VIRTIS Rosetta geometry files

VIR-LES-TN-2338
Version 1.0

	NAME	FUNCTION	SIGNATURE	DATE
Prepared by	S. Erard S. Jacquinod C. Leyrat X. Bonnin			**10/7/2019**
Checked by	F. Capaccioni			
Approved by				
Authorized by				

TABLE OF CONTENTS

.

DOCUMENT CHANGE RECORD

Issue	Date	#	New Paragraph	Description of the modification	Reason of the modification
Draft 01	25/09/2007	1		First draft for Mars flyby, adapted from VVEx document	
Draft 02	20/11/2007	2		Finalized for Mars and Earth flybys	
Draft 03	2/11/2008	3		Update after Steins flyby	
	5/11/2008	4		Added detailed pointing information in Appendix A	
	20/01/2010	5		Added Earth and Moon DTM information. Figures updated.	General update after ESB3
Draft 04	17/06/2011	6		Fixed doc reference Added IDL plane # in table	
Draft 05	1/06/2012	6		Added Lutetia flyby information, updated doc reference	Update after successful geometry computation for Lutetia
Draft 06 *Interm. version*	11-28/ 08/2014 then 18/10/2014	7		Updated FoV, labels + SPICE reference for first 67P data + added Table 3 for special parameters	Update for 67P phase
Draft 06c *not distributed*	15/01/2015	7		Updated references to 67P shape models Added Table 1 for shape model references Added code history (TBC if useful)	Shape 5 on 67P
Draft 06d	18/10/2015	7		Other modif from extended geom doc 0.7e, including new Table 1 for reference frames	
Draft 06e	28/10/2015	7		Minor adaptations, clarification of elevation parameter	
Draft 06f	15/02/2016	9		Update of reference frame for 67P + new Rosetta frame kernel	Updated for shap5 v1.1
Version 06g	23/03/2016	9		Minor updates	Answers to archive science review comments; figures 2/5 fixed
Draft 07	28/10/2015	8		Added description of new geometry planes for 67P (including late addition of pointing direction in body-fixed frame) + changed definition of tangent point for 67P (concave). + update of coordinate system names/IDs + slant distance is actually computed on the shape model + Relaxed GEOMINDEX specification (now taken care of at RSGS) + upated file dimension information + added new Table 1 with reference frames in use + integration of modifications in 6e (v7e) + new modifications in 7f	New geometry cubes, georos 7.0
Version 07g	19/9/2016	10		Final plane definitions in 7g (first release) Clarification of some parameters Reflect recent changes in v6f/g + include recent user comments. From now on, the same code generates regular and extended files. Some planes have changed also in regular files.	Finalization, tests.
Version 07h	10/7/2019	10		Quick/partial update for reference to 67P	Update of shape model in

				shape model. TBC: Uncertainties, update RD, Table 2, section 2.2.1. To do: proof-reading, remove obsolete or historical steps	use + only extended geometry to be provided in the archive
Version 1.0	02/03/2020	11		Thye version 0.7h is turned to 1.0.	use + only extended geometry to be provided in the archive

1- Introduction

This document defines the format and contents of the VIRTIS Rosetta geometry files for both M and H channels during the asteroids, Mars, and Earth flybys, and early phases of 67P observations. These files are distributed to the science team, and are part of the archive delivered to PSA.

1.1 Applicable / Reference Documents

- AD1: EAICD Virtis Rosetta, VIR-INAF-IC-007, Issue 4.1 (24/3/2014)
- AD2 : VIRTIS PDS/IDL software library VVX-LES-SW-2264, Issue 3.3 (1/7/2015)
- AD3: Rosetta Payload Boresight Alignment Details. RO-EST-TN-3305. Issue 2, rev. g (21 July 2014).

+ Spice kernels provided by ESA (IK and FK).

