	2022-08-30T08:14:00.545	
30-Aug-22	242	Approach Opnav 14	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399561229_13832	dart_0399561467_05221	2022-08-30T13:14:00.550	
30-Aug-22	242	Approach Opnav 15	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399579229_13734	dart_0399579467_05113	2022-08-30T18:14:00.558	
30-Aug-22	242	Approach Opnav 16	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399597229_13030	dart_0399597467_04414	2022-08-30T23:14:00.553	
31-Aug-22	243	Approach Opnav 17	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399615229_12887	dart_0399615464_09847	2022-08-31T04:14:00.560	
31-Aug-22	243	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0399615464_48409	dart_0399615497_11193	2022-08-31T04:17:56.271	
31-Aug-22	243	Approach Opnav 18	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399633229_13037	dart_0399633467_04427	2022-08-31T09:14:00.573	
31-Aug-22	243	Approach Opnav 19	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399651229_12370	dart_0399651467_03741	2022-08-31T14:14:00.570	
31-Aug-22	243	Approach Opnav 20	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399669229_16370	dart_0399669467_07755	2022-08-31T19:14:00.659	
1-Sep-22	244	Approach Opnav 21	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399687229_16267	dart_0399687464_13226	2022-09-01T00:14:00.667	
1-Sep-22	244	Bias characterization	34	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0399687465_21030	dart_0399687497_09758	2022-09-01T00:17:56.762	
1-Sep-22	244	Approach Opnav 22	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399705229_15828	dart_0399705467_07201	2022-09-01T05:14:00.668	
1-Sep-22	244	Approach Opnav 23	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399723229_14515	dart_0399723467_05885	2022-09-01T10:14:00.651	
1-Sep-22	244	Approach Opnav 24	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399741229_13512	dart_0399741467_04895	2022-09-01T15:14:00.641	
1-Sep-22	244	Approach Opnav 25	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399759229_13431	dart_0399759467_04822	2022-09-01T20:14:00.649	
2-Sep-22	245	Approach Opnav 26	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399777229_13795	dart_0399777464_10760	2022-09-02T01:14:00.666	
2-Sep-22	245	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0399777464_49322	dart_0399777497_12107	2022-09-02T01:17:56.377	
2-Sep-22	245	Approach Opnav 27	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399795229_13699	dart_0399795467_05079	2022-09-02T06:14:00.674	
2-Sep-22	245	Approach Opnav 28	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399813229_12865	dart_0399813467_04241	2022-09-02T11:14:00.667	

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2-Sep-22	245	Approach Opnav 29	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399831229_12396	dart_0399831467_03780	2022-09-02T16:14:00.668	
2-Sep-22	245	Approach Opnav 30	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399849229_16519	dart_0399849467_07895	2022-09-02T21:14:00.760	
3-Sep-22	246	Approach Opnav 31	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399867229_16008	dart_0399867464_12966	2022-09-03T02:14:00.759	
3-Sep-22	246	Bias characterization	34	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0399867465_20770	dart_0399867497_09498	2022-09-03T02:17:56.855	
3-Sep-22	246	Approach Opnav 32	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399885229_15514	dart_0399885467_06892	2022-09-03T07:14:00.759	
3-Sep-22	246	Approach Opnav 33	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399903229_14627	dart_0399903467_06002	2022-09-03T12:14:00.751	
3-Sep-22	246	Approach Opnav 34	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399921229_13700	dart_0399921467_05076	2022-09-03T17:14:00.742	
3-Sep-22	246	Approach Opnav 35	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399939229_12698	dart_0399939467_04072	2022-09-03T22:14:00.732	
4-Sep-22	247	Approach Opnav 36	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399957229_16537	dart_0399957464_13484	2022-09-04T03:14:00.819	
4-Sep-22	247	Bias characterization	34	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0399957465_21289	dart_0399957497_10015	2022-09-04T03:17:56.914	
4-Sep-22	247	Approach Opnav 37	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399975229_15652	dart_0399975467_07029	2022-09-04T08:14:00.811	
4-Sep-22	247	Approach Opnav 38	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0399993229_15333	dart_0399993467_06715	2022-09-04T13:14:00.814	
4-Sep-22	247	Approach Opnav 39	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400011229_14786	dart_0400011467_06174	2022-09-04T18:14:00.813	
4-Sep-22	247	Approach Opnav 40	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400029229_14626	dart_0400029467_06006	2022-09-04T23:14:00.820	
5-Sep-22	248	Approach Opnav 41	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400047229_14107	dart_0400047464_11059	2022-09-05T04:14:00.819	
5-Sep-22	248	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0400047464_49621	dart_0400047497_12404	2022-09-05T04:17:56.529	
