2016 Dawn/FC
Framing Cameras

FC STANDARD DATA PRODUCTS AND ARCHIVE VOLUME SOFTWARE INTERFACE SPECIFICATION

(FC Archive Product and Volume SIS)

Version 1.3
August 15, 2016

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Table of Contents

1. INTRODUCTION

This document describes the contents and types of archive volumes belonging to all of the VIR NASA level 1 (CODMAC levels 2 and 3) data sets. This includes detailed descriptions of the data formats to allow users to read the data products.

1.1. Distribution List

Table 1: Distribution List

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1.2. Document Change Log

Table 2: Document Change History

Change	**Date**	**Affected Portions**
Boilerplate Draft	02 Nov 2007	All
First Draft	25 Jun 2009	All
Second Draft	21. Oct 2009	All

Table 2: Document Change History		
Change	**Date**	**Affected Portions**
Third Draft	21. July 2010	All
Fourth Draft	28. Aug 2010	All
Fifth Draft	1. Oct 2012	Removed VIR references from section 2.3 Added information on 2.4 w.r.t. windowed mode and user-defined windows Added information on 6.1. w.r.t. windowed mode Added information on 6.3 w.r.t. the relationship between data object pointers and image object.
Sixth Draft	8.Mar 2013	Addressed issues reported in VSA/VSS/VSH delta review.
Version 1.0	17.Oct 2013	Sections 1, 3-6
Version 1.1	16.Dec 2013	Section 5.2
Version 1.2	17.Feb 2016	Sections 1.6, 3.1, 5.5.2, 6.3
Version 1.3	15 Aug. 2016	Section 4.3 – Volume naming convention

1.3. TBD Items

Table 3 *: TBD Items*		
Item	Section	Pages

1.4. Acronyms and Abbreviations

Table 4: Acronyms and Abbreviations	
Acronym	Definition
ASCII	American Standard Code for Information Interchange
CDROM	Compact Disc, Read Only Memory
CODMAC	Committee on Data Management and Computation
DSC	Dawn Science Center
DSDb	Dawn Science Database
DSN	Deep Space Network

Table 4: Acronyms and Abbreviations	
Acronym	Definition
DVD	Digital Versatile Disc
EDR	Experiment Data Records
FC	Framing Camera(s)
FLTOPS	JPL Multi-mission Flight Operations
Gb	Gigabit(s)
GB	Gigabyte(s)
GRaND	Gamma Ray and Neutron Detector
HAMO	High Altitude Mapping Orbit
ISO	International Standards Organization
JPL	Jet Propulsion Laboratory
LAMO	Low Altitude Mapping Orbit
NSSDC	National Space Science Data Center
PDB	Project Database
PDS	Planetary Data System
RDR	Reduced Data Records
RMOC	Remote Mission Operations Center
SAMO	Survey Altitude Mapping Orbit
SBN	Small Bodies Node
ST	Science Team
SIS	Software Interface Specification
TBD	To Be Determined
UCLA	University of California, Los Angeles
VIR	Visual and Infrared Mapping Spectrometer

1.5. Glossary

Archive – An archive consists of one or more Data Sets along with all the documentation and ancillary information needed to understand and use the data. An archive is a logical construct independent of the medium on which it is stored.

Archive Volume – A collection of files formatted according to the PDS Archive Volume standards. This collection may be electronic or stored on a PDS approved physical media such as DVD or CDROM.

Archive Volume Set – A collection of one or more Archive Volumes used to store a single Data Set or collection of related Data Sets.

Catalog Information – High-level descriptive information about a Data Set (e.g., mission description, spacecraft description, instrument description), expressed in Object Description Language (ODL), which is suitable for loading into a PDS catalog.

Data Product – A labeled grouping of data resulting from a scientific observation, usually stored in one file. A product label identifies, describes, and defines the structure of the data. An example of a Data Product is a planetary image, a spectral table, or a time series table.

Data Set – A Data Set is a collection of Data Products from a single instrument that have a common data processing level, together with supporting documentation and ancillary files.

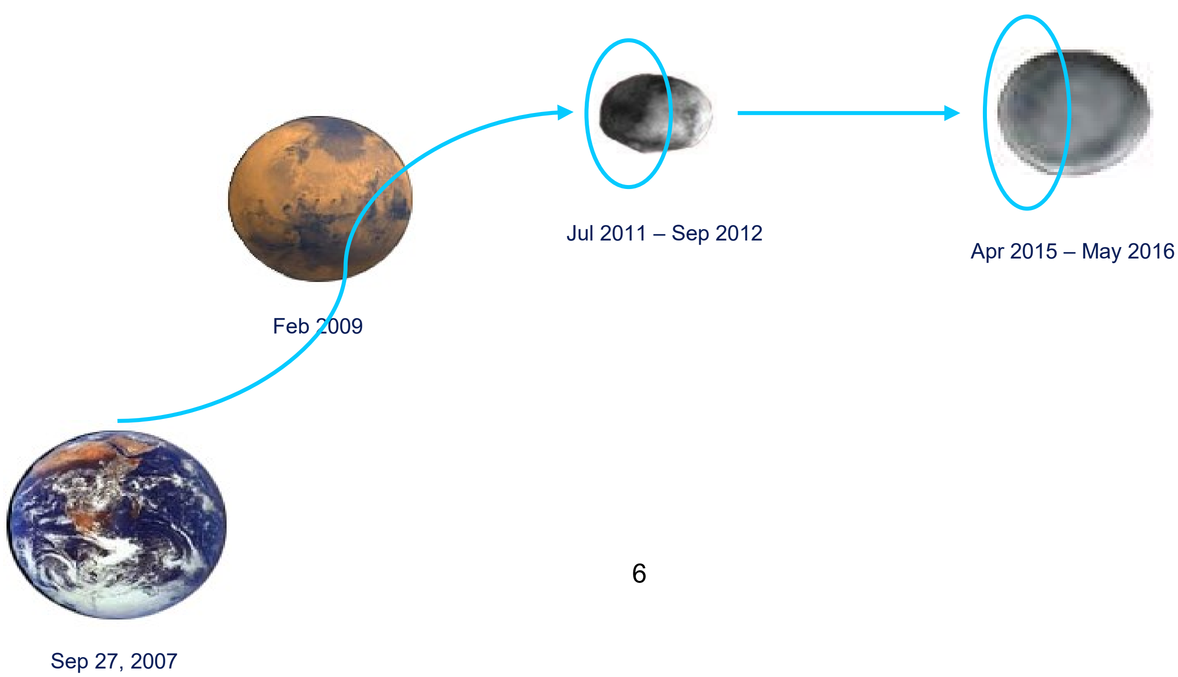
Standard Data Product – A Data Product generated in a predefined way using well-understood procedures, processed in "pipeline" fashion. Data Products that are generated in a non-standard way are sometimes called *special Data Products*.

1.6. Dawn Mission Overview

The overall scientific goal of the Dawn mission is to achieve an understanding of the conditions and processes during one of the solar system’s first epochs. It achieves this by flying to and orbiting the main belt asteroids (protoplanets) Ceres and Vesta, orbiting Vesta for a period of not less than seven months and Ceres for not less than five months. At least one and a half months at Vesta are below a mean altitude of 200km, and at least one month of Ceres is below a mean altitude of 700km.

The launch period for Dawn opened on September 26, 2007 and the spacecraft launched on September 27, 2007 at 11:34:00.372 UTC. Dawn is an ion-propelled spacecraft capable of visiting multiple targets in the main asteroid belt. Dawn arrived at Vesta on July 16, 2011, and departed Vesta on September 5, 2012. In the ISB navigation plan, Dawn arrives at Ceres on March 29, 2015, where Dawn orbits until the end of the baseline mission. Dawn flew by Mars in February 2009 en route to Vesta.

The Dawn spacecraft carries three science instruments. The data from these three instruments,



when combined, provides information to characterize Vesta and Ceres. The instrument suite consists of redundant framing cameras (FC1 and FC2), a visible and infrared mapping spectrometer (VIR), and a gamma ray and neutron detector (GRaND). In addition to these instruments, radiometric and optical navigation (OpNav) data are used to determine the gravity field and thus bulk properties and internal structure of the two bodies.

Figure 1 Overview of Dawn Mission.

Dawn is an asteroid mapping mission. Each asteroid encounter is nominally sub-divided into three mapping phases, each at different altitudes, and each with different science objectives and primary experiments. Shortly after orbit capture the spacecraft enters into a survey altitude mapping orbit where the VIR instrument is primary. This phase is relatively short, lasting for only 6-7 orbits. Global spectroscopy data and low resolution global image mosaics are acquired during these phases at each asteroid. After survey, the spacecraft is maneuvered into a high altitude mapping orbit (HAMO) where the FC instrument is primary. Medium resolution global stereo imaging is performed at this altitude (950 km Vesta, 1950 km Ceres) while local high resolution spectroscopy data is acquired. Finally, the spacecraft proceeds to the low altitude mapping orbit (LAMO) where the GRaND and gravity experiments will collect their prime data and additional, local, high resolution imaging and spectroscopy data will be acquired. On asteroid approach, all of the instruments perform in-flight calibrations and acquire data that will be used to characterize the hazards of the near asteroid environment (dust) and search for moons.

1.7. Content Overview

Chapter 2 describes the FC instrument, including its primary science objectives, detectors, electronics, optics, operation, and calibration.

Chapter 3 describes the data sets, data volume, data processing and production, data flow, and scientific data validation.

Chapter 4 describes the archive volume generation, volume naming conventions, production, and PDS peer review.

Chapter 5 describes the PDS archive volume structure, the contents of each directory, and the various file naming conventions.

Chapter 6 describes the format of the EDR and RDR data files

Appendix A provides example PDS labels for the data files, index and geometry tables, and an example document label.

Appendix B lists the support staff and cognizant personnel associated with the archive generation and validation.

1.8. Scope

This specification applies to all archive volumes containing FC data products for the duration of its mission.

1.9. Relationship to Other Dawn Archives

Higher level products, such as, for example, mosaics, and stereo images, are foreseen but will be defined and detailed later on.

1.10. Applicable Documents

Archive Description Documents

Planetary Science Data Dictionary Document, August 28, 2002, Planetary Data System, JPL D-7116, Rev. E

Planetary Data System Standards Reference, March 20, 2006, Version 3.7. JPL D-7669, Part 2.

Planetary Data System Archive Preparation Guide, August 29, 2006, Version 1.1. JPL D-31224.

Dawn Science Data Management Plan, May 3, 2007, DAWN-31-4032, JPL D-25901, Rev. A.

Instrument Papers or other technical documents

Dawn Framing Camera FM Housekeeping Calibration Information, K.-Michael Aye, MPS report DA-FC-MPAE-TN-033 (21 June 2007).

Calibration Pipeline, Schröder, S.E. and P. Gutierrez-Marques, MPS report DA-FC-MPAE-RP-272 (28 Jan 2008).

Dawn Mission to Vesta and Ceres, C.T. Russell, F. Capaccioni, A. Coradini, M.C. De Sanctis, W.C. Feldman and 11 others, Earth, Moon and Planets 101, 65-91, 2007.

1.11. Audience

This specification is useful to those who wish to understand the format and content of the FC PDS data product archive collection. Typically, these individuals would be scientists, data analysts, or software engineers.

2. FC Instrument Description

FC is a multi-spectral high resolution framing camera. It can take images in a broadband visible filter and 7 narrow band filters ranging from 450 to 980 nm with an IFOV of 96 millirad x 96 millirad.

The camera is composed by a Camera Head and an Electronic Box. The first one contains a 1024 x 1024 front lit CCD with its proximity electronics and its radiator, the filter wheel, the lens barrel, a baffle and the protective front door. The electronic box houses the power converter module, the mechanism controller unit and the data processing unit.

The camera is autonomously controlled by the data processing unit, which is in charge of all the communications with the spacecraft and controlling all the other subunits.

2.1. Science Objectives

The architecture of the camera makes it suitable for various scientific and operational purposes. The science objectives of the FC are the characterization of Vesta and Ceres by means of their most relevant parameters:

- volume
- spin state
- topography
- physical surface properties
- color variation and related mineralogy
- evolution (crater records)
- environment (search for dust and satellites)
- In addition to the scientific goals, the FC will also accomplish operational goals such as:
- optical navigation (ground control points)
- mission safety (presence of objects in the orbit)

2.2. Detectors

The optics of the Framing Camera consists of an F/8 rad-hard refractive lens system, a set of filters, and a baffle in front of the lens system. The 5.5° x 5.5° field of view is achieved with a focal length of 150 mm and aperture of 19 mm. The lens system with baffle is mounted in front of the CCD by means of a lens barrel.

Between the lens barrel and the CCD lies the filter wheel with its selection of filters as shown in the graph below.

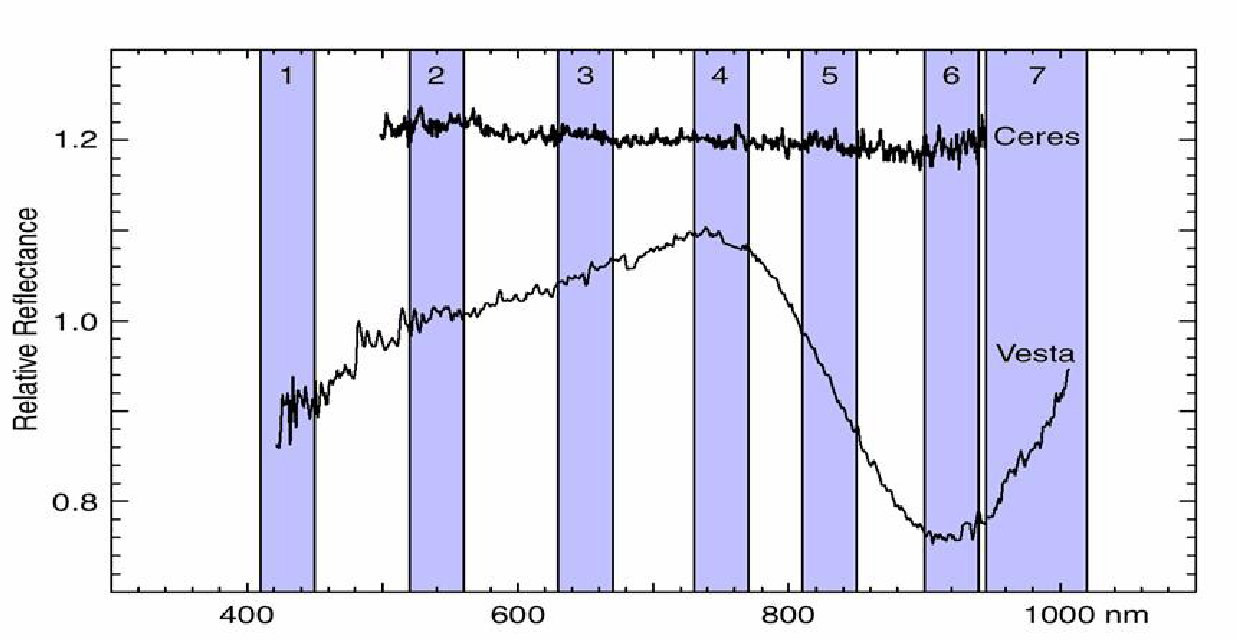


Figure 2:
Location of the bandpasses within the spectrum of Vesta and Ceres. See Table 7 for a correspondence between bands and filter numbers.

The CCD has a 1024x1024 sensitive area with 14 µm pitch, representing a field of view of 93 µrad per pixel. The exposure time can be commanded from 1 ms to several thousands of seconds. The image information collected in the sensitive area during the exposure time is transferred on a fast mode to the shielded area in 1.32 ms. Then the image information is amplified and read at a 1 Mpixel/s rate and transferred to the data processing unit.

