Dawn/VIR
Visual and InfraRed Mapping Spectrometer

VIR STANDARD DATA PRODUCTS AND ARCHIVE VOLUME SOFTWARE INTERFACE SPECIFICATION

(VIR Archive Product and Volume SIS)

Version 1.11
March 23, 2017

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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*

Distribution List	
Name	**Email**
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1.2 Document Change Log

Table 2. *Document Change Log*

Document Change History		
Change	**Date**	**Affected Portions**
Boilerplate Draft	11/02/2007	All
Updated boilerplate, Inserted VIR label information and INDEX file description	11/21/2008	All
First draft	2/3/2009	All
Second draft	12/2011	Includes description of updated EDR qube format
Version 1.2	4/2011	Includes description of updated EDR (ISIS3-compliant) label
Version 1.3	6/2011	Updated description of labels and data formats
Version 1.4	10/2011	Updated
Version 1.5	08/2012	Updated following review held in May, 2012
Version 1.6	10/2012	Updated following review held in September, 2012
Version 1.7	11/2013	Update for Vesta data archive
Version 1.8	02/2014	Updated following Vesta peer review
Version 1.9	01/2016	Updated following Ceres Approach/Survey peer review
Version 1.10	09/2016	Ceres HAMO peer review updates
Version 1.11	03/2017	Updated 3-micron region calibration

Document Change History		
Change	Date	Affected Portions
		description

1.3 TBD Items

Table 3. *TBD Items*

TBD Items		
Item	Section	Pages

1.4 Acronyms and Abbreviations

Table 4. *Acronyms and Abbreviations*

Acronyms and Abbreviations	
Acronym	Definition
ASCII	American Standard Code for Information Interchange
CCD	Charge-Coupled Device
CDROM	Compact Disc, Read Only Memory
CODMAC	Committee on Data Management and Computation
DSC	Dawn Science Center
DSDb	Dawn Science Database
DVD	Digital Versatile Disc
EDR	Experiment Data Record
EGSE	Electrical Ground Supporting Equipment
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
HK	HouseKeeping
ISIS	Integrated Software for Imaging Spectrometers
ISO	International Standards Organization
JPL	Jet Propulsion Laboratory
LAMO	Low Altitude Mapping Orbit
NASA	National Aeronautics and Space Administration
NSSDC	National Space Science Data Center
PDB	Project Database
PDS	Planetary Data System
RDR	Reduced Data Record
RMOC	Remote Mission Operations Center
SAMO	Survey Altitude Mapping Orbit

Acronyms and Abbreviations	
Acronym	Definition
SBN	Small Bodies Node
SCET	SpaceCraft Elapsed Time
ST	Science Team
SIS	Software Interface Specification
TBD	To Be Determined
UCLA	University of California, Los Angeles
UTC	Coordinated Universal Time
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 Dawn mission studied two main belt asteroids, Vesta and Ceres. Both bodies are believed to have accreted early in the history of the solar system. They have been selected because while they can speak to conditions and processes early in the formation of the solar system, they developed into two characteristically different bodies. Vesta is a dry differentiated body with a surface showing signs of resurfacing. Ceres has a primitive surface containing water-bearing minerals and may possess a weak atmosphere. By studying both these bodies, the Dawn mission was designed compare the different evolutionary path each took as well as characterize conditions of the early solar system.

To carry out its scientific mission, the Dawn spacecraft carried three science instruments. These instruments were: a visible camera (FC), a visible and infrared mapping spectrometer (VIR), and a gamma ray and neutron spectrometer (GRaND). In addition to these instruments, radiometric and optical navigation data provided data relating to the gravity field and thus bulk properties and internal structure of the two bodies (GSE).

The Dawn spacecraft was launched on September 27, 2007 on a Delta II 2925-9.5 Heavy from Cape Canaveral Air Force Station. Using its ion propulsion subsystem Dawn departed for Vesta, flying by Mars in February 2009. The spacecraft arrived at Vesta on July 16, 2011, performed its orbital operations there, and departing on September 5, 2012. Dawn arrived at Ceres on March 5, 2015, where Dawn orbited until the end of the baseline mission (Figure 1). The Dawn extended mission began July 1, 2016, with the spacecraft continuing its orbital operations at Ceres.

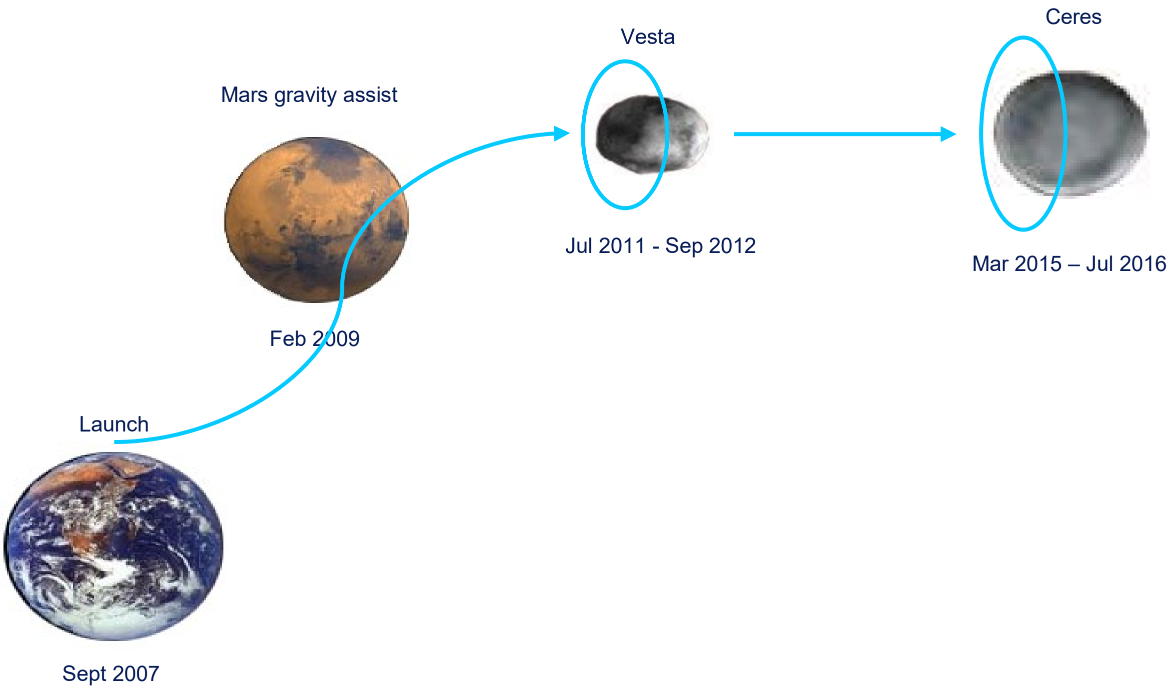

Figure 1. *Overview of Dawn mission.*

Dawn was an asteroid mapping mission. Each asteroid encounter was 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 entered a survey altitude mapping orbit where the VIR instrument was primary. This phase was relatively short, lasting for only 6-7 orbits. Global spectroscopy data and low resolution global image mosaics were acquired during these phases at each asteroid. After survey, the spacecraft was maneuvered into a high altitude mapping orbit (HAMO) where the FC instrument was primary. Medium resolution global stereo imaging was performed at this altitude (950 km Vesta, 1950 km Ceres) while local high resolution spectroscopy data was acquired. Finally, the spacecraft proceeded to the low altitude mapping orbit (LAMO) where the GRaND and gravity experiments collected their prime data and additional, local, high resolution imaging and spectroscopy data were acquired. On asteroid approach, all of the instruments performed in-flight calibrations and acquired data that were used to characterize the hazards of the near asteroid environment (dust) and search for moons.

1.7 Content Overview

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

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.

Appendix C lists the software that can be used to access and visualize the VIR data.

1.8 Scope

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

1.9 Relationship to Other Dawn Archives

This document primarily describes the VIR L-1A (EDR) and L-1B (RDR) archives. The VIR team has also produced a L-2 (DDR) global mosaics volume for Vesta, and plans a similar volume for Ceres.

1.10 Applicable Documents

Planetary Science Data Dictionary Document, November12, 2009, Planetary Data System, JPL D-7116, Rev. E

Planetary Data System Standards Reference, February 27, 2009, Version 3.8. JPL D-7669, Part 2.

Planetary Data System Archive Preparation Guide, June 4, 2008, Version 1.3. JPL D-31224.

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

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.

The VIR spectrometer, M.C. De Sanctis et al., Space Sci Rev DOI 10.1007/s11214-010-9668-5

DAWN VIR Calibration Document, G. Filacchione, E. Ammannito, Version 2.1, November 2013

1.11 Audience

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

2 . VIR Instrument Description

VIR is an imaging spectrometer having moderate spectral resolution that combines two data channels in one instrument. The two data channels, Visible (spectral range 0.25-1 micron) and Infrared (spectral range 0.95-5 micron), are committed to spectral mapping and are housed in the same optical subsystem. The instrument is composed by the Optics Module (OM), the Proximity Electronic box (PEM), housed inside the Optics Module, and the Main Electronics box (ME). The PEM contains all the electronics needed to interface the Main Electronics, to drive the FPAs, the scan mirror and the cover mechanism and to perform the acquisition and conversion of the science and housekeeping data. The ME manages the operation of the two channels, gathers data and housekeeping information, stores the data, performs data compression, controls the cryo-cooler and interfaces the instrument with the S/C. A complete description of the instrument and its performance can be found in *The VIR spectrometer,* M.C. De Sanctis et al., Space Sci Rev DOI 10.1007/s11214-010-9668-5. Additional description of the VIR calibration is provided in the VIR Calibration document, located in the DOCUMENT/VIR_CALIBRATION directory of the L1B archive volumes (see section 5.5). Documentation of known calibration limitations and instrument artifacts in the data are provided in the data set catalog files located in the CATALOG directory of all VIR archive volumes (see section 5.3).

2.1 Science Objectives

A Multispectral Imager - covering the range from the near UV (0.25 micron) to the near IR (5.0 micron) and having moderate to high spectral resolution and imaging capabilities - is an appropriate instrument for the determination of global (size, shape, albedo, etc.), and local (mineralogical features, topography, roughness, dust and gas production rates, etc.) properties of Vesta and Ceres. The primary scientific objectives of VIR during the Dawn mission are:

- study the mineralogy of Vesta and Ceres, and their environment,
- determine the nature of rock-forming minerals and their relative abundances,
- measure the temperature of their surfaces,
- generate physiographic maps of the surfaces.

Secondary objectives are:

- provide synthetic maps of the surface,
- merge data from different instruments through data fusion techniques,
- identify gaseous species emitted by the surface and physical condition of the exosphere, if any.

2.2 Detectors

The VIR optical system is a Shafer telescope matched through a slit to an Offner grating spectrometer. The Shafer consists of 5 mirrors mounted on an aluminum optical bench. The primary mirror is a scanning Beryllium mirror driven by a torque motor. The bench is machined from a single aluminum alloy billet and acts both as a cold plate and optical support structure, mounted on the ledge of the Cold Box. The Offner spectrometer consists of a mirror and a spherical convex diffraction grating housed in an aluminum structure that is flange mounted to the telescope.

The Optical Head contains the following items:

- telescope optical components, mountings and optical bench, and scan unit,
- spectrometer optical components, mountings and housing
- internal calibration system
- slit and shutter mechanism

- visible detector assembly
- infrared detector assembly
- external and internal baffles
- cover unit
- radiators

2.3 Electronics

2.3.1 Proximity Electronics

The Proximity Electronics consists of the following items:

- box structure
- mother board and connectors
- CCD boards
- IR board
- scan mirror and cover board

2.3.2 Main Electronics

The ME is physically separated from the Optics Module. It consists of the Digital Processing Units (DPUs), the S/C interface control units, the power supply for all the sub-units of the instrument excluding the cryocooler, the interface units and the coolers electronics. The DPU, S/C interfaces, instrument interfaces are also called DHSU (Data Handling and Support Unit). The VIR sub-systems (PEM, coolers, covers and scan mirror) are switched on/off by means of the Power Distribution Unit (PDU) of the ME/power supply unit, controlled by the DHSU. The main tasks of the DHSU are:

- acquire, pre-process, compress and format the science and calibration data
- control and power switch the sub-systems, the coolers and the covers
- health check the instrument and provide the operational status of VIR to the S/C
- execute uplink and downlink activities to and from VIR
- interpret and execute the telecommands
- manage and synchronize the activities between VIR and the S/C
- store the science data in the instrument Mass Memory (2 Gbit), before downloading to the S/C solid state recorder.

2.4 Operational Modes

In order to have more flexibility during the data acquisitions, 10 different operative modes have been implemented in the VIR flight software. Each mode is unique and is defined by a combination of parameters as spatial resolution, spectral resolution and slit dimension. The use of a specific mode is useful to reduce the data volume when full resolution is not required or to improve the SNR when the observation conditions are poor.

VIR has 10 operative modes depending on the spatial and spectral resolution. The maximum total resolution includes 432x256 pixels (high spectral and high spatial resolution), while the minimum total resolution includes 144x64 pixels (low spectral and low spatial resolution). For each acquisition, one of the possible operative modes is selected and it must be the same for both the IR and VIS channel.

Each focal plane is divided in 432 bands (spectral dimensions) and 256 samples (slit dimension). A Full Frame (FF) is composed by (432x256) pixels. A Sub-Frame (SF) is composed by (144x64) pixels while a Reduced Frame (RF) is composed by (432x64) pixels. In fig. 2 the frame, sub-frame and reduced-frame definitions are explained.

FF= Full Frame (432x256) pixels

SF=Sub-Frame (144x64) pixels

RF=Reduced Frame (432x64) pixels

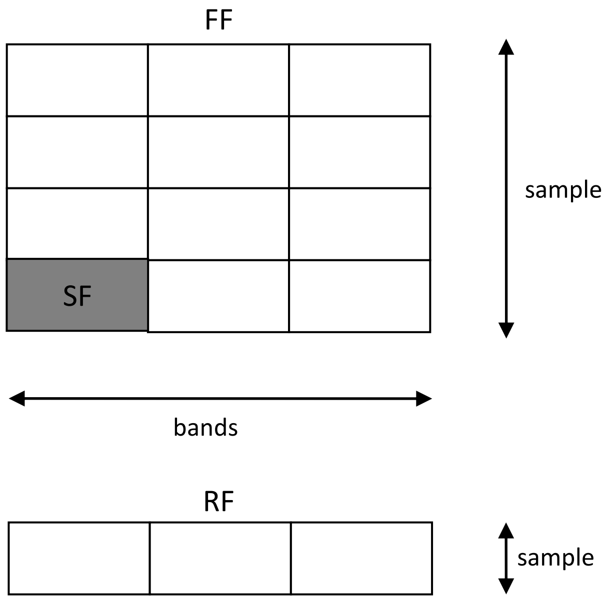

Figure 2. *Frame, sub-frame and reduced-frame definitions*

The modes can be classified in four sub-modes:

1. Full slit
   In all four of the full slit modes all 12 sub-frames (four spatial, three spectral) are acquired (see fig.2), however, the onboard electronics can reduce the data volume (and resolution) by binning in the spatial, spectral, or both dimensions. In the "high spectral and high spatial" resolution mode, there is no binning and each pixel has its intrinsic resolution for a total of 432x256 pixels per image. The "high spectral and low spatial" resolution mode has 4 pixel bins in the spatial dimension thereby reducing the spatial resolution while preserving the spectral resolution an resulting in an image with 432x64 pixels. The "low spectral and high spatial" resolution mode has 3 pixel spectral bins yielding an image with 144x256 pixels. Finally, the "low spectral and low spatial" resolution mode has four spatial and three spectral bins producing an image with 144x64 pixels.

2. Quarter slit
   When in this mode, a quarter of the slit (3 sub-frames, see fig. 2) is acquired and has only one binning for the low spectral and high spatial resolution to get an image of 144x64 pixels. The high spectral and high spatial resolution in this mode gives an image of 432x64 pixels. Which quarter of the slit is acquired is decided by the operator, usually the one centered at the boresight is used but this is not a constraint. The actual position along the slit of the acquired quarter can be found in the VIR_IR_START_X_POSITION, VIR_IR_START_Y_POSITION, VIR_VIS_START_X_POSITION and VIR_VIS_START_Y_POSITION keyword.

3. Summing
   When in this mode, every stored frame is the result of a sum, pixel by pixel, of 4 consecutive acquisitions. Two resolutions are possible: High spectral low spatial (432x64) and Low spectral low spatial (144x64). Assuming the same choice of resolution, there is no difference in the qube size if in full slit, summing or average. The difference is in the acquisition duration; every frame in summing or average mode takes 4 times longer the equivalent frame in full slit mode.

4. Averaging
   When in this mode, every stored frame is the result of an average pixel by pixel of 4 consecutive acquisitions. High spectral low spatial (432x64) and Low spectral low spatial (144x64). This mode and the summing one are used to improve the SNR when the observation conditions are particularly poor.

In the table 5 a summing of the image size for the different modes is showed.

Table 5. *VIR Operational modes*

Mode	Number of pixels stored	Number of Sub-Frames
Full slit		
High spectral high spatial	432x256	12
High spectral low spatial	432x64	3
Low spectral high spatial	144x256	4
Low spectral low spatial	144x64	1
Quarter slit		
High spectral high spatial	432x64	3
Low spectral high spatial	144x64	1
Summing		
High spectral low spatial	432x64	3
Low spectral low spatial	144x64	1
Averaging		
High spectral low spatial	432x64	3
Low spectral low spatial	144x64	1

2.5 Ground calibration

Before the integration of the VIR experiment on the DAWN spacecraft a full calibration of the instrument has been performed to completely characterize the instrumental performances. The calibrations steps necessary to correctly retrieve the scientific information from VIR data are:

1) Geometric calibration: measurement of IFOV, FOV and in-field distortions;
2) Spectral calibration: correlation between spectral dispersion axis of the focal planes with wavelength;
3) Spatial calibration: evaluation of the flat-field matrices necessary to homogenize the focal planes responses;
4) Radiometric calibration: determination of the Instrument Transfer Function (ITF), that

allows to convert digital numbers (DN) in physical units of spectral radiance (W m^{-2} $micron^{-1}$ $sterad^{-1}$).

