**VIRTIS**

ISTITUTO NAZIONALE
DI ASTROFISICA

# ROSETTA – VIRTIS
# Derived Data
# To Planetary Science Archive
# Interface Control Document
# VIR-INAF-IC-008
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## Distribution List

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# Change Log

| Date | Sections Changed | Reasons for Change |
|---|---|---|
| 29/01/2020 | 3.1.4<br>2.2 | Start and stop time added to the filename<br>Added description of Maps Products |
| | | |
| | | |
| | | |

# Summary

# 1 Introduction

## 1.1 Purpose and Scope

The purpose of this EAICD (Experimenter to (Science) Archive Interface Control Document) is two folds. First it provides users of the VIRTIS instrument with detailed description of the derived products and a reference list of the articles in which is explained how they were generated, including data sources and destinations. Secondly, it is the official interface between the instrument team and the archiving authority.

## 1.2 Archiving Authorities

The Planetary Data System Standard is used as archiving standard by

- NASA for U.S. planetary missions, implemented by PDS
- ESA for European planetary missions, implemented by the Research and Scientific Support Department (RSSD) of ESA

### 1.2.1 ESA's Planetary Science Archive (PSA)

ESA implements an online science archive, the PSA,

- to support and ease data ingestion
- to offer additional services to the scientific user community and science operations teams as e.g.
    - search queries that allow searches across instruments, missions and scientific disciplines
    - several data delivery options as
        - direct download of data products, linked files and data sets
        - ftp download of data products, linked files and data sets

The PSA aims for online ingestion of logical archive volumes and will offer the creation of physical archive volumes on request.

## 1.3 Contents

This document describes the data flow of the VIRTIS instrument Level 5 data for their insertion into the PSA. It includes information on how data were processed, formatted, labeled and uniquely identified. The document discusses general naming schemes for data volumes, data sets, and data files. Standards used to generate the products are explained. The design of the data set structure and the data product is given. Examples of the data labels are given.

## 1.4 Intended Readership

The staff of the archiving authority (Planetary Science Archive, ESA, RSSD, design team) and any potential user of the VIRTIS data in the scientific community.

## 1.5 Applicable Documents

**[AD 1].** Planetary Data System Preparation Workbook, February 1, 1995, Version 3.1, JPL, D-7669, Part1

**[AD 2].** Planetary Data System Standards Reference, August 3, 2003, Version 3.6, JPL, D-7669, Part 2
**[AD 3].** Rosetta Archive Generation, Validation and Transfer Plan, January 10, 2006, RO-EST-PL- 5011
**[AD 4].** Rosetta Archive Conventions, January 10, 2006, RO-EST-TN-3372
**[AD 5].** Planetary Science Data Dictionary, Revision D, JPL D-7116, July 15, 1996
**[AD 6].** VIRTIS Data Archive Format, April 29, 2002, VIR-ORS-RS-1146, Version 3.4
**[AD 7].** Update to VIRTIS Rosetta Archive Format, July 20, 2006, VIR-ORS-RS-2251, Issue 2.5
**[AD 8].** VIRTIS EAICD, VIR-INAF-007, January, 2020, issue 4.8

## 1.6 Relationships to Other Interfaces

The Maps (Level 5 data) described in this document were generated from calibrated data cubes [AD 8]; changes in the calibration process could affect the Level 5 data. Any future reprocessing of the data, for whatever reason, even if the labels are not affected, that will have an impact on the Level 5 data shall be described and new version of the Maps, when published, will be added and described in this document.

## 1.7 Acronyms and Abbreviations

**ADC**: Analog Digital Converter

**ASDC**: ASI Data Centre

**CMWS**: Control and Monitoring WorkStation

**DHSU**: Data Handling System Unit

**EDR**: Experimental Data Record

**EGSE**: Electrical Ground Support Equipment

**MTP**: Medium Term Plan

**STP**: Short Term Plan

## 1.8 Contact Names and Addresses

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# 2 Overview of Data Handling Process and Product Generation

## 2.1 Data Handling Process

Table 2-1 describes the VIRTIS data processing levels as used in this document. The archive contains the DDR (level 5) data.

| Processing Level ID (CODMAC level) | PRODUCT_TYPE | Description |
|---|---|---|
| 1 | **UDR** | Raw data that have been separated by instrument and sorted by orbit number. Contains all TM from VIRTIS (science and housekeeping data). |
| 2 | **EDR** | PDS formatted data, including decompressed science data, housekeeping selection, and geometry data. Science data are still in DN. |
| 3 | **RDR** | Science data calibrated in physical units (radiance) + timing as OBT |
| 5 | **DDR** | High-level derived product such as compositional maps... |