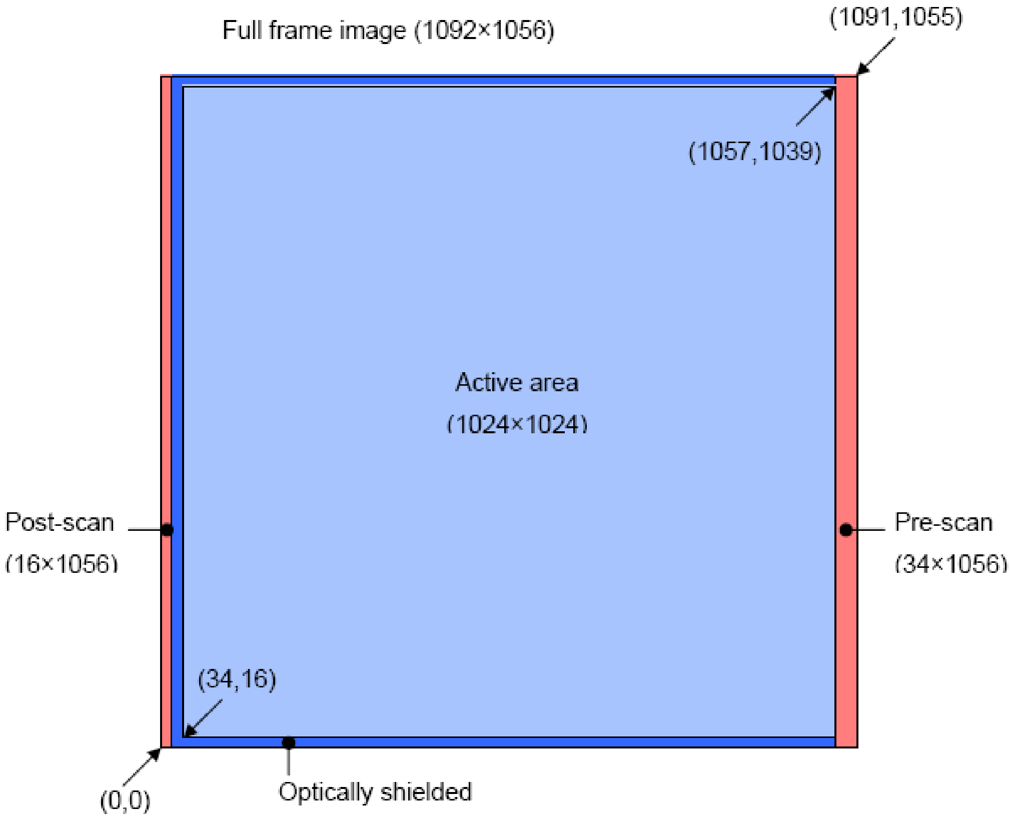


Figure 3: Active 1024x1024 pixel region on the whole CCD

2.3. Electronics

The Framing Camera contains mainly four electronic subsytems, the Data Processing Unit (DPU), the Mechanism Controller Unit (MCU), the Power Converter Unit (PCU) and the Front-End Electronics (FEE).

The Data Processing Unit controls the camera as a whole and each of the subsystems, decodes the ground commands and transmits scientific and engineering data to the spacecraft. It also contains the mass memory to store the images in the time since they are acquired until they are transmitted to the spacecraft for forwarding to ground. Finally, it also performs the necessary on-board processing of the images, discarding non-relevant parts of the frame and compressing the images to reduce the data volume to be transmitted to ground.

The Mechanism Controller Unit commands the front door and filter wheel mechanisms and reads out the associated temperature and position sensors.

The Power Converter Unit supplies the camera with the voltages needed for correct operation. It is fed from the 28 V unregulated power bus and provides

2.4. Operational Modes

The Framing Camera can be operated to acquire a single image per command. This mode of operation requires the most time for sequence generation and for execution because it has to be verified that an image acquisition is finished before commanding a new one.

By using higher level UDPs it is possible to acquire several images with one command at a higher acquisition rate. The currently fastest rate is about one image every 4 seconds with no need for adding any margin on top of it.

The instrument can acquire several kinds of images as listed in the table below.

Table 5: Image acquisition Modes

Mode	Decription
Test Pattern	1024x1024 pixel with grayscale from 0 DN to 16383 DN
Full-Full-Frame	Readout of the whole 1092x1056 pixel CCD
Full-Frame	Readout of the active 1024x1024 pixel region plus optical shield regions
Windowed Mode	Readout of up to 10 user-defined windows within the 1024x1024 pixel active area of CCD. The image is originally acquired as a Full-frame and then cropped in different windows, all of them with the same filter and exposure time. The windows are defined by issuing commands prior to the acquisition of the image, and these windows remain valid until a new definition is sent.

2.5. Operational Considerations

The framing cameras mass memory is 1GB. This is enough to store around 450 uncompressed full images each 2.2 MB. With lossless compression this number grows to 800 or even more images.

The second limiting factor for the number of images that can be acquired in a certain time is the maximal image acquisition rate. When no filter wheel changes are required this is approximately 1 image every 4 seconds. This time is needed for memory allocation, readout of the CCD, writing the image to memory.

Typical times for processing of the images are one minute to compress with a compression ratio of ~2 and another minute to stream the compressed image into the space craft recorder at a transmission rate of the MILbus of 150 kb/s.

The FC1 CCD is known to be affected by residual, or extra charge. Extra charge is charge that is already present on the CCD before the start of an exposure, and is caused by insufficient draining by the anti-blooming gates. It may occur when imaging an extended source, with its intensity depending on the radiant flux. It was first identified in a very brief (1 msec) clear filter exposure of the inside of an integrating sphere acquired on 8 March 2006. The extra charge was found to be variable over the active area, and to differ significantly from pixel to pixel. At the particular radiant flux used in the experiment (F1 charge rate $6.7 \cdot 10^4$ DN s^{-1}) it amounts to several hundreds of DN for some pixels. It is unknown how the extra charge scales to the radiant flux level expected at Vesta, which is two orders of magnitude higher than the flux achieved in the experiment. The FC2 CCD was exposed to much lower flux levels than FC1 in the integrating sphere on 12 August 2005, and extra charge was absent. The FC1 images did show traces of extra charge at these low levels. Yet it is possible that at the much higher Vesta flux the FC2 will also be found to be affected. The residual charge is also temperature dependent, which might have an impact on the temperature to operate at Vesta and Ceres.

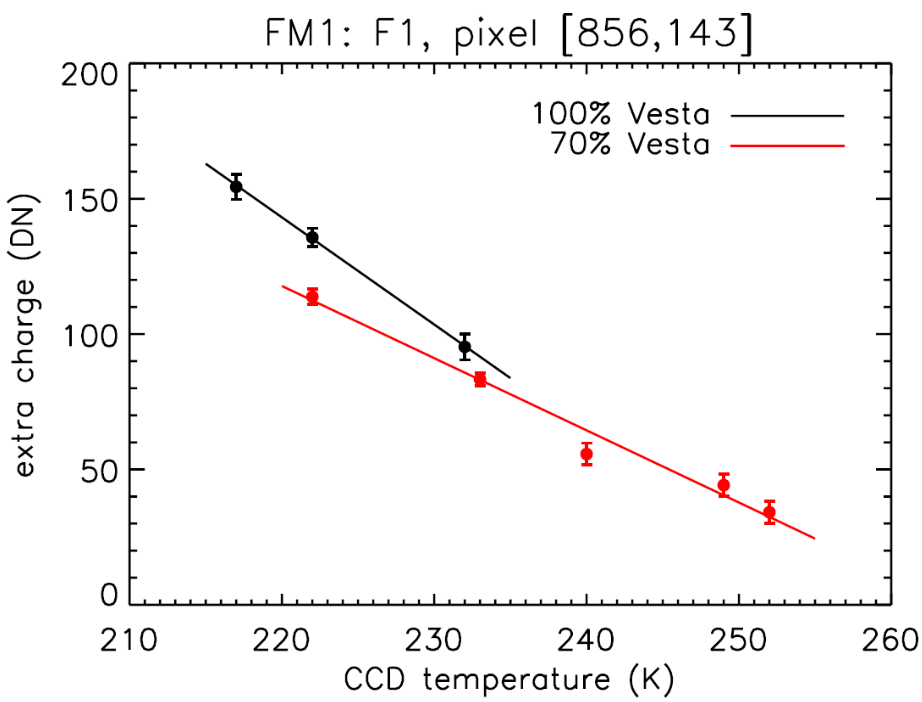


Figure 4: Temperature dependency of extra charge

2.6. Filters

The FC has 8 filters at its disposal, numbered from F1 to F8. F1 is a broadband (clear) filter, sensitive in the wavelength interval from 400 to 1100 nm peaking at 700 nm. The narrow-band color filters are of the interference type, and have the following effective wavelengths:

Table 6: FC Filter Parameters

Filter	Band #	Color	Effective wavelength [nm]	FWHM [nm]
F2	2	Green	555	+15, -28
F3	4	Red	749	+22, -22
F4	6	NIR	917	+24, -21
F5	7	NIR	965	+56, -29
F6	5	NIR	829	+15, -18

F7	3	Red	653	+18, -24
F8	1	Blue	438	+10, -30

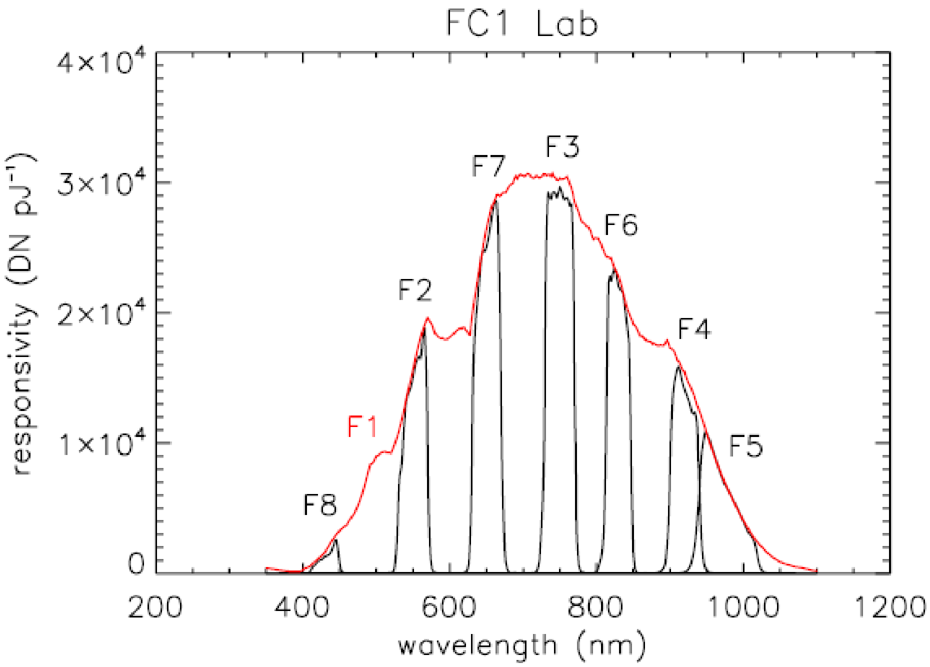


Figure 5: The FC1 absolute responsivity for the different filters as determined from the lab calibration.

2.7. Optics

The optical design was developed by Kayser-Threde based on the missions requirements. The telecentric four-lens design is derived from a triplet with split third lens to allow telecentricity in image space. The design is optimized for low distortion.

The chromatic variation of the focal plane was compensated for by varying the filter thickness with filter central wavelength. Chromatic aberration was compensated for by the choice of glasses used for the lenses, crown glass with positive refractive power in the first lens followed by two flint lenses of negative refractive power and a forth with positive refractive power. Spherical aberration is corrected with an aspherical first surface.

To maintain a fixed focal length under changing temperatures, the two central lenses are mounted in an inner barrel with a different thermal expansion coefficient than the main barrel. The resulting differential movement with changing temperatures maintains a constant focal plane location within a range of 30 µm.

The optical design required an adequate back focal length to accommodate the filter wheel mechanism inside the camera head, between the lens system and the CCD. The filter wheel transports the eight filters with the lower filter surface at a constant clearance from the CCD. The overall spectral range of the optical system is 400-1050 nm. The band passes are obtained by a multilayered, thin film deposition on the front and back surfaces of silica (Suprasil) substrates. Filter dimensions are 20 mm by 20 mm, with the thickness specified for the band pass.

Table 7: Camera Optics Parameters		
Parameter	FC1	FC2
Focal Length, mm	150.0	150.0
f/ratio	f/8	f/8
IFOV, µrad/pixel	93.3	93.3
Field of view, °		
Cross-track	5.46	5.46
Along-track	5.46	5.46

2.8. Onboard software version

Table 8: Onboard Software Version		
Version	Loaded FC1	Loaded FC2
3.01.05	Prior to Launch	Prior to Launch
3.03.02	DC014 2008-04-02	DC014 2008-04-01
3.04.02	DC034 2009-12-02	DC034 2009-12-01
3.05.01	DC048 2011-03-16	DC048 2011-03-15
3.09.03	DC072 2014-06-23	DC074 2014-08-19

2.9. Ground Calibration

The FC has been calibrated using the results of laboratory and in-flight measurements. The lab measurements were acquired at the Max Planck Institute for Solar System Research, and were aimed at determining the dark current and the absolute photometric response in each of the filters. Flat fields were acquired by imaging the inside of an integrating sphere.

2.10. Inflight Calibration

The in-flight measurements, acquired during the Initial Check-Out campaign in the months after launch, focused on characterizing the dark current and geometric distortion (through observation of star fields), and validating the lab radiometric calibration (photometric standard stars). The calibration pipeline is described by [Schröder & Gutierrez-Marques 2008].

Dark current, and the associated emergence of bad pixels, and the amount of geometric distortion will continue to be monitored during bi-annual check-outs. Images acquired during the Mars

Gravity Assist will enable us to validate the lab flat fields. A better understanding of the FC flat field response and in-field stray light characteristics may require reprocessing of data in the future.

3. Data Set Overview

Two data sets will be delivered for each mission phase: one raw (EDR) data set, and one calibrated (RDR) data set.

3.1. Data Sets

Table 9: PDS Data Sets		
Data Set ID	**Standard Data Product id**	**Data Set Description**
DAWN-CAL-FC1-2-EDR-CALIB-IMAGES-V1.0	FC_IMAGE	FC1 Raw L1A (EDR) calibration images
DAWN-X-FC1-2-EDR-CRUISE-IMAGES-V1.0	FC_IMAGE	FC1 Raw L1A (EDR) cruise images
DAWN-CAL-FC2-2-EDR-CALIB-IMAGES-V1.0	FC_IMAGE	FC2 Raw L1A (EDR) calibration images
DAWN-X-FC2-2-EDR-CRUISE-IMAGES-V1.0	FC_IMAGE	FC2 Raw L1A (EDR) cruise images
DAWN-M-FC2-2-EDR-MARS-IMAGES-V1.0	FC_IMAGE	FC2 Raw L1A (EDR) Mars flyby images
DAWN-A-FC2-2-EDR-VESTA-IMAGES-V1.0	FC_IMAGE	FC2 Raw L1A (EDR) Vesta images
DAWN-A-FC2-2-EDR-CERES-IMAGES-V1.0	FC_IMAGE	FC2 Raw L1A (EDR) Ceres images
DAWN-X-FC1-3-RDR-CRUISE-IMAGES-V1.0	FC_IMAGE	FC1 Calibrated L1B (RDR) cruise images
DAWN-X-FC2-3-RDR-CRUISE-IMAGES-V1.0	FC_IMAGE	FC2 Calibrated L1B (RDR) cruise images
DAWN-M-FC2-3-RDR-MARS-IMAGES-V1.0	FC_IMAGE	FC2 Calibrated L1B (RDR) Mars flyby images
DAWN-A-FC2-3-RDR-VESTA-IMAGES-V1.0	FC_IMAGE	FC2 Calibrated L1B (RDR) Vesta images
DAWN-A-FC2-3-RDR-CERES-IMAGES-V1.0	FC_IMAGE	FC2 Calibrated L1B (RDR) Ceres images

3.2. Level-0 Data Flow

The DSC captures all of the payload instrument telemetry frames as binary files after the data have been cleaned up in the post-pass processing (reconstructed level-0 data). Post-pass processing is completed with 8 hours of each pass and typically is able to fix minor forms of data corruption (partial packet reconstruction, dropped time tags, etc.). These files are inventoried within the Dawn Science Database (DSDb) and made available to the teams for download at any time. The DSC prepares the documentation and metadata required in order to submit these products to the PDS to be saved (rather than archived). The PDS documentation threshold for saved data sets is substantially lower than for archived products. The raw decoded frames are not considered to be useful for the general science community but the bits will be preserved in their rawest form. The DSC will submit the telemetry frames to the PDS Small Bodies Node (SBN) within a week of the end of each science phase. All level-0 data products are created with PDS "minimum" labels. Each level-0 data file contains the CCSDS (Consultative Committee for Space Data Systems) packets for a single APID (Application Process Identifier).