5-Sep-22	248	Approach Opnav 42	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400065229_13537	dart_0400065467_04924	2022-09-05T09:14:00.817	
5-Sep-22	248	Approach Opnav 43	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400083229_13127	dart_0400083467_04507	2022-09-05T14:14:00.819	
5-Sep-22	248	Approach Opnav 44	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400101229_13074	dart_0400101467_04466	2022-09-05T19:14:00.828	

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6-Sep-22	249	Approach Opnav 45	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400119229_12978	dart_0400119464_09930	2022-09-06T00:14:00.835	
6-Sep-22	249	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0400119464_48492	dart_0400119497_11275	2022-09-06T00:17:56.546	
6-Sep-22	249	Approach Opnav 46	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400137229_12292	dart_0400137467_03670	2022-09-06T05:14:00.831	
6-Sep-22	249	Approach Opnav 47	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400155229_16866	dart_0400155467_08251	2022-09-06T10:14:00.933	
6-Sep-22	249	Approach Opnav 48	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400173229_16337	dart_0400173467_07716	2022-09-06T15:14:00.932	
6-Sep-22	249	Approach Opnav 49	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400191229_15539	dart_0400191467_06916	2022-09-06T20:14:00.926	
7-Sep-22	250	Approach Opnav 50	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400209229_14641	dart_0400209464_11589	2022-09-07T01:14:00.917	
7-Sep-22	250	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0400209465_00151	dart_0400209497_12934	2022-09-07T01:17:56.628	
7-Sep-22	250	Approach Opnav 51	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400227229_13797	dart_0400227467_05174	2022-09-07T06:14:00.910	
7-Sep-22	250	Approach Opnav 52	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400245229_13162	dart_0400245467_04542	2022-09-07T11:14:00.907	
7-Sep-22	250	Approach Opnav 53	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400263229_12472	dart_0400263467_03851	2022-09-07T16:14:00.903	
7-Sep-22	250	Approach Opnav 54	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400281229_16458	dart_0400281467_07836	2022-09-07T21:14:00.993	
8-Sep-22	251	Approach Opnav 55	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400299229_15727	dart_0400299464_12678	2022-09-08T02:14:00.988	
8-Sep-22	251	Bias characterization	34	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0400299465_20482	dart_0400299497_09210	2022-09-08T02:17:57.083	
8-Sep-22	251	Approach Opnav 56	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400317229_15319	dart_0400317467_06703	2022-09-08T07:14:00.990	
8-Sep-22	251	Approach Opnav 57	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400335229_15211	dart_0400335467_06597	2022-09-08T12:14:00.997	
8-Sep-22	251	Approach Opnav 58	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400353229_15036	dart_0400353467_06423	2022-09-08T17:14:01.003	
8-Sep-22	251	Approach Opnav 59	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400371229_14958	dart_0400371467_06345	2022-09-08T22:14:01.012	
9-Sep-22	252	Approach Opnav 60	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400389229_14804	dart_0400389464_11760	2022-09-09T03:14:01.018	

Date (UTC)	Day of Year	Sequence Purpose	Images Acquired	Image Size	Of Interest	First Image Name Prefix	Last Image Name Prefix	First Image UTC	Data Quality Note
9-Sep-22	252	Bias characterization	34	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0400389465_19564	dart_0400389497_08292	2022-09-09T03:17:57.114	
9-Sep-22	252	Approach Opnav 61	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400407229_14587	dart_0400407467_05976	2022-09-09T08:14:01.024	
9-Sep-22	252	Approach Opnav 62	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400425229_14717	dart_0400425467_06105	2022-09-09T13:14:01.036	
9-Sep-22	252	Approach Opnav 63	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400443229_14582	dart_0400443467_05968	2022-09-09T18:14:01.043	
9-Sep-22	252	Approach Opnav 64	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400461229_14416	dart_0400461467_05803	2022-09-09T23:14:01.050	
10-Sep-22	253	Approach Opnav 65	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400479229_14305	dart_0400479464_11262	2022-09-10T04:14:01.057	
10-Sep-22	253	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0400479464_49824	dart_0400479498_10751	2022-09-10T04:17:56.768	
10-Sep-22	253	Approach Opnav 66	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400497229_14220	dart_0400497467_05610	2022-09-10T09:14:01.065	
10-Sep-22	253	Approach Opnav 67	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400515229_14240	dart_0400515467_05628	2022-09-10T14:14:01.075	
10-Sep-22	253	Approach Opnav 68	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400533229_14153	dart_0400533467_05540	2022-09-10T19:14:01.083	
11-Sep-22	254	Approach Opnav 69	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400551229_13958	dart_0400551464_10913	2022-09-11T00:14:01.089	