These quantities, continuously checked during the flight at each switch-on of the experiment, are used in the data pipeline before the scientific analysis. All the known instrumental effects are corrected during the calibration pipeline (ie spectral tilt). Up to now, we do not have evidence of spectral smile, however, for this one as for any other effect, a correction procedure will be included if in the future such effects will be quantified.

3 . Data Set Overview

For each mission phase, 4 data sets will be delivered: raw visible, raw infrared, calibrated visible and calibrated infrared, all arranged as “qubes”.

3.1 Data Sets

Table 6. *PDS Data Sets*

Proc Level	Data Set ID	DATA_SET_NAME
EDR NASA-1A	DAWN-X-VIR-2-EDR-VIS-CRUISE-SPECTRA-V1.0	DAWN VIR RAW (EDR) CRUISE CHECKOUT/CALIB VISIBLE SPECTRA V1.0
	DAWN-A-VIR-2-EDR-VIS-VESTA-SPECTRA-V1.0	DAWN VIR RAW (EDR) VESTA VISIBLE SPECTRA V1.0
	DAWN-A-VIR-2-EDR-VIS-CERES-SPECTRA-V1.0	DAWN VIR RAW (EDR) CERES VISIBLE SPECTRA V1.0
	DAWN-X-VIR-2-EDR-IR-CRUISE-SPECTRA-V1.0	DAWN VIR CRUISE RAW (EDR) CHECKOUT/CALIB INFRARED SPECTRA V1.0
	DAWN-A-VIR-2-EDR-IR-VESTA-SPECTRA-V1.0	DAWN VIR RAW (EDR) VESTA INFRARED SPECTRA V1.0
	DAWN-A-VIR-2-EDR-IR-CERES-SPECTRA-V1.0	DAWN VIR RAW (EDR) CERES INFRARED SPECTRA V1.0
RDR NASA-1B	DAWN-X-VIR-3-RDR-VIS-CRUISE-SPECTRA-V1.0	DAWN VIR CAL (RDR) CRUISE CHECKOUT/CALIB VISIBLE SPECTRA V1.0
	DAWN-A-VIR-3-RDR-VIS-VESTA-SPECTRA-V1.0	DAWN VIR CAL (RDR) VESTA VISIBLE SPECTRA V1.0
	DAWN-A-VIR-3-RDR-VIS-CERES-SPECTRA-V1.0	DAWN VIR CAL (RDR) CERES VISIBLE SPECTRA V1.0
	DAWN-X-VIR-3-RDR-IR-CRUISE-SPECTRA-V1.0	DAWN VIR CAL (RDR) CRUISE CHECKOUT/CALIB INFRARED SPECTRA V1.0
	DAWN-A-VIR-3-RDR-IR-VESTA-SPECTRA-V1.0	DAWN VIR CAL (RDR) VESTA INFRARED SPECTRA V1.0
	DAWN-A-VIR-3-RDR-IR-CERES-SPECTRA-V1.0	DAWN VIR CAL (RDR) CERES INFRARED SPECTRA V1.0

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) (TBC) 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. 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.

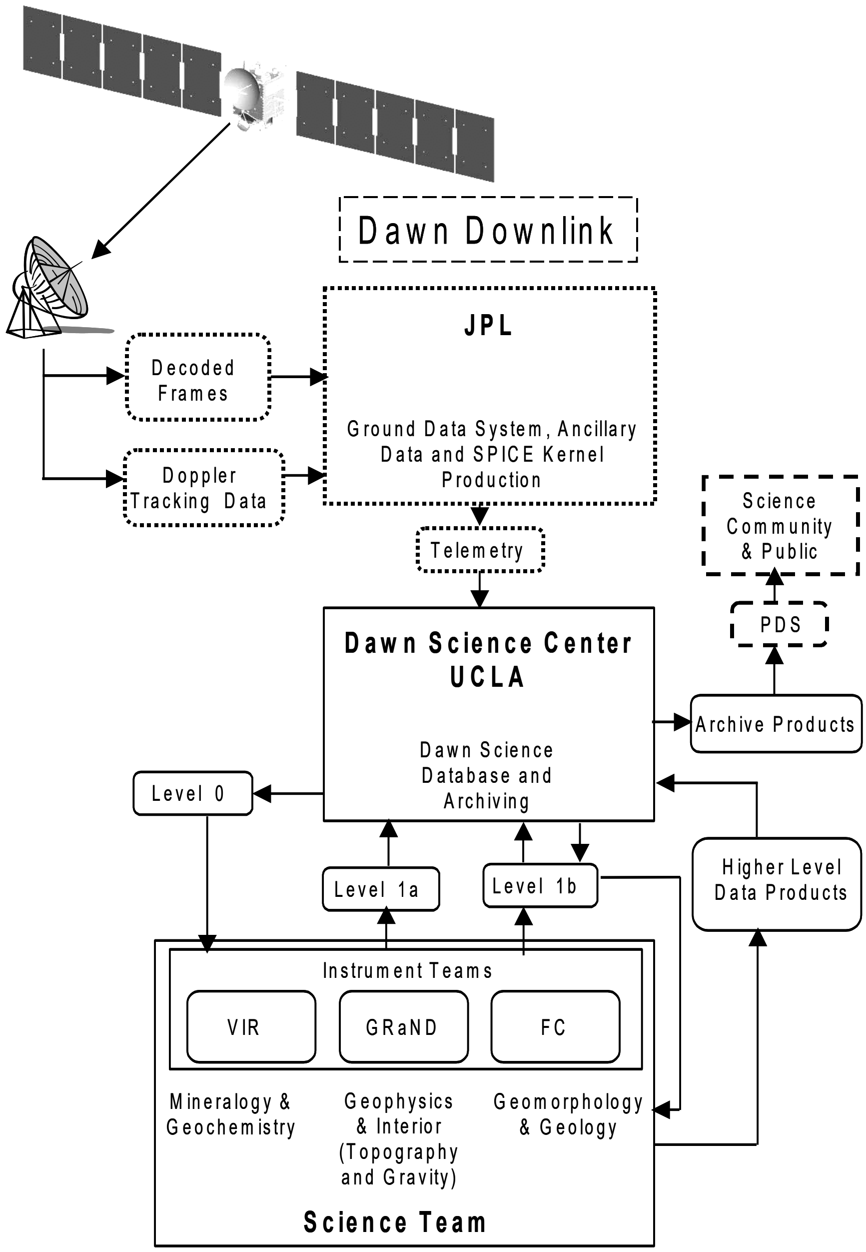

Figure 3. *Dawn Science Data Flow. SPAA elements and products are outlined with solid black lines, MOS components with dotted lines, and PDS components with dashed lines.*

3.3 Data Processing

3.3.1 EDR (Level 1a) Data Processing and Production

Level-0 data are retrieved by the VIR team and stored in the local archive, located at IFSI in Rome. The data are then fed into the EGSE and transformed in Level 1a data with a detached label.

3.3.2 RDR (Level 1b) Data Processing and Production

The functional steps that are being performed to create level 1b data, starting from level 1a data created by the ESGE, are listed below. A flowchart of this process is provided in Figure 4. The performed steps are the same for the two focal planes, but different algorithms are being used. More details can be found in the *DAWN VIR Calibration Document.*

- The first step is the identification of the defective pixels. This activity has been done during the calibration of the focal planes, before the integration of the instrument.
- The second step is the check of the saturated pixels. This activity is actually related to the validation of the data. However, it is performed during the calibration process even if an ASCII file is created in order to get inputs for the validation process.
- The third step is the dark frames subtraction, which is made using the dark frames acquired together with the science data. A detailed explanation of the dark current subtraction procedure can be found in Section 8 of the *DAWN VIR Calibration Document.*
- The fourth step is the spectral calibration: a central wavelength and a spectral width are associated with every spectral channel of VIR. The coefficients were previously computed and are listed in an ASCII file used as input by the calibration procedure.
- The fifth step is the flat field correction. The coefficients used in this step were previously computed and are listed in an ASCII file used as input by the calibration procedure.
- The sixth and last step is the radiometric calibration: a radiance value is associated with every pixel in the core. The coefficients used in this step were previously computed and are listed in an ASCII file used as input by the calibration procedure.

The output of the calibration pipeline is a calibrated 3D matrix for each focal plane, to be used as input for the procedure creating the PDS level 1b archives.

Note that for Vesta calibrated (ITF V1) values in the spectral range [2.534μm - 3.272μm] were initially set to null due to problems in producing a good calibration at those wavelengths when compared to known sources. Prior to arrival at Ceres, the VIR team was able to produce an improved calibration (ITF V2) which removed the artifacts in the 3-micron region. The new calibration covers the full spectral range and is appropriate for use at both Vesta and Ceres. However, contamination in the 3-micron region that occurred during the Vesta HAMO 1 (VSH) phase related to cold-trapped volatiles which mimics a water vapor absorption has not been dealt with yet effectively, thus that portion of the spectrum has still been omitted from the VSH data. More information about this contamination is provided in the DATA_CONFIDENCE_NOTE section of the IR data set catalog files.

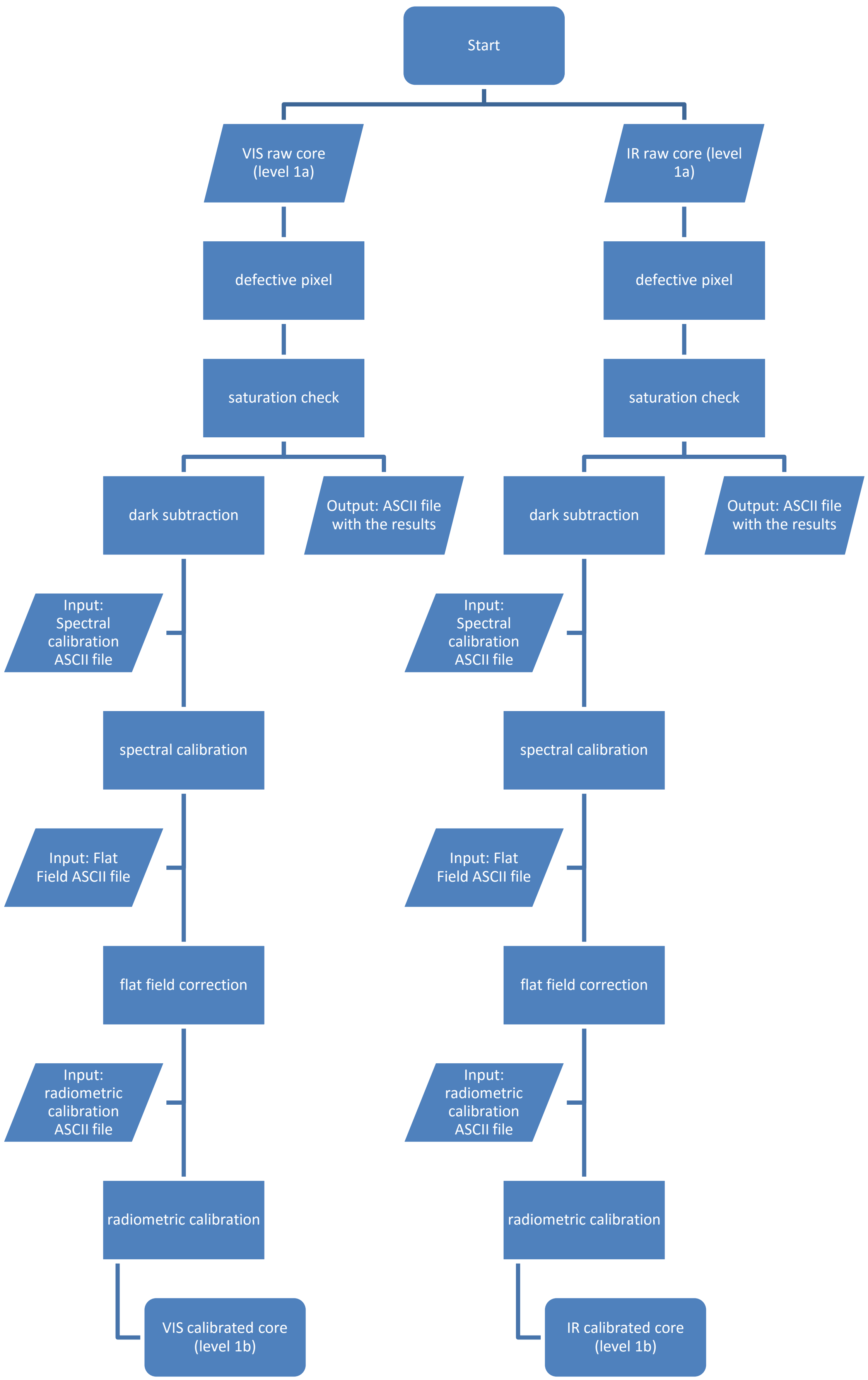

Figure 4. *Flowchart of the VIR data calibration pipeline*

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 VIR team and delivered to the DSC for use by the Science Team and eventual archive (see schedule) by the PDS. The VIR 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.CAT, 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 VIR team to produce calibrated level 1b (RDR) data products (radiometrically corrected spectra). The VIR team produces the processed products using the archived EDR data sets. The RDR data products, together with the calibration files that have been used in the calibration process, 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 VIR team may choose to update the data in the DSDb using the latest version of the calibration. The VIR 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 VIR 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 7. *Data Release Schedule*

Level 0	DSC	Apr 2009	Aug 2011 to Jul 2012	Mar 2015 to Aug 2015
EDR - Level 1a	VIR/DSC	Oct 2009	Dec 2011 to Dec 2012	May 2015 to Sep 2015
RDR - Level 1b	VIR/DSC	Oct 2009	Apr 2013	Jan 2016
Derived Data	VIR	Apr 2010	Nov 2013	Jan 2016

* Assumes current project schedule (arrival and departure dates)

4 . Archive Volumes

This chapter describes the format of VIR standard product archive volumes. Data that comprise the VIR 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 Format

Disk formats for the archive volumes will conform to the PDS standard for the applicable media. At present, the plan is to archive VIR 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.

4.2 Volume Labeling and Identification

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

DWNtpVIR_dl
where:
d – detector (V – VIS; I – IR),
l – processing level (1A – EDR; 1B – RDR;),
t – mission target (X – cruise; M – Mars ; V – Vesta; C - Ceres).
P – mission phase (only used for Ceres volumes: A – Approach; S – Survey; H – HAMO; L – LAMO)

For example, the Vesta VIS EDR volume will be named DWNVVIR_V1A and the Ceres Approach/RC3 IR RDR volume will be DWNCAVIR_I1B.

4.3 Data Validation

4.3.1 Instrument Team Validation

The VIR 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. If the data set is complete, the value of the keyword DATA_QUALITY_ID is set to 1. If the data set is not complete, the EDR data are not padded with 0, and there is no way to reconstruct the missing information.
- 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.

4.3.2 Science Team Validation

The Dawn Science Team has access to the VIR 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 VIR 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 VIR team so that they can be corrected.

4.3.3 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 VIR standard product archive collection volumes, including the file names, file contents, file types, and organizations responsible for providing the files. All the ancillary files described herein appear on each VIR 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 8. *Root Directory Contents*

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
MD5_CHECKSUM.TXT	File containing a listing of the MD5 checksum, and file location of every file on the volume.	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 GEOM_INDEX.TAB file contains a listing of geometrical parameters associated with each data file. The values provided in this table have been extracted from the individual data product labels. GEOM_INDEX.TAB is described by a detached PDS label (GEOM_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 9. *Index Table Contents*

INDEX Table Contents			
Column Name	**Format**	**Units**	**Description**
DATA_SET_ID	A38		Identifier of the data set to which the product belongs
FILE_SPEC_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		Identifier of the volume on which the product is archived
PRODUCT_CREATION_TIME	A23		File creation date/time
START_TIME	A23		File start time – UTC at spacecraft
STOP_TIME	A23		File end time – UTC at spacecraft
IMAGE_MID_TIME	A23		The center time of the image or cube

5.3 CATALOG Directory Contents

The completed PDS catalog files in the CATALOG directory provide a top-level understanding of the Dawn/VIR mission and its data products. The information necessary to create the files is provided by the VIR 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 10. *Catalog Directory Contents*

CATALOG Directory Contents		
File Name	**File Contents**	**File Provided By**
CATINFO.TXT	A description of the contents of this directory	DSC
VIR_*DDD*_*PPP*_*TTT*_DS.CAT	PDS Data Set catalog description of the data set included on this volume *DDD* = detector (IR or VIS) *PPP* = processing (EDR or RDR) *TTT* = mission phase target (CRUISE, VESTA, or CERES)	VIR Team
dawninsthost.cat	PDS instrument host (spacecraft) catalog description of the Dawn spacecraft	DSC
VIR_INST.CAT	PDS instrument catalog description of the VIR instrument	VIR Team
dawnmission.cat	PDS mission catalog description of the Dawn mission	DSC
VIR_PERSON.CAT	PDS personnel catalog description of VIR Team members and other persons involved with generation of VIR Data Products	VIR Team
VIR_REF.CAT	VIR-related references mentioned in other *.CAT files	VIR Team
X_TARG.CAT	PDS catalog description of target X (when included in the volume)	DSC

5.4 CALIB Directory Contents

The calibration directory contains calibration files and procedures. Text files are described by attached PDS labels. Formatted documents are described by detached PDS labels.
The calibration files contained in this directory are usually made available together with the calibrated (RDR level) data files.