*Table 2-1: Data level definition.*

## 2.2 Data Description

In this data volume are present maps of selected spectral marker or Spectral Indicators. These parameters helps considerably in reducing the dimensionality of the data, hence their analysis, still preserving the relevant information contained in the spectra. As **all** the maps that will be injected into PSA as Level 5 products will only be those contained in published papers, the details for the derivation of the Spectral Indicators will be provided in the paper themselves. However, as we have identified a limited number of typology of spectral markers which will be used, here below we provide a brief description of the full set of the possible spectral markers (or Spectral Indicators) and their potential relevance for the data interpretation. Should the need arise for new Spectral Indicators the present document will be updated and their description added.

- **TP** Temperature; this represent the surface temperature as derived from the IR radiance in the 4-5 µm range. Details of the Bayesian approach adopted for the derivation of the Surface Temperature are given in *Tosi, F. et al. Thermal measurements of dark and bright surface features on Vesta as derived from Dawn/VIR. Icarus 240, 36–57 (2014)*.
- **EM** Emissivity; this is the emissivity of the surface in the range 4-5 µm; the emissivity is derived as a byproduct of the application of the algorithm adopted for the retrieval of the surface temperature.

- **BA** Band Area; for a given identified absorption feature we can calculate 4 descriptive parameters (Area, Depth, Centre wavelength and skewedness, or asymmetry) which are correlated to specific information; the Band Area is derived according to the formula:

$$\int_a^b 1 - \frac{\text{reflectance}(\lambda)}{\text{continuum}(\lambda)}\, d\lambda$$

  This in fact represent the area contained under the continuum, calculated as a linear fit of the reflectance between the two wavelengths located at the shoulders of the band indicated as a and b in the formula (see also *Raponi et al. The temporal evolution of exposed water-ice-rich areas on the surface of 67P/CG: spectral analysis*, MNRAS 2016).
- **BD** Band Depth; the standard definition of the band depth follows the formula:

$$BD = 1 - R_b/R_c$$

  Where $R_b$ is the reflectance of the band at the minimum of the absorption (after removal of the continuum), and $R_c$ is the reflectance of the continuum at the same wavelength. The BD is a measure of the abundance of absorbers in the soil.
- **BC** Band Centre; The Band Centre is calculated, after continuum removal, as the position of the minimum of a polynomial fit to the band shape. The continuum is calculated interpolating the reflectances at the two wavelengths located at the shoulders of the band. The BC is related to the composition of the surface.
- **BS** band Skewness; the skewness is an evaluation of the asymmetry of the band using the same polynomial fit used for the BC.
- **SL** Spectral Slope; Spectral slopes are calculated as the linear fit to a portion of the spectrum between two specified start and stop wavelengths.
- **AL** Albedo; this is the absolute reflectance (photometrically corrected) at a given wavelength.
- **BR** Band Ratio; this is the ratio between the area of two different bands and is used to evaluate the abundance ratio of specific compounds.
- **WI** Water Ice abundance; this is derived as a best fit, using a radiative transfer model, to the measured reflectance of a mixtures of various end-members (pure components of the mixtures) for which the optical constants are known.

All the geometric data are computed using the shape mode 5 (cg—scp-shap5-V1.1_Cedric.TPC)

The algorithms used to produce the maps and a deep discussion on the various parameters represented in the maps and their scientific significance are described in the scientific publication from which they were extracted. The reference to the publication itself is reported in the label file. The full set of references to the publication used is reported in the REF.CAT file in the CATALOG folder.

### 2.3 Data Format

The maps in this volume are in table format. This is an unusual format for a map, but the comet shape is also unusual. For the time being we used the standard approach of cylindrical projection with lat/lon coordinates, however due to the peculiar shape of the comet, we can have different point with the same lat/lon coordinates, especially near the Neck region. For this reason, we are working to generate maps not related to the lat/lon coordinate system but expressed in terms of ortogonal coordinates X,Y,Z, relating each map to the adopted shape model. For the above reason in the present dataset we adopted a format which will be compatible with the final format of the maps.

# 3 Archive Format and Content

This section describes the features of the VIRTIS Derived Product Archive volumes, including the file names, file contents, and file types, which apply to VIRTIS Derived Data Sets. More details on the data sets are provided in Section 4.