11-Sep-22	254	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0400551464_49475	dart_0400551497_12259	2022-09-11T00:17:56.800	
11-Sep-22	254	Approach Opnav 70	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400569229_13778	dart_0400569467_05164	2022-09-11T05:14:01.095	
11-Sep-22	254	Approach Opnav 71	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400587229_13771	dart_0400587467_05161	2022-09-11T10:14:01.105	
11-Sep-22	254	Approach Opnav 72	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400605229_13709	dart_0400605467_05095	2022-09-11T15:14:01.113	
11-Sep-22	254	Approach Opnav 73	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400623229_13589	dart_0400623467_04976	2022-09-11T20:14:01.121	
12-Sep-22	255	Approach Opnav 74	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	idart_0400641229_13209	dart_0400641464_10156	2022-09-12T01:14:01.123	
12-Sep-22	255	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0400641464_48718	dart_0400641498_09644	2022-09-12T01:17:56.833	
12-Sep-22	255	Approach Opnav 75	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400659229_12303	dart_0400659467_03679	2022-09-12T06:14:01.115	

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12-Sep-22	255	Approach Opnav 76	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400677229_16336	dart_0400677467_07712	2022-09-12T11:14:01.205	
12-Sep-22	255	9.25-h Lightcurve (14:20 UTC through 23:35 UTC)	7481	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400688389_15492	dart_0400721639_45080	2022-09-12T14:20:01.194	
13-Sep-22	256	Approach Opnav 79	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400731229_12993	dart_0400731464_09936	2022-09-13T02:14:01.167	
13-Sep-22	256	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0400731465_22551	dart_0400731498_09423	2022-09-13T02:17:57.359	
13-Sep-22	256	Approach Opnav 80	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400749229_16558	dart_0400749467_07931	2022-09-13T07:14:01.249	
13-Sep-22	256	Approach Opnav 81	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400767229_15618	dart_0400767467_06991	2022-09-13T12:14:01.239	
13-Sep-22	256	Approach Opnav 82	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400785229_14545	dart_0400785467_05922	2022-09-13T17:14:01.228	
13-Sep-22	256	Approach Opnav 83	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400803229_13798	dart_0400803467_05178	2022-09-13T22:14:01.223	
14-Sep-22	257	Approach Opnav 84	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400821229_13293	dart_0400821464_10245	2022-09-14T03:14:01.222	
14-Sep-22	257	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0400821464_48807	dart_0400821497_11590	2022-09-14T03:17:56.933	
14-Sep-22	257	Approach Opnav 85	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400839229_12931	dart_0400839467_04322	2022-09-14T08:14:01.225	
14-Sep-22	257	Approach Opnav 86	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400857229_12947	dart_0400857467_04333	2022-09-14T13:14:01.235	
14-Sep-22	257	Approach Opnav 87	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400875229_12635	dart_0400875467_04018	2022-09-14T18:14:01.238	
14-Sep-22	257	Approach Opnav 88	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400893229_12176	dart_0400893467_03558	2022-09-14T23:14:01.239	
15-Sep-22	258	Approach Opnav 89	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400911229_16539	dart_0400911464_13491	2022-09-15T04:14:01.336	
15-Sep-22	258	Bias characterization	34	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0400911465_21296	dart_0400911497_10023	2022-09-15T04:17:57.431	
15-Sep-22	258	Approach Opnav 90	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400929229_16139	dart_0400929467_07525	2022-09-15T09:14:01.338	
15-Sep-22	258	Approach Opnav 91	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400947229_15777	dart_0400947467_07160	2022-09-15T14:14:01.340	
15-Sep-22	258	Approach Opnav 92	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400965229_15930	dart_0400965467_07325	2022-09-15T19:14:01.353	

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16-Sep-22	259	Approach Opnav 93	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0400983229_15556	dart_0400983464_12508	2022-09-16T00:14:01.355	
16-Sep-22	259	Bias characterization	34	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0400983465_20312	dart_0400983497_09039	2022-09-16T00:17:57.451	
16-Sep-22	259	Approach Opnav 94	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401001229_15034	dart_0401001467_06417	2022-09-16T05:14:01.355	
16-Sep-22	259	Approach Opnav 95	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401019229_14776	dart_0401019467_06162	2022-09-16T10:14:01.359	
16-Sep-22	259	Approach Opnav 96	207	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401037229_14445	dart_0401037427_31957	2022-09-16T15:14:01.362	
16-Sep-22	259	Approach Opnav 97	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401055229_14076	dart_0401055467_05458	2022-09-16T20:14:01.365	