The Doppler Tracking data are used by the NAV and Gravity Science teams and do not flow into the TDS (Telemetry Data Server). These data flow from the DSN into the OSCAR-X system where they are accessible to the gravity team at JPL. Since these data do not flow directly into the DSC, the DSC staff will manually retrieve them from OSCAR-X and load them into the DSDb. Gravity Science investigators that are not at JPL will use the DSDb to retrieve the level-0 data for their analysis. This process is described in the operational interface agreement (OIA-DSC-409) between the Gravity Science Team and the DSC. Unlike the decoded frames, the level-0 Doppler Tracking data are archived with the PDS. DSC prepares these data for archive and submits them to the PDS SBN at the same time as the level-1a data products from the payload instruments.

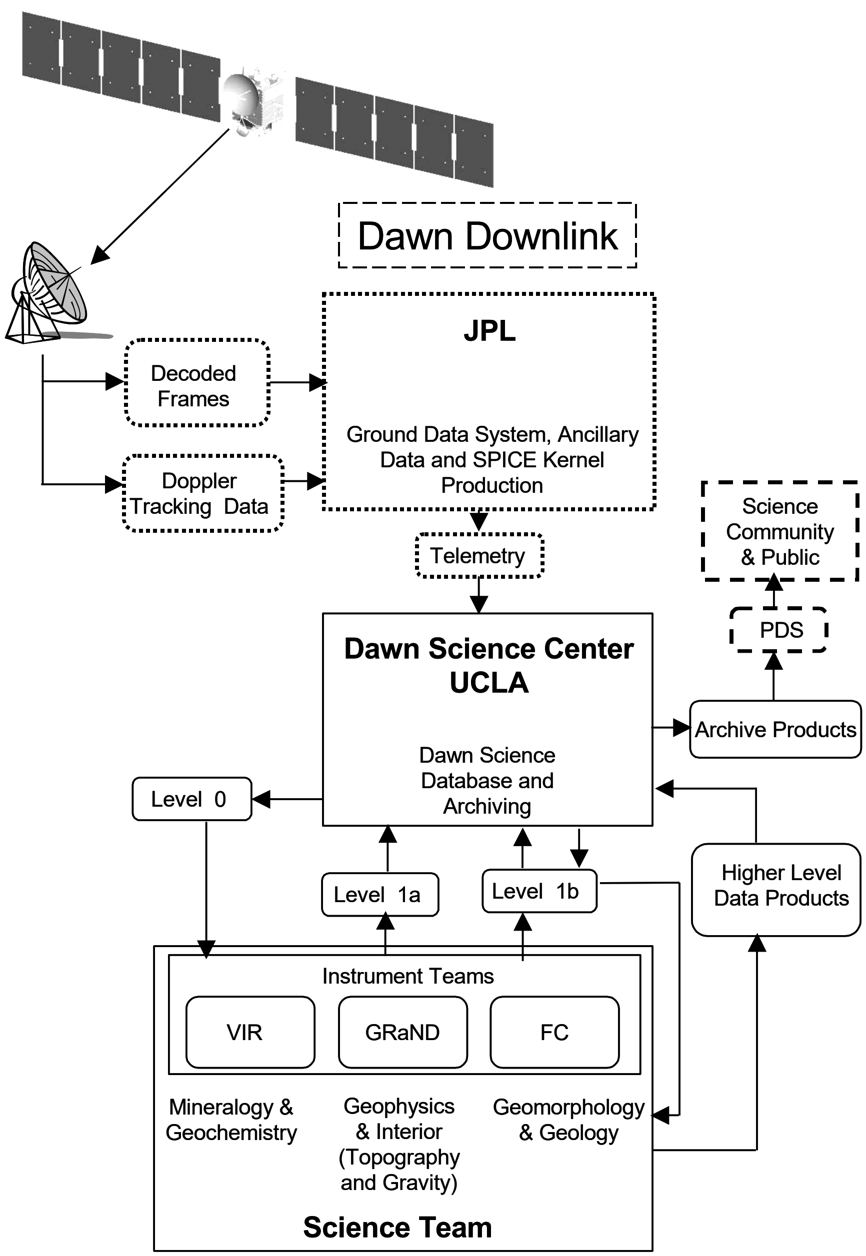


Figure 6: Dawn Science Data Flow. SPAA elements and products are outlined with solid black lines, MOS components with dotted lines, and PDS components with dashed lines.

3.3. Data Processing and Production Pipeline

3.3.1. ***EDR (Level 1a) Data Production Pipeline***

The data reduction pipeline is implemented in a tailored application called Calliope. The input to the application comprises a set of images in PDS format, a configuration file and various reference data files.

The PDS files to be fed into the pipeline are the direct output of Trap, the so-called Level 1a of image processing, where the images are uncompressed and reconstructed back to image format but the value of the pixel is a plain digital number.

3.3.2. ***RDR (Level 1b) Data Production Pipeline***

The configuration file, also called mission calibration description file, is an XML file describing the different operational slots and the reference files to be used for the calibration of the images in each one. It also contains some constants for the calibration image, such as the radiometric calibration coefficients, dark current curve and any other constant that can be applied to all the pixels in the sensor.

The reference files are typically synthetic images that represent the distribution of a magnitude over all the pixels in the sensor, such as the dark current generation rate or the sensitivity of the pixel. These files help correcting the differences among pixels to provide a measurement of the real light flux as accurate as possible. Being Dawn a long term mission, these images, as the related constants, are bound to change throughout the mission and the configuration file captures this effect by matching each reference file and constant to its corresponding time of application.

3.4. Data Flow

The Instrument Teams retrieve the reconstructed Level-0 data from the DSDb and use it to produce the Level-1a (raw, reformatted) data sets. The raw telemetry data are decompressed, decoded, and formatted into scientifically useful data structures. These products, along with their required PDS documentation, form the level-1a data sets (EDRs). The Instrument Teams extract the reconstructed spacecraft ephemeris and pointing data (SPICE kernels) from the DSDb and use these data to compute the various geometry data that are included in the PDS labels associated with each data product. The Instrument Teams are required to submit the PDS-labeled EDRs to the DSDb within 7 days after the reconstructed data are made available to the teams (see OIA-DSC-406). These data are then available to the rest of the Science Team for validation and preliminary analysis. If any problems are discovered during validation or analysis, new products are produced by the FC team and delivered to the DSC for use by the Science Team and eventual archive (see schedule) by the PDS. The FC team also generates PDS catalog files and other documentation (activity reports, instrument performance reports, calibrations, etc.) and provides these files to the DSC for the internal distribution and archive.

After the data are validated by the Dawn Science Team, the DSC packages the data, catalog files, and documentation into PDS-compliant archive data volumes, one volume for each data set according to PDS volume organization standards (JPL-D-7669). The DSC is responsible for the creation of the PDS required files associated with archive volumes (AAREADME.TXT, VOLDESC.SFD, etc.), including the index table. The DSC then delivers the volumes to the PDS SBN in accordance with the SBN standard data delivery practices at the time of each delivery. Presently, the PDS SBN accepts volumes delivered electronically, on CDROM, and on DVD-R. EDR data volumes are to be delivered to the PDS SBN for peer review within 90 days of the end of each science phase (Approach, Survey, HAMO, LAMO, etc.). The DSC is responsible for following the archive submissions through the PDS peer review process until the data are finally accepted into the PDS archive. The Instrument Teams will support the DSC during this PDS process by providing any additional documentation that is requested by the PDS peer review panel.

Additional data processing is performed by the FC team to produce calibrated level 1b (RDR) data products (radiometrically corrected spectra). The FC team produces the processed products using the archived EDR data sets. The RDR data products are submitted to the DSDb within a few months of the receipt of the corrected telemetry by ground data system. If during the course of the mission an improved calibration becomes available, the FC team may choose to update the data in the DSDb using the latest version of the calibration. The FC team is not obligated to provide updated RDR data products and any such resubmission would be negotiated with the Science Team. The DSDb system supports the resubmission of data sets.

The DSC has the same roles and responsibilities with respect to the generation of PDS archive compliant volumes for the RDR data sets as it does for the EDR data sets. Final RDR data volumes are publicly released by the PDS SBN within 6 months after asteroid departure. In order to support this schedule, peer review copies of the archive volumes will normally be delivered to the SBN 2 months prior to the final data release. The DSC and FC Teams will support the PDS peer review process of the RDR data sets in the same manner as the EDR data sets. Peer review liens will be addressed in time to support the public release date. Final (corrected) archive volumes will be delivered to the SBN two weeks prior to the public release.

3.5. Data Release Schedule*

Table 10: Data Release Schedule

Data Product	Provider	Mars	Vesta	Ceres
Level 0	DSC	Apr 2009	Oct 2011 to Apr 2012	Mar 2015 to Aug 2015
EDR - Level 1a	FC/DSC	Oct 2009	Dec 2011 to Jun 2012	May 2015 to Sep 2015
RDR - Level 1b	FC/DSC	Oct 2009	Aug 2012	Jan 2016

Derived Data	FC	Apr 2010	Feb 2013 to Aug 2014	Jan 2016

* Assumes current project schedule (arrival and departure dates)

4. Archive Volumes

This chapter describes the format of FC standard product archive volumes. Data that comprise the FC standard product archives will be formatted in accordance with Planetary Data System specifications [Planetary Science Data Dictionary, 2008; Planetary Data System Archive Preparation Guide, 2006; PDS Standards Reference, 2007].

4.1. Volume Creation

The DSC collects the data files and labels provided by the FC team onto archive volumes. Each archive volume contains all FC data available for the time interval covered by the archive volume. Once all of the data files, labels, and ancillary data files are organized onto an archive volume, the DSC adds all of the PDS required files (AAREADME, INDEX, ERRATA, etc.) and produces the physical media.

4.2. Volume Format

Disk formats for the archive volumes will conform to the PDS standard for the applicable media. At present, the plan is to archive FC data in online data volumes that are delivered to the SBN electronically. Although the volumes will be electronic, they will comply with the same volume organization standards that PDS formerly used to describe physical volumes on DVD or CDROM media.

4.3. Volume Labeling and Identification

Each FC data set will be archived on a separate PDS volume. The volume naming convention is:

DWNp(s)FCn_lx

where:

p – mission phase (X = cruise; M = Mars ; V = Vesta; C = Ceres),

(s) – sub-phase, Ceres volumes only, (A=Approach, S = Survey, H=HAMO, L=LAMO)

n – Framing Camera number,

l – processing level (1A = EDR; 1B = RDR).

For example, the FC2 Mars EDR volume will be named DWNMFC2_1A or DWNCHFC2_1B for Ceres HAMO calibrated data.

Due to constraints on the length of VOLUME_ID's, the Calibration volumes will follow a slightly different convention. For these volumes the naming convention is:

DWNCALFCnl

where:

n – Framing Camera number,

l – processing level (1A = EDR; 1B = RDR).

For example, the FC1 Calibration volume will be named DWNCALFC11A.

4.4. Data Validation

4.4.1. *Instrument Team Validation*

The FC team will be making the following checks on the data, before submitting them to the DSC:

- Completeness of the data set: it is checked that all the expected data were received by the EGSE and that there is no loss of packets.
- Acquisition conditions: analysis of the telemetry to see if the instrument operated nominally.
- Quality of the data: check of the saturation, SNR (signal-to-noise ratio) and, if applicable, the quality of the outputs of the calibration pipeline.

4.4.2. *Science Team Validation*

The Dawn Science Team has access to the FC EDR and RDR data sets for several months prior to their public release by the PDS. These are the data that the Science team uses for its initial data analysis and interpretation. Any data processing errors that are discovered through the use of the data are reported back to the FC team so that they can be corrected. In addition, the Science Team uses the same documentation that is later released to the PDS during its analysis. If any of the documentation is unclear, or if there are omissions in the documentation that hinder data analysis, these problems are reported back to the FC team so that they can be corrected.

4.4.3. *PDS Peer Review*

The peer review panel consists of members of the instrument team, the DSC, and members of the PDS Small Bodies and Engineering Nodes, and at least two outside scientists actively working in the field of asteroid remote sensing science. The DSC is responsible for generating and delivering PDS-compliant volumes to the SBN. The PDS personnel are responsible for verifying that the volume(s) are fully compliant with PDS standards. The instrument team and outside science reviewers are responsible for verifying the content of the data set, the completeness of the documentation, and the usability of the data in its archive format. The peer review process is a two part process. First, the panel reviews this document and verifies that a volume produced to this specification will be useful. Next, the panel reviews a specimen volume to verify that the volume meets this specification and is indeed acceptable.

During the peer review process, the panel will normally identify errors or omissions in the archive documentation, problems with conformance with the PDS standards. All accepted peer review liens will be resolved prior to the public release of the data. Liens that require data product updates, or updates to the instrument or data set documentation will be addressed by the VIR team. Any problems identified with the volume format, volume documentation, index files, or other products produced by the Dawn Science Center will be corrected by the DSC. After the liens are resolved, the DSC will create and submit an updated archive volume to the PDS Small Bodies Node.

5. Archive Volume Contents

This section describes the contents of the FC standard product archive collection volumes, including the file names, file contents, file types, and organizations responsible for providing the files. The complete directory structure is shown in Appendix A. All the ancillary files described herein appear on each FC archive volume, except where noted.

5.1. Root Directory Contents

The following files are contained in the root directory, and are produced by the DSC at UCLA. With the exception of the hypertext file and its label, all of these files are required by the PDS Archive Volume organization standards.

Table 11: Root Directory Contents

File Name	File Contents	File Provided By
AAREADME.TXT	This file completely describes the Volume organization and contents (PDS label attached).	DSC
ERRATA.TXT	A cumulative listing of comments and updates concerning all INST_ID Standard Data Products on all INST_ID Volumes in the Volume set published to date.	DSC
VOLDESC.CAT	A description of the contents of this Volume in a PDS format readable by both humans and computers.	DSC

5.2. INDEX Directory Contents

The following files are contained in the INDEX directory and are produced by the DSC. The INDEX.TAB file contains a listing of all data products on the archive volume and is described by a detached PDS label (INDEX.LBL). The index table, label, and index information (INDXINFO.TXT) files are required by the PDS volume standards. The index tables include both required and optional columns.