## 3.1 Format and Conventions

### 3.1.1 Deliveries and Archive Volume Format

Delivery of data from the VIRTIS team to the PSA for archiving is done through Internet, using the PVV tool, according to the release concept described in [AD 3]. In conformity with guidelines also provided in [AD 3], data are organized so that one VIRTIS data set will coincide with a single logical volume. An example is shown in Table 3-1.

| Data Set Name | Volume ID |
|---|---|
| ROSETTA-ORBITER VIRTIS 5 V1.0 | ROVIR_3007 |

*Table 3-1: VIRTIS Data Sets and corresponding Volume ID's example.*

### 3.1.2 Data Set ID Formation

The value of this keyword is formed following the PDS rules and the Rosetta archive conventions as written in[AD 4]. For each delivery, the raw data from a mission phase will be found in a dataset. An example is shown in Table 3-2

| Data Set Name | Data Set ID |
|---|---|
| ROSETTA-ORBITER VIRTIS 5 V1.0 | RO-VIRTIS-5-V1.0 |

*Table 3-2: VIRTIS Data Set ID's example.*

### 3.1.3 Data Directory Naming Convention

The /data directory is structured in subdirectories containing different types of products. At the moment only the MAP subdirectory is implemented. The products are split in two sub folder to divide the product coming from the imager from the other:

*/data/MAP/VIRTIS_M*: contains maps derived by VIRTIS-M Datasets;
*/data/MAP/VIRTIS_H:* contains maps derived by VIRTIS-H Datasets;

### 3.1.4 Filenaming Convention

The data are naming using the following format: *<code>_<target>_<time>_<version>.map*

The *code* field is formed by two parts: *<type><subtype>*.
The sub-field *type* is 2 alphabetic characters long and the possible values are reported in Table 3-3.

| Type | Description |
|---|---|
| TP | Temperature |
| EM | Emissivity |
| BA | Band Area |
| BD | Band Depth |
| BC | Band Center |
| BS | Band Skewness |
| SL | Spectral Slope |
| AL | Albedo |
| BR | Band Ratio |
| WI | Water Ice |

*Table 3-3: Values for the sub-field type.*

The sub-field *subtype* is 2 numeric character long and is optional. The admitted combinations *type subtypes* are reported in Table 3-4.

| Type | Subtype | Description |
|---|---|---|
| AL | 01 | Albedo at 550 nm |
| BA | 01 | Band Area at 3.2 µm |
| BC | 01 | Band center at 3200 nm |
| | 02 | Band Area at 3.2 µm (different algorithm) |
| BD | 01 | Band depth at 3200 nm |
| | 02 | Band depth at 2000 nm |
| SL | 01 | Spectral slope 500-800 nm |

| | | |
|---|---|---|
| | 02 | Spectral slope 1000-2500 nm |
| | 03 | Spectral slope 0,5-0,8 µm(different algorithm) |
| | 04 | Spectral slope 1,0-2,35 µm |
| WI | 01 | Water ice abundance |

*Table 3-4: Admitted combination of type and subtype fields.*

The *target* field is 3 characters long and describe if the target of the map is global, of an area of the comet or of a specific feature of the surface. The admitted values are reported in Table 3-5.

| Target | Description |
|---|---|
| Glb | Global |
| Loc | Local, specific comet area |
| *Tar* | Target Name, specific feature |

*Table 3-5: Admitted values for the target field.*

The *time* field if formed by 2 sub fields, *<start_time>_<stop_time>*, and describe the start and stop phase, extremes included. Each field is formed by 1 char and 3 numbers. The first character could be *M* or *S* and indicate if the start or stop field is a medium or a short-term plan period, the numbers are the sequential number for the MTP and the STP.

The last field is the *version*. The version is reported as a capital V and two numbers.

E.g. **SL01_GLB_M006_V01.TAB**: first version of the spectral slope global map, in the visible, for the MTP006.

## 3.2 Standards Used in Data Product Generation

### 3.2.1 PDS Standards

All the data released by the VIRTIS Team for archiving are compliant with the Planetary Data System (PDS3) standard. This standard imposes requirements on several aspects of the data product generation process, among which the need for a detailed documentation describing the origin, structure and processing undergone by data, for their accurate location in space and time, and in general for all auxiliary and ancillary data which are needed for the scientific use of the data products. This information has to be provided in an Object Description Language (ODL), in the format keyword = value, where keyword is a standard term used to label a parameter (e.g. latitude), and value is any allowed information quantifying that parameter.