17-Sep-22	260	Approach Opnav 98	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401073229_13470	dart_0401073464_10419	2022-09-17T01:14:01.362	
17-Sep-22	260	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0401073464_48981	dart_0401073497_11764	2022-09-17T01:17:57.073	
17-Sep-22	260	Approach Opnav 99	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401091229_12751	dart_0401091467_04130	2022-09-17T06:14:01.358	
17-Sep-22	260	Approach Opnav 100	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401109229_16879	dart_0401109467_08258	2022-09-17T11:14:01.450	
17-Sep-22	260	Approach Opnav 101	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401127229_16089	dart_0401127467_07466	2022-09-17T16:14:01.444	
17-Sep-22	260	Approach Opnav 102	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401145229_15199	dart_0401145467_06577	2022-09-17T21:14:01.436	
19-Sep-22	262	Approach Opnav 112	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401325228_12877	dart_0401325466_04241	2022-09-19T23:14:00.487	
20-Sep-22	263	Approach Opnav 113	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401343228_16027	dart_0401343463_12965	2022-09-20T04:14:00.560	
20-Sep-22	263	Bias characterization	34	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0401343464_20769	dart_0401343496_09494	2022-09-20T04:17:56.655	
20-Sep-22	263	Approach Opnav 114	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401361228_14379	dart_0401361466_05746	2022-09-20T09:14:00.537	
20-Sep-22	263	Approach Opnav 115	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401379228_12795	dart_0401379466_04163	2022-09-20T14:14:00.515	
20-Sep-22	263	Approach Opnav 116	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401397228_16034	dart_0401397466_07402	2022-09-20T19:14:00.589	
21-Sep-22	264	Approach Opnav 117	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401415228_14501	dart_0401415463_11439	2022-09-21T00:14:00.568	

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21-Sep-22	264	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0401415464_00001	dart_0401415496_12783	2022-09-21T00:17:56.279	
21-Sep-22	264	Approach Opnav 118	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401433228_12951	dart_0401433466_04318	2022-09-21T05:14:00.547	
21-Sep-22	264	Approach Opnav 119	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401451228_16168	dart_0401451466_07534	2022-09-21T10:14:00.621	
21-Sep-22	264	Approach Opnav 120	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401469228_14446	dart_0401469466_05812	2022-09-21T15:14:00.597	
21-Sep-22	264	Approach Opnav 121	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401487228_12808	dart_0401487466_04174	2022-09-21T20:14:00.574	
22-Sep-22	265	Approach Opnav 122	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401505228_15872	dart_0401505463_12807	2022-09-22T01:14:00.645	
22-Sep-22	265	Bias characterization	34	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0401505464_20611	dart_0401505496_09336	2022-09-22T01:17:56.740	
22-Sep-22	265	Approach Opnav 123	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401523228_14171	dart_0401523466_05537	2022-09-22T06:14:00.620	
22-Sep-22	265	Approach Opnav 124	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401541228_12375	dart_0401541466_03739	2022-09-22T11:14:00.594	
22-Sep-22	265	Approach Opnav 125	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401559228_15415	dart_0401559466_06781	2022-09-22T16:14:00.665	
22-Sep-22	265	Approach Opnav 126	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401577228_13601	dart_0401577466_04965	2022-09-22T21:14:00.638	
23-Sep-22	266	Approach Opnav 127	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401595228_16559	dart_0401595463_13493	2022-09-23T02:14:00.707	
23-Sep-22	266	Bias characterization	34	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0401595464_21297	dart_0401595496_10022	2022-09-23T02:17:56.802	
23-Sep-22	266	Approach Opnav 128	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401613228_14696	dart_0401613466_06061	2022-09-23T07:14:00.680	
23-Sep-22	266	Approach Opnav 129	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401631228_12871	dart_0401631466_04234	2022-09-23T12:14:00.653	
23-Sep-22	266	Approach Opnav 130	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401649228_15683	dart_0401649466_07047	2022-09-23T17:14:00.719	
23-Sep-22	266	Approach Opnav 131	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401667228_13784	dart_0401667466_05146	2022-09-23T22:14:00.691	
24-Sep-22	267	Streaming Test	1271	512x512	Taken in rolling shutter; 30X 90 ms exposure time; loose pointing; cal table on	dart_0401674617_14430	dart_0401676033_33024	2022-09-24T00:17:09.708	Cal table that was applied is designed only for global shutter mode; cal table was also corrupted; pointing was loose so Didymos is often not found in the FOV; purpose of

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									these images was to test the data link with New Norcia.