Table 11. *CALIB Directory Contents*

CALIB Directory Contents		
File Name	**File Contents**	**File Provided By**
CALINFO.TXT	A description of the contents of this directory	DSC
DAWN_VIR_VIS_RESP_V1.TXT	432x256 floating precision matrix containing the Instrumental Transfer Function, including the VIS flat-field.	VIR Team
DAWN_VIR_IR_RESP_V1.TXT	432x256 floating precision matrix containing the Instrumental Transfer Function, including the IR flat-field.	VIR Team
DAWN_VIR_VIS_HIGHRES_SPECAL_V1.TXT	The file contains the wavelengths, of the 432 bands of the visible focal plane (high spectral modes, see 2.4).	VIR Team
DAWN_VIR_IR_HIGHRES_SPECAL_V1.TXT	The file contains the wavelengths of the 432 bands of the infrared focal plane (high spectral modes, see 2.4).	VIR Team

CALIB Directory Contents		
File Name	**File Contents**	**File Provided By**
DAWN_VIR_VIS_NOMRES_SPECAL_V1.TXT	The file contains the wavelengths of the 144 bands of the visible focal plane (low spectral modes, see 2.4).	VIR Team
DAWN_VIR_IR_NOMRES_SPECAL_V1.TXT	The file contains the wavelengths of the 144 bands of the infrared focal plane (low spectral modes, see 2.4).	VIR Team
DAWN_VIR_IR_SOLAR_SPECTRUM_V2.TAB	The file contains solar spectrum irradiance for the infrared channel.	VIR Team
DAWN_VIR_VIS_SOLAR_SPECTRUM_V2.TAB	The file contains solar spectrum irradiance for the visible channel.	VIR Team
DAWN_VIR_VIS_WIDTH432_V1.TXT	The file contains the widths of the 432 bands of the visible focal plane (high spectral modes, see 2.4).	VIR Team
DAWN_VIR_IR_WIDTH432_V1.TXT	The file contains the widths of the 432 bands of the infrared focal plane (high spectral modes, see 2.4).	VIR Team
DAWN_VIR_VIS_WIDTH144_V1.TXT	The file contains the widths of the 144 bands of the visible focal plane (low spectral modes, see 2.4).	VIR Team
DAWN_VIR_IR_WIDTH144_V1.TXT	The file contains the widths of the 144 bands of the infrared focal plane (low spectral modes, see 2.4).	VIR Team

5.5 DOCUMENT Directory Contents

Archive documents are stored in the DOCUMENT directory branch of the archive volume. Each document is located in a separate subdirectory. Documents are stored either in simple ASCII text files with attached PDS labels (*.TXT) or in PDF-A (archive PDF) format with detached PDS labels.

Table 12. *Document Directory Contents*

DOCUMENT Directory Contents		
File Name	**File Contents**	**File Provided By**
DOCINFO.TXT	A description of the contents of this directory	DSC
SCIENCE_PLAN	A directory containing copies of the Dawn Science Plan	Dawn Project
CERES_COORD_SYS	A directory containing copies of the Ceres coordinate system description	Dawn Project
SIS	A directory containing copies the data product and archive volume SIS (this document)	VIR Team
VESTA_COORDINATES	A directory containing copies of the Vesta Coordinate Systems Document	Dawn Project
VIR_CALIBRATION	A directory containing copies of the VIR Calibration Document	VIR Team
VIR_LAMP_DESCRIPTION	A directory containing a copy of a document describing the VIR internal calibration lamp	DSC
ENVI_TUTORIAL	A directory containing copies of the VIR ENVI Tutorial document	
ISIS_TUTORIAL	A directory containing copies of the VIR ISIS Tutorial document	

5.6 DATA Directory

The DATA directory contains the data products (labeled data files) produced by the VIR team.

5.6.1 File Naming Conventions

VIR spectral data are stored in QUBE format with detached PDS labels. Data cubes are named according to the suffix indicating the channel, the processing level, the spacecraft clock reset number and the acquisition SC_CLOCK_START_COUNT (integer part). The naming convention is the following:

VIR_sss_ll_v_ sctime _z

where:

- *VIR* indicates the instrument, fixed
- *sss* indicates the sensor, IR or VIS for the infrared or visible spectrometers respectively
- *ll* indicates the processing level, either 1A or 1B
- *v* indicates the clock reset number
- *sctime* is the acquisition SC_CLOCK_START_COUNT (integer part)
- *z* indicates the data file version (1-9)

The extension is always QUB. For example, visible channel raw data acquisitions starting at SC_CLOCK_START_COUNT = 21983325.39258 are named:

VIR_VIS_1A_1_21983325_1.QUB

Due to internal synchronization delays, the same acquisition could be shifted by few seconds among the two channels.

The housekeeping data related to a given qube are stored in a table with a detached label. The extension of the file containing the table is TAB. The filename is similar to the corresponding data Qube, but for a 'HK' inserted before the file version number. As an example, the housekeeping information of the qube VIR_VIS_1A_1_21983325_1.QUB is stored in the file VIR_VIS_1A_1_21983325_HK_1.TAB. The HK tables for a give spectra are identical in both the 1A and 1B data.

The 1B data also includes "quality qubes". These files have a 'QQ' inserted before the file version number. Quality qubes contain information related to the calibration of the associated data qube.

5.6.2 Data Organization and Sub-directories

The DATA directory will normally be divided into subdirectories by observing period in order to keep the number of data files in each directory manageable. The cruise calibration volume will eventually contain many years of data. The first level of subdivision of this volume will be mission phase. The Vesta and Ceres data volumes will be subdivided by observation. Phase and observation level directories will be named following the convention:

*yyyymmdd*_xxx

where:

yyyymmdd = start date (*yyyy*=year, *mm*=month, *dd*=day)

xxx = phase or observation ID

Examples:

20110929_HAMO

20111006_CYCLE1

20110814_CYCLE2

if the mission timeline remains as it is today.

5.6.3 Required Files

Every file in the DATA path of a VIR archive volume is described by an external (detached) PDS label.

5.7 GEOMETRY Directory Contents

The GEOMETRY directory contains copies of the VIR SPICE metakernel (TM) files. TM files are SPICE text kernels that list the SPICE kernels that were used in data processing and in the calculation of the geometry parameters contained in the data label files. The SPICE kernels listed in these TM files are archived at the PDS-NAIF node.

VIR TM files are named according to the convention:

DAWN_*phase*_R*nn*.TM

where:

phase	indicates the mission phase covered by the TM file
nn	indicates the TM file version number

For example the file DAWN_VSH_R03.TM is version 3 of the Vesta Science HAMO (VSH) metakernel.

5.8 BROWSE Directory

To the moment, there are no planned BROWSE products.

6 . Data Format Descriptions

6.1.1 VIR data File Structure

EDR and RDR data products are organized in a similar way, that is three-dimensional matrices (a QUBE) containing the data + a TABLE containing associated housekeeping information. The labels are always detached.
A QUBE object is a multidimensional array (called the core) of sample values in multiple dimensions. The core is homogeneous, and can consist of unsigned byte, signed half-word or floating point full-word elements. QUBEs of one to three dimensions may have optional suffix areas in each axis.

The QUBE is the main data structure of the ISIS (Integrated Software for Imaging Spectrometers) system. A frequently used specialization of the QUBE object is the ISIS Standard Qube, which is a three-dimensional QUBE with two spatial dimensions and one spectral dimension. Its axes have the interpretations 'sample', 'line' and 'band'. Three physical storage orders are allowed: band-sequential, line-interleaved (band-interleaved-by-line) and sample-interleaved (band-interleaved-by-pixel).

The implementation selected for VIR data does not include suffix areas; the associated information is instead stored in a table.

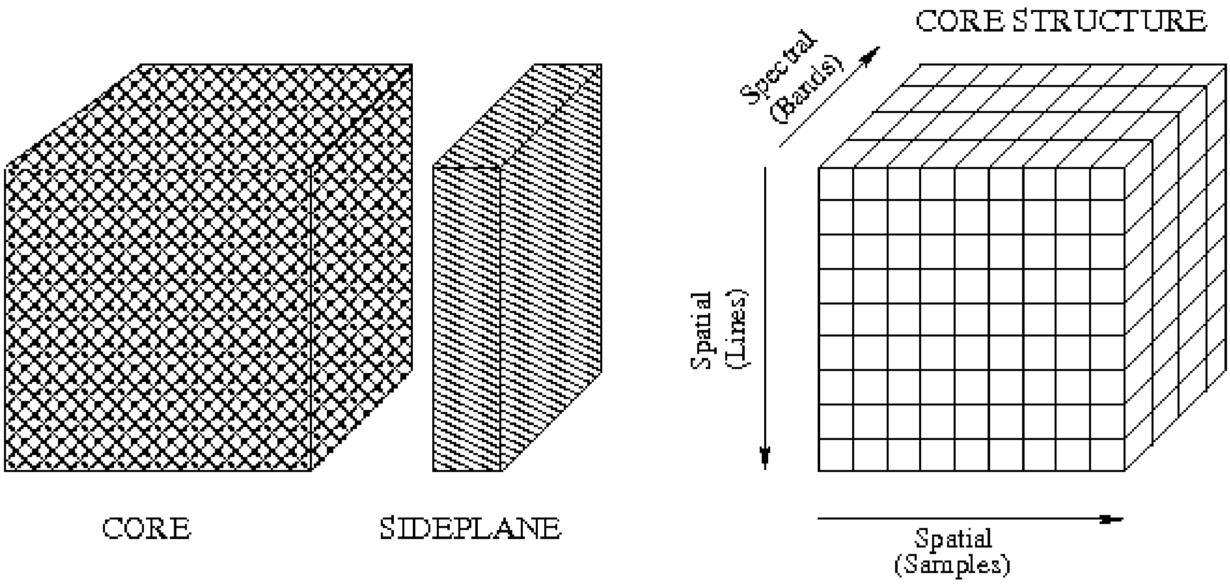

Figure 5. *Generic ISIS Cube Structure*

6.1.2 VIR EDR data File Structure

The VIR EDR data sets use the 3-D core structure to store the instrument data. A table is storing instrument housekeeping data. Spectra are stored intact for single sample (most rapidly varying component in the 3-D structure). All samples are collected at a single time, and are thus the next most rapidly varying component of the data core. Finally, QUBEs are constructed by assembling spatial lines that are either acquired in a push-broom mode (value field of the keyword SCAN_MODE_ID set to 0) or by using the VIR scan mirror that moves the slit across the target body. The line direction is the most slowly varying component in the data core.

The data files include the data QUBE itself, a TABLE with the instrument housekeeping and the two detached labels. The labels are ASCII text and can be viewed using normal text viewers.

The following definitions apply to both EDR and RDR qubes (see fig. 6).

- Co-ordinate along x (slit axis) = SAMPLE
- Co-ordinate along y (scan axis) = LINE
- Co-ordinate along λ (spectral axis) = BAND

In the following table, the co-ordinate sizes for the different VIR operative modes are listed.

Table 13. *VIR operative modes*

OPERATIVE MODE	#BANDS	#SAMPLES [1]	#LINES [2]
science full slit			
LOW SPATIAL LOW SPECTRAL	288 binning 3 (144 VIS + 144 IR)	64 binning 4	3600 [3]
HIGH SPATIAL LOW SPECTRAL	288 binning 3 (144 VIS + 144 IR)	256	900 [3]
HIGH SPECTRAL LOW SPATIAL	864 (432 VIS +432 IR)	64 binning 4	1200 [3]
HIGH SPECTRAL HIGH SPATIAL	864 (432 VIS +432 IR)	256	300 [3]
science quarter slit[4]			
HIGH SPECTRAL HIGH SPATIAL	864 (432 VIS +432 IR)	64	1200 [3]
LOW SPECTRAL HIGH SPATIAL	288 binning 3 (144 VIS + 144 IR)	64	3600 [3]
Calibration			
HIGH SPECTRAL HIGH SPATIAL	864 (432 VIS +432 IR)	256	35

[1] The max number of samples is also called swath width (Δx)

[2] The max number of lines is also called swath length (Δy)

[3] The number of lines to saturate the VIR on board mass memory of 1 Gbits (TBC)

[4] The science quarter slit is an operational mode selectable by command: the position of the quarter slit is selectable by TC for the VIS channel, while it is fixed for the IR channel.

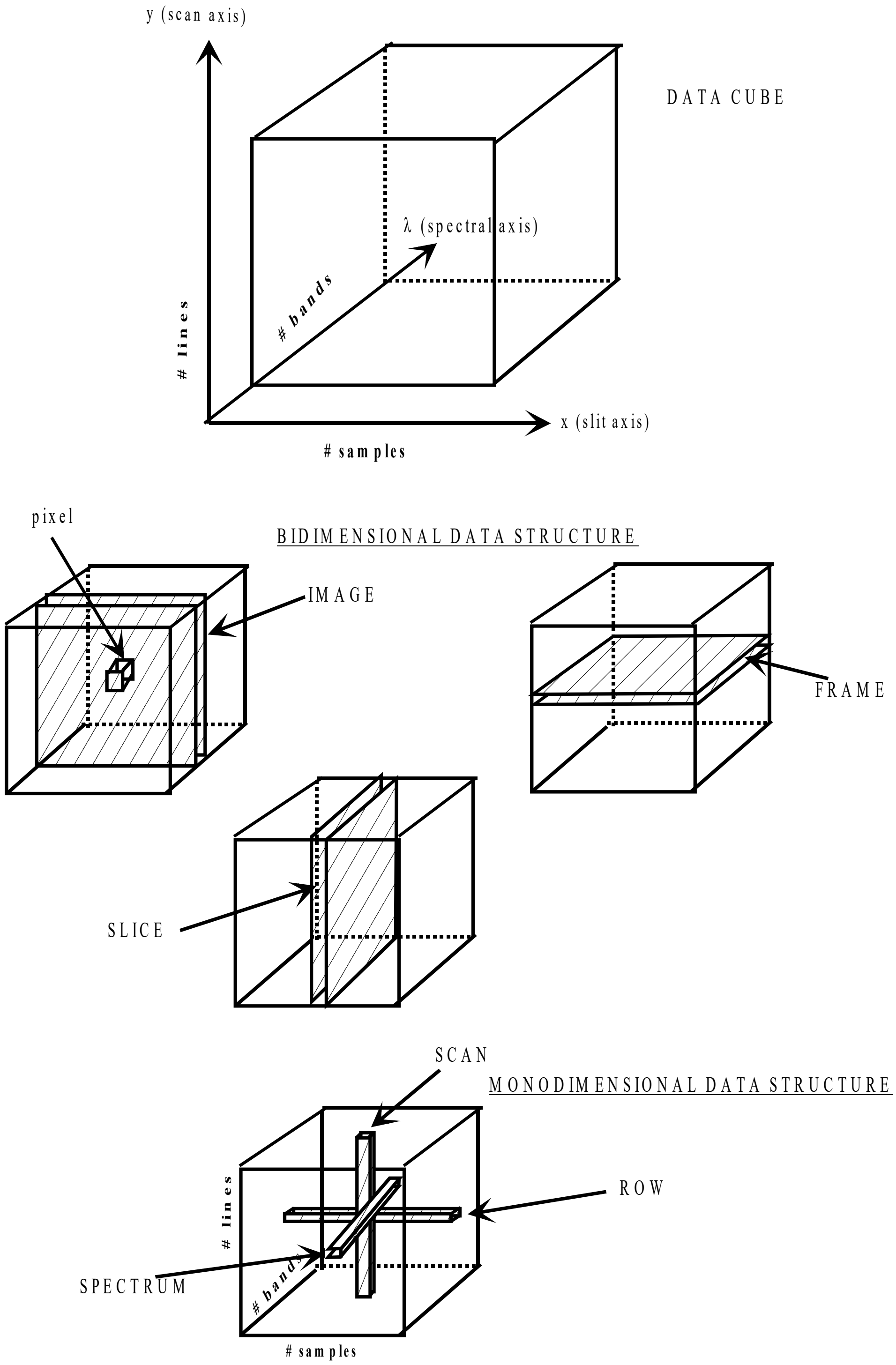

Figure 6. *Definitions of data types*

A <u>DATA CUBE</u> is a 3-dimensional matrix representing a set of data, i.e. the digital number vs. the two spatial co-ordinates (x,y) and the spectral one (λ).
An <u>IMAGE</u> is a 2-dimensional matrix of the data cube, defined by selecting its # BAND.
A <u>FRAME</u> is a 2-dimensional matrix of the data cube, defined by selecting its # LINE (scan mirror in a fixed position).
A <u>SLICE</u> is a 2-dimensional matrix of the data cube, defined by selecting its # SAMPLE.
A <u>PIXEL</u> is an element of the image (associated to a # BAND), defined by selecting # SAMPLE and # LINE (i.e. spatial coordinates (x,y)).
For each pixel it is useful to define the following data structures:

- SPECTRUM, that is a 1-dimensional array along the λ axis of the data cube, passing through the selected pixel;
- ROW, that is a 1-dimensional array along the x axis of the data cube, passing through the selected pixel;
- SCAN, that is a 1-dimensional array along the y axis of the data cube, passing through the selected pixel.

6.1.2.1 Table structure

The frames composing a qube are downloaded as a series of packets, containing part of a given frame. Each packet begins with a secondary header, while a primary header is downloaded at the beginning of each stream of packets. All the housekeeping information related to the frames is coming with the primary and secondary header of the packets. The HK parameters are stored in a table as 33 fields with a variable number of bytes. Every line in the table corresponds to a frame in the qube data file. The number of table rows actually used is identical for each frame. This number is written in the value field of SUFFIX_ITEM keyword (see section 6.2). The following table details the content of the HK table.