Table 12: Index Directory Contents

File Name	File Contents	File Provided By
INDXINFO.TXT	A description of the contents of this directory	DSC
INDEX.TAB	A table listing all INST_ID data products on this volume	DSC
INDEX.LBL	A PDS detached label that describes INDEX.TAB	DSC
GEOM_INDEX.TAB	A table containing Dawn geometry information associated with the data products (images) on this volume.	DSC
GEOM_INDEX.LBL	A PDS detached label describing GEOM_INDEX.TAB	DSC

Table 13: Index Table (INDEX.TAB) Contents

Column Name	Format	Units	Description

Table 13: Index Table (INDEX.TAB) Contents			
Column Name	**Format**	**Units**	**Description**
DATA_SET_ID	A40		Unique identifier for the data set of which the file is a part
FILE_SPECIFICATION_NAME	A80		Complete path and file name relative to the volume root directory
PRODUCT_ID	A30		PDS Product Identifier (typically file name, minus extension and version)
VOLUME_ID	A11		Unique identifier for the volume on which the file is located
PRODUCT_CREATION_TIME	A24		File creation date/time
START_TIME	A24		File start time – UTC at spacecraft
STOP_TIME	A24		File end time – UTC at spacecraft
EXPOSURE_DURATION	F10.3	msec	Time between the opening and closing of the camera aperature.
INSTRUMENT_ID	A3		FC camera ID

Table 14: Geometry Index Table (GEOM_INDEX.TAB) Contents			
Column Name	**Format**	**Units**	**Description**
INSTRUMENT_ID	A3		FC camera ID
IMAGE_TIME	A24		Center time of the images
FILE_SPECIFICATION_NAME	A80		Complete path and file name relative to the volume root directory
TARGET_NAME	A20		Name of the observed target (e.g. Mars, Vesta. Aldebaran)
MISSION_PHASE_NAME	A30		Identifier associated with the Dawn mission phase
OBSERVATION_NAME	A30		Identifier associated with the imaging session
ORBIT_NUMBER	I4		Orbit number (N/A unless target = VESTA or CERES)
COORDINATE_SYSTEM_NAME	A30		Full name of coordinate system to which state vectors are referenced
SPACECRAFT_ALTITUDE	F8.1	km	S/C altitude relative to the target, kilometers (N/A for calibration targets)
TARGET_CENTER_DISTANCE	F8.1	km	Instrument distance to target center, kilometers (N/A for calibration targets)
SLANT_DISTANCE	F8.1	km	Slant distance to the target evaluated at the center pixel of the image
CENTER_LATITUDE	F7.3	deg	Center pixel planetocentric latitude for the image/spectra (N/A for calibration targets)
CENTER_LONGITUDE	F8.3	deg	Center pixel planetocentric east longitude for the image/spectra (N/A for calibration targets)
INCIDENCE_ANGLE	F6.2	deg	Incidence angle at the center of the image/spectra
EMISSION_ANGLE	F6.2	deg	Emission angle at the center of the image/spectra
PHASE_ANGLE	F6.2	deg	Phase angle at the center of the image/spectra

Table 14: Geometry Index Table (GEOM_INDEX.TAB) Contents			
Column Name	**Format**	**Units**	**Description**
MINIMUM_LATITUDE	F7.3	deg	Minimum latitude of the image
MAXIMUM_LATITUDE	F7.3	deg	Maximum latitude of the image
WESTERNMOST_LONGITUDE	F8.3	deg	Minimum (westernmost) latitude of the image
EASTERNMOST_LONGITUDE	F8.3	deg	Maximum (easternmost) latitude of the image
SUB_SPACECRAFT_LATITUDE	F7.3	deg	Sub-spacecraft planetocentric latitude (N/A for calibration targets)
SUB_SPACECRAFT_LONGITUDE	F8.3	deg	Sub-spacecraft planetocentric east longitude (N/A for calibration targets)
SUB_SOLAR_LATITUDE	F6.2	deg	Sub-solar latitude on the target in planetocentric coordinates
SUB_SOLAR_LONGITUDE	F6.2	deg	Sub-solar longitude on the target in planetocentric coordinates
LOCAL_HOUR_ANGLE	F6.2	deg	Local hour angle at the center of the image/spectra
SC_TARGET_POSITION * (_X, _Y, _Z)	I8 (x3)	km	3 S/C position vector components relative to the target in planetocentric coordinates, kilometers
SC_TARGET_VELOCITY * (_X, _Y, _Z)	F7.1 (x3)	km/ sec	3 S/C velocity vector componenets relative to the target in planetocentric coordinates, kilometers
RIGHT_ASCENSION	F8.4	deg	EME-2000 right ascension of the center pixel in the image/spectra
DECLINATION	F8.4	deg	EME-2000 declination of the center pixel in the image/spectra
TWIST_ANGLE	F8.4	deg	Angle of rotation about line from camera to center pixel relative to EME-2000
CELESTIAL_NORTH_CLOCK_ANGLE	F7.3	deg	North celestial clock angle evaluated at the center pixel of the image/spectra
SPACECRAFT_SOLAR_DISTANCE	F8.1	km	S/C distance to the Sun center, kilometers
SC_SUN_POSITION_* (_X, _Y, _Z)	I8 (x3)	km	3 S/C position vector components relative to the Sun in EME-2000 coordinates, kilometers
SC_SUN_VELOCITY_* (_X, _Y, _Z)	F7.1 (x3)	km/ sec	3 S/C velocity vector components relative to the Sun in EME-2000 coordinates, kilometers

5.3. CATALOG Directory Contents

The completed PDS catalog files in the CATALOG directory provide a top-level understanding of the Dawn/FC mission and its data products. The information necessary to create the files is provided by the FC team and formatted into standard template formats by the DSC. The files in this directory are coordinated with the data engineers at both the DSC and the PDS SBN.

Table 15: Catalog Directory Contents

File Name	File Contents	File Provided By
CATINFO.TXT	A description of the contents of this directory	DSC
fc*_ds.cat	PDS Data Set catalog description of the data for the XXX dataset	FC Team
dawninsthost.cat	PDS instrument host (spacecraft) catalog description of the Dawn spacecraft	DSC
fc*_instrument.cat	PDS instrument catalog description of the FC instrument	FC Team
dawnmission.cat	PDS mission catalog description of the Dawn mission	DSC
personnel.cat	PDS personnel catalog description of FC Team members and other persons involved with generation of FC Data Products	FC Team
reference.cat	FC-related references mentioned in other *.CAT files	FC Team
ttt.CAT	PDS catalog description of target *ttt* (if provided for the volume).	DSC

5.4. DOCUMENT Directory Contents

Archive documents are stored in the DOCUMENT directory branch of the archive volume. All documents are stored as PDF-A (archive PDF), and HTML versions. The HTML version consists of a "clean" HTML file (an HTML with minimal markup), with images saved as separate in separate files in some image format (e.g. JPEG, or PNG). The HTML constitutes the plain ASCII text version required by PDS standards. The DOCUMENT directory contains a separate sub-directory for each document in which all of the files associated with that document are located.

Table 16: DOCUMENT Directory Contents

File Name	File Contents	File Provided By
DOCINFO.TXT	A description of the contents of this directory	DSC
CALIBRATION_PIPELINE	Sub-directory containing the FC Calibration Pipeline description document	FC Team
SCIENCE_PLAN	Sub-directory containing the Dawn Science Plan document	Dawn Project
SIS	Sub-directory containing the FC Archive SIS (this document)	FC Team
VESTA_COORDINATES	Sub-directory containing a document describing the various coordinate systems that have been used for Vesta image products (Vesta volumes only)	

5.5. DATA (Standard Products) Directory Contents and Naming Conventions

The DATA directory contains the actual Data Products produced by the FC team.

5.5.1. ***Required Files***

Every file in the DATA path of an Archive Volume is described by a PDS label. Both text documentation files and image files have internal (attached) PDS labels. The attached label file for image files is an ASCII header section pre-pended to the images.

5.5.2. ***DATA Sub-Directory Naming Convention***

All archive volumes will have a separate sub-directory for each phase and observation. These sub-directories will be named according to the convention:

YYYYMMDD_ XXXXXX

where:

YYYYMMDD is the date of the observation (4-digit year, 2-digit month, 2-digit day)

XXXXXX is the phase or observation name

For example, the sub-directory for the data from the FC2 Straylight Test performed 31 Mar 2009 (DOY 90) would be:

20090331_STRAYLIGHT

5.5.3. ***File Naming Conventions***

FC image files will be named according to the following convention:

FC*xllimageid_yydddhhmmss*F*nz*.IMG

where:

FC*x*	indicates the instrument
ll	indicates the data processing level (e.g. 1A, 1B, etc.)
IMAGEID	image id (7 characters, zero-padded)
yyddd	indicates the image acquisition year/doy
hhmmss	indicates the image SCET (UT)
F*n*	*n* indicates the filter number used in capturing the image (see Table 6)
z	indicates the data file version (A-Z)

6. Data Format Descriptions

6.1. FC EDR Image File Structure

The images have an attached header, so the file consist of two parts: The image label followed by the image objects. Both, the EDR and RDR (level 1a and level 1b) products follow the same file structure. The labels contain the same keywords but number and size of the image objects may vary.

Depending on the image acquisition mode, each EDR will contain one or more image objects in the same file, all of them taken with the same filter and exposure time. Each of these images will be identified (see below) with a name, width and height, and the real CCD coordinates of the first row and column of the frame. In the cases where the image has been acquired in windowed mode with more than one window, there will be an additional 1024x1024 "IMAGE" frame with black background and all the small windows overlaid in their right positions within the CCD active area..

All image objects contain raw digital numbers of type "LSB_UNSIGNED_INTEGER".

6.2. FC RDR Image File Structure

RDR images are reduced to the size of the active area of the CCD of 1024x1024 pixel. All pervious image objects inside this region are merged into a single image object called "IMAGE". After the radiometric calibration the the DNs represent real physical units of type "PC_REAL"

A more detailed description of the format can be found in the following section.

6.3. EDR and RDR Data Product Format Description

Table 17:FC Data Label Contents

Keyword	Value Units	Value Description
PDS Version Keywords		
PDS_VERSION_ID		The version number of the PDS standards documents that is valid when a data product label is created. Values for the PDS_VERSION_ID are formed by appending the integer for the latest version number to the letters 'PDS'. Mandatory. PDS_VERSION_ID = "PDS3"
LABEL_ REVISION_ NOTE		Free-form unlimited length character string providing information regarding the revision

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		status and authorship of a PDS label. This should include the latest revision date and author of the current version, but may include a more complete history. This element is required in all Catalog labels and should be the second element in the label. The entry is **optional** but highly recommended. Several fields are separated by semicolons. Example values: “20080201, PGM, DAWN FC V1.5”
File Characteristics		
RECORD_TYPE		Indicates the record format of a file. RECORD_TYPE = “FIXED_LENGTH”
RECORD_BYTES		Indicates the number of bytes in a physical file record, including record terminators and separators. When RECORD_TYPE = STREAM (e.g. a SPREADSHEET), its value is set to the length of the longest record in the file. RECORD_BYTES = “512”
FILE_RECORDS		Indicates the number of physical file records, including both label records and data records.
LABEL_RECORDS		Indicates the number of physical file records that contain only label information. The number of data records in a file is determined by subtracting the value of LABEL_RECORDS from the value of FILE_RECORDS. Typically = 19 … 27
FILE_NAME		Provides the location independent name of a file. It excludes node or volume location, directory path names, and version specification. To promote portability across multiple platforms, PDS requires the FILE_NAME to be limited to a 27-character base name, a full stop (. period), and a 3-character extension. Valid characters include capital letters A - Z, numerals 0 - 9, and the underscore character (_). The

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		FILE_NAME will be generated by TRAP at MPS. See section 5.6.3 for naming convention
Pointers to Data Objects (Typically the PDS label has 20 … 27 records.)		
^IMAGE		A regular array of sample values. Image objects are normally processed with special display tools to produce a visual representation of the sample values. This is done by assigning brightness levels or display colors to the various sample values. Images are composed of LINES and SAMPLES. They may contain multiple bands, in one of several storage orders. The particulars of each of the data objects are detailed in a corresponding image object (see below), including width, height and coordinates of the first line and sample. Name of image object needs to end with *_IMAGE. Other examples: **^FRAME_0_IMAGE, ^FRAME_1_IMAGE, ^FRAME_2_IMAGE, ^FRAME_3_IMAGE, …** Typically = 21 …28
^*_IMAGE (2nd pointer)		Typically = 4000 … 9000
^*_IMAGE (3rd pointer)		Typically = 4000 … 9000
^*_IMAGE (4th pointer)		Typically = 4000 … 9000
^*_IMAGE (5th pointer)		Typically = 4000 … 9000
^HISTORY		A pointer to a part of the image that contains information about the history of the image, located between the header and the image data.
Software		
SOFTWARE_DESC		Describes the functions performed by the data processing software. If the subject software is a program library, this element may provide a list of the contents of the library. Example values: **"TRAP.EXE"**

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
SOFTWARE_LICENSE_TYPE		Indicates the licensing category under which this software falls. Example values: **"COMMERCIAL"**
SOFTWARE_ID		A short-hand notation for the software name, typically sixteen characters in length or less (e.g., tbtool, lablib3). Example values: **"TRAP"**
SOFTWARE_NAME		Identifies data processing software such as a program or a program library. Example values: **"TRAP"**
SOFTWARE_VERSION_ID		Indicates the version (development level) of a program or a program library. Example values: **"2.24"**
SOFTWARE_RELEASE_DATE		Provides the date as of which a program was released for use. SOFTWARE_RELEASE_DATE = YYYY-MM-DD
Telemetry Identification Section		
TELEMETRY_FORMAT_ID		Provides the version of the UDP library which is loaded into the instrument's NVRAM. 302 = UDP library v. 3.02 303 = UDP library v. 3.03 304 = UDP library v. 3.04 305 = UDP library v. 3.05 Example values: **"302", "303", "304", "305"**
Product Identification		
DATA_SET_NAME		Provides the full name given to a data set or a data product. The data_set_name typically identifies the instrument that acquired the data, the target of that instrument, and the processing level of the data. A data set is a logical group of different products. DATA_SET_NAME will be provided by DSC.

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
DATA_SET_ID		A unique alphanumeric identifier for a data set or a data product. The data_set_id value for a given data set or product is constructed according to flight project naming conventions. In most cases the data_set_id is an abbreviation of the data_set_name. DATA_SET_ID wil be provided by DSC.
PRODUCT_ID		Represents a permanent, unique identifier assigned to a data product by its producer. The PRODUCT_ID will be generated from the filename by MPS. It contains seven digits, starting with **0000000** for the first image. Note: In the PDS, the value assigned to PRODUCT_ID must be unique within its data set. Additional note: The PRODUCT_ID can describe the lowest-level data object that has a PDS label. PRODUCT_ID = "nnnnnnn"
PRODUCT_TYPE		Identifies the type or category of a product within a data set. PRODUCT_TYPE =**"**DATA**"**
STANDARD_DATA_PRODUCT_ID		Used to link a data product (file) to a standard data product (collection of similar files) described within software interface specification document for a particular data set. STANDARD_DATA_PRODUCT_ID = "FC_IMAGE"
PRODUCER_FULL_NAME		Provides the full_name of the individual mainly responsible for the production of a data set. Note: This individual does not have to be registered with the PDS.
PRODUCER_INSTITUTION_NAME		Identifies a university, research center, NASA center or other institution associated with the production of a data set. This would generally be an institution associated

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		with the element PRODUCER_FULL_NAME. Value = “MAX PLANCK INSTITUT FUER SONNENSYSTEMFORSCHUNG”
PRODUCT_CREATION_TIME		Defines the UTC system format time when a product was created. Value comes from the FC. PRODUCT_CREATION_TIME = ”YYYY-MM-DDThh:mm:ss.sss”
PRODUCT_VERSION_ID		Identifies the version of an individual product within a data set. The version is indicated by one character, starting with **A** for the first version, followed by **B** … Note: This is not the same as the data set version that is an element of the DATA_SET_ID value. PRODUCT_VERSION_ID is intended for use within AMMOS to identify separate iterations of a given product, which will also have a unique FILE_NAME. PRODUCT_VERSION_ID = “X”
RELEASE_ID		Identifies the unique identifier associated with a specific release of a data set. All initial releases should use a RELEASE_ID value of '0001'. Subsequent releases should use a value that represents the next increment over the previous RELEASE_ID (e.g., the second release should use a RELEASE_ID of '0002'). Releases are done when an existing data set or portion of a data set becomes available for distribution. Note: The DATA_SET_ID and RELEASE_ID are used as a combined key to ensure all releases are unique. Typically = 0001
Mission Identification		
INSTRUMENT_HOST_ID		Provides a unique identifier for the host where an instrument is located. This host can be either a spacecraft or an earth base (e.g., and observatory or laboratory on the earth). Thus, the INSTRUMENT_HOST_ID