24-Sep-22	267	Approach Opnav 132	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401685228_16564	dart_0401685463_13496	2022-09-24T03:14:00.756	
24-Sep-22	267	Bias characterization	34	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0401685496_10025	dart_0401685496_10025	2022-09-24T03:18:28.625	
24-Sep-22	267	Approach Opnav 133	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401703228_14676	dart_0401703466_06040	2022-09-24T08:14:00.728	
24-Sep-22	267	Approach Opnav 134	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401721228_12764	dart_0401721466_04127	2022-09-24T13:14:00.700	
24-Sep-22	267	Approach Opnav 135	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401739228_15681	dart_0401739466_07045	2022-09-24T18:14:00.768	
24-Sep-22	267	Approach Opnav 136	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401757228_13722	dart_0401757466_05084	2022-09-24T23:14:00.738	
26-Sep-22	269	Approach Opnav 141	245	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401847228_13483	dart_0401847463_10415	2022-09-26T00:14:00.814	
26-Sep-22	269	Bias characterization	35	1024x1024	Taken in rolling shutter; 30X gain; 1-INT exposure time	dart_0401847463_48977	dart_0401847496_11757	2022-09-26T00:17:56.524	
26-Sep-22	269	Approach Opnav 142	82	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401865228_12176	dart_0401865466_03554	2022-09-26T05:14:00.797	
26-Sep-22	269	Approach Opnav 143	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401872428_12592	dart_0401872666_03961	2022-09-26T07:14:00.810	
26-Sep-22	269	Approach Opnav 144	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401879628_12938	dart_0401879866_04305	2022-09-26T09:14:00.821	
26-Sep-22	269	Approach Opnav 145	248	1024x1024	Taken in rolling shutter; 30X 90 ms exposure time	dart_0401886828_13253	dart_0401887066_04620	2022-09-26T11:14:00.831	
26-Sep-22	269	SMARTNav Streaming Test (Impact-21.5h -- 10 mins)	135	512x512	Taken in global shutter; 1X 90 ms exposure time, SMARTNav Cal Table On	dart_0401852652_13597	dart_0401853247_16080	2022-09-26T01:44:24.819	
26-Sep-22	269	Pre-terminal Streaming Test (Impact-6h -- 30 mins)	1586	512x512	Taken in global shutter; 1X 5 ms exposure time, SMARTNav Cal Table On	dart_0401908482_2506	dart_0401910250_16052	2022-09-26T17:14:55.079	
26-Sep-22	269	Terminal (Impact-4h through Impact-4min)	13400	512x512	Taken in global shutter; 1X 5 ms exposure time, SMARTNav Cal Table On	dart_0401914835_32124	dart_0401929787_00585	2022-09-26T19:00:48.224	The calibrated versions of these images are in units of I/F.
26-Sep-22	269	Terminal (Impact-4min through Impact)	236	512x512	Taken in global shutter; 1X 5 ms exposure time, SMARTNav Cal Table On	dart_0401929788_46871	dart_0401930050_41838	2022-09-26T23:10:01.527	The calibrated versions of these images are in units of I/F. The final 65 images have TARGET=65803 Didymos I (Dimorphos).