Table 14. *Information stored on each row of the housekeeping table*

Start byte	Field name	Unit	Description
1	VERSION, TYPE, SECONDARY HEADER FLAG		Information derived from the secondary header of the packet containing the frame
4	APID		Information deriving from the secondary header of the packet containing the frame
8	PACKETS SEQUENCE CONTROL		Information deriving from the secondary header of the packet containing the frame
14	PACKETS LENGTH		Information deriving from the secondary header of the packet containing the frame
19	SCET TIME (CLOCK)		Spacecraft elapsed time referred to the frame
34	FRAME NUMBER		Number of frames in the current subsession/sequence step
38	FRAME COUNT		Frame in the current sub-session/ sequence step counter
42	SUBFRAME COUNT		Sub-frame in the current frame counter
45	PACKETS COUNT		Packet in the current sub-frame counter
48	SHUTTER STATUS		Status of the shutter during the data acquisition:

			1 = open; 0 = close (dark current acquisition)
57	CHANNEL IDENTIFIER		Identifier of the channel: 1 = VIS; 0 = IR
61	COMPRESSION MODE		Type of compression applied on the onboard data, before the transmission to Earth.
82	SPECTRAL RANGE		Spectral range that has been actually acquired.
107	CURRENT MODE		Operative mode (see tab. 5, pag. 14)
120	CURRENT SUBMODE		Operative submode (see tab. 5, pag. 14)
135	M IR EXPOSURE TIME	s	IRFPA exposure time
146	M IR TEMPERATURE	K	IRFPA temperature
157	M CCD EXPOSURE TIME	s	CCD exposure time
168	M CCD TEMPERATURE	K	CCD temperature
179	M MIRROR SINUS	DEG	Sinus of the electrical angle of the scan unit (commanded)
190	M MIRROR COSINE	DEG	Cosinus of the electrical angle of the scan unit (commanded)
201	M SPECTROMETER TEMPERATURE	K	Temperature of the spectrometer
212	M TELESCOPE TEMPERATURE	K	Temperature of the telescope
223	CCE COLD TIP	K	
234	RADIATOR TEMPERATURE	K	Temperature of the radiator
245	M SU MOTOR CURRENT	A	Scan unit motor temperature
256	LEDGE TEMPERATURE	K	Optical mounting ledge temperature
267	START NOISY BITS		This information is related to the compression algorithm applied onboard on the data.
270	END NOISY BITS		This information is related to the compression algorithm applied onboard on the data.
273	CR ROW		This information is related to the compression algorithm applied onboard on the data.
276	NUMBER OF NOISY BITS		This information is related to the compression algorithm applied onboard on the data.
279	SUB-FRAME DATA		This information is related to the compression algorithm applied onboard on the data.

285	SEQUENCE STEP		Step in the the TC sequence at the origin of the data

6.1.3 VIR RDR Data File Structure

The logical object that is storing the calibrated data is a QUBE with a detached label. Information relevant to the calibration process is stored in another qube formed by three planes (called 'quality qube'), with detached label. The filenames of the calibrated data are following the same formation rules as the raw data. A 'QQ' is inserted before the file version number in the filename of the quality qube.

The data in a RDR cube are expressed in radiance physical units (W m^{-2} μm^{-1} $sterad^{-1}$), saved in floating precision in BIP format (Bands, Sample, Line). The label is similar to the one of the corresponding EDR cube; a "NOTE" in the HISTORY OBJECT is keeping trace of the ITF file used in the calibration process.

The quality qube contains three planes:

- **first plane**: central wavelength of each pixel of the frame. This information is calculated through the on-ground spectral calibration measurements. The bands x sample matrix is expressed in floating precision in physical units (μm) and is generated by the calibration pipeline;
- **second plane**: FWHM of each pixel of the frame. The bands x sample matrix is expressed in floating precision in physical units (nm) and is generated by the calibration pipeline. During the on ground measurements the FWHM values were estimated only for the bands 93-96, 172-176, 412-415 for the VIS channel, and for bands 1-3, 212-215, 418-428 for the IR channel.
- **third plane**: flags identifying the quality of the signal of each pixel according to the following code (TBC):

VIS	
Regular pixel	0
Filter	1
Defective pixel	2
Detilt empty zone	3
Filter+Defective pixel	4
Filter+Detilt empty zone	5
Defective pixel + Detilt empty zone	6
Filter+Defective pixel+Detilt empty zone	7

IR	
Regular pixel	0
Filter	1
Defective pixel	2
IRFPA failure zone	3
Filter+Defective pixel	4

Filter+IRFPA failure zone	5
Defective pixel + IRFPA failure zone	6
Filter+Defective pixel+IRFPA failure zone	7

This information is stored in a byte array of bands x sample elements by the calibration pipeline. The array is single precision floating point by construction, including this plane.

6.2 VIR Labels description

The keywords contained in the VIR data products labels are listed in the following tables, together with a short description.

Table 15. *Keywords contained in the VIR data products labels*

Keyword	Value Units	Value Description
PDS_VERSION_ID		Value = “PDS3” This is the version number of the PDS standard document that is valid when a data product label is created.
LABEL_REVISION_NOTE		Information on the actual version of the label
DATA_SET_NAME		See Table 6 for a list of valid values
DATA_SET_ID		See Table 6 for a list of valid values
PRODUCT_ID		Actual name of the file containing the data; see section 5.6.1
PRODUCT_TYPE		Possible values: EDR or RDR
PRODUCER_FULL_NAME		Value = “A. CORADINI”
PRODUCER_INSTITUTION_NAME		Value = "ISTITUTO NAZIONALE DI ASTROFISICA" Identifies the organization responsible for developing the data products.
PRODUCT_CREATION_TIME		Contains the date and time at which the PDS file was created in PDS time format.
PRODUCT_VERSION_ID		The version number of the PDS product.
RECORD_TYPE		Value = “FIXED_LENGTH” All VIR data files will be using a fixed-length record format.
RECORD_BYTES		Value = 512 All VIR data files have a record length of 512 bytes.
FILE_RECORDS		The number of records number in the data file.
LABEL_RECORDS		The number of records of size RECORD_BYTES used by the label.
START_TIME		START_TIME gives the corrected UTC spacecraft time for the observation start. Format: yyyy-mm-ddThh:mm:ss.sss
STOP_TIME		STOP_TIME gives the corrected UTC spacecraft time for the observation stop; this keyword must always be present even if the stop time is unknown or unavailable.
IMAGE_MID_TIME		Corrected UTC spacecraft time for the middle observation time.
SPACECRAFT_CLOCK_START_COUNT		Start time represented in the native spacecraft clock counter format. Example: “1/250684401.857”

Keyword	Value Units	Value Description
SPACECRAFT_CLOCK_STOP_COUNT		Stop time represented in the native spacecraft clock counter format.
INSTRUMENT_HOST_NAME		Value = “DAWN”
INSTRUMENT_HOST_ID		Value = “DAWN”
MISSION_PHASE_NAME		See DAWN_MISSION.CAT for a list of valid values.
INSTRUMENT_NAME		Value = “VISIBLE AND INFRARED SPECTROMETER”
INSTRUMENT_ID		Value = “VIR”
INSTRUMENT_TYPE		Value = "IMAGING SPECTROMETER"
RIGHT_ASCENSION	degrees	EME-2000 right ascension of the center pixel in the image/spectra
DECLINATION	degrees	EME-2000 declination of the center pixel in the image/spectra
TWIST_ANGLE	degrees	The twist_angle element provides the angle of rotation about the optical axis relative to celestial coordinates. Together with the RIGHT_ASCENSION and DECLINATION values defines the pointing direction and orientation
CELESTIAL_NORTH_CLOCK_ANGLE	degrees	North celestial clock angle evaluated at the center pixel of the image/spectra
QUATERNION		Four values compose the quaternion; see kw QUATERNION_DESC
QUATERNION_DESC		The 4 parameters are calculated at the center time of the observation which is IMAGE_MID_TIME. The quaternion has the form: w, x, y, z (i.e. SPICE format)
SPACECRAFT_SOLAR_DISTANCE	km	The spacecraft_solar_distance element provides the distance from the spacecraft to the center of the sun
SC_SUN_POSITION_VECTOR	km	The sc_sun_position_vector element indicates the 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
SC_SUN_VELOCITY_VECTOR	km/s	The sc_sun_velocity_vector element indicates the 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
SPICE_FILE_NAME		Provides the name of the SPICE metakernel file, the file that identifies kernels used in data processing and geometry parameter calculations. e.g. “DAWN_VSH_R03.TM”
TARGET_NAME		Name of the observed target (e.g. “MARS”, “4 VESTA”, “ALPHA CARINAE”, etc.)
TARGET_TYPE		Target type (e.g. “PLANET”, “ASTEROID”, “STAR”)
COORDINATE_SYSTEM_NAME		Identifier indicating the coordinate system to which the state vectors are referenced.
COORDINATE_SYSTEM_CENTER_NAME		This kw identifies a named target, such as the Sun, a planet, a satellite or a spacecraft, as being the location of the center of the reference coordinate system. (e.g. “4 VESTA”)
SUB_SPACECRAFT_ LATITUDE	degrees	Planetocentric latitude in COORDINATE_SYSTEM_NAME coordinates from SPICE
SUB_SPACECRAFT_ LONGITUDE	degrees	Planetocentric longitude in COORDINATE_SYSTEM_NAME coordinates from SPICE
SUB_SPACECRAFT_AZIMUTH	degrees	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

Keyword	Value Units	Value Description
		edge of the image. From SPICE
SPACECRAFT_ALTITUDE	km	This keyword provides the distance from the spacecraft to the nearest point on a reference surface of the target body measured normal to that surface
TARGET_CENTER_DISTANCE	km	Distance between the instrument and the center of mass of the target, from SPICE
SC_TARGET_POSITION_VECTOR		S/C position vector relative to the target in planetocentric coordinates
SC_TARGET_VELOCITY_VECTOR		S/C velocity vector relative to the target in planetocentric coordinates
LOCAL_HOUR_ANGLE		Local hour angle at the center of the image/spectra
SUB_SOLAR_LATITUDE	degrees	Sub-solar latitude on the target in planetocentric coordinates
SUB_SOLAR_LONGITUDE	degrees	Sub-solar longitude on the target in planetocentric coordinates
SUB_SOLAR_AZIMUTH	degrees	Sub-solar azimuth angle at the center of the image/spectra
INCIDENCE_ANGLE	degrees	Incidence angle at the center of the image/spectra
EMISSION_ANGLE	degrees	Emission angle at the center of the image/spectra
PHASE_ANGLE	degrees	Phase angle at the center of the image/spectra
SLANT_DISTANCE		Slant distance to the target evaluated at the center pixel of the image
MINIMUM_LATITUDE	degrees	The MINIMUM_LATITUDE specifies the southernmost latitude of the target, computed in the body-fixed, rotating coordinate system specified by the COORDINATE_SYSTEM_NAME keyword. For the determination of this values, the geometric values computed for the center of each element of the field of view (pixel) are considered. Each value is expressed in degrees in the [-90°, 90°] range, F9.5 format.
CENTER_LATITUDE	degrees	Center pixel planetocentric latitude for the image/spectra (N/A for calibration targets)
MAXIMUM_LATITUDE	degrees	The MAXIMUM_LATITUDE specifies the northernmost latitude of the target, computed in the body-fixed, rotating coordinate system specified by the COORDINATE_SYSTEM_NAME keyword. For the determination of this values, the geometric values computed for the center of each element of the field of view (pixel) are considered. Each value is expressed in degrees in the [-90°, 90°] range, F9.5 format.
WESTERNMOST_LONGITUDE	degrees	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. Each value is expressed in degrees, F9.5 format, in the [0°, 360°] range.
CENTER_LONGITUDE	degrees	Center pixel planetocentric longitude for the image/spectra (N/A for calibration targets)
EASTERNMOST_LONGITUDE	degrees	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 numercial value of longitude unless it crosses the Prime Meridian. Each value is expressed in degrees, F9.5 format, in the [0°, 360°] range.
HORIZONTAL_PIXEL_SCALE	m	Horizontal pixel size in meters
VERTICAL_PIXEL_SCALE	m	Vertical pixel size in meters

Keyword	Value Units	Value Description
NORTH_AZIMUTH	degrees	North azimuth angle evaluated at the center pixel of the image/spectra
ORBIT_NUMBER		Asteroid orbit number or “N/A”
PROCESSING_LEVEL_ID		CODMAC level (2 for EDR, 3 for RDR)
DATA_QUALITY_ID		Data quality indicator. Possible values are 0 if lines are missing, 1 if the data are complete; "NULL" is unevaluated.
DATA_QUALITY_DESC		Description of data quality kw.
TELEMETRY_SOURCE_ID		This keyword identifies the EGSE used to produce the data file.
CHANNEL_ID		Possible values: “VIS” and “IR”. This keyword identifies the instrument channel producing the data and can have 2 possible
SOFTWARE_VERSION_ID		This keyword identifies the software used to write the labels and format the data.
INSTRUMENT_MODE_ID		The value of this keyword identifies the instrument mode. The valid values are the followings: • S_H_SPE_H_SPA_F • S_H_SPE_L_SPA_F • S_H_SPE_L_SPA_F_SUM • S_L_SPE_H_SPA_F • S_L_SPE_L_SPA_F • S_L_SPE_L_SPA_F_SUM • S_H_SPE_H_SPA_Q • S_L_SPE_H_SPA_Q • S_H_SPE_L_SPA_F_MEA • S_L_SPE_L_SPA_F_MEA • C_H_SPE_H_SPA_F • C_H_SPE_L_SPA_F • SPARE • C_L_SPE_H_SPA_F • C_L_SPE_L_SPA_F • C_H_SPE_H_SPA_Q • C_L_SPE_H_SPA_Q
INSTRUMENT_MODE_DESC		This keyword describes the different values that INSTRUMENT_MODE_ID can assume S_H_SPE_H_SPA_F: Science, high spectral high spatial, Full slit S_H_SPE_L_SPA_F: Science, high spectral low spatial, Full slit S_H_SPE_L_SPA_F_SUM: Science, high spectral low spatial, Summing S_L_SPE_H_SPA_F: Science, Low spectral high spatial, Full slit S_L_SPE_L_SPA_F: Science, Low spectral low spatial, Full slit S_L_SPE_L_SPA_F_SUM: Science, Low spectral low spatial, Summing S_H_SPE_H_SPA_Q: Science, high spectral high spatial, Quarter slit S_L_SPE_H_SPA_Q: Science, low spectral high spatial, Quarter slit S_H_SPE_L_SPA_F_MEA: Science, high spectral low spatial, Meaning S_L_SPE_L_SPA_F_MEA: Science, low spectral low spatial, Meaning C_H_SPE_H_SPA_F: Calibration, high spectral high spatial, Full slit C_H_SPE_L_SPA_F: Calibration, high spectral low spatial, Full slit SPARE: CALIBRATION Spare C_L_SPE_H_SPA_F: Calibration, low spectral high spatial, Full slit C_L_SPE_L_SPA_F: Calibration, low spectral low

Keyword	Value Units	Value Description
		spatial, Full slit C_H_SPE_H_SPA_Q: Calibration, high spectral high spatial, Quarter slit C_L_SPE_H_SPA_Q: Calibration, low spectral high spatial, Quarter slit"
ENCODING_TYPE		Value (normally) = "0" (decompressed)
SCAN_MODE_ID		Scan mirror mode identifier. It is an integer in the range 0 to 10. 0 means that the mirror has not been used. The VIR scan mirror performs, when commanded, an angular movement around an axis parallel to the slit direction (y direction). There can be 10 different modes, each one identifying a given angular movement.
DAWN:SCAN_PARAMETER		See SCAN_PARAMETER_DESC. Example: "(-1.0, 0.1, 1, 33)"
SCAN_PARAMETER_DESC		"SCAN_START_ANGLE", "SCAN_STOP_ANGLE", "SCAN_STEP_ANGLE", "SCAN_STEP_NUMBER" This kw describes the movement of the scan mirror, defining start, stop and step angles. The fourth parameter is the number of acquisitions performed within one single scan unit position.
DAWN:SCAN_PARAMETER_UNIT		Value = ("DEGREES", "DEGREES", "DEGREES", "DIMENSIONLESS")
FRAME_PARAMETER		See FRAME_PARAMETER_DESC e.g. (100, 1, 5000, 5) This kw gives the details of the acquisition of the frames. EXPOSURE_DURATION is the integration time expressed in milliseconds; it is the exposure time of elementary exposures when summing is performed. FRAME_SUMMING is the number of elementary exposures summed during a time step (i.e, to build a frame). The product of EXPOSURE_DURATION and FRAME_SUMMING is the total integration time for each frame. EXTERNAL_REPETITION_TIME is the time required for a frame acquisition cycle (> EXPOSURE_DURATION x FRAME_SUMMING). DARK_ACQUISITION_RATE is the number of frames acquired between two background measurements.
FRAME_PARAMETER_DESC		("EXPOSURE_DURATION", "FRAME_SUMMING", "EXTERNAL_REPETITION_TIME", "DARK_ACQUISITION_RATE")
DAWN: FRAME_PARAMETER_UNIT		Value =("S", "DIMENSIONLESS", "S", "DIMENSIONLESS")
DAWN:VIR_IR_START_X_POSITION		This keyword gives the X coordinate of the first CCD pixel used on the IR FPA. This quantity determines the correspondence between wavelength and spectral channels.
DAWN:VIR_IR_START_Y_POSITION		This keyword gives the Y coordinate of the first CCD pixel used on the IR FPA. This quantity determines the correspondence between wavelength and spectral channels.
DAWN:VIR_VIS_START_X_POSITION		This keyword gives the X coordinate of the first CCD pixel used on the VIS FPA. This quantity determines the correspondence between wavelength and spectral channels.
DAWN:VIR_VIS_START_Y_POSITION		This keyword gives the Y coordinate of the first CCD pixel used on the VIS FPA. This quantity determines the correspondence between