- RD1: Seidelman et al., Report of the IAU/IAG working group on cartographic coordinates and rotational elements: 2006. *Celestial Mechanics and Dynamical Astronomy* **98**: 155–180, 2007.
- RD2: Smith, D., G. Neumann, R. E. Arvidson, E. A. Guinness and S. Slavney, "Mars Global Surveyor Laser Altimeter Mission Experiment Gridded Data Record", NASA Planetary Data System, MGS-M-MOLA-5-MEGDR-L3-V1.0, 2003.
- RD3: Hastings, David A., Paula K. Dunbar, Gerald M. Elphingstone, Mark Bootz, Hiroshi Murakami, Hiroshi Maruyama, Hiroshi Masaharu, Peter Holland, John Payne, Nevin A. Bryant, Thomas L. Logan, J.-P. Muller, Gunter Schreier, and John S. MacDonald, 1999. The Global Land One-kilometer Base Elevation (GLOBE) Digital Elevation Model, Version 1.0. NOAA, National Geophysical Data Center (http://www.ngdc.noaa.gov/mgg/topo/globe.html).
- RD4: Zuber, M. T., CLEM1 LUNAR TOPOGRAPHY V1.0, CLEM1-L-LIDAR-5-TOPO-V1.0, NASA Planetary Data System, 1996.
- RD5: Jorda et al., ROS_STEINS_V04.TPC, January 2009 (Steins PCK from Osiris team)
- RD6: Jorda et al., SteinsFinal.dsk, 2009 (Steins DSK from Osiris team)
- RD7: Osiris pointing position relative to other boresights on Rosetta, RO-RIS-MPAE-TN-051, Issue 1.0, Rev.d (18 Jan 2008).
- RD8: Archinal et al., Report of the IAU/IAG working group on cartographic coordinates and rotational elements: 2009. *Celestial Mechanics and Dynamical Astronomy* **109**: 101–135, 2011.
- RD9: ROS_LUTETIA_RSOC_V03.TPC, Oct 2011 (Attitude kernel reconstructed from Osiris images, for Lutetia Closest Approach)
- RD10: Kamp et al., lutetia_gaskell_mikko_v4-sbd1.ver, Oct 2011 (Lutetia DSK from Osiris images)
- RD11: Scholten et al., Reference frames and mapping schemes of comet 67P - v2 (25 Sept. 2015)

1.2 Acronyms and Abbreviations

EDR: Experimental Data Record
EGSE: Electrical Ground Support Equipment
FPA: Focal Plane Arrays
DTM : Digital Terrain Model
DSK : Digital Shape Kernel
HK: HouseKeeping parameters
IDL: Interactive Data Language
IR: InfraRed
ME: Main Electronic
MSB: Most Significant Byte first
OBT: On-Board Time
PCK : Planetary Constants Kernel
PDS: Planetary Data System
PSA: Planetary Science Archive
RDR: Reduced Data Record
RMOC: Rosetta Mission Operations Centre
SCET: SpaceCraft Elapsed Time (on-board time measured in s from launch)
SI: Système International d'unités

SPICE : Spacecraft Planet Instrument C-matrix Events
TM: Telemetry
UTC: Universal Time Corrected
VIRTIS: Visible Infra Red Thermal Imaging Spectrometer

2- Detailed specifications

The VIRTIS/Rosetta data archive contains geometrical information together with the data at various processing levels. This includes:

1) General/averaged information contained in the PDS label of data files, pertaining to the overall session.

2) Detailed information on a pixel basis, required to plot the data and to analyze them in details. This information is stored in separated geometry files associated to the data files.

The detailed information is stored in separate files, so as to decouple maintenance of the data on one hand, and of the geometry on the other hand. Practically, the geometry files have to be generated several times, as navigation Spice kernels are updated by ESA. This scheme also preserves the possibility to generate and maintain calibrated/derived data files easily.

Consequently, there is one geometry file associated to each data file. This implies that the geometry files are relevant to one focal plane only (separated files for H, M-vis, M-IR). When processing a data file, only the corresponding geometry file needs to be loaded.

Geometry information in the data files labels is computed and implemented in Rome through the SPICE system. Detailed geometry computations are later performed by a specific IDL library developed and maintained in Meudon (GeoRos), relying on the Spice toolkit for IDL (ICY, version N0065 from July 2014). The types of information are described in the next sections.