#### *3.2.1.1 START_TIME and STOP_TIME values formation*

The PDS formation rule for dates and time in UTC is: YYYY-MM-DDThh:mm:ss.fff or YYYY-DDDThh:mm:ss.fff, with:

- YYYY year (0000-9999);
- MM month (01-12);
- DD day of month (01-31);
- DDD day of year (001-366);
- T date/time separator;

- hh hour (00-23);
- mm minute (00-59);
- ss second (00-59);
- fff fractions of second (000-999) (restricted to 3 digits).

### 3.2.2 Reference Systems

During the cruise phase of Rosetta, always the planetocentric body-fixed rotating coordinate system is used in order to compute geometric quantities relative to targets in the solar system. The planetocentric latitude is the angle between the equatorial plane and a vector connecting the point of interest and the origin of the coordinate system. Latitudes are defined to be positive in the northern hemisphere of the body, where north is in the direction of Earth's angular momentum vector, i.e., pointing toward the northern hemisphere of the solar system invariant plane. Longitudes increase toward the east, making the planetocentric system right-handed.

The easternmost (rightmost) longitude of a target is the maximum numerical value of longitude unless it crosses the Prime Meridian. For the Earth and the Moon, PDS supports the traditional use of the range [-180,180] in which case the easternmost (rightmost) longitude is the maximum numerical value of longitude unless it crosses 180. As regards the longitude, for the Earth and the Moon, the traditional use of the range [-180,180] is allowed. More information on the subject can be found in *VIRTISROS_GEOMETRY.PDF* released within the data-set.

### 3.2.3 Volume Set

As the concept of a volume as defined in the PDS standard is based on physical media, e.g. CD-Rs, the PSA does not use the name volume. Instead, the concept of deliveries is defined for the PSA and the term delivery is used for the PSA. However, here and in the following sections we will use the word "volume" to refer to a standard PDS directory structure for a data set in which the entire data set consists of a single (virtual) volume. Different VIRTIS data sets will be organized as separate virtual volumes, and the concept of volume set will not be used.

### 3.2.4 Data Set

The value of the keyword DATA_SET_NAME is formed following the PDS rules and the Rosetta archive conventions as written in [AD 4], so, for example, the DATA_SET_NAME for first data set delivery will have the value:

ROSETTA-ORBITER VIRTIS 5 V1.0

### 3.2.5 Directories

VIRTIS data sets are organized into one data set on one virtual volume and use the standard PDS volume structure. This standard structure is described in Section 19.3 of [AD 2], and shown in the figure below. For the derived dataset not all the directories was been implemented.

The content of each directory shown in Figure 3-1is detailed in the following sections.

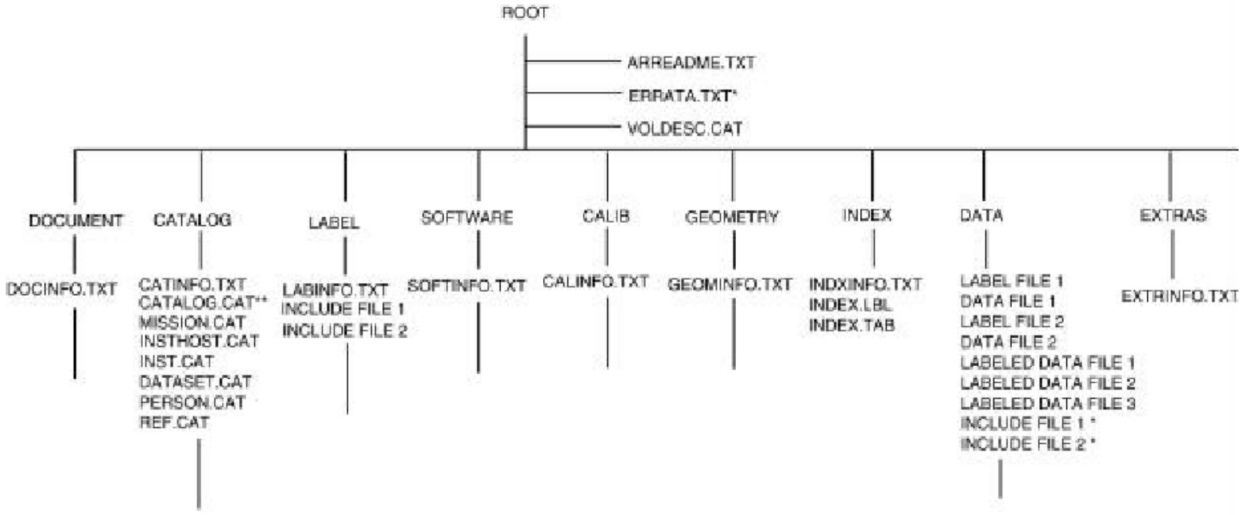


*Figure 3-1: Folder structure in a PDS3 Volume*

#### 3.2.5.1 RootDirectory

Files in this directory are provided by the VIRTIS science team, and will remain the same across different volumes.

| File Name | File Contents |
|---|---|
| AAREADME.TXT | Volume content and format information |
| VOLDESC.CAT | Description of the contents of the volume in a PDS format readable by both humans and computers |

*Table 3-6: Files located in the root directory of a VIRTIS data volume.*

#### 3.2.5.2 CALIBRATION Directory

The *CALIBRATION* directory was not implemented in this version of the dataset.