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		element can contain values which are either SPACECRAFT_ID values or EARTH_BASE_ID values. In SPICE “DAWN” and “-203” are both valid IDs. INSTRUMENT_HOST_ID = “DAWN”
INSTRUMENT_HOST_NAME		Provides the full name of the host on which an instrument is based. This host can be either a spacecraft or an earth base. Thus, the INSTRUMENT_HOST_NAME element can contain values which are either SPACECRAFT_NAME values or EARTH_BASE_NAME values. INSTRUMENT_HOST_NAME = “DAWN”
MISSION_ID		Provides a synonym or mnemonic for the MISSION_NAME element. MISSION_ID = “DAWN”
MISSION_NAME		Identifies a major planetary mission or project. A given planetary mission may be associated with one or more spacecraft. MISSION_NAME = “DAWN MISSION TO VESTA AND CERES”
MISSION_PHASE_NAME		Provides the commonly used identifier of a mission phase. A list with the possible values will be distributed by DSC. Example values: **"Ground Testing", “ICO”, “EMC” …**
Instrument Descriptions		
INSTRUMENT_ID		Provides an abbreviated name or acronym which identifies an instrument. Example values: **“FC1”, “FC2”**
INSTRUMENT_NAME		Provides the full name of an instrument. Note: The associated INSTRUMENT_ID element provides an abbreviated name or acronym for the instrument. Example values: **“DAWN FRAMING CAMERA 1”** or **“DAWN FRAMING CAMERA 2”**
OBSERVATION_ID		Uniquely identifies a scientific observation

Table 17:FC Data Label Contents

Keyword	Value Units	Value Description
		within a data set. Mostly important for multi-instrument observation campaigns. The OBSERVATION_ID comes from DSC.
OBSERVATION_TYPE		Identifies the general type of an observation. Mostly important for multi-instrument observation campaigns. Example value: **“DARKS”**
INSTRUMENT_TYPE		Identifies the type of an instrument. INSTRUMENT_TYPE = "FRAME CCD REFRACTING TELESCOPE"
DETECTOR_DESC		Describes a detector utilized by an instrument. DETECTOR_DESC = "1092x1056 PIXELS FRONTLIT FRAMETRANSFER CCD DETECTOR"
DETECTOR_TYPE		Identifies the type of an instrument's detector. DETECTOR_TYPE = "SI CCD"
DETECTOR_TEMPERATURE	K	The temperature that the instrument (detector) operated at while a measurement was made. The temperature is measured by the FC’s sensor and calibrated in Kelvin. The value is the same as in T_CCD. Lower limit red: -95.0 deg C Lower limit yellow: -75.0 deg C Upper limit yellow: +35.0 deg C Upper limit red: +40.0 deg C Range: **000.000 … 999.999 <kelvin>** DETECTOR_TEMPERATURE = “TTT.TTT <KELVIN>”
Time Identification		
SPACECRAFT_CLOCK_START_COUNT		Provides the value of the spacecraft clock at the beginning of a time period of interest. The FC’s clock is synchronized with the S/C-clock once a second and stored in the data transmitted. The S/C-clock-time is approximately SCET.

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		Range: **000000000000:000 … 999999999999:255** SPACECRAFT_CLOCK_ START_COUNT = "xxxxxxxxxxxx:xxx"
SPACECRAFT_CLOCK_STOP_COUNT		Provides the value of the spacecraft clock at the end of a time period of interest. The FC's clock is synchronized with the S/C-clock once a second and stored in the data transmitted. The S/C-clock-time is approximately SCET. Range: **000000000000:000 … 999999999999:255** SPACECRAFT_CLOCK_STOP_COUNT = "xxxxxxxxxxxx:xxx"
START_TIME		Provides the date and time of the beginning of an event or observation (whether it is a spacecraft, ground based, or system event) in UTC. START_TIME is calculated at MPS by TRAP with the SPICE S/C-clock-kernel. START_TIME = YYYY-DDDThh:mm:ss.sss
DAWN:ALT_START_TIME		For readability purposes, the start time is also provided in YYYY-MM-DDThh:mm:ss.sss format in this field
STOP_TIME		Provides the date and time of the end of an observation or event (whether it be a spacecraft, ground based, or system event) in UTC. STOP_TIME is calculated at MPS by TRAP with the SPICE S/C-clock-kernel. The STOP_TIME is the START_TIME plus EXPOSURE_DURATION plus 193 ms of delay and can contain a rounding error of up to 2 ms. STOP_TIME = YYYY-DDDThh:mm:ss.sss
DAWN:ALT_STOP_TIME		For readability purposes, the stop time is also provided in YYYY-MM-DDThh:mm:ss.sss format in this field
System Hardware and Software Configuration		
DAWN: DPU_HARDWARE_ID		Both DPUs for FC1 and FC2 have the same DPU ID because they are identical.

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		Example value: “1.04”
DAWN:DPU_SOFTWARE_VERSION		Currently used version of the FC onboard software Example value: “3.01”
DAWN:UDPLIB_SOFTWARE_VERSION		Currently used version of the FC UDP library Example value: “3.01.05”
DAWN:PCU_HARDWARE_ID		An analog value showing the hardware ID of the PCU. The actual value can jitter around the nominal. ~3.00 = PCU ID of FC1 (FS1) ~2.00 = PCU ID of FC2 (FM2) Example values = **2.00, 3.00**
DAWN: FEE_HARDWARE_ID		017.10.10 = FEE ID of FC1 (FS1) 017.09.09 = FEE ID of FC2 (FM2) 063.15.15 indicates that the FEE is off or busy and cannot transmit its ID. Example Values: **"017.09.09", "017.10.10"**
DAWN: MCU_HARDWARE_ID		10 = MCU ID of FC1 (FS1) 12 = MCU ID of FC2 (FM2) Example Values: **"10", "12"**
Mechanism Status		
DAWN: FILTER_ENCODER		FILTER_NUMBER = (((64 + 4 + encoderOnClearFilter - FILTER_ENCODER) / 8) MOD 8) + 1 encoderOnClearFilter is a hardware-dependent constant; filterEncoder is the current readout of the encoder; filterNumber return a value in the range [1..8]. All the operation are integer operations, MOD represents modulo and / is the integer division. The subtraction is negative (F1 - Fx) because the encoder value decreases with increasing filter number.

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		Range: **0 … 63**
FILTER_NUMBER		Indicates the filter number that was placed in front of the CCD when the image was acquired. "1" = clear filter, "2" … "8" = band pass filters. In the case of windowed images, this value is the same for all the sub-frames. Example Values: "**1", "2", "3", "4", "5", "6", "7", "8"**
DAWN: FRONT_DOOR_ENCODER		The Front Door is closed if FRONT_DOOR_ENCODER shows the nominal value +/- 1 and otherwise is open. Range: **0 … 63**
DAWN: FRONT_DOOR_STATUS_ID		Indicates the status of the front door, covering the aperture, when the image was acquired. In the case of windowed images, this value is the same for all the sub-frames. CLOSED = Front Door is closed. OPEN = Front Door is open. Example values: "**OPEN", "CLOSED"**
Image Acquisition Options		
DAWN:DATA_ROUTING_ID		Describes the priority of the acquired image and thus how it was handled on board. Op-Nav = The image is processed with highest priority and streamed into VR10 of the s/c. Science 1 = The image is processed with high priority and streamed into VR8 of the s/c. Science 2 = The image is processed with mid priority and streamed into VR8 of the s/c. Science 3 = The image is processed with low priority and streamed into VR8 of the s/c. Science 4 = The image is processed with least priority and streamed into VR8 of the

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		s/c. Example Values: "**Op-Nav", "Science 1", "Science 2", "Science 3", "Science 4"**
EXPOSURE_DURATION	ms	The exposure_duration element provides the value of the time interval between the opening and closing of an instrument aperture (such as a camera shutter). In the case of windowed images, this value is the same for all the sub-frames. Example values: **0.000 <millisecond>**
DAWN:USE_PRE_CLEAR		OFF = No pre-clear of the CCD prior to an image acquisition. ON = A pre-clear of the CCD, 193 ms prior to an image acquisition, removes all charge that is on the CCD at this moment Example values: **"ON", "OFF", "UNK"**
DAWN:IMAGE_ACQUIRE_MODE		Describes the mode of image acquisition. NORMAL = The image was acquired with Front Door open. DARK = The image was acquired with Front Door closed and the Callamp off. FLATFIELD = The image was acquired with Front Door closed and the Callamp on. STORAGE = The image shows the readout of the storage area of the CCD. SERIAL = The artificial image shows the readout of the serial register. TEST_CH = The artificial iamge shows a test pattern with DNs from 0 to 16382. Example Values: **"TEST_CH", "DARK", "FLATFIELD", "SERIAL", "NORMAL", "STORAGE"**
DAWN:CALLAMP_STROBE_TIME	µs	Callamp strobe time is measured in microseconds after callamp switch on. callamp switch off time = START_TIME + DAWN_CALLAMP_DELAY_TIME +

Table 17:FC Data Label Contents

Keyword	Value Units	Value Description
		DAWN_CALLAMP_STROBE_TIME Range: **0 … 4000000000 < microsecond>**
DAWN:CALLAMP_DELAY_TIME	µs	Callamp switch on delay measured in microseconds after START_TIME. Callamp can be switched on before (< 193000 microseconds\`), at (= 193000 microseconds\`), or after (> 193000 microseconds\`) begin of exposure." Range: **0 … 4000000000 <microsecond>**
DAWN:CALLAMP_FREQUENCY	kHz	determined by the internal 24 MHz clock and an integer divisor. CALLAMP_FREQUENCY = 24 MHz / Value The standard callamp frequency is 100 kHz (24MHz / 240). Range: **0.0 … 250.0 <kilohertz>**
DAWN:CALLAMP_DUTY	%	The callamp can be run at various duty cycles between 0.0% and 100.0% by using only every other pulse of the callamp frequency to trigger the callamp. DAWN_CALLAMP_DUTY = CALLAMP_FREQUENCY / Value * 100% Range: **0.0 … 100.0**
Data Compression		
PIXEL_AVERAGING_WIDTH		Located in the IMAGE object, provides the horizontal dimension, in pixels, of the area over which pixels were averaged prior to image compression. PIXEL_AVERAGING_WIDTH = “1”
PIXEL_AVERAGING_HEIGHT		Located in the IMAGE object, provides the vertical dimension, in pixels, of the area over which pixels were averaged prior to image compression. PIXEL_AVERAGING_HEIGHT= “1”
INST_CMPRS_TYPE		Located in the IMAGE object, identifies the type of on-board compression used for data storage and transmission. Examples: **“NOTCOMP”, “SPIHT”**

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
INST_CMPRS_NAME		Located in the IMAGE object, identifies the type of on-board compression used for data storage and transmission. Example values: **“SPIHT_LIFT”, “SPIHT_TAP”**
Power Converter Switch Status		
DAWN:FEE_FLAG		Indicates status of the FEE during image acquisition. OFF = FEE is disabled, images cannot be acquired ON = FEE is enabled, images can be acquired Example values: “**ON”, “OFF”**
DAWN:HEATER0_FLAG		Indicates status of the Camera Head Heater. OFF = The CH heater (HEATER0) is switched on. ON = The CH heater (HEATER0) is switched off. The heater produces 4.4 W (5.6 Ohm at +5 V) Example values: “**ON”, “OFF”**
DAWN:HEATER1_FLAG		Indicates the status of the Baffle Heater OFF = The Baffle heater (HEATER1) is switched on. ON = The Baffle heater (HEATER1) is switched off. The heater produces 1.0 W (26 Ohm at +5 V) Example values: “**ON”, “OFF”**
DAWN:CALLAMP_ENABLE_FLAG		Indicates if callamp is enabled or disabled during image acquisition. OFF = callamp set to disabled ON = callamp set to enabled Example values: “**ON”, “OFF”**
DAWN:MCU_MOTOR_POWER_FLAG		Indicates if the motors for the mechanisms

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		are powered. This switch and flag are independent of the MCU power flag. OFF = Both motors (Front Door and Filterwheel) are unpowered. ON = Both motors are powered. Either to hold their position or to move to another position. Example values: "**ON", "OFF"**
DAWN:MCU_FLAG		Indicates if the MCU is powered. It is independent of the MCU motor power flag. OFF = MCU is disabled, mechanisms cannot be moved ON = MCU is enabled, mechanisms (filterwheel and front door) can be moved Example values: "**ON", "OFF"**
DAWN:FSA_SHOOT_FLAG		Determines if the Fail-Safe Actuator is active. OFF = The Fail Safe Actuator for the Front Door is switched off. ON = The Fail Safe Actuator for the Front Door is switched on. The front door is being opened once for ever. Example values: "**ON", "OFF"**
DAWN:FSA_SHOOT_ENABLE_FLAG		Determines if the Fail Safe Actuator is enabled. For safety reasons, the FSA requires two switches to be active at the same time in order to be active. One of them alone will have no effect OFF = The Fail Safe Actuator for the Front Door is disabled. ON = The Fail Safe Actuator for the Front Door is enabled. FSA_SHOOT_FLAG can be switched ON now. Example values: "**ON", "OFF"**
Power System Status		
DAWN:V_28	V	Location: PCU H/K Sensor: Main +28V Voltage Monitor Sensor Type: Voltage Sensor

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		Gain: 0.04 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 V_28 = DN * Gain + Offset + Sensor Offset [V] Lower limit red: 20.0 V Lower limit yellow: 21.5 V Upper limit yellow: 35.5 V Upper limit red: 37.0 V Range: **-9999.999 … 9999.999 <volt>**
DAWN:V_16	V	Name: V16V15 Location: PCU H/K Sensor: PCU Voltage Monitor Sensor Type: Voltage Sensor Gain: 0.000165 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 V_16 = DN * Gain + Offset + Sensor Offset [V] Lower limit red: 14.7 V Lower limit yellow: 15.2 V Upper limit yellow: 16.5 V Upper limit red: 17.0 V Range: **-9999.999 … 9999.999 <volt>**
DAWN:V_12	V	Name: V12FEE Location: PCU H/K Sensor: PCU Voltage Monitor Sensor Type: Voltage Sensor Gain: 0.0012 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 V_12 = DN * Gain + Offset + Sensor Offset [V] Lower limit red: 11.0 V Lower limit yellow: 11.7 V

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		Upper limit yellow: 12.5 V Upper limit red: 13.0 V Range: **-9999.999 … 9999.999 <volt>**
DAWN:V_5	V	Name: V5FEE Location: PCU H/K Sensor: PCU Voltage Monitor Sensor Type: Voltage Sensor Gain: 0.00052 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 V_5 = DN * Gain + Offset + Sensor Offset [V] Lower limit red: 4.5 V Lower limit yellow: 4.7 V Upper limit yellow: 5.5 V Upper limit red: 5.8 V Range: **-9999.999 … 9999.999 <volt>**
DAWN:V_M5	V	Name: V-5FEE Location: PCU H/K Sensor: PCU Voltage Monitor Sensor Type: Voltage Sensor Gain: -0.0005 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 V_M5 = DN * Gain + Offset + Sensor Offset [V] Lower limit red: -5.8 V Lower limit yellow: -5.5 V Upper limit yellow: -4.7 V Upper limit red: -4.5 V Range: **-9999.999 … 9999.999 <volt>**
DAWN:V_5_ANALOG	V	Name: V5AN Location: PCU H/K Sensor: PCU Voltage Monitor Sensor Type: Voltage Sensor Gain: 0.00052 Offset: 0