Keyword	Value Units	Value Description
		wavelength and spectral channels.
MAXIMUM_INSTRUMENT_TEMPERATURE		See INSTRUMENT_TEMPERATURE_POINT keyword to specify the measurement locations e.g. (176.6, 143.6, 144.6, 74.7)
INSTRUMENT_TEMPERATURE_POINT		("FOCAL_PLANE", "TELESCOPE", "SPECTROMETER", "CRYOCOOLER")
DAWN: INSTRUMENT_TEMPERATURE_UNIT	K	Value = ("K", "K" ,"K" , "K")
PHOTOMETRIC_CORRECTION_TYPE		Value (normally) = NONE
OBJECT = QUBE (EDR data)		
AXES		AXES is the number of data axes in the QUBE object (always 3). AXES = 3
AXIS_NAME		Value = "(BAND, SAMPLE, LINE)" AXIS_NAME indicates the organization of the object, bands interleaved by pixels, or BIP. It means that a complete spectrum is written contiguously, and spectra acquired at the same time step are written in sequence.
CORE_ITEMS		CORE_ITEMS are the dimensions of the data cube. The three values specified are the spectral and spatial dimensions of the detector after binning (derived from INSTRUMENT_MODE_ID), and the number of frames acquired in the session. e.g. = (432, 256, 33)
CORE_ITEM_BYTES		CORE_ITEM_BYTES and CORE_ITEM_TYPE give the type of data in the cube core: CORE_ITEM_BYTES = 2 (16 bit integers) for raw data, and 4 (32 bit reals) for calibrated data, whatever the architecture used to write the data files (i.e., EGSE will not change byte encoding relative to the output of the instrument).
CORE_ITEM_TYPE		CORE_ITEM_BYTES and CORE_ITEM_TYPE give the type of data in the cube core: CORE_ITEM_TYPE = "MSB_INTEGER" (16 bit integers, MSB encoding) for raw data, and "IEEE_REAL" (32 bit reals) for calibrated data, whatever the architecture used to write the data files (i.e., EGSE will not change byte encoding relative to the output of the instrument).
CORE_BASE		CORE_BASE and CORE_MULTIPLIER allow scaling of data (useful for calibrated data only): true_value = BASE + (MULTIPLIER * stored_value). Values below the keyword CORE_VALID_MINIMUM are reserved for special use, following an ISIS convention. CORE_BASE = 0 always in this data set
CORE_MULTIPLIER		CORE_MULTIPLIER = 1.0 always in this data set.
CORE_VALID_MINIMUM		Values below the keyword CORE_VALID_MINIMUM are reserved for special use, following an ISIS convention. Value = 0
CORE_NULL		CORE_NULL is an optional code indicating invalid data. Value = -32768
CORE_LOW_REPR_SATURATION		Value = -32767 – always in this data set
CORE_LOW_INSTR_SATURATION		Value = -32767 – always in this data set
CORE_HIGH_REPR_SATURATION		Value = -32767 – always in this data set
CORE_HIGH_INSTR_SATURATION		Value = -32767 – always in this data set
CORE_NAME		CORE_NAME is the physical quantity recorded in the cube (required for ISIS).

Keyword	Value Units	Value Description
		Value = “RAW_DATA_NUMBER”
CORE_UNIT		CORE_UNIT is the unit of data stored in the cube. Value = “DIMENSIONLESS”
SUFFIX_BYTES		Number of suffix bytes; it is always 4 only for ISIS compliance, since there are no suffix planes
SUFFIX_ITEMS		Suffix planes: always (0,0,0) because there are no suffix planes
BAND_BIN_CENTER		Vector containing the center wavelength value to which each band is corresponding
BAND_BIN_WIDTH		Vector containing the width of the wavelength value to which each band is corresponding
BAND_BIN_UNIT		Units in which the wavelength are given
BAND_BIN_ORIGINAL_BAND		Vector giving the correspondence with the original bands

6.2.1 VIR Local keywords

A small number of local keywords has been defined in order to better describe VIR data. The VIR local keywords, with their meaning and values, are the following:

Table 16. *VIR Local keywords*

Keyword	Value Units	Value Description
DAWN:SCAN_PARAMETER		This kw defines the movement of the scan mirror, defining start, stop and step angles. The fourth parameter is the number of acquisitions performed within one single scan unit position (as described by SCAN_PARAMETER_DESC). Example: “(-1.0, 0.1, 1, 33)”
DAWN:SCAN_PARAMETER_UNIT		This keyword defines the units used in SCAN_PARAMETER Value = (“DEGREES”, “DEGREES”, “DEGREES”, “DIMENSIONLESS”)
DAWN: FRAME_PARAMETER_UNIT		This keyword defines the units used in FRAME_PARAMETER Value = (“S”, “DIMENSIONLESS”, “S”, “DIMENSIONLESS”)
DAWN: INSTRUMENT_TEMPERATURE_UNIT	K	This keyword defines the units of MAXIMUM_INSTRUMENT_TEMPERATURE Value = (”K”, ” K”, ” K”, ” K)
DAWN:VIR_IR_START_X_POSITION		This keyword gives the X coordinate of the first CCD pixel used on the IR FPA (spectral pixel). This quantity determines the correspondence between wavelength and spectral channels.
DAWN:VIR_IR_START_Y_POSITION		This keyword gives the Y coordinate of the first CCD pixel used on the IR FPA (spatial pixel). This quantity determines the correspondence between wavelength and spectral channels.
DAWN:VIR_VIS_START_X_POSITION		This keyword gives the X coordinate of the first CCD pixel used on the VIS FPA (spectral pixel). This quantity determines the correspondence between wavelength and spectral channels.
DAWN:VIR_VIS_START_Y_POSITION		This keyword gives the Y coordinate of the first CCD pixel used on the VIS FPA (spatial pixel). This quantity determines the correspondence between wavelength and spectral channels.

Appendix A. Sample PDS Labels

Data Product Labels: EDR data

This is an example of a detached label for an IR EDR file, named *VIR_IR_1A_1_369819195_2.QUB*. The data have been acquired with the infrared channel, during the Vesta Transfer to HAMO phase of the mission.

```
PDS_VERSION_ID = PDS3
LABEL_REVISION_NOTE = "MTC_11-10-2011"

/* Dataset and Product Information */
DATA_SET_NAME = "DAWN VIR RAW (EDR) VESTA INFRARED SPECTRA V1.0"
DATA_SET_ID = "DAWN-A-VIR-2-EDR-IR-VESTA-SPECTRA-V1.0"
PRODUCT_ID = "VIR_IR_1A_1_369819195"
PRODUCT_TYPE = EDR
PRODUCER_FULL_NAME = "A. CORADINI"
PRODUCER_INSTITUTION_NAME = "ISTITUTO NAZIONALE DI ASTROFISICA"
PRODUCT_CREATION_TIME = 2014-01-02T14:26:40.300
PRODUCT_VERSION_ID = "02"

/* File Information */
RECORD_TYPE = FIXED_LENGTH
RECORD_BYTES = 512
FILE_RECORDS = 26784
LABEL_RECORDS = 46

/* Time Information */
START_TIME = 2011-09-20T19:32:08.774
STOP_TIME = 2011-09-20T19:42:18.516
IMAGE_MID_TIME = 2011-09-20T19:37:13.645
SPACECRAFT_CLOCK_START_COUNT = "1/369819194.8588"
SPACECRAFT_CLOCK_STOP_COUNT = "1/369819804.6010"

/* Mission description parameters */
INSTRUMENT_HOST_NAME = "DAWN"
INSTRUMENT_HOST_ID = "DAWN"
MISSION_PHASE_NAME = "VESTA TRANSFER TO HAMO (VTH)"

/* Instrument description parameters */
INSTRUMENT_NAME = "VISIBLE AND INFRARED SPECTROMETER"
INSTRUMENT_ID = "VIR"
INSTRUMENT_TYPE = "IMAGING SPECTROMETER"
DESCRIPTION = "Geometrical data use the Claudia Double-Prime
coordinate system. For further information please refer to the coordinate
system document in the Document directory"

/* Celestial Geometry                                      */
RIGHT_ASCENSION                = 294.982 <degrees>
DECLINATION                    = -45.862 <degrees>
TWIST_ANGLE                    = 212.773 <degrees>
CELESTIAL_NORTH_CLOCK_ANGLE    = 327.227 <degrees>
QUATERNION                     = (  0.18145,
                                   -0.06296,
                                   -0.92459,
                                    0.32901 )
QUATERNION_DESC                = "
     Above parameters are calculated at the center time of the observation
```

```
     which is 2011-09-20T19:37:13.645.  The quaternion has the form:
     w, x, y, z (i.e. SPICE format)."

/* Solar geometry                                             */
SPACECRAFT_SOLAR_DISTANCE        =   341460541.0 <km>
SC_SUN_POSITION_VECTOR           = ( -282638804.9 <km>,
                                      162420911.9 <km>,
                                      101636875.2 <km> )

SC_SUN_VELOCITY_VECTOR           = ( -12.248 <km/s>,
                                     -15.261 <km/s>,
                                      -4.342 <km/s> )

/* SPICE Kernels                                              */
SPICE_FILE_NAME                  = "DAWN_VTH_R02.TM"

TARGET_NAME                      = "4 VESTA"
TARGET_TYPE                      = "ASTEROID"

/* COORDINATE SYSTEM                                          */
COORDINATE_SYSTEM_NAME           = "VESTA_FIXED"
COORDINATE_SYSTEM_CENTER_NAME    = "4 VESTA"

/* Geometry in "VESTA_FIXED" coordinates from SPICE           */
SUB_SPACECRAFT_LATITUDE          =  -4.168 <degrees>
SUB_SPACECRAFT_LONGITUDE         =  254.994 <degrees>
SUB_SPACECRAFT_AZIMUTH           = 139.951 <degrees>
SPACECRAFT_ALTITUDE              =        667.1 <km>
TARGET_CENTER_DISTANCE           =        947.3 <km>
SC_TARGET_POSITION_VECTOR        = (        317.0 <km>,
                                           -650.3 <km>,
                                           -612.8 <km> )

SC_TARGET_VELOCITY_VECTOR        = (   0.053 <km/s>,
                                      -0.073 <km/s>,
                                       0.101 <km/s> )

LOCAL_HOUR_ANGLE                 = 147.408 <degrees>
SUB_SOLAR_LATITUDE               = -27.351 <degrees>
SUB_SOLAR_LONGITUDE              =  287.585 <degrees>
SUB_SOLAR_AZIMUTH                = 108.928 <degrees>

/* Illumination                                               */
INCIDENCE_ANGLE                  =  31.075 <degrees>
EMISSION_ANGLE                   =  16.426 <degrees>
PHASE_ANGLE                      =  40.769 <degrees>

/* Image parameters                                           */
SLANT_DISTANCE                   =        673.1 <km>
MINIMUM_LATITUDE                 = -17.882 <degrees>
CENTER_LATITUDE                  = -11.818 <degrees>
MAXIMUM_LATITUDE                 =  -6.141 <degrees>
WESTERNMOST_LONGITUDE            =  263.691 <degrees>
CENTER_LONGITUDE                 =  254.711 <degrees>
EASTERNMOST_LONGITUDE            =  245.728 <degrees>
HORIZONTAL_PIXEL_SCALE           =   168.286 <m/pixel>
VERTICAL_PIXEL_SCALE             =   168.286 <m/pixel>
NORTH_AZIMUTH                    = 136.862 <degrees>
ORBIT_NUMBER                     = "N/A"

/* Data description parameters */
PROCESSING_LEVEL_ID = "2"
DATA_QUALITY_ID = "1"
```

```
DATA_QUALITY_DESC = "0:INCOMPLETE; 1:COMPLETE"
TELEMETRY_SOURCE_ID = "EGSE"
CHANNEL_ID = "IR"
SOFTWARE_VERSION_ID = "EGSE V1.14,AMDLSpace"

/* Instrument status */
INSTRUMENT_MODE_ID = "S_H_SPE_H_SPA_F"
INSTRUMENT_MODE_DESC =
 "S_H_SPE_H_SPA_F: Science, high spectral high spatial, Full slit
  S_H_SPE_L_SPA_F: Science, high spectral low spatial, Full slit
  S_H_SPE_L_SPA_F_SUM: Science, high spectral low spatial, Summing
  S_L_SPE_H_SPA_F: Science, Low spectral high spatial, Full slit
  S_L_SPE_L_SPA_F: Science, Low spectral low spatial, Full slit
  S_L_SPE_L_SPA_F_SUM: Science, Low spectral low spatial, Summing
  S_H_SPE_H_SPA_Q: Science, high spectral high spatial, Quarter slit
  S_L_SPE_H_SPA_Q: Science, low spectral high spatial, Quarter slit
  S_H_SPE_L_SPA_F_MEA: Science, high spectral low spatial, Meaning
  S_L_SPE_L_SPA_F_MEA: Science, low spectral low spatial, Meaning
  C_H_SPE_H_SPA_F: Calibration, high spectral high spatial, Full slit
  C_H_SPE_L_SPA_F: Calibration, high spectral low spatial, Full slit
  SPARE: CALIBRATION Spare
  C_L_SPE_H_SPA_F: Calibration, low spectral high spatial, Full slit
  C_L_SPE_L_SPA_F: Calibration, low spectral low spatial, Full slit
  C_H_SPE_H_SPA_Q: Calibration, high spectral high spatial, Quarter slit
  C_L_SPE_H_SPA_Q: Calibration, low spectral high spatial, Quarter slit"
ENCODING_TYPE = "N/A"
SCAN_MODE_ID = "4"
DAWN:SCAN_PARAMETER = (-3.7, -3.7, 4500, 60)
SCAN_PARAMETER_DESC = ("SCAN_START_ANGLE", "SCAN_STOP_ANGLE",
 "SCAN_STEP_ANGLE","SCAN_STEP_NUMBER")
DAWN:SCAN_PARAMETER_UNIT = ("DEGREES", "DEGREES", "DEGREES", "DIMENSIONLESS")
FRAME_PARAMETER = (0.7, 1, 10, 59)
FRAME_PARAMETER_DESC = ("EXPOSURE_DURATION", "FRAME_SUMMING",
"EXTERNAL_REPETITION_TIME", "DARK_ACQUISITION_RATE")
DAWN:FRAME_PARAMETER_UNIT = ("S", "DIMENSIONLESS", "S", "DIMENSIONLESS")
DAWN:VIR_IR_START_X_POSITION=1
DAWN:VIR_IR_START_Y_POSITION=7
MAXIMUM_INSTRUMENT_TEMPERATURE = (80.5, 138.6, 138.6, 74.6)
INSTRUMENT_TEMPERATURE_POINT = ("FOCAL_PLANE", "TELESCOPE", "SPECTROMETER",
"CRYOCOOLER")
DAWN:INSTRUMENT_TEMPERATURE_UNIT = ("K", "K", "K", "K")
PHOTOMETRIC_CORRECTION_TYPE = "NONE"

/* Pointers to first record of objects in file */
^HISTORY = 48
OBJECT = HISTORY
END_OBJECT = HISTORY
^QUBE = "VIR_IR_1A_1_369819195_2.QUB"

/* Description of the object contained in the file */
OBJECT = QUBE

/*    Standard cube Keywords */
 AXES = 3
 AXIS_NAME = (BAND, SAMPLE, LINE)
 CORE_ITEMS = ( 432, 256, 62 )
 CORE_ITEM_BYTES = 2
 CORE_ITEM_TYPE = MSB_INTEGER
 CORE_BASE = 0.0
 CORE_MULTIPLIER = 1.0
 CORE_VALID_MINIMUM = 0
 CORE_NULL = -32768
 CORE_LOW_REPR_SATURATION = -32767
```

```
 CORE_LOW_INSTR_SATURATION = -32767
 CORE_HIGH_REPR_SATURATION = -32767
 CORE_HIGH_INSTR_SATURATION = -32767
 CORE_NAME = "RAW DATA NUMBER"
 CORE_UNIT = DIMENSIONLESS

/*  Suffix definition */
 SUFFIX_BYTES = 4
 SUFFIX_ITEMS = (    0,    0,    0)

/* Spectral axis description */

   GROUP = BAND_BIN

   BAND_BIN_CENTER =
(1.021,1.030,1.040,1.049,1.059,1.068,1.078,1.087,1.096,1.106,1.115,1.125,
1.134,1.144,1.153,1.163,1.172,1.182,1.191,1.200,1.210,1.219,1.229,1.238,
1.248,1.257,1.267,1.276,1.286,1.295,1.305,1.314,1.323,1.333,1.342,1.352,
1.361,1.371,1.380,1.390,1.399,1.409,1.418,1.428,1.437,1.446,1.456,1.465,
1.475,1.484,1.494,1.503,1.513,1.522,1.532,1.541,1.550,1.560,1.569,1.579,
1.588,1.598,1.607,1.617,1.626,1.636,1.645,1.655,1.664,1.673,1.683,1.692,
1.702,1.711,1.721,1.730,1.740,1.749,1.759,1.768,1.777,1.787,1.796,1.806,
1.815,1.825,1.834,1.844,1.853,1.863,1.872,1.882,1.891,1.900,1.910,1.919,
1.929,1.938,1.948,1.957,1.967,1.976,1.986,1.995,2.005,2.014,2.023,2.033,
2.042,2.052,2.061,2.071,2.080,2.090,2.099,2.109,2.118,2.127,2.137,2.146,
2.156,2.165,2.175,2.184,2.194,2.203,2.213,2.222,2.232,2.241,2.250,2.260,
2.269,2.279,2.288,2.298,2.307,2.317,2.326,2.336,2.345,2.355,2.364,2.373,
2.383,2.392,2.402,2.411,2.421,2.430,2.440,2.449,2.459,2.468,2.477,2.487,
2.496,2.506,2.515,2.525,2.534,2.544,2.553,2.563,2.572,2.582,2.591,2.600,
2.610,2.619,2.629,2.638,2.648,2.657,2.667,2.676,2.686,2.695,2.705,2.714,
2.723,2.733,2.742,2.752,2.761,2.771,2.780,2.790,2.799,2.809,2.818,2.827,
2.837,2.846,2.856,2.865,2.875,2.884,2.894,2.903,2.913,2.922,2.932,2.941,
2.950,2.960,2.969,2.979,2.988,2.998,3.007,3.017,3.026,3.036,3.045,3.055,
3.064,3.073,3.083,3.092,3.102,3.111,3.121,3.130,3.140,3.149,3.159,3.168,
3.177,3.187,3.196,3.206,3.215,3.225,3.234,3.244,3.253,3.263,3.272,3.282,
3.291,3.300,3.310,3.319,3.329,3.338,3.348,3.357,3.367,3.376,3.386,3.395,
3.405,3.414,3.423,3.433,3.442,3.452,3.461,3.471,3.480,3.490,3.499,3.509,
3.518,3.527,3.537,3.546,3.556,3.565,3.575,3.584,3.594,3.603,3.613,3.622,
3.632,3.641,3.650,3.660,3.669,3.679,3.688,3.698,3.707,3.717,3.726,3.736,
3.745,3.754,3.764,3.773,3.783,3.792,3.802,3.811,3.821,3.830,3.840,3.849,
3.859,3.868,3.877,3.887,3.896,3.906,3.915,3.925,3.934,3.944,3.953,3.963,
3.972,3.982,3.991,4.000,4.010,4.019,4.029,4.038,4.048,4.057,4.067,4.076,
4.086,4.095,4.104,4.114,4.123,4.133,4.142,4.152,4.161,4.171,4.180,4.190,
4.199,4.209,4.218,4.227,4.237,4.246,4.256,4.265,4.275,4.284,4.294,4.303,
4.313,4.322,4.332,4.341,4.350,4.360,4.369,4.379,4.388,4.398,4.407,4.417,
4.426,4.436,4.445,4.454,4.464,4.473,4.483,4.492,4.502,4.511,4.521,4.530,
4.540,4.549,4.559,4.568,4.577,4.587,4.596,4.606,4.615,4.625,4.634,4.644,
4.653,4.663,4.672,4.682,4.691,4.700,4.710,4.719,4.729,4.738,4.748,4.757,
4.767,4.776,4.786,4.795,4.804,4.814,4.823,4.833,4.842,4.852,4.861,4.871,
4.880,4.890,4.899,4.909,4.918,4.927,4.937,4.946,4.956,4.965,4.975,4.984,
4.994,5.003,5.013,5.022,5.032,5.041,5.050,5.060,5.069,5.079,5.088,5.098)

     BAND_BIN_WIDTH  =
(0.0140,0.0140,0.0140,0.0140,0.0140,0.0140,0.0140,0.0140,0.0140,0.0139,
0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,
0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0138,0.0138,0.0138,
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0.0126,0.0126,0.0126,0.0126,0.0126,0.0126,0.0125,0.0125,0.0125,0.0125,0.0125,
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0.0158,0.0159,0.0159,0.0160,0.0160,0.0161,0.0162,0.0162,0.0163,0.0163,0.0164,
0.0164,0.0165,0.0165,0.0166,0.0167,0.0167,0.0168,0.0168,0.0169,0.0169,0.0170,
0.0171,0.0171,0.0172,0.0172,0.0173,0.0173,0.0174,0.0175,0.0175,0.0176,0.0176,
0.0177,0.0178,0.0178,0.0179,0.0180,0.0180,0.0181,0.0181,0.0182,0.0183,0.0183,
0.0184,0.0185,0.0185,0.0186)

 BAND_BIN_UNIT = MICROMETER

    BAND_BIN_ORIGINAL_BAND =
(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,
 29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,
 54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,
 79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100,101,102,
103,104,105,106,107,108,109,110,111,112,113,114,115,116,117,118,119,120,121,
122,123,124,125,126,127,128,129,130,131,132,133,134,135,136,137,138,139,140,
141,142,143,144,145,146,147,148,149,150,151,152,153,154,155,156,157,158,159,
160,161,162,163,164,165,166,167,168,169,170,171,172,173,174,175,176,177,178,
179,180,181,182,183,184,185,186,187,188,189,190,191,192,193,194,195,196,197,
198,199,200,201,202,203,204,205,206,207,208,209,210,211,212,213,214,215,216,
217,218,219,220,221,222,223,224,225,226,227,228,229,230,231,232,233,234,235,
236,237,238,239,240,241,242,243,244,245,246,247,248,249,250,251,252,253,254,
255,256,257,258,259,260,261,262,263,264,265,266,267,268,269,270,271,272,273,
274,275,276,277,278,279,280,281,282,283,284,285,286,287,288,289,290,291,292,
293,294,295,296,297,298,299,300,301,302,303,304,305,306,307,308,309,310,311,
312,313,314,315,316,317,318,319,320,321,322,323,324,325,326,327,328,329,330,
331,332,333,334,335,336,337,338,339,340,341,342,343,344,345,346,347,348,349,
350,351,352,353,354,355,356,357,358,359,360,361,362,363,364,365,366,367,368,
369,370,371,372,373,374,375,376,377,378,379,380,381,382,383,384,385,386,387,
388,389,390,391,392,393,394,395,396,397,398,399,400,401,402,403,404,405,406,
407,408,409,410,411,412,413,414,415,416,417,418,419,420,421,422,423,424,425,
426,427,428,429,430,431,432)

END_GROUP = BAND_BIN

END_OBJECT                     = QUBE
END

OBJECT = HISTORY
```

```
END_OBJECT = HISTORY
```