A "geometric index" file was initially required by ESA specifications, together with a description of each data file. This specification appears to be deprecated and therefore this discussion has been removed from the present document.

2.1 Data file labels

Data file labels are described in the current versions of the EAICD [AD 1], and derived documents.
These geometric quantities are computed with the SPICE system, then included in the PDS labels of the data files written by the EGSE. This means that the raw data files are written in two steps:

1) Formatting in EGSE, with attached PDS labels. The geometrical keywords have dummy values (such as "NULL").

2) Computation of geometrical quantities with the SPICE system, outside the EGSE. Files generated in the first step are edited and completed with the proper values for the geometric keywords, derived from SPICE analysis. This activity is performed in Rome. It also covers general keywords such as target identification, the values of which are derived from science planning. This information is also stored in the database in Meudon once for all, so that keyword values may be updated in later stages.

The updated data files are distributed to the science team. The calibrated or derived data files are written from these versions, with complete labels that include values associated to the geometrical keywords.

There are currently two versions of the geometry files generated in Meudon.
- Version 6 files (with extension .GEO) contain a standard number of parameters allowing a correct interpretation of the data. This is based on 67P shape model 5, which is partly outdated.
- Version 7 files ~~are an extended version of the~~ same files with additional planes as described below.

2.2 Geometry files contents

The Virtis/Rosetta geometry files for the three focal planes are written by the GEOROS software developed in Meudon. This system makes use of the SPICE kernels distributed by ESA, of Virtis-M CK kernels computed in Rome to handle the scanning mirror angle, and when relevant of target DSK kernels providing a plate model. M CK kernels are generated after observations from TM information, and reflect what has actually been done.

As mentioned above, geometry is computed and stored independently for each FPA. Virtis geometry files contain a cube with structure related to the data file, so that there is a direct correspondence between the two:

• Raw data cube dimensions = (X, Y, Z), where X is the number of spectral channels. X and Y depend on instrumental mode, and Z depends on session duration. The sideplane contains the housekeeping parameters.
• Calibrated data cubes dimensions = (X, Y", Z"). A small side plane is associated, containing only the spacecraft time (SCET) of acquisition.
• Geometry cube dimensions = (N, Y', Z'), where N is the # of geometrical parameters for this FPA/channel and geometry file version. There is no sideplane associated to the cube core.

- For M cubes, Z'=Z" is equal to the number of spectral frames in the data cube, while Z is equal to the number of spectral frames + dark current frames. The same applies to H cubes in backup (frame transfer) mode. In H nominal mode however, dark frames are stored independently.
- M geometry cubes always have Y' = Y (value depends on binning mode).
- For H in backup mode, X = 432 and Y = 256 (detector size), whereas Y'=Y"= 1 (each data frame contains a detector image, but is described by 1 single geometry column).
- H cubes in nominal mode always have Y = Y'= 64 and Z = Z' is the number of 64-spectra sets. Y" = Y x Z, and X" = 1 (therefore the second dimension is always degenerated, and the spectra are stored in chronologic order with their associated SCET — the raw data files dimensions are maintained for the geometry files which have no associated sideplane).

Geometry files for M and H channels have different parameters, reflecting their different acquisition scheme and optical design. Geometry files for 67P contain more parameters than for other targets, owing to the shape of the comet nucleus.
The geometry cubes are stored as long signed integers with MSB encoding. A simple conversion coefficient is used to accommodate the data in this format, so as to preserve accuracy (see below).
The geometry files are handled directly by the VIRTIS IDL library and its front-end routine virtispds [AD 2].

2.2.1 Reference surfaces

For observations of the target bodies, each observed pixel is projected successively at the surface, and the coordinates of the IFOV corners and center are written in the geometry files. During computations, two projection surfaces are used (ellipsoid and Digital Terrain Model when available). Successive Rosetta targets are handled differently, but during the cruise phase only the coordinates projected on the DTM are written in the geometry files. Practically, the differences are almost unnoticeable, except for the asteroids. The reference frames used in the archive are listed in Table 1, together with their definition kernels (maintained by the PSA and NAIF, and distributed by ESA). Venus and Jupiter have been observed as calibration targets only.