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
	V	Sensor Offset FC1: 0 Sensor Offset FC2: 0 V_5_ANALOG = DN * Gain + Offset + Sensor Offset [V] Lower limit red: 4.5 V Lower limit yellow: 4.7 V Upper limit yellow: 5.5 V Upper limit red: 5.8 V Range: **-9999.999 … 9999.999 <volt>**
DAWN:V_M5_ANALOG	V	Name: V-5AN Location: PCU H/K Sensor: PCU Voltage Monitor Sensor Type: Voltage Sensor Gain: -0.0005 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 V_M5_ANALOG = DN * Gain + Offset + Sensor Offset [V] Lower limit red: -5.8 V Lower limit yellow: -5.5 V Upper limit yellow: -4.7 V Upper limit red: -4.5 V Range: **-9999.999 … 9999.999 <volt>**
DAWN:V_3_3	V	Name: V3.3AN Location: PCU H/K Sensor: PCU Voltage Monitor Sensor Type: Voltage Sensor Gain: 0.00033 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 V_3_3 = DN * Gain + Offset + Sensor Offset [V] Lower limit red: 3.0 V Lower limit yellow: 3.2 V Upper limit yellow: 3.7 V Upper limit red: 3.9 V

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		Range: **-9999.999 … 9999.999 <volt>**
DAWN:V_2_5	V	Name: V2.5AN Location: PCU H/K Sensor: PCU Voltage Monitor Sensor Type: Voltage Sensor Gain: 0.00025 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 V_2_5 = DN * Gain + Offset + Sensor Offset [V] Lower limit red: 2.1 V Lower limit yellow: 2.3 V Upper limit yellow: 2.8 V Upper limit red: 3.0 V Range: **-9999.999 … 9999.999 <volt>**
DAWN:I_28	A	Name: C28M Location: PCU H/K Sensor: MAIN +28V Current Monitor Sensor Type: Current Sensor Gain: 0.0016 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 I_28 = DN * Gain + Offset + Sensor Offset [mA] Lower limit red: 200 mA Lower limit yellow: 250 mA Upper limit yellow: 1200 mA Upper limit red: 1400 mA Range: **-9999.999 … 9999.999 <milliampere>**
DAWN:I_16	mA	Name: C16V15 Location: PCU H/K Sensor: PCU Current Monitor Sensor Type: Current Sensor Gain: 0.009 Offset: 0

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		Sensor Offset FC1: 0 Sensor Offset FC2: 0 I_16 = DN * Gain + Offset + Sensor Offset [mA] Lower limit red: 20 mA Lower limit yellow: 30 mA Upper limit yellow: 60 mA Upper limit red: 100 mA Range: **-9999.999 … 9999.999 <milliampere>**
DAWN:I_12	mA	Name: C12FEE Location: PCU H/K Sensor: PCU Current Monitor Sensor Type: Current Sensor Gain: 0.02 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 I_12 = DN * Gain + Offset + Sensor Offset [mA] Lower limit red: 50 mA Lower limit yellow: 60 mA Upper limit yellow: 100 mA Upper limit red: 200 mA Range: **-9999.999 … 9999.999 <milliampere>**
DAWN:I_5	mA	Name: C5FEE Location: PCU H/K Sensor: PCU Current Monitor Sensor Type: Current Sensor Gain: 0.05 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 I_5 = DN * Gain + Offset + Sensor Offset [mA] Lower limit red: 100 mA Lower limit yellow: 250 mA

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		Upper limit yellow: 350 mA Upper limit red: 400 mA Range: **-9999.999 … 9999.999 <milliampere>**
DAWN:I_M5	mA	Name: C-5FEE Location: PCU H/K Sensor: PCU Current Monitor Sensor Type: Current Sensor Gain: -0.015 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 I_M5 = DN * Gain + Offset + Sensor Offset [mA] Lower limit red: -200 mA Lower limit yellow: -120 mA Upper limit yellow: -60 mA Upper limit red: -30 mA Range: **-9999.999 … 9999.999 <milliampere>**
DAWN:I_5_ANALOG	mA	Name: C5AN Location: PCU H/K Sensor: PCU Current Monitor Sensor Type: Current Sensor Gain: 0.2 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 I_5_ANALOG = DN * Gain + Offset + Sensor Offset [mA] Lower limit red: 75 mA Lower limit yellow: 100 mA Upper limit yellow: 1150 mA Upper limit red: 1300 mA Range: **-9999.999 … 9999.999 <milliampere>**
DAWN:I_M5_ANALOG	mA	Name: C-5AN Location: PCU H/K Sensor: PCU Current Monitor

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		Sensor Type: Current Sensor Gain: -0.015 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 I_M5_ANALOG = DN * Gain + Offset + Sensor Offset [mA] Lower limit red: -100 mA Lower limit yellow: -60 mA Upper limit yellow: -20 mA Upper limit red: -10 mA Range: **-9999.999 … 9999.999 <milliampere>**
DAWN:I_3_3	mA	Name: C3.3AN Location: PCU H/K Sensor: PCU Current Monitor Sensor Type: Current Sensor Gain: 0.15 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 I_3_3 = DN * Gain + Offset + Sensor Offset [mA] Lower limit red: 100 mA Lower limit yellow: 170 mA Upper limit yellow: 850 mA Upper limit red: 1400 mA Range: **-9999.999 … 9999.999 <milliampere>**
DAWN:I_2_5	mA	Name: C2.5AN Location: PCU H/K Sensor: PCU Current Monitor Sensor Type: Current Sensor Gain: 0.15 Offset: 0 Sensor Offset FC1: 0 Sensor Offset FC2: 0 I_2_5 = DN * Gain + Offset + Sensor Offset [mA]

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		Lower limit red: 250 mA Lower limit yellow: 300 mA Upper limit yellow: 900 mA Upper limit red: 1000 mA Range: **-9999.999 … 9999.999 <milliampere>**
Calibrated Temperatures		
DAWN:T_CCD	K	The temperature that the instrument (detector) operated at while a measurement was made. The temperature is measured by the FC's sensor and calibrated in Kelvin. The value is the same as for DETECTOR_TEMPERATURE. Lower limit red: -95.0 deg C Lower limit yellow: -75.0 deg C Upper limit yellow: +35.0 deg C Upper limit red: +40.0 deg C Range: **-999.999 … 999.999 <kelvin>** DAWN:T_CCD = TTT.TTT <kelvin>
DAWN:T_DPU	K	DPU Board temperature, measured by FC's thermistor HK-Tdpu. Lower limit red: -40.0 deg C Lower limit yellow: -35.0 deg C Upper limit yellow: +80.0 deg C Upper limit red: +90.0 deg C Range: **-999.999 … 999.999 <kelvin>** DAWN:T_DPU = TTT.TTT <kelvin>
DAWN:T_DCDC	K	PCU DC-converter-board temperature, measured by FC's thermistor HK-Tpcu1. Lower limit red: -40.0 deg C Lower limit yellow: -35.0 deg C Upper limit yellow: +70.0 deg C Upper limit red: +80.0 deg C Range: **-999.999 … 999.999 <kelvin>**

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		DAWN:T_DCDC = TTT.TTT <kelvin>
DAWN:T_F12	K	PCU Board temperature, measured by FC's thermistorHK-Tpcu2. Lower limit red: -40.0 deg C Lower limit yellow: -35.0 deg C Upper limit yellow: +70.0 deg C Upper limit red: +80.0 deg C Range: **-999.999 … 999.999 <kelvin>** DAWN:T_F12 = TTT.TTT <kelvin>
DAWN:T_CSC	K	PCU Board temperature, measured by FC's thermistor HK-Tpcu3. Lower limit red: -40.0 deg C Lower limit yellow: -35.0 deg C Upper limit yellow: +70.0 deg C Upper limit red: +80.0 deg C Range: **-999.999 … 999.999 <kelvin>** DAWN:T_CSC = TTT.TTT <kelvin>
DAWN:T_COVER_MOTOR	K	Front door motor temperature, measured by FC's thermistor TCM. Lower limit red: -55.0 deg C Lower limit yellow: -50.0 deg C Upper limit yellow: +50.0 deg C Upper limit red: +60.0 deg C Range: **-999.999 … 999.999 <kelvin>** DAWN:T_COVER_MOTOR = TTT.TTT <kelvin>
DAWN:T_LENS_BARREL	K	Lens barrel temperature, measured by FC's thermistor TLB. Lower limit red: -55.0 deg C Lower limit yellow: -50.0 deg C Upper limit yellow: +40.0 deg C Upper limit red: +45.0 deg C Range: **-999.999 … 999.999 <kelvin>**

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		DAWN:T_LENS_BARREL = TTT.TTT <kelvin>
DAWN:T_BAFFLE	K	Baffle temperature, measured by FC's thermistor TLB. Lower limit red: -55.0 deg C Lower limit yellow: -50.0 deg C Upper limit yellow: +40.0 deg C Upper limit red: +45.0 deg C Range: **-999.999 … 999.999 <kelvin>** DAWN:T_BAFFLE = TTT.TTT <kelvin>
DAWN:T_FILTER_MOTOR	K	Filter motor temperature, measured by FC's thermistor TFM. Lower limit red: -55.0 deg C Lower limit yellow: -50.0 deg C Upper limit yellow: +50.0 deg C Upper limit red: +60.0 deg C Range: **-999.999 … 999.999 <kelvin>** DAWN:T_FILTER_MOTOR = TTT.TTT <kelvin>
DAWN:T_STRUCTURE	K	Camera head structure temperature, measured by FC's thermistor TCS. Lower limit red: -55.0 deg C Lower limit yellow: -50.0 deg C Upper limit yellow: +40.0 deg C Upper limit red: +45.0 deg C Range: **-999.999 … 999.999 <kelvin>** DAWN:T_STRUCTURE = TTT.TTT <kelvin>
DAWN:T_RAD_MOTOR	K	Radiator temperature, measured by FC's thermistor TRD. Note: This is not a motor temperature! Lower limit red: -115.0 deg C Lower limit yellow: -95.0 deg C Upper limit yellow: +35.0 deg C

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		Upper limit red: +40.0 deg C Range: **-999.999 … 999.999 <kelvin>** DAWN:T_RAD_MOTOR = TTT.TTT <kelvin>
Test Setup Configuration		
DAWN:PURPOSE		Used during ground tests to describe the purpose of the test. Typically = "N/A" for flight images
DAWN:OPERATOR		Used during ground tests to indicate the responsible operator of the test. Typically = "N/A" for flight images
DAWN:SUBJECT		Used during ground tests to describe the subject used during the test. Typically = "N/A" for flight images
DAWN:TEST_LAMP		Used during ground tests to define the lamp used during the test. Typically = "N/A" for flight images
DAWN:TARGET		Used during ground tests to describe the target the FC was pointing at during the test. Typically = "N/A" for flight images
DAWN:CHAMBER		This keyword was used during ground tests to describe the test environment. Typically = "N/A" for flight images
Pointing		
RIGHT_ASCENSION	deg	Provides the value of right ascension, which is defined as the arc of the celestial equator between the vernal equinox and the point where the hour circle through the point in question intersects the celestial equator (reckoned eastward). Right ascension is used in conjunction with the DECLINATION keyword to specify a point on the sky. Range: **0.000 … 360.000 <degree>**
DECLINATION	deg	Provides the value of an angle on the celestial sphere, measured north from the

Table 17:FC Data Label Contents

Keyword	Value Units	Value Description
		celestial equator to the point in question. (For points south of the celestial equator, negative values are used.) Declination is used in conjunction with the RIGHT_ASCENSION keyword to specify a point on the sky. Range: **-90.000 … 90.000 <degree>**
TWIST_ANGLE	deg	Provides the angle of rotation about an optical axis relative to celestial coordinates. The RIGHT_ASCENTION, DECLINATION, and TWIST_ANGLE elements define the pointing direction and orientation of an image or scan platform. Note: The specific mathematical definition of TWIST_ANGLE depends on the value of the TWIST_ANGLE_TYPE element. If unspecified, TWIST_ANGLE_TYPE = GALILEO for Galileo data and TWIST_ANGLE_TYPE = DEFAULT for all other data. Range: **0.000 … 360.000 <degree>**
CELESTIAL_NORTH_CLOCK_ANGLE	deg	Specifies the direction of celestial north at the center of an image. It is measured from the 'upward' direction, clockwise to the direction toward celestial north (declination = +90 degrees), when the image is displayed as defined by the SAMPLE_DISPLAY_DIRECTION and LINE_DISPLAY_DIRECTION elements. The epoch of the celestial coordinate system is J2000 unless otherwise indicated. Range: **0.000 … 360.000 <degree>**
QUATERNION	n/a	Specifies a quaternion, which is a four-component representation of a rotation matrix. This particular definition is focused on the PDS use of quaternions; one should refer to other sources for a more complete discourse on quaternion math. A quaternion may be used to specify the rotation of one Cartesian reference frame-- sometimes referred to as the base frame or the 'From'

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		frame--into coincidence with a second Cartesian reference frame--sometimes referred to as the target reference frame or the 'To' frame. Unlike an Euler rotation where three sequential rotations about primary axes are used, a quaternion rotation is a single action, specified by a Cartesian vector used as the positive axis of the rotation (right hand rule) and the magnitude (an angle) of rotation about that axis. A quaternion has four components. One of the components is a scalar, a function of the angle of rotation (cosine of half the rotation angle), while the remaining three components are used to specify a vector, given in the base reference frame, about which the rotation will be made. In the PDS context a quaternion has a magnitude of one, and so may be treated as a unit quaternion. In many cases a time tag (epoch) must be associated with the quaternion because the orientation varies over time. A time tag is not needed if the 'To' and 'From' frames have a fixed offset. QUATERNION = “(Q1, Q2, Q3, Q4)” Example value: **(0.9643781086, 0.1998558870, -0.02085268255, -0.1720396867)**
Spice Kernels		
SPICE_FILE_NAME		Provides the names of the SPICE files used in processing the data. SPICE_FILE_NAME = ("SPK_KERNEL_1", "SPK_KERNEL_2", "C_KERNEL_1", "C_KERNEL_2", "I_KERNEL" "SC_FRAMES_KERNEL", "ASTEROID_FRAMES_KERNEL", "PCK_KERNEL", "LEAPSECONDS_KERNEL", "SCLK_KERNEL", "SHAPE_MODEL")
Coordinate System		
COORDINATE_SYSTEM_NAME		Provides the full name of the coordinate

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		system to which the state vectors are referenced. PDS has currently defined body-fixed rotating coordinate systems. The Planetocentric system has an origin at the center of mass of the body. The planetocentric latitude is the angle between the equatorial plane and a vector connecting the point of interest and the origin of the coordinate system. Latitudes are defined to be positive in the northern hemisphere of the body, where north is in the direction of Earth's angular momentum vector, i.e., pointing toward the hemisphere north of the solar system invariant plane. Longitudes increase toward the east, making the Planetocentric system right-handed. The Planetographic system has an origin at the center of mass of the body. The planetographic latitude is the angle between the equatorial plane and a vector through the point of interest, where the vector is normal to a biaxial ellipsoid reference surface. Planetographic longitude is defined to increase with time to an observer fixed in space above the object of interest. Thus, for prograde rotators (rotating counter clockwise as seen from a fixed observer located in the hemisphere to the north of the solar system invariant plane), planetographic longitude increases toward the west. For a retrograde rotator, planetographic longitude increases toward the east. Note: If this data element is not present in the PDS Image Map Projection Object (for pre-V3.1 PDS Standards), the default coordinate system is assumed to body rotating Planetographic.
COORDINATE_SYSTEM_CENTER_NAME		Identifies a named target, such as the Sun, a planet, a satellite or a spacecraft, as being the location of the center of the

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		reference coordinate system. The COORDINATE_SYSTEM_CENTER_NAME element can also be used to identify a barycenter used for a SPICE s_ or p_kernel.
Orbit Geometry		
TARGET_NAME		Identifies a target. The target may be a planet, satellite, ring, region, feature, asteroid or comet. See target_type. TARGET_NAME = "TARG_NAME" Example values: "**VEGA", "1 CERES", "4 VESTA"**
TARGET_TYPE		Identifies the type of a named target. The TARGET_TYPE will be described by DSC or from PDS.
SUB_SPACECRAFT_LATITUDE	deg	Provides the latitude of the subspacecraft point. The subspacecraft point is that point on a body which lies directly beneath the spacecraft. If the point, described by this keyword does not fall on the target described in TARGET_NAME, then the value for this keyword will be N/A (not applicable).
SUB_SPACECRAFT_LONGITUDE	deg	Provides the longitude of the subspacecraft point. The subspacecraft point is that point on a body's reference surface where a line from the spacecraft center to the body center intersects the surface. If the point, described by this keyword does not fall on the target described in TARGET_NAME, then the value for this keyword will be N/A (not applicable). Note: The COORDINATE_SYSTEM_TYPE data element should be used in conjunction with this data element.
SUB_SPACECRAFT_AZIMUTH	deg	Provides the value of the angle between the line from the center of an image to the subspacecraft point and a horizontal reference line (in the image plane) extending from the image center to the middle right edge of the image. The values

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		of this angle increase in a clockwise direction. If the point, described by this keyword does n ot fall on the target described in TARGET_NAME, then the value for this keyword will be N/A (not applicable).
SPACECRAFT_ALTITUDE	km	Provides the distance from the spacecraft to a reference surface of the target body measured normal to that surface.
TARGET_CENTER_DISTANCE	km	Provides the distance between an instrument and the center of mass of the named target.
ORBIT_NUMBER		Identifies the number of the orbital revolution of the spacecraft around a target body.
SC_TARGET_POSITION_VECTOR	km	Indicates the x-, y-, z- components of the position vector from observer to target center expressed in J2000 coordinates, and corrected for light time and stellar aberration, evaluated at epoch at which image was taken.
SC_TARGET_VELOCITY_VECTOR	km/s	Indicates the x-, y-, z- components of the velocity vector of target relative to observer, expressed in J2000 coordinates, and corrected for light time, evaluated at epoch at which image was taken.
LOCAL_HOUR_ANGLE	deg	Provides a measure of the instantaneous apparent sun position at the subspacecraft point. The LOCAL_HOUR_ANGLE is the angle between the extension of the vector from the Sun to the target body and the vector projection on the target body's ecliptic plane of a vector from the target body's planetocentric center to the observer (usually, the spacecraft). This angle is measured in a counterclockwise direction when viewed from north of the ecliptic plane. It may be converted from an angle in degrees to a local time, using the conversion of 15 degrees per hour, for those planets for which the rotational direction corresponds with the direction of measure of the angle.