Here follows the detached label of the file containing the housekeeping information related to the IR qube with the filename *VIR_IR_1A_1_369819195_2.QUB*. The file with the housekeeping information is named *"VIR_IR_1A_1_369819195_HK_2.TAB"*.

```
PDS_VERSION_ID                 = "PDS3"
DATA_SET_ID                    = "DAWN-A-VIR-2-EDR-IR-VESTA-SPECTRA-V1.0"
PRODUCT_ID                     = "VIR_IR_1A_1_369819195_HK"
PRODUCT_TYPE                   = "ENGINEERING_DATA"
PRODUCT_VERSION_ID             = "02"
PRODUCT_CREATION_TIME          = 2014-01-02T14:26:40.300

RECORD_TYPE                    = FIXED_LENGTH
RECORD_BYTES                   = 288
FILE_RECORDS                   = 62

START_TIME                     = 2011-09-20T19:32:08.774
STOP_TIME                      = 2011-09-20T19:42:18.516
SPACECRAFT_CLOCK_START_COUNT   = "1/369819194.8588"
SPACECRAFT_CLOCK_STOP_COUNT    = "1/369819804.6010"

INSTRUMENT_HOST_NAME           = "DAWN"
INSTRUMENT_HOST_ID             = "DAWN"
MISSION_PHASE_NAME             = "VESTA TRANSFER TO HAMO (VTH)"
TARGET_NAME                    = "4 VESTA"
INSTRUMENT_NAME                = "VISIBLE AND INFRARED SPECTROMETER"
INSTRUMENT_ID                  = "VIR"
DESCRIPTION                    = ""

^TABLE                         = "VIR_IR_1A_1_369819195_HK_2.TAB"
OBJECT                         = TABLE
  INTERCHANGE_FORMAT           = ASCII
  ROWS                         = 62
  COLUMNS                      = 33
  ROW_BYTES                    = 288
  DESCRIPTION                  = ""

  OBJECT                       = COLUMN
    NAME                       = "VERSION, TYPE, SECONDARY HEADER FLAG"
    COLUMN_NUMBER              = 1
    UNIT                       = "N/A"
    DATA_TYPE                  = ASCII_INTEGER
    START_BYTE                 = 1
    BYTES                      = 2
    DESCRIPTION                = ""
  END_OBJECT                   = COLUMN

  OBJECT                       = COLUMN
    NAME                       = "APID"
    COLUMN_NUMBER              = 2
    UNIT                       = "N/A"
    DATA_TYPE                  = ASCII_INTEGER
    START_BYTE                 = 4
    BYTES                      = 3
```

```
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "PACKET SEQUENCE CONTROL"
  COLUMN_NUMBER               = 3
  UNIT                        = "N/A"
  DATA_TYPE                   = ASCII_INTEGER
  START_BYTE                  = 8
  BYTES                       = 5
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "PACKETS LENGTH"
  COLUMN_NUMBER               = 4
  UNIT                        = "N/A"
  DATA_TYPE                   = ASCII_INTEGER
  START_BYTE                  = 14
  BYTES                       = 4
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "SCET TIME (CLOCK)"
  COLUMN_NUMBER               = 5
  UNIT                        = "N/A"
  DATA_TYPE                   = ASCII_REAL
  START_BYTE                  = 19
  BYTES                       = 12
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "FRAME NUMBER"
  COLUMN_NUMBER               = 6
  UNIT                        = "N/A"
  DATA_TYPE                   = ASCII_INTEGER
  START_BYTE                  = 34
  BYTES                       = 3
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "FRAME COUNT"
  COLUMN_NUMBER               = 7
  UNIT                        = "N/A"
  DATA_TYPE                   = ASCII_INTEGER
  START_BYTE                  = 38
  BYTES                       = 3
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "SUBFRAME COUNT"
  COLUMN_NUMBER               = 8
  UNIT                        = "N/A"
  DATA_TYPE                   = ASCII_INTEGER
  START_BYTE                  = 42
  BYTES                       = 2
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN
```

```
OBJECT                        = COLUMN
  NAME                        = "PACKETS COUNT"
  COLUMN_NUMBER               = 9
  UNIT                        = "N/A"
  DATA_TYPE                   = ASCII_INTEGER
  START_BYTE                  = 45
  BYTES                       = 2
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "SHUTTER STATUS"
  COLUMN_NUMBER               = 10
  UNIT                        = "N/A"
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 48
  BYTES                       = 8
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "CHANNEL ID"
  COLUMN_NUMBER               = 11
  UNIT                        = "N/A"
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 57
  BYTES                       = 3
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "COMPRESSION MODE"
  COLUMN_NUMBER               = 12
  UNIT                        = "N/A"
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 61
  BYTES                       = 20
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "SPECTRAL RANGE"
  COLUMN_NUMBER               = 13
  UNIT                        = "N/A"
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 82
  BYTES                       = 24
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "CURRENT MODE"
  COLUMN_NUMBER               = 14
  UNIT                        = "N/A"
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 107
  BYTES                       = 12
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "CURRENT SUBMODE"
  COLUMN_NUMBER               = 15
```

```
  UNIT                        = "N/A"
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 120
  BYTES                       = 14
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "IR EXPO"
  COLUMN_NUMBER               = 16
  UNIT                        = "S"
  DATA_TYPE                   = ASCII_REAL
  START_BYTE                  = 135
  BYTES                       = 10
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "IR TEMP"
  COLUMN_NUMBER               = 17
  UNIT                        = "K"
  DATA_TYPE                   = ASCII_REAL
  START_BYTE                  = 146
  BYTES                       = 10
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "CCD EXPO"
  COLUMN_NUMBER               = 18
  UNIT                        = "S"
  DATA_TYPE                   = ASCII_REAL
  START_BYTE                  = 157
  BYTES                       = 10
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "CCD TEMP"
  COLUMN_NUMBER               = 19
  UNIT                        = "K"
  DATA_TYPE                   = ASCII_REAL
  START_BYTE                  = 168
  BYTES                       = 10
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "MIRROR SIN"
  COLUMN_NUMBER               = 20
  UNIT                        = "DIMENSIONLESS"
  DATA_TYPE                   = ASCII_REAL
  START_BYTE                  = 179
  BYTES                       = 10
  DESCRIPTION                 = ""
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = "MIRROR COS"
  COLUMN_NUMBER               = 21
  UNIT                        = "DIMENSIONLESS"
  DATA_TYPE                   = ASCII_REAL
  START_BYTE                  = 190
```

```
  BYTES                     = 10
  DESCRIPTION               = ""
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
  NAME                      = "SPECT TEMP"
  COLUMN_NUMBER             = 22
  UNIT                      = "K"
  DATA_TYPE                 = ASCII_REAL
  START_BYTE                = 201
  BYTES                     = 10
  DESCRIPTION               = ""
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
  NAME                      = "TELE TEMP"
  COLUMN_NUMBER             = 23
  UNIT                      = "K"
  DATA_TYPE                 = ASCII_REAL
  START_BYTE                = 212
  BYTES                     = 10
  DESCRIPTION               = ""
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
  NAME                      = "COLD TIP TEMP"
  COLUMN_NUMBER             = 24
  UNIT                      = "K"
  DATA_TYPE                 = ASCII_REAL
  START_BYTE                = 223
  BYTES                     = 10
  DESCRIPTION               = ""
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
  NAME                      = "RADIATOR TEMP"
  COLUMN_NUMBER             = 25
  UNIT                      = "K"
  DATA_TYPE                 = ASCII_REAL
  START_BYTE                = 234
  BYTES                     = 10
  DESCRIPTION               = ""
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
  NAME                      = "SU MOTOR CURR"
  COLUMN_NUMBER             = 26
  UNIT                      = "A"
  DATA_TYPE                 = ASCII_REAL
  START_BYTE                = 245
  BYTES                     = 10
  DESCRIPTION               = ""
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
  NAME                      = "LEDGE TEMP"
  COLUMN_NUMBER             = 27
  UNIT                      = "K"
  DATA_TYPE                 = ASCII_REAL
  START_BYTE                = 256
  BYTES                     = 10
  DESCRIPTION               = ""
END_OBJECT                  = COLUMN
```

```
  OBJECT                        = COLUMN
    NAME                        = "START NOISY BITS"
    COLUMN_NUMBER               = 28
    UNIT                        = "N/A"
    DATA_TYPE                   = ASCII_INTEGER
    START_BYTE                  = 267
    BYTES                       = 2
    DESCRIPTION                 = ""
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    NAME                        = "END NOISY BITS"
    COLUMN_NUMBER               = 29
    UNIT                        = "N/A"
    DATA_TYPE                   = ASCII_INTEGER
    START_BYTE                  = 270
    BYTES                       = 2
    DESCRIPTION                 = ""
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    NAME                        = "CR ROW"
    COLUMN_NUMBER               = 30
    UNIT                        = "N/A"
    DATA_TYPE                   = ASCII_INTEGER
    START_BYTE                  = 273
    BYTES                       = 2
    DESCRIPTION                 = ""
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    NAME                        = "NOF NOISY BITS"
    COLUMN_NUMBER               = 31
    UNIT                        = "N/A"
    DATA_TYPE                   = ASCII_INTEGER
    START_BYTE                  = 276
    BYTES                       = 2
    DESCRIPTION                 = ""
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    NAME                        = "SUBFRAME DATA"
    COLUMN_NUMBER               = 32
    UNIT                        = "N/A"
    DATA_TYPE                   = ASCII_INTEGER
    START_BYTE                  = 279
    BYTES                       = 5
    DESCRIPTION                 = ""
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    NAME                        = "SEQ STEP"
    COLUMN_NUMBER               = 33
    UNIT                        = "N/A"
    DATA_TYPE                   = ASCII_INTEGER
    START_BYTE                  = 285
    BYTES                       = 2
    DESCRIPTION                 = ""
  END_OBJECT                    = COLUMN
END_OBJECT                      = TABLE
END
```