#### 3.2.5.3 Catalog Directory

Files in this directory are catalogue files, that is files containing PDS catalogue objects. Such objects provide high-level information suitable for loading into a database to facilitate searches across data sets, collections and volumes. These files are provided by the VIRTIS science team, with the concurrence of the PSA, and will remain the same across different volumes.

| File Name | File Contains |
|---|---|
| CATINFO.TXT | Text description of the directory contents |
| MISSION.CAT | PDS catalogue object for the mission |
| INSTHOST.CAT | PDS catalogue object for the spacecraft |
| INST.CAT | PDS catalogue object for the instrument |
| TARGET.CAT | PDS catalogue object for the targets |
| DATASET.CAT | PDS catalogue object for the VIRTIS data set |
| REF.CAT | PDS catalogue object for references appearing in the documentation |

*Table 3-7: Files located in the CATALOG subdirectory of a VIRTIS data volume.*

#### 3.2.5.4 Index Directory

This directory contains indexes, that is files with information that allows a user to locate data of interest. Within the Planetary Science Archive (PSA), index files fulfill two more purposes. First, some index files are read by database software and allow the ingestion of additional parameters into the database. Secondly, the PSA is using the index files to check for correct deliveries of data set revisions into the PSA. Indexes are written as INDEX_TABLE objects, that is a specific type of PDS ASCII TABLE objects, and are provided with detached PDS label files.

The set of index files for VIRTIS, as required in [AD 3], is:

| File Name | File Contents |
|---|---|
| INDXINFO.TXT | Text description of the directory contents |
| INDEX.LBL | Detached PDS label to describe INDEX.TAB |
| INDEX.TAB | PDS table, listing all files in the DATA directory for the corresponding release and revision. |

*Table 3-8: Files located in the INDEX subdirectory of a VIRTIS data volume.*

The Index File (.LBL and .TAB) contains a lists all data files on the volume, the path to the directory containing the file and the name of the file in the archive. For each file information is given about time at which data in the file begin/end, number of rows and number of bytes in rows in the .TAB file.

#### *3.2.5.5 BROWSE Directory and Browse Files*

The *BROWSE* directory was not implemented in this version of the dataset.

#### *3.2.5.6 GEOMETRY Directory*

The *GEOMETRY* directory was not implemented in this version of the dataset.

#### *3.2.5.7 Software Directory*

The *SOFTWARE* directory was not implemented in this version of the dataset.

#### *3.2.5.8 Gazetter Directory*

The *GAZETTER* directory was not implemented in this version of the dataset.

#### *3.2.5.9 Label Directory*

The *LABEL* directory was not implemented in this version of the dataset.

#### *3.2.5.10 Document Directory*

Files in this directory are provided by the VIRTIS science team, and are the same for all the volumes.

| File Name | File Contents |
|---|---|
| DOCINFO.TXT | Text description of the directory contents |
| **********.LBL | PDS labels for all the documents contained in the directory |
| RO_VIRTIS_DDR_EAICD.ASC | VIRTIS EAICD (this document) in ASCII text |
| RO_VIRTIS_DDR_EAICD.PDF | VIRTIS EAICD (this document) in PDF format |

*Table 3-9: Files located in the DOCUMENT subdirectory of a VIRTIS data volume.*

#### *3.2.5.11 Extras Directory*

The *EXTRA* directory was not implemented in this version of the dataset.

#### *3.2.5.12 Data Directory*

The *DATA* directory is structured in subdirectories containing different types of products. At the moment, only the MAP subdirectory is implemented. The products are split in two sub-folders to distinguish the products coming from the two VIRTIS channel, although no Level 5 data have been generated so far for the VIRTIS-H channel:

**/data/MAP/VIRTIS_M**: contains maps derived by VIRTIS-M Datasets;
**/data/MAP/VIRTIS_H**: contains maps derived by VIRTIS-H Datasets;