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
SUB_SOLAR_LATITUDE	deg	Provides the latitude of the subsolar point. The subsolar point is that point on a body's reference surface where a line from the body center to the sun center intersects that surface.
SUB_SOLAR_LONGITUDE	deg	Provides the longitude of the subsolar point. The subsolar point is that point on a body's reference surface where a line from the body center to the sun center intersects that surface. Note: The COORDINATE_SYSTEM_TYPE data element should be used in conjunction with this data element.
SUB_SOLAR_AZIMUTH	deg	Provides the value of the angle between the line from the center of an image to the subsolar point and a horizontal reference line (in the image plane) extending from the image center to the middle right edge of the image. The values of this angle increase in a clockwise direction.
SOLAR_LONGITUDE	deg	Provides the value of the angle between the body-Sun line at the time of interest and the body-Sun line at the vernal equinox. This provides a measure of season on a target body, with values of 0 to 90 degrees representing northern spring, 90 to 180 degrees representing northern summer, 180 to 270 degrees representing northern autumn and 270 to 360 degrees representing northern winter.
SOLAR_ELONGATION		The angle between the line of sight of observation and the direction of the Sun.
Solar Geometry		
SPACECRAFT_SOLAR_DISTANCE	km	Provides the distance from the spacecraft to the center of the sun.
SC_SUN_POSITION_VECTOR:	km	Indicates the x-, y-, and z- components of the position vector from observer to sun, center expressed in J2000 coordinates, and corrected for light time and stellar aberration, evaluated at epoch at which image was taken.

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
SC_SUN_VELOCITY_VECTOR	km/s	Indicates the x-, y-, and z- components of the velocity vector of sun relative to observer, expressed in J2000 coordinates, and corrected for light time, evaluated at epoch at which image was taken.
Illumination		
INCIDENCE_ANGLE	deg	Provides a measure of the lighting condition at the intercept point. Incidence angle is the angle between the local vertical at the intercept point (surface) and a vector from the intercept point to the sun. The INCIDENCE_ANGLE varies from 0 degrees when the intercept point coincides with the sub-solar point to 90 degrees when the intercept point is at the terminator (i.e., in the shadowed or dark portion of the target body). Thus, higher values of INCIDENCE_ANGLE indicate the existence of a greater number of surface shadows.
EMISSION_ANGLE	deg	Provides the value of the angle between the surface normal vector at the intercept point and a vector from the intercept point to the spacecraft. The EMISSION_ANGLE varies from 0 degrees when the spacecraft is viewing the subspacecraft point (nadir viewing) to 90 degrees when the intercept is tangent to the surface of the target body. Thus, higher values of EMISSION_ANGLE indicate more oblique viewing of the target. Values in the range of 90 to 180 degrees are possible for ring data.
PHASE_ANGLE	deg	Provides a measure of the relationship between the instrument viewing position and incident illumination (such as solar light). PHASE_ANGLE is measured at the target; it is the angle between a vector to the illumination source and a vector to the instrument. If not specified, the target is assumed to be at the center of the instrument field of view. If illumination is from behind the instrument, PHASE_ANGLE will be small.

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
Image Parameters		
SAMPLE_DISPLAY_DIRECTION		This is the preferred orientation of samples within a line for viewing on a display device. The default is right, meaning samples are viewed from left to right on the display. SAMPLE_DISPLAY_DIRECTION = “RIGHT”
LINE_DISPLAY_DIRECTION		This is the preferred orientation of lines within an image for viewing on a display device. The default value is down; meaning lines are viewed top to bottom on the display. LINE_DISPLAY_DIRECTION = "UP”
SLANT_DISTANCE	km	Provides a measure of the distance from an observing position (e.g., a spacecraft) to a point on a target body. If not specified otherwise, the target point is assumed to be at the center of the instrument field of view.
MINIMUM_LATITUDE	deg	This specifies the southernmost latitude of a spatial area, such as a map, mosaic, bin, feature, or region. If the point, described by this keyword does not fall on the target described in TARGET_NAME, then the value for this keyword will be N/A (not applicable).
CENTER_LATITUDE	deg	This provides a reference latitude for certain map projections. For example, in an Orthographic projection, the CENTER_LATITUDE along with the CENTER_LONGITUDE defines the point or tangency between the sphere of the planet and the plane of the projection. The MAP_SCALE (or MAP_RESOLUTION) is typically defined at the CENTER_LATITUDE and CENTER_LONGITUDE. In unprojected images, CENTER_LATITUDE represents the latitude at the center of the image frame. If the point, described by this keyword does not fall on the target described in TARGET_NAME, then the value for this keyword will be N/A (not

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		applicable).
MAXIMUM_LATITUDE	deg	This specifies the northernmost latitude of a spatial area, such as a map, mosaic, bin, feature, or region. If the point, described by this keyword does not fall on the target described in TARGET_NAME, then the value for this keyword will be N/A (not applicable).
WESTERNMOST_LONGITUDE	deg	The following definitions describe WESTERNMOST_LONGITUDE for the body-fixed, rotating coordinate systems: For Planetocentric coordinates and for Planetographic coordinates in which longitude increases toward the east, the westernmost (leftmost) longitude of a spatial area (e.g., a map, mosaic, bin, feature or region) is the minimum numerical value of longitude unless it crosses the Prime Meridian. For Planetographic coordinates in which longitude increases toward the west (prograde rotator), the westernmost (leftmost) longitude of a spatial area (e.g., a map, mosaic, bin, feature or region) is the maximum numerical value of longitude unless it crosses the Prime Meridian. If the point, described by this keyword does not fall on the target described in TARGET_NAME, then the value for this keyword will be N/A (not applicable).
CENTER_LONGITUDE	deg	This provides a reference longitude for certain map projections. For example, in an Orthographic projection, the CENTER_LONGITUDE along with the CENTER_LATITUDE defines the point or tangency between the sphere of the planet and the plane of the projection. The MAP_SCALE (or MAP_RESOLUTION) is typically defined at the CENTER_LATITUDE and CENTER_LONGITUDE. In unprojected images, CENTER_LONGITUDE represents

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		the longitude at the center of the image frame. If the point, described by this keyword does not fall on the target described in TARGET_NAME, then the value for this keyword will be N/A (not applicable).
EASTERNMOST_LONGITUDE	deg	The following definitions describe easternmost longitude for the body-fixed, rotating coordinate systems: For Planetocentric coordinates and for Planetographic coordinates in which longitude increases toward the east, the easternmost (rightmost) longitude of a spatial area (e.g., a map, mosaic, bin, feature or region) is the maximum numerical value of longitude unless it crosses the Prime Meridian. For Planetographic coordinates in which longitude increases toward the west, the easternmost (rightmost) longitude of a spatial area (e.g., a map, mosaic, bin, feature or region) is the minimum numerical value of longitude unless it crosses the Prime Meridian. If the point, described by this keyword does not fall on the target described in TARGET_NAME, then the value for this keyword will be N/A (not applicable).
HORIZONTAL_PIXEL_SCALE	km	This indicates the horizontal picture scale. The unit for this value is < METER/PIXEL>.
VERTICAL_PIXEL_SCALE	km	This indicates the vertical picture scale. The unit for this value is < METER/PIXEL>.
RETICLE_POINT_RA	deg	This refers to the right ascension of the principle points of the camera. It contains five values, one for the cameras boresight vector and four for the corners of the FOV.
RETICLE_POINT_DECLINATION	deg	This refers to the declination of the principle

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		points of the camera. It contains five values, one for the cameras boresight vector and four for the corners of the FOV.
RETICLE_POINT_LONGITUDE	deg	This provides the longitude of the surface intercept points of the principle points of the camera. It contains five values, one for the cameras boresight vector and four for the corners of the FOV.
RETICLE_POINT_LATITUDE	deg	This element provides the latitude of the surface intercept points of the principle points of the camera. It contains five values, one for the cameras boresight vector and four for the corners of the FOV.
NORTH_AZIMUTH	deg	This element provides the value of the angle between a line from the image center to the north pole and a reference line in the image plane. The reference line is a horizontal line from the image center to the middle right edge of the image. This angle increases in a clockwise direction.
LIMB_ANGLE	deg	This element provides the value of the angle between the center of an instrument's field of view and the nearest point on the lit limb of the target body. LIMB_ANGLE values are positive off-planet and negative on-planet.
Image Object		
OBJECT		An image object is a regular array of sample values. Image objects are normally processed with special display tools to produce a visual representation of the sample values. This is done by assigning brightness levels or display colors to the various sample values. Images are composed of LINE_SAMPLES and LINES. They may contain multiple bands, in one of several storage orders. Example values: **IMAGE, *_IMAGE**
INTERCHANGE_FORMAT		Represents the manner in which data items are stored. Example values: “**BINARY”, “ASCII”.**

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
LINE_SAMPLES		This indicates the total number of data instances along the horizontal axis of an image. Example values: **1 … 1092**
LINES		This element indicates the total number of data instances along the vertical axis of an image. Note: In PDS label convention, the number of lines is stored in a 32-bit integer field. The minimum value of 0 indicates no data received. Example values: **0 … 1056**
BANDS		This element indicates the number of bands in an image or other object. BANDS = 1
SAMPLE_BITS		Indicates the stored number of bits, or units of binary information, contained in a LINE_SAMPLE value. SAMPLE_BITS = 16
SAMPLE_TYPE		Indicates the data storage representation of sample value. SAMPLE_TYPE = "LSB_UNSIGNED_INTEGER"
FIRST_LINE		This element indicates the line within a source image that corresponds to the first line in a sub-image. First pixel on the CCD is [1,1]. Example:**1 … 1056**
FIRST_LINE_SAMPLE		This element indicates the sample within a source image that corresponds to the first sample in a sub-image. First pixel on the CCD is [1,1]. Example: **1 … 1092**
UNIT		The unit element provides the full name or standard abbreviation of a unit of measurement in which a value is expressed.

Table 17:FC Data Label Contents		
Keyword	**Value Units**	**Value Description**
		For Level 1A images: “DU” For Level 1B clear filter images: “W.m**-2.sr**-1” For Level 1B color filter images “W.m**-2.nm**-1.sr**-1”
INST_CMPRS_NAME		see under data compression
INST_CMPRS_RATIO		This value represents the ratio between the amount of image data transmitted for this particular image object and the raw size of the image. For this reason, if a file contains several image object it is possible that each one has a different compression ratio. The compression ratio is the achieved value, not the commanded one, so if an image is commanded to compress 1:2 but it can be compressed without loss to 1:2.15 this will be the value shown
INST_CMPRS_TYPE		see under data compression
PIXEL_AVERAGING_HEIGHT		Indicates the number of pixel in the column direction that were averaged before transmission. Given that the image is always shown in the original resolution, the binned pixels are expanded back to the original size by having PIXEL_AVERAGING_HEIGHT rows with exactly the same values
PIXEL_AVERAGING_WIDTH		Indicates the number of pixel in the row direction that were averaged before transmission. Given that the image is always shown in the original resolution, the binned pixels are expanded back to the original size by having PIXEL_AVERAGING_WIDTH columns with exactly the same values
END_OBJECT		Indicates the end of the image object. END_OBJECT = IMAGE
History		
OBJECT		OBJECT = HISTORY
SOFTWARE_RELEASE_DATE		See under Software

Table 17:FC Data Label Contents

Keyword	Value Units	Value Description
PRODUCT_CREATION_TIME		See under Product Identification
SOFTWARE_DESC		See under Software
FILENAME		See under File Characteristics
END_OBJECT		Indicates the end of the history object. END_OBJECT = HISTORY