Data Product Labels: RDR data

Here follows the detached label of the RDR qube called : *VIR_IR_1B_1_369819195_2.QUB*

```
PDS_VERSION_ID = PDS3
LABEL_REVISION_NOTE = "MTC_11-10-2011"

/* Dataset and Product Information */
DATA_SET_NAME = "DAWN VIR CAL (RDR) VESTA INFRARED SPECTRA V1.0"
DATA_SET_ID = "DAWN-A-VIR-3-RDR-IR-VESTA-SPECTRA-V1.0"
PRODUCT_ID = "VIR_IR_1B_1_369819195"
PRODUCT_TYPE = RDR
PRODUCER_FULL_NAME = "A. CORADINI"
PRODUCER_INSTITUTION_NAME = "ISTITUTO NAZIONALE DI ASTROFISICA"
PRODUCT_CREATION_TIME = 2014-02-04T10:28:31.476
PRODUCT_VERSION_ID = "02"

/* File Information */
RECORD_TYPE = FIXED_LENGTH
RECORD_BYTES = 512
FILE_RECORDS = 49
LABEL_RECORDS = 48

/* Time Information */
START_TIME = 2011-09-20T19:32:08.774
STOP_TIME = 2011-09-20T19:42:18.516
IMAGE_MID_TIME = 2011-09-20T19:37:13.645
SPACECRAFT_CLOCK_START_COUNT = "1/369819194.8588"
SPACECRAFT_CLOCK_STOP_COUNT = "1/369819804.6010"

/* Mission description parameters */
INSTRUMENT_HOST_NAME = "DAWN"
INSTRUMENT_HOST_ID = "DAWN"
MISSION_PHASE_NAME = "VESTA TRANSFER TO HAMO (VTH)"

/* Instrument description parameters */
INSTRUMENT_NAME = "VISIBLE AND INFRARED SPECTROMETER"
INSTRUMENT_ID = "VIR"
INSTRUMENT_TYPE = "IMAGING SPECTROMETER"
DESCRIPTION = "Geometrical data use the Claudia Double-Prime
coordinate system. For further information please refer to the coordinate
system document in the Document directory"

/* Celestial Geometry                                          */
RIGHT_ASCENSION                  =  294.982 <degrees>
DECLINATION                      =  -45.862 <degrees>
TWIST_ANGLE                      =  212.773 <degrees>
CELESTIAL_NORTH_CLOCK_ANGLE      =  327.227 <degrees>
QUATERNION                       = (  0.18145,
                                     -0.06296,
                                     -0.92459,
                                      0.32901 )
QUATERNION_DESC                  = "
     Above parameters are calculated at the center time of the observation
     which is 2011-09-20T19:37:13.645.  The quaternion has the form:
     w, x, y, z (i.e. SPICE format)."

/* Solar geometry                                              */
SPACECRAFT_SOLAR_DISTANCE        =   341460541.0 <km>
SC_SUN_POSITION_VECTOR           = ( -282638804.9 <km>,
                                      162420911.9 <km>,
```

```
                                     101636875.2 <km> )

SC_SUN_VELOCITY_VECTOR           = ( -12.248 <km/s>,
                                    -15.261 <km/s>,
                                     -4.342 <km/s> )

/* SPICE Kernels                                            */
SPICE_FILE_NAME                  = "DAWN_VTH_R02.TM"

TARGET_NAME                      = "4 VESTA"
TARGET_TYPE                      = "ASTEROID"

/* COORDINATE SYSTEM                                        */
COORDINATE_SYSTEM_NAME           = "VESTA_FIXED"
COORDINATE_SYSTEM_CENTER_NAME    = "4 VESTA"

/* Geometry in "VESTA_FIXED" coordinates from SPICE         */
SUB_SPACECRAFT_LATITUDE          =  -4.168 <degrees>
SUB_SPACECRAFT_LONGITUDE         =  254.994 <degrees>
SUB_SPACECRAFT_AZIMUTH           = 139.951 <degrees>
SPACECRAFT_ALTITUDE              =         667.1 <km>
TARGET_CENTER_DISTANCE           =         947.3 <km>
SC_TARGET_POSITION_VECTOR        = (         317.0 <km>,
                                          -650.3 <km>,
                                          -612.8 <km> )

SC_TARGET_VELOCITY_VECTOR        = (   0.053 <km/s>,
                                     -0.073 <km/s>,
                                      0.101 <km/s> )

LOCAL_HOUR_ANGLE                 = 147.408 <degrees>
SUB_SOLAR_LATITUDE               = -27.351 <degrees>
SUB_SOLAR_LONGITUDE              =  287.585 <degrees>
SUB_SOLAR_AZIMUTH                = 108.928 <degrees>

/* Illumination                                             */
INCIDENCE_ANGLE                  =  31.075 <degrees>
EMISSION_ANGLE                   =  16.426 <degrees>
PHASE_ANGLE                      =  40.769 <degrees>

/* Image parameters                                         */
SLANT_DISTANCE                   =         673.1 <km>
MINIMUM_LATITUDE                 = -17.882 <degrees>
CENTER_LATITUDE                  = -11.818 <degrees>
MAXIMUM_LATITUDE                 =  -6.141 <degrees>
WESTERNMOST_LONGITUDE            =  263.691 <degrees>
CENTER_LONGITUDE                 =  254.711 <degrees>
EASTERNMOST_LONGITUDE            =  245.728 <degrees>
HORIZONTAL_PIXEL_SCALE           =   168.286 <m/pixel>
VERTICAL_PIXEL_SCALE             =   168.286 <m/pixel>
NORTH_AZIMUTH                    = 136.862 <degrees>
ORBIT_NUMBER                     = "N/A"

/* Data description parameters */
PROCESSING_LEVEL_ID = "3"
DATA_QUALITY_ID = "1"
DATA_QUALITY_DESC = "0:INCOMPLETE; 1:COMPLETE"
TELEMETRY_SOURCE_ID = "EGSE"
CHANNEL_ID = "IR"
SOFTWARE_VERSION_ID = "VIR Calibration 2.0"

/* Instrument status */
INSTRUMENT_MODE_ID = "S_H_SPE_H_SPA_F"
```

```
INSTRUMENT_MODE_DESC =
 "S_H_SPE_H_SPA_F: Science, high spectral high spatial, Full slit
  S_H_SPE_L_SPA_F: Science, high spectral low spatial, Full slit
  S_H_SPE_L_SPA_F_SUM: Science, high spectral low spatial, Summing
  S_L_SPE_H_SPA_F: Science, Low spectral high spatial, Full slit
  S_L_SPE_L_SPA_F: Science, Low spectral low spatial, Full slit
  S_L_SPE_L_SPA_F_SUM: Science, Low spectral low spatial, Summing
  S_H_SPE_H_SPA_Q: Science, high spectral high spatial, Quarter slit
  S_L_SPE_H_SPA_Q: Science, low spectral high spatial, Quarter slit
  S_H_SPE_L_SPA_F_MEA: Science, high spectral low spatial, Meaning
  S_L_SPE_L_SPA_F_MEA: Science, low spectral low spatial, Meaning
  C_H_SPE_H_SPA_F: Calibration, high spectral high spatial, Full slit
  C_H_SPE_L_SPA_F: Calibration, high spectral low spatial, Full slit
  SPARE: CALIBRATION Spare
  C_L_SPE_H_SPA_F: Calibration, low spectral high spatial, Full slit
  C_L_SPE_L_SPA_F: Calibration, low spectral low spatial, Full slit
  C_H_SPE_H_SPA_Q: Calibration, high spectral high spatial, Quarter slit
  C_L_SPE_H_SPA_Q: Calibration, low spectral high spatial, Quarter slit"
ENCODING_TYPE = "N/A"
SCAN_MODE_ID = "4"
DAWN:SCAN_PARAMETER = (-3.7, -3.7, 4500, 60)
SCAN_PARAMETER_DESC = ("SCAN_START_ANGLE", "SCAN_STOP_ANGLE",
 "SCAN_STEP_ANGLE","SCAN_STEP_NUMBER")
DAWN:SCAN_PARAMETER_UNIT = ("DEGREES", "DEGREES", "DEGREES", "DIMENSIONLESS")
FRAME_PARAMETER = (0.7, 1, 10, 59)
FRAME_PARAMETER_DESC = ("EXPOSURE_DURATION", "FRAME_SUMMING",
"EXTERNAL_REPETITION_TIME", "DARK_ACQUISITION_RATE")
DAWN:FRAME_PARAMETER_UNIT = ("S", "DIMENSIONLESS", "S", "DIMENSIONLESS")
DAWN:VIR_IR_START_X_POSITION=1
DAWN:VIR_IR_START_Y_POSITION=7
MAXIMUM_INSTRUMENT_TEMPERATURE = (80.5, 138.6, 138.6, 74.6)
INSTRUMENT_TEMPERATURE_POINT = ("FOCAL_PLANE", "TELESCOPE", "SPECTROMETER",
"CRYOCOOLER")
DAWN:INSTRUMENT_TEMPERATURE_UNIT = ("K", "K", "K", "K")
PHOTOMETRIC_CORRECTION_TYPE = "NONE"

/* Pointers to first record of objects in file */
^HISTORY = 49
OBJECT = HISTORY
END_OBJECT = HISTORY
^QUBE = "VIR_IR_1B_1_369819195_2.QUB"
NOTE = "ITF used for this file is DAWN_VIR_IR_RESP_V1.DAT"

/* Description of the object contained in the file */
OBJECT = QUBE

/*    Standard cube Keywords */
 AXES = 3
 AXIS_NAME = (BAND, SAMPLE, LINE)
CORE_ITEMS= (432, 256, 60)
 CORE_ITEM_BYTES = 4
 CORE_ITEM_TYPE = "IEEE_REAL"
 CORE_BASE = 0.0
 CORE_MULTIPLIER = 1.0
 CORE_VALID_MINIMUM = 0
 CORE_NULL = -32768
 CORE_LOW_REPR_SATURATION = -32767
 CORE_LOW_INSTR_SATURATION = -32767
 CORE_HIGH_REPR_SATURATION = -32767
 CORE_HIGH_INSTR_SATURATION = -32767
 CORE_NAME = "SPECTRAL RADIANCE"
 CORE_UNIT = "W/(m**2*sr*micron)"
```

```
/*  Suffix definition */
 SUFFIX_BYTES = 4
 SUFFIX_ITEMS = (    0,   0,    0)

/* Spectral axis description */

    GROUP = BAND_BIN

    BAND_BIN_CENTER =
(1.021,1.030,1.040,1.049,1.059,1.068,1.078,1.087,1.096,1.106,1.115,1.125,
1.134,1.144,1.153,1.163,1.172,1.182,1.191,1.200,1.210,1.219,1.229,1.238,
1.248,1.257,1.267,1.276,1.286,1.295,1.305,1.314,1.323,1.333,1.342,1.352,
1.361,1.371,1.380,1.390,1.399,1.409,1.418,1.428,1.437,1.446,1.456,1.465,
1.475,1.484,1.494,1.503,1.513,1.522,1.532,1.541,1.550,1.560,1.569,1.579,
1.588,1.598,1.607,1.617,1.626,1.636,1.645,1.655,1.664,1.673,1.683,1.692,
1.702,1.711,1.721,1.730,1.740,1.749,1.759,1.768,1.777,1.787,1.796,1.806,
1.815,1.825,1.834,1.844,1.853,1.863,1.872,1.882,1.891,1.900,1.910,1.919,
1.929,1.938,1.948,1.957,1.967,1.976,1.986,1.995,2.005,2.014,2.023,2.033,
2.042,2.052,2.061,2.071,2.080,2.090,2.099,2.109,2.118,2.127,2.137,2.146,
2.156,2.165,2.175,2.184,2.194,2.203,2.213,2.222,2.232,2.241,2.250,2.260,
2.269,2.279,2.288,2.298,2.307,2.317,2.326,2.336,2.345,2.355,2.364,2.373,
2.383,2.392,2.402,2.411,2.421,2.430,2.440,2.449,2.459,2.468,2.477,2.487,
2.496,2.506,2.515,2.525,2.534,2.544,2.553,2.563,2.572,2.582,2.591,2.600,
2.610,2.619,2.629,2.638,2.648,2.657,2.667,2.676,2.686,2.695,2.705,2.714,
2.723,2.733,2.742,2.752,2.761,2.771,2.780,2.790,2.799,2.809,2.818,2.827,
2.837,2.846,2.856,2.865,2.875,2.884,2.894,2.903,2.913,2.922,2.932,2.941,
2.950,2.960,2.969,2.979,2.988,2.998,3.007,3.017,3.026,3.036,3.045,3.055,
3.064,3.073,3.083,3.092,3.102,3.111,3.121,3.130,3.140,3.149,3.159,3.168,
3.177,3.187,3.196,3.206,3.215,3.225,3.234,3.244,3.253,3.263,3.272,3.282,
3.291,3.300,3.310,3.319,3.329,3.338,3.348,3.357,3.367,3.376,3.386,3.395,
3.405,3.414,3.423,3.433,3.442,3.452,3.461,3.471,3.480,3.490,3.499,3.509,
3.518,3.527,3.537,3.546,3.556,3.565,3.575,3.584,3.594,3.603,3.613,3.622,
3.632,3.641,3.650,3.660,3.669,3.679,3.688,3.698,3.707,3.717,3.726,3.736,
3.745,3.754,3.764,3.773,3.783,3.792,3.802,3.811,3.821,3.830,3.840,3.849,
3.859,3.868,3.877,3.887,3.896,3.906,3.915,3.925,3.934,3.944,3.953,3.963,
3.972,3.982,3.991,4.000,4.010,4.019,4.029,4.038,4.048,4.057,4.067,4.076,
4.086,4.095,4.104,4.114,4.123,4.133,4.142,4.152,4.161,4.171,4.180,4.190,
4.199,4.209,4.218,4.227,4.237,4.246,4.256,4.265,4.275,4.284,4.294,4.303,
4.313,4.322,4.332,4.341,4.350,4.360,4.369,4.379,4.388,4.398,4.407,4.417,
4.426,4.436,4.445,4.454,4.464,4.473,4.483,4.492,4.502,4.511,4.521,4.530,
4.540,4.549,4.559,4.568,4.577,4.587,4.596,4.606,4.615,4.625,4.634,4.644,
4.653,4.663,4.672,4.682,4.691,4.700,4.710,4.719,4.729,4.738,4.748,4.757,
4.767,4.776,4.786,4.795,4.804,4.814,4.823,4.833,4.842,4.852,4.861,4.871,
4.880,4.890,4.899,4.909,4.918,4.927,4.937,4.946,4.956,4.965,4.975,4.984,
4.994,5.003,5.013,5.022,5.032,5.041,5.050,5.060,5.069,5.079,5.088,5.098)

      BAND_BIN_WIDTH  =
(0.0140,0.0140,0.0140,0.0140,0.0140,0.0140,0.0140,0.0140,0.0140,0.0139,
0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,0.0139,
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```

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0.0158,0.0159,0.0159,0.0160,0.0160,0.0161,0.0162,0.0162,0.0163,0.0163,0.0164,
0.0164,0.0165,0.0165,0.0166,0.0167,0.0167,0.0168,0.0168,0.0169,0.0169,0.0170,
0.0171,0.0171,0.0172,0.0172,0.0173,0.0173,0.0174,0.0175,0.0175,0.0176,0.0176,
0.0177,0.0178,0.0178,0.0179,0.0180,0.0180,0.0181,0.0181,0.0182,0.0183,0.0183,
0.0184,0.0185,0.0185,0.0186)

 BAND_BIN_UNIT = MICROMETER

    BAND_BIN_ORIGINAL_BAND =
(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,
 29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,
 54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,
 79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100,101,102,
103,104,105,106,107,108,109,110,111,112,113,114,115,116,117,118,119,120,121,
122,123,124,125,126,127,128,129,130,131,132,133,134,135,136,137,138,139,140,
141,142,143,144,145,146,147,148,149,150,151,152,153,154,155,156,157,158,159,
160,161,162,163,164,165,166,167,168,169,170,171,172,173,174,175,176,177,178,
179,180,181,182,183,184,185,186,187,188,189,190,191,192,193,194,195,196,197,
198,199,200,201,202,203,204,205,206,207,208,209,210,211,212,213,214,215,216,
217,218,219,220,221,222,223,224,225,226,227,228,229,230,231,232,233,234,235,
236,237,238,239,240,241,242,243,244,245,246,247,248,249,250,251,252,253,254,
255,256,257,258,259,260,261,262,263,264,265,266,267,268,269,270,271,272,273,
274,275,276,277,278,279,280,281,282,283,284,285,286,287,288,289,290,291,292,
293,294,295,296,297,298,299,300,301,302,303,304,305,306,307,308,309,310,311,
312,313,314,315,316,317,318,319,320,321,322,323,324,325,326,327,328,329,330,
331,332,333,334,335,336,337,338,339,340,341,342,343,344,345,346,347,348,349,
350,351,352,353,354,355,356,357,358,359,360,361,362,363,364,365,366,367,368,
369,370,371,372,373,374,375,376,377,378,379,380,381,382,383,384,385,386,387,
388,389,390,391,392,393,394,395,396,397,398,399,400,401,402,403,404,405,406,
407,408,409,410,411,412,413,414,415,416,417,418,419,420,421,422,423,424,425,
426,427,428,429,430,431,432)

END_GROUP = BAND_BIN

END_OBJECT                     = QUBE
END

OBJECT = HISTORY




END_OBJECT = HISTORY
```