Appendix A. Sample PDS Labels

A.1. EDR (Level 1a) Data Product Label

A sample label of a level 1a image acquired during VSA.

```
PDS_VERSION_ID                    = PDS3
LABEL_REVISION_NOTE               = "20080201, PGM, DAWN FC V1.5"

/* FILE CHARACTERISTICS */

RECORD_TYPE                       = FIXED_LENGTH
RECORD_BYTES                      = 512
FILE_RECORDS                      = 4303
LABEL_RECORDS                     = 26
FILE_NAME                                                          =
"FC21A0001898_11123133516F1C.IMG"

/* POINTERS TO DATA OBJECTS */

^IMAGE                            = 28
^FRAME_2_IMAGE                    = 4124
^FRAME_3_IMAGE                    = 4207
^FRAME_4_IMAGE                    = 4240
^FRAME_5_IMAGE                    = 4272
^HISTORY                          = 27

/* SOFTWARE */

SOFTWARE_DESC                     = "TRAP.EXE"
SOFTWARE_LICENSE_TYPE             = "COMMERCIAL"
SOFTWARE_ID                       = "TRAP"
SOFTWARE_NAME                     = "TRAP"
SOFTWARE_VERSION_ID               = "Trap v3.21"
SOFTWARE_RELEASE_DATE             =

/*   TELEMETRY IDENTIFICATION   */
```

```
TELEMETRY_FORMAT_ID              = "305"

/*   PRODUCT IDENTIFICATION   */

DATA_SET_NAME                    = "DAWN FC2 RAW (EDR) VESTA
IMAGES V1.0"
DATA_SET_ID                      = "DAWN-A-FC2-2-EDR-VESTA-
IMAGES-V1.0"
PRODUCT_ID                       = "0001898"
PRODUCT_TYPE                     = "DATA"
STANDARD_DATA_PRODUCT_ID         = "FC_IMAGE"
PRODUCER_FULL_NAME               = "PABLO GUTIERREZ-MARQUES"
PRODUCER_INSTITUTION_NAME        =
"MAX PLANCK INSTITUT FUER SONNENSYSTEMFORSCHUNG"
PRODUCT_CREATION_TIME            = 2012-09-21T00:31:07.000
PRODUCT_VERSION_ID               = "C"
RELEASE_ID                       = "N/A"

/*   MISSION IDENTIFICATION   */

INSTRUMENT_HOST_ID               = "DAWN"
INSTRUMENT_HOST_NAME             = "DAWN"
MISSION_ID                       = "DAWN"
MISSION_NAME                     = "DAWN MISSION TO VESTA AND
CERES"
MISSION_PHASE_NAME               = "VESTA SCIENCE APPROACH (VSA)"

/*   INSTRUMENT DESCRIPTION   */

INSTRUMENT_ID                    = "FC2"
INSTRUMENT_NAME                  = "FRAMING CAMERA 2"
OBSERVATION_ID                   = "NAV_VSA_OpNav_001"
OBSERVATION_TYPE                 = "N/A"
INSTRUMENT_TYPE                  = "FRAME CCD REFRACTING
TELESCOPE"
DETECTOR_DESC                    = "1092x1056 PIXELS FRONTLIT
FRAMETRANSFER CCD"
DETECTOR_TYPE                    = "SI CCD"
DETECTOR_TEMPERATURE             = 217.703 <kelvin>
```

```
/*   TIME IDENTIFICATION   */

SPACECRAFT_CLOCK_START_COUNT     = "357701782:182"
SPACECRAFT_CLOCK_STOP_COUNT      = "357701784:103"
START_TIME                       = 2011-123T13:35:16.604
ALT_START_TIME                   = 2011-05-03T13:35:16.604
STOP_TIME                        = 2011-123T13:35:18.295
ALT_STOP_TIME                    = 2011-05-03T13:35:18.295

/*   SYSTEM HARDWARE AND SOFTWARE CONFIGURATION   */

DPU_HARDWARE_ID                  = "1.04"
DPU_SOFTWARE_VERSION             = "3.05"
UDPLIB_SOFTWARE_VERSION          = "3.05.01"
PCU_HARDWARE_ID                  = 2.04
FEE_HARDWARE_ID                  = "017.09.09"
MCU_HARDWARE_ID                  = "12"

/*   MECHANISM STATUS   */

FILTER_ENCODER                   = 62
FILTER_NUMBER                    = "1"
FRONT_DOOR_ENCODER               = 53
FRONT_DOOR_STATUS_ID             = OPEN

/*   IMAGE ACQUISITION OPTIONS   */

DATA_ROUTING_ID                  = "OP-NAV"
EXPOSURE_DURATION                = 1500.000 <millisecond>
USE_PRE_CLEAR                    = ON
IMAGE_ACQUIRE_MODE               = NORMAL
CALLAMP_STROBE_TIME              = "N/A"
CALLAMP_DELAY_TIME               = "N/A"
CALLAMP_FREQUENCY                = "N/A"
CALLAMP_DUTY                     = "N/A"

/*   POWER CONVERTER SWITCH STATUS   */
```

```
FEE_FLAG                          = ON
HEATER0_FLAG                      = OFF
HEATER1_FLAG                      = OFF
CALLAMP_ENABLE_FLAG               = OFF
MCU_MOTOR_POWER_FLAG              = ON
MCU_FLAG                          = ON
FSA_SHOOT_FLAG                    = OFF
FSA_SHOOT_ENABLE_FLAG             = OFF

/*   POWER SYSTEM STATUS   */

V_28                              = 29.960 <volt>
V_16                              = 16.091 <volt>
V_12                              = 12.078 <volt>
V_5                               = 5.178 <volt>
V_M5                              = -5.045 <volt>
V_5_ANALOG                        = 5.285 <volt>
V_M5_ANALOG                       = -5.165 <volt>
V_3_3                             = 3.333 <volt>
V_2_5                             = 2.502 <volt>
I_28                              = 670.400 <milliampere>
I_16                              = 58.950 <milliampere>
I_12                              = 83.120 <milliampere>
I_5                               = 301.050 <milliampere>
I_M5                              = -89.415 <milliampere>
I_5_ANALOG                        = 274.800 <milliampere>
I_M5_ANALOG                       = -27.255 <milliampere>
I_3_3                             = 233.550 <milliampere>
I_2_5                             = 623.100 <milliampere>

/*   CALIBRATED TEMPERATURES   */

T_CCD                             = 217.703 <kelvin>
T_DPU                             = 295.373 <kelvin>
T_DCDC                            = 284.224 <kelvin>
T_F12                             = 289.032 <kelvin>
T_CSC                             = 289.223 <kelvin>
```

```
T_COVER_MOTOR                    = 248.285 <kelvin>
T_LENS_BARREL                    = 250.280 <kelvin>
T_BAFFLE                         = 245.290 <kelvin>
T_FILTER_MOTOR                   = 255.267 <kelvin>
T_STRUCTURE                      = 257.262 <kelvin>
T_RAD_MOTOR                      = 201.400 <kelvin>

/*   TEST SETUP CONFIGURATION   */

PURPOSE                          = "N/A"
OPERATOR                         = "N/A"
SUBJECT                          = "N/A"
TEST_LAMP                        = "N/A"
TARGET                           = "N/A"
CHAMBER                          = "N/A"

/*   POINTING   */

RIGHT_ASCENSION                  = 242.114 <degree>
DECLINATION                      = -10.303 <degree>
TWIST_ANGLE                      = 157.516 <degree>
CELESTIAL_NORTH_CLOCK_ANGLE      = 337.516 <degree>
QUATERNION                       = (
0.2726699208
,0.0361773630
,0.7668872106
,-0.5798502556
)

/*   SPICE KERNELS   */

SPICE_FILE_NAME                  = (
"sclk\DAWN_203_SCLKSCET.00033.tsc"
,"lsk\naif0010.tls"
,"spk\dawn_rec_110416-110802_110913_v1.bsp"
,"ck\dawn_sc_110502_110508.bc"
,"ik\dawn_fc_v02.ti"
,"fk\dawn_v11.tf"
```

```
,"fk\dawn_vesta_v00.tf"
,"pck\pck00010.tpc"
,"spk\de421.bsp"
,"pck\dawn_vesta_v06.tpc"
,"spk\sb_vesta_110211.bsp"
,"fk\dawn_vesta_v00.tf"
)

/*   COORDINATE SYSTEM   */

COORDINATE_SYSTEM_NAME            = "VESTA_FIXED"
COORDINATE_SYSTEM_CENTER_NAME     = "VESTA"
DESCRIPTION                       =
"Geometry in this label is provided in the 'Claudia Double-Prime'
coordinate system. This coordinate system is described in the
Coordinate
System Document a copy of which is provided in the DOCUMENT
directory of
the volume containing these data."

/*   ORBIT GEOMETRY   */

SUB_SPACECRAFT_LATITUDE           = -9.4039579780 <degree>
SUB_SPACECRAFT_LONGITUDE          = -128.6270021576 <degree>
SUB_SPACECRAFT_AZIMUTH            = 347.2407265139 <degree>
SPACECRAFT_ALTITUDE               = 1217900.599 <kilometer>
TARGET_CENTER_DISTANCE            = 1218180.495 <kilometer>
ORBIT_NUMBER                      = 0
SC_TARGET_POSITION_VECTOR         = (
-564241.970 <kilometer>
,-1057521.444 <kilometer>
,-217354.809 <kilometer>
)
SC_TARGET_VELOCITY_VECTOR         = (
0.2423863152 <kilometer per second>
,0.2919059905 <kilometer per second>
,0.0480260765 <kilometer per second>
)
LOCAL_HOUR_ANGLE                  = 34.5958333333 <degree>
```

SUB_SOLAR_LATITUDE = -21.2919125621 <degree>
SUB_SOLAR_LONGITUDE = -85.8961305238 <degree>
SUB_SOLAR_AZIMUTH = 348.6646461405 <degree>
SOLAR_LONGITUDE = 4.0485266559 <degree>
SOLAR_ELONGATION = 137.1899463467 <degree>
TARGET_NAME = "4 VESTA"
TARGET_TYPE = "ASTEROID"

/* SOLAR GEOMETRY */

SPACECRAFT_SOLAR_DISTANCE = 324631696.697 <kilometer>
SC_SUN_POSITION_VECTOR = (
-77012928.997 <kilometer>
,289344195.903 <kilometer>
,125437967.000 <kilometer>
)
SC_SUN_VELOCITY_VECTOR = (
-20.1664138673 <kilometer per second>
,-4.4582053097 <kilometer per second>
,0.8240700348 <kilometer per second>
)

/* ILLUMINATION */

INCIDENCE_ANGLE = "N/A"
EMISSION_ANGLE = "N/A"
PHASE_ANGLE = "N/A"

/* IMAGE PARAMETERS */

SAMPLE_DISPLAY_DIRECTION = "RIGHT"
LINE_DISPLAY_DIRECTION = "UP"
SLANT_DISTANCE = "N/A"
MINIMUM_LATITUDE = "N/A"
CENTER_LATITUDE = "N/A"
MAXIMUM_LATITUDE = "N/A"
WESTERNMOST_LONGITUDE = "N/A"
CENTER_LONGITUDE = "N/A"

```
EASTERNMOST_LONGITUDE              = "N/A"
HORIZONTAL_PIXEL_SCALE             = "N/A"
VERTICAL_PIXEL_SCALE               = "N/A"
RETICLE_POINT_RA                   = (
242.114 <degree>
,238.468 <degree>
,243.639 <degree>
,245.727 <degree>
,240.624 <degree>
)
RETICLE_POINT_DECLINATION          = (
-10.303 <degree>
,-11.760 <degree>
,-13.868 <degree>
,-8.805 <degree>
,-6.731 <degree>
)
RETICLE_POINT_LONGITUDE            = (
"N/A"
,"N/A"
,"N/A"
,"N/A"
,"N/A"
)
RETICLE_POINT_LATITUDE             = (
"N/A"
,"N/A"
,"N/A"
,"N/A"
,"N/A"
)
NORTH_AZIMUTH                      = 248.8042998028 <degree>

/* IMAGE OBJECT */

OBJECT                             = IMAGE
        INTERCHANGE_FORMAT                 = BINARY
        LINE_SAMPLES                       = 1024
```

```
        LINES                               = 1024
        BANDS                               = 1
        SAMPLE_BITS                         = 16
        SAMPLE_TYPE                         = "LSB_UNSIGNED_INTEGER"
        FIRST_LINE                          = 17
        FIRST_LINE_SAMPLE                   = 35
        UNIT                                = "DU"
        INST_CMPRS_NAME                     =
"Set Partitioning in Hierarchical Trees (SPIHT LIFT)"
        INST_CMPRS_RATIO                    = 5.05
        INST_CMPRS_TYPE                     = "LOSSLESS"
        PIXEL_AVERAGING_WIDTH               = 1
        PIXEL_AVERAGING_HEIGHT              = 1
END_OBJECT                          = IMAGE


/* FRAME_2_IMAGE OBJECT */

OBJECT                              = FRAME_2_IMAGE
        INTERCHANGE_FORMAT                  = BINARY
        LINE_SAMPLES                        = 10
        LINES                               = 1054
        BANDS                               = 1
        SAMPLE_BITS                         = 32
        SAMPLE_TYPE                         = "PC_REAL"
        FIRST_LINE                          = 2
        FIRST_LINE_SAMPLE                   = 2
        UNIT                                = "DU"
        INST_CMPRS_NAME                     = "N/A"
        INST_CMPRS_RATIO                    = 0.00
        INST_CMPRS_TYPE                     = "LOSSLESS"
        PIXEL_AVERAGING_WIDTH               = 1
        PIXEL_AVERAGING_HEIGHT              = 1
END_OBJECT                          = FRAME_2_IMAGE


/* FRAME_3_IMAGE OBJECT */
```

```
OBJECT                              = FRAME_3_IMAGE
        INTERCHANGE_FORMAT                  = BINARY
        LINE_SAMPLES                        = 8
        LINES                               = 1054
        BANDS                               = 1
        SAMPLE_BITS                         = 16
        SAMPLE_TYPE                         = "LSB_UNSIGNED_INTEGER"
        FIRST_LINE                          = 2
        FIRST_LINE_SAMPLE                   = 16
        UNIT                                = "DU"
        INST_CMPRS_NAME                     = "N/A"
        INST_CMPRS_RATIO                    = 0.00
        INST_CMPRS_TYPE                     = "LOSSLESS"
        PIXEL_AVERAGING_WIDTH               = 1
        PIXEL_AVERAGING_HEIGHT              = 1
END_OBJECT                          = FRAME_3_IMAGE


/* FRAME_4_IMAGE OBJECT */

OBJECT                              = FRAME_4_IMAGE
        INTERCHANGE_FORMAT                  = BINARY
        LINE_SAMPLES                        = 1024
        LINES                               = 8
        BANDS                               = 1
        SAMPLE_BITS                         = 16
        SAMPLE_TYPE                         = "LSB_UNSIGNED_INTEGER"
        FIRST_LINE                          = 3
        FIRST_LINE_SAMPLE                   = 35
        UNIT                                = "DU"
        INST_CMPRS_NAME                     = "N/A"
        INST_CMPRS_RATIO                    = 0.00
        INST_CMPRS_TYPE                     = "LOSSLESS"
        PIXEL_AVERAGING_WIDTH               = 1
        PIXEL_AVERAGING_HEIGHT              = 1
END_OBJECT                          = FRAME_4_IMAGE
```

```
/* FRAME_5_IMAGE OBJECT */

OBJECT                                  = FRAME_5_IMAGE
        INTERCHANGE_FORMAT                      = BINARY
        LINE_SAMPLES                            = 1024
        LINES                                   = 8
        BANDS                                   = 1
        SAMPLE_BITS                             = 16
        SAMPLE_TYPE                             = "LSB_UNSIGNED_INTEGER"
        FIRST_LINE                              = 1047
        FIRST_LINE_SAMPLE                       = 35
        UNIT                                    = "DU"
        INST_CMPRS_NAME                         = "N/A"
        INST_CMPRS_RATIO                        = 0.00
        INST_CMPRS_TYPE                         = "LOSSLESS"
        PIXEL_AVERAGING_WIDTH                   = 1
        PIXEL_AVERAGING_HEIGHT                  = 1
END_OBJECT                              = FRAME_5_IMAGE

END
```

A.2. Index Table Label

A.3. Example Document Label

```
PDS_VERSION_ID              = PDS3
LABEL_REVISION_NOTE         = "2009-01-29, Schröder"
OBJECT                      = INSTRUMENT
 INSTRUMENT_HOST_ID         = "DAWN"
 INSTRUMENT_ID              = "FC2"

 OBJECT                     = INSTRUMENT_INFORMATION
  INSTRUMENT_NAME           = "DAWN_FC2"
  INSTRUMENT_TYPE           = "FRAME CCD REFRACTING TELESCOPE"
  INSTRUMENT_DESC           = "
```

Appendix B. Support Staff and Cognizant Persons

Table 18: INST_ID Archive Generation Support Staff			
Instrument Team			
Mr. Holger Sierks	Max-Planck-Institut für Sonnensystemforschung Max-Planck-Str. 2 37191 Katlenburg-Lindau Germany	+49 5556 979	sierks@mps.mpg.de
Mr. Pablo Gutierrez-Marques	Max-Planck-Institut für Sonnensystemforschung Max-Planck-Str. 2 37191 Katlenburg-Lindau Germany	+49 5556 979	gutiererz@mps.mpg.de
Mr. Thorsten Maue	Max-Planck-Institut für Sonnensystemforschung Max-Planck-Str. 2 37191 Katlenburg-Lindau Germany	+49 5556 979	maue@mps.mpg.de
Mr. Stefan Schröder	Max-Planck-Institut für Sonnensystemforschung Max-Planck-Str. 2 37191 Katlenburg-Lindau Germany	+49 5556 979	schroder@mps.mpg.de
DSC			
Mr. Steven P. Joy PPI Operations Manager	UCLA-IGPP 405 Hilgard Ave Los Angeles, CA 90095-1567	310-825-3506	sjoy@igpp.ucla.edu
Mr. Joe Mafi PPI Data Engineer	UCLA-IGPP 405 Hilgard Ave Los Angeles, CA 90095-1567	310-206-6073	jmafi@igpp.ucla.edu
SBN			