This is the detached label of the “quality qube” *VIR_VIS_1B_1_369819195_QQ_2.QUB,* associated with the qube *VIR_VIS_1B_1_369819195_2.QUB:*

```
PDS_VERSION_ID = PDS3
LABEL_REVISION_NOTE = "MTC_11-10-2011"

/* Dataset and Product Information */
DATA_SET_NAME = "DAWN VIR CAL (RDR) VESTA INFRARED SPECTRA V1.0"
DATA_SET_ID = "DAWN-A-VIR-3-RDR-IR-VESTA-SPECTRA-V1.0"
PRODUCT_ID = "VIR_IR_1B_1_369819195_QQ"
PRODUCT_TYPE = RDR
PRODUCER_FULL_NAME = "A. CORADINI"
PRODUCER_INSTITUTION_NAME = "ISTITUTO NAZIONALE DI ASTROFISICA"
PRODUCT_CREATION_TIME = 2014-02-04T10:28:31.476
PRODUCT_VERSION_ID = "02"

/* File Information */
RECORD_TYPE = FIXED_LENGTH
RECORD_BYTES = 512
FILE_RECORDS = 30
LABEL_RECORDS = 29

/* Time Information */
START_TIME = 2011-09-20T19:32:08.774
STOP_TIME = 2011-09-20T19:42:18.516
IMAGE_MID_TIME = 2011-09-20T19:37:13.645
SPACECRAFT_CLOCK_START_COUNT = "1/369819194.8588"
SPACECRAFT_CLOCK_STOP_COUNT = "1/369819804.6010"

/* Mission description parameters */
INSTRUMENT_HOST_NAME = "DAWN"
INSTRUMENT_HOST_ID = "DAWN"
MISSION_PHASE_NAME = "VESTA TRANSFER TO HAMO (VTH)"

/* Instrument description parameters */
INSTRUMENT_NAME = "VISIBLE AND INFRARED SPECTROMETER"
INSTRUMENT_ID = "VIR"
INSTRUMENT_TYPE = "IMAGING SPECTROMETER"
DESCRIPTION = "Geometrical data use the Claudia Double-Prime
coordinate system. For further information please refer to the coordinate
system document in the Document directory"

/* Celestial Geometry                                       */
RIGHT_ASCENSION                 =  294.982 <degrees>
DECLINATION                     =  -45.862 <degrees>
TWIST_ANGLE                     =  212.773 <degrees>
CELESTIAL_NORTH_CLOCK_ANGLE     =  327.227 <degrees>
QUATERNION                      = (  0.18145,
                                    -0.06296,
                                    -0.92459,
                                     0.32901 )
QUATERNION_DESC                 = "
     Above parameters are calculated at the center time of the observation
     which is 2011-09-20T19:37:13.645.  The quaternion has the form:
     w, x, y, z (i.e. SPICE format)."

/* Solar geometry                                           */
SPACECRAFT_SOLAR_DISTANCE       =   341460541.0 <km>
SC_SUN_POSITION_VECTOR          = ( -282638804.9 <km>,
                                     162420911.9 <km>,
```

```
                                       101636875.2 <km> )

SC_SUN_VELOCITY_VECTOR             = ( -12.248 <km/s>,
                                       -15.261 <km/s>,
                                        -4.342 <km/s> )

/* SPICE Kernels                                              */
SPICE_FILE_NAME                    = "DAWN_VTH_R02.TM"

TARGET_NAME                        = "4 VESTA"
TARGET_TYPE                        = "ASTEROID"

/* COORDINATE SYSTEM                                          */
COORDINATE_SYSTEM_NAME             = "VESTA_FIXED"
COORDINATE_SYSTEM_CENTER_NAME      = "4 VESTA"

/* Geometry in "VESTA_FIXED" coordinates from SPICE           */
SUB_SPACECRAFT_LATITUDE            =  -4.168 <degrees>
SUB_SPACECRAFT_LONGITUDE           =  254.994 <degrees>
SUB_SPACECRAFT_AZIMUTH             = 139.951 <degrees>
SPACECRAFT_ALTITUDE                =        667.1 <km>
TARGET_CENTER_DISTANCE             =        947.3 <km>
SC_TARGET_POSITION_VECTOR          = (        317.0 <km>,
                                             -650.3 <km>,
                                             -612.8 <km> )

SC_TARGET_VELOCITY_VECTOR          = (   0.053 <km/s>,
                                        -0.073 <km/s>,
                                         0.101 <km/s> )

LOCAL_HOUR_ANGLE                   = 147.408 <degrees>
SUB_SOLAR_LATITUDE                 = -27.351 <degrees>
SUB_SOLAR_LONGITUDE                =  287.585 <degrees>
SUB_SOLAR_AZIMUTH                  = 108.928 <degrees>

/* Illumination                                               */
INCIDENCE_ANGLE                    =  31.075 <degrees>
EMISSION_ANGLE                     =  16.426 <degrees>
PHASE_ANGLE                        =  40.769 <degrees>

/* Image parameters                                           */
SLANT_DISTANCE                     =        673.1 <km>
MINIMUM_LATITUDE                   = -17.882 <degrees>
CENTER_LATITUDE                    = -11.818 <degrees>
MAXIMUM_LATITUDE                   =  -6.141 <degrees>
WESTERNMOST_LONGITUDE              =  263.691 <degrees>
CENTER_LONGITUDE                   =  254.711 <degrees>
EASTERNMOST_LONGITUDE              =  245.728 <degrees>
HORIZONTAL_PIXEL_SCALE             =   168.286 <m/pixel>
VERTICAL_PIXEL_SCALE               =   168.286 <m/pixel>
NORTH_AZIMUTH                      = 136.862 <degrees>
ORBIT_NUMBER                       = "N/A"

/* Data description parameters */
PROCESSING_LEVEL_ID = "3"
DATA_QUALITY_ID = "1"
DATA_QUALITY_DESC = "0:INCOMPLETE; 1:COMPLETE"
TELEMETRY_SOURCE_ID = "EGSE"
CHANNEL_ID = "IR"
SOFTWARE_VERSION_ID = "VIR Calibration 2.0"

/* Instrument status */
INSTRUMENT_MODE_ID = "S_H_SPE_H_SPA_F"
```

```
INSTRUMENT_MODE_DESC =
 "S_H_SPE_H_SPA_F: Science, high spectral high spatial, Full slit
  S_H_SPE_L_SPA_F: Science, high spectral low spatial, Full slit
  S_H_SPE_L_SPA_F_SUM: Science, high spectral low spatial, Summing
  S_L_SPE_H_SPA_F: Science, Low spectral high spatial, Full slit
  S_L_SPE_L_SPA_F: Science, Low spectral low spatial, Full slit
  S_L_SPE_L_SPA_F_SUM: Science, Low spectral low spatial, Summing
  S_H_SPE_H_SPA_Q: Science, high spectral high spatial, Quarter slit
  S_L_SPE_H_SPA_Q: Science, low spectral high spatial, Quarter slit
  S_H_SPE_L_SPA_F_MEA: Science, high spectral low spatial, Meaning
  S_L_SPE_L_SPA_F_MEA: Science, low spectral low spatial, Meaning
  C_H_SPE_H_SPA_F: Calibration, high spectral high spatial, Full slit
  C_H_SPE_L_SPA_F: Calibration, high spectral low spatial, Full slit
  SPARE: CALIBRATION Spare
  C_L_SPE_H_SPA_F: Calibration, low spectral high spatial, Full slit
  C_L_SPE_L_SPA_F: Calibration, low spectral low spatial, Full slit
  C_H_SPE_H_SPA_Q: Calibration, high spectral high spatial, Quarter slit
  C_L_SPE_H_SPA_Q: Calibration, low spectral high spatial, Quarter slit"
ENCODING_TYPE = "N/A"
SCAN_MODE_ID = "4"
DAWN:SCAN_PARAMETER = (-3.7, -3.7, 4500, 60)
SCAN_PARAMETER_DESC = ("SCAN_START_ANGLE", "SCAN_STOP_ANGLE",
 "SCAN_STEP_ANGLE","SCAN_STEP_NUMBER")
DAWN:SCAN_PARAMETER_UNIT = ("DEGREES", "DEGREES", "DEGREES", "DIMENSIONLESS")
FRAME_PARAMETER = (0.7, 1, 10, 59)
FRAME_PARAMETER_DESC = ("EXPOSURE_DURATION", "FRAME_SUMMING",
"EXTERNAL_REPETITION_TIME", "DARK_ACQUISITION_RATE")
DAWN:FRAME_PARAMETER_UNIT = ("S", "DIMENSIONLESS", "S", "DIMENSIONLESS")
DAWN:VIR_IR_START_X_POSITION=1
DAWN:VIR_IR_START_Y_POSITION=7
MAXIMUM_INSTRUMENT_TEMPERATURE = (80.5, 138.6, 138.6, 74.6)
INSTRUMENT_TEMPERATURE_POINT = ("FOCAL_PLANE", "TELESCOPE", "SPECTROMETER",
"CRYOCOOLER")
DAWN:INSTRUMENT_TEMPERATURE_UNIT = ("K", "K", "K", "K")
PHOTOMETRIC_CORRECTION_TYPE = "NONE"

/* Pointers to first record of objects in file */
^HISTORY = 30
OBJECT = HISTORY
END_OBJECT = HISTORY
^QUBE = "VIR_IR_1B_1_369819195_QQ_2.QUB"

/* Quality Cube */
OBJECT  = QUBE
 AXES                        = 3
 AXIS_NAME                   = (BAND,SAMPLE,LINE)
 CORE_ITEMS                  = (432,256,3)
 CORE_ITEM_BYTES             = 4
 CORE_ITEM_TYPE              = "IEEE_REAL"
 CORE_BASE                   = 0.0
 CORE_MULTIPLIER             = 1.0
 CORE_VALID_MINIMUM          = 0
 CORE_NULL                   = -32768
 CORE_LOW_REPR_SATURATION    = -32767
 CORE_LOW_INSTR_SATURATION   = -32767
 CORE_HIGH_REPR_SATURATION   = -32767
 CORE_HIGH_INSTR_SATURATION  = -32767
 CORE_NAME                   = ("WAVELENGTH","FWHM","FLAG")
 CORE_UNIT                   = ("MICRON","MICRON","DIMENSIONLESS")

 SUFFIX_BYTES                = 4
 SUFFIX_ITEMS                = (0, 0, 0)
END_OBJECT  = QUBE
```

```
END

OBJECT = HISTORY




END_OBJECT = HISTORY
```

The format of the detached PDS label for the housekeeping data associated with the RDR data is identical to of the EDR HK files. Please see the sample EDR HK label above for details.

Index Table Label

At following is an example detached for an INDEX table (INDEX.TAB).

```
PDS_VERSION_ID                 = PDS3
RECORD_TYPE                    = FIXED_LENGTH
RECORD_BYTES                   = 263
FILE_RECORDS                   = 4150
^HEADER                        = ("INDEX.TAB", 1)
^INDEX_TABLE                   = ("INDEX.TAB", 2)
INSTRUMENT_HOST_ID             = "DAWN"

OBJECT                         = HEADER
  HEADER_TYPE                  = "TEXT"
  DESCRIPTION                  = "A header row containing a list of column
                                  names."
  RECORDS                      = 1
  BYTES                        = 263
END_OBJECT                     = HEADER

OBJECT                         = INDEX_TABLE
  INTERCHANGE_FORMAT           = ASCII
  INDEX_TYPE                   = SINGLE
  DESCRIPTION                  = "INDEX.TAB lists all the data files on
                                  this volume. It starts on line two
                                  because the first row has column headers"
  ROW_BYTES                    = 263
  ROWS                         = 4149
  COLUMNS                      = 8

  OBJECT                       = COLUMN
    NAME                       = DATA_SET_ID
    DESCRIPTION                = "A unique alphanumeric identifier for a data
                                  set."
    DATA_TYPE                  = CHARACTER
    START_BYTE                 = 2
    BYTES                      = 38
  END_OBJECT                   = COLUMN

  OBJECT                       = COLUMN
    NAME                       = FILE_SPECIFICATION_NAME
```

```
  DESCRIPTION                 = "The full path and file name relative to the
                                 root level of the archive volume."
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 43
  BYTES                       = 82
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = PRODUCT_ID
  DESCRIPTION                 = "A permanent, unique identifier assigned to
                                 a data product. The PRODUCT_ID must be unique
                                 within its data set."
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 128
  BYTES                       = 23
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = VOLUME_ID
  DESCRIPTION                 = "A unique identifier for a data volume."
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 154
  BYTES                       = 11
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = PRODUCT_CREATION_TIME
  DESCRIPTION                 = "The UTC system format time when a product
                                 was created."
  DATA_TYPE                   = TIME
  START_BYTE                  = 167
  BYTES                       = 23
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = START_TIME
  DESCRIPTION                 = "The date and time of the beginning of an
                                 event or observation (whether it be a
                                 spacecraft, ground-based, or system event) in
                                 UTC."
  DATA_TYPE                   = TIME
  START_BYTE                  = 191
  BYTES                       = 23
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  NAME                        = STOP_TIME
  DESCRIPTION                 = "The date and time of the end of an
                                 observation or event (whether it be a
                                 spacecraft, ground-based, or system event) in
                                 UTC."
  DATA_TYPE                   = TIME
  START_BYTE                  = 215
  BYTES                       = 23
```

```
  END_OBJECT                  = COLUMN

  OBJECT                      = COLUMN
    NAME                      = IMAGE_MID_TIME
    DESCRIPTION               = "The time at which the exposure of the image
                                 was half way through its duration."
    DATA_TYPE                 = TIME
    START_BYTE                = 239
    BYTES                     = 23
  END_OBJECT                  = COLUMN

END_OBJECT                    = INDEX_TABLE
END
```

Example Document Label

The following is an example detached label for the Dawn Science Plan document.

```
PDS_VERSION_ID           = PDS3
MISSION_NAME             = "DAWN MISSION TO VESTA AND CERES"
INSTRUMENT_HOST_NAME     = "DAWN"
INSTRUMENT_NAME          = "FRAMING CAMERA 2"
INSTRUMENT_ID            = "FC2"
DATA_SET_ID              = {"DAWN-CAL-FC1-2-EDR-CALIB-IMAGES-V1.0",
                            "DAWN-CAL-FC2-2-EDR-CALIB-IMAGES-V1.0",
                            "DAWN-A-FC2-2-EDR-VESTA-IMAGES-V1.0",
                            "DAWN-A-FC2-3-RDR-VESTA-IMAGES-V1.0",
                            "DAWN-A-GRAND-2-EDR-VESTA-COUNTS-V1.0",
                            "DAWN-A-GRAND-3-RDR-VESTA-COUNTS-V1.0",
                            "DAWN-A-VIR-2-EDR-IR-VESTA-SPECTRA-V1.0",
                            "DAWN-A-VIR-2-EDR-VIS-VESTA-SPECTRA-V1.0",
                            "DAWN-A-VIR-3-RDR-IR-VESTA-SPECTRA-V1.0",
                            "DAWN-A-VIR-3-RDR-VIS-VESTA-SPECTRA-V1.0",
                            "DAWN-M-FC2-2-EDR-MARS-IMAGES-V1.0",
                            "DAWN-M-FC2-3-RDR-MARS-IMAGES-V1.0",
                            "DAWN-M-GRAND-2-EDR-MARS-COUNTS-V1.0",
                            "DAWN-M-GRAND-3-RDR-MARS-COUNTS-V1.0",
                            "DAWN-X-FC1-2-EDR-CRUISE-IMAGES-V1.0",
                            "DAWN-X-FC1-3-RDR-CRUISE-IMAGES-V1.0",
                            "DAWN-X-FC2-2-EDR-CRUISE-IMAGES-V1.0",
                            "DAWN-X-FC2-3-RDR-CRUISE-IMAGES-V1.0",
                            "DAWN-X-GRAND-2-EDR-CRUISE-COUNTS-V1.0",
                            "DAWN-X-VIR-2-EDR-IR-CRUISE-SPECTRA-V1.0",
                            "DAWN-X-VIR-2-EDR-VIS-CRUISE-SPECTRA-V1.0",
                            "DAWN-X-VIR-3-RDR-IR-CRUISE-SPECTRA-V1.0",
                            "DAWN-X-VIR-3-RDR-VIS-CRUISE-SPECTRA-V1.0"}
PRODUCT_ID               = "DAWN_SCIENCE_PLAN"
PRODUCT_TYPE             = "DOCUMENT"
RECORD_TYPE              = STREAM
DESCRIPTION              = "
      This document describes the plans for acquiring Dawn science data on the
      way to, and in orbit about, the two protoplanets 4 Vesta and 1 Ceres,
      that will be visited by the Dawn spacecraft. It represents the high
      level plan for Dawn mission science operations. An update to the
      Science Plan is developed prior to arrival at each body. This version
```

```
      contains an as-flown update for all mission phases through the Vesta
      orbital phase."

^PDF_DOCUMENT            = "DAWN_SCIPLAN_V4_4.PDF"
^HTML_DOCUMENT           = "DAWN_SCIPLAN_V4_4.HTM"
^JPEG_DOCUMENT           = {
                            "DAWN_SCIPLAN_V4_4_FIG2_1A.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG2_1B.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_10.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_11.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_12.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_13.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_14.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_15.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_16.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_17.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_18.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_19.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_1A.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_1B.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_20.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_21.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_22.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_23.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_24.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_25.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_26.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_27.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_28.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_29.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_3.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_4.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_5.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_6.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_7.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_8.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG4_9.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG6A.JPG",
                            "DAWN_SCIPLAN_V4_4_FIG6B.JPG"}

OBJECT                   = PDF_DOCUMENT
  DOCUMENT_NAME          = "DAWN SCIENCE PLAN"
  DOCUMENT_TOPIC_TYPE    = "MISSION SCIENCE"
  PUBLICATION_DATE       = 2013-03-26
  INTERCHANGE_FORMAT     = BINARY
  DOCUMENT_FORMAT        = "ADOBE PDF"
  FILES                  = 1
  ENCODING_TYPE          = "PDF-ADOBE-1.5"
  DESCRIPTION            = "
    PDF version of the Dawn Science Plan document."
END_OBJECT               = PDF_DOCUMENT

OBJECT                   = HTML_DOCUMENT
  DOCUMENT_NAME          = "DAWN SCIENCE PLAN"
```

```
  DOCUMENT_TOPIC_TYPE   = "MISSION SCIENCE"
  PUBLICATION_DATE      = 2013-03-26
  INTERCHANGE_FORMAT    = ASCII
  DOCUMENT_FORMAT       = "HTML"
  FILES                 = 1
  DESCRIPTION           = "
    This document is an HTML version of the Dawn Science Plan document. This
    version has been generated with minimal HTML markup to enhance its
    readability in a text viewer."
END_OBJECT              = HTML_DOCUMENT

OBJECT                  = JPEG_DOCUMENT
  DOCUMENT_NAME         = "DAWN SCIENCE PLAN"
  DOCUMENT_TOPIC_TYPE   = "MISSION SCIENCE"
  PUBLICATION_DATE      = 2013-03-26
  INTERCHANGE_FORMAT    = BINARY
  DOCUMENT_FORMAT       = "JPG"
  FILES                 = 33
  ENCODING_TYPE         = "JPEG"
  DESCRIPTION           = "
    These are JPEG images of equations and figures appearing the the Dawn
    Science Plan document, and which are referenced by the HTML version of
    that document."
END_OBJECT              = JPEG_DOCUMENT

END
```

Appendix B. Support staff and cognizant personnel

Here follows a list of the support staff and cognizant personnel associated with the archive generation and validation.

Name	Role	e-mail address
Maria Teresa Capria	VIR Data archiving responsible	mariateresa.capria@iaps.inaf.it
Eleonora Ammannito		eleonora.ammannito@iaps.inaf.it
Marco Giardino	VIR Data archiving	marco.giardino@iaps.inaf.it
Gianrico Filacchione	Calibration process	gianrico.filacchione@iaps.inaf.it
Sergio Fonte		sergio.fonte@iaps.inaf.it
Raffaella Noschese	EGSE	raffaella.noschese@iaps.inaf.it
Federico Tosi	Geometries	federico.tosi@iaps.inaf.it

Appendix C. Software that can be used to work with the data

Visualization of the VIR qubes

VIR qubes, both EDR and RDR, have a very simple format and can be visualized without difficulty with many codes. They are ISIS3_compliant. The VIR team is releasing the QubeReader, a Java code that can be downloaded from the website:
http://galactica.ifsi-roma.inaf.it/solarsystem/downloadsPage/VIRReader/virReader.php

On the same website usage information is available.