COORDINATE_SYSTEM_ID	COORDINATE_SYSTEM_NAME	Kernel	Target
10012	IAU_VENUS	Generic spice kernels	Venus
10013	IAU_EARTH	Generic spice kernels	Earth
10020	IAU_MOON	Generic spice kernels	Moon
10014	IAU_MARS	Generic spice kernels	Mars
10015	IAU_JUPITER	Generic spice kernels	Jupiter
2002867	STEINS_FIXED	ROS_V25.TF	Steins
-2260021	ROS_LUTETIA	ROS_LUTETIA_RSOC_V03.TF	Lutetia
-1000012000	67P/C-G_CK	ROS_CHURYUMOV_V01.TF	67P

Table 1: Body-fixed reference frames in use for solar system bodies

<u>Mars 2007 swing-by (MSB)</u>

The projection surfaces used for Mars observations during the 2007 swing-by (MSB) are:

1) The Mars reference ellipsoid defined in IAU 2006 standard [RD1, RD8]. This surface is the one described in generic SPICE kernels.
2) The Mars DTM measured by MOLA [RD2]. Only the 32 pixels/degree version is used for VIRTIS.

The estimated accuracy on the pointing direction is ~0.02°.

Earth swing-bys (ESB1/2/3)

A similar system is used for the observations of the Earth and the Moon during the 2005, 2007 and 2009 swing-bys (ESB1, ESB2, ESB3). The projection surfaces used are:

1) The Earth and Moon reference ellipsoid defined in the IAU 2006 standard (see [RD1, RD8]). Those are provided in generic SPICE kernels.
2) The Earth DTM measured by GLOBE [RD3] and the Moon DTM measured by the LIDAR instrument onboard the Clementine spacecraft [RD4]. The resolutions of the Earth and Moon DTM used for the Rosetta swing-bys are respectively 32 pixels/degree and 4 pixels/degree.

Steins fly-by (AFB1)

For the observations of the asteroid Steins during the 2008 fly-by, the projection surfaces used are:

1) The Steins reference ellipsoid updated from OSIRIS observations during the Rosetta fly-by. The corresponding SPICE PCK file is provided by the OSIRIS team and distributed by ESA: ROS_STEINS_V04.TPC [RD5].
2) The Steins 3D plate model derived from OSIRIS observations during the Rosetta fly-by. This model is also provided by the OSIRIS team as a Digital Shape Kernel (DSK) SPICE file: SteinsFinal.dsk [RD6].

The VIRTIS Spice computation uses an attitude kernel reconstructed to fit successive Osiris images, which is now distributed by ESA.

According to IAU conventions, the polar axis in this model is oriented along the spin axis of the asteroid. Because Steins has a retrograde rotation, this implies that the North Pole actually points in the southern celestial hemisphere at the time of the fly-by.

Lutetia fly-by (AFB2)

For the observations of the asteroid Lutetia during the 2010 fly-by, the projection surfaces used are:

1) The Lutetia reference ellipsoid updated from OSIRIS observations during the Rosetta fly-by. The corresponding SPICE PCK file is provided by the OSIRIS team and distributed by ESA: ROS_LUTETIA_RSOC_V03.TPC [RD9].
2) The Lutetia 3D plate model derived from OSIRIS observations during the Rosetta fly-by. We use a model provided by Lucas Kamp (from the MIRO team), which is then transformed into a Digital Shape Kernel (DSK) SPICE file: lutetia_gaskell_mikko_v4-sbd1.dsk [RD10].

The VIRTIS Spice computation uses an attitude kernel reconstructed to fit successive Osiris images. This kernel is now distributed by ESA. In addition, the BODY_FRAME variable is set to ROS_LUTETIA instead of LUTETIA_FIXED.

67P observations

For the observations of 67P after June 2014 (prelanding and escort phases), the projection surfaces used are:

1) A reference ellipsoid for 67P.
2) A 3D shape model of the nucleus, associated to Spice kernels for comet rotation and prime meridian, and for comet trajectory.
Several shape models have been used in succession. The shape model in use, as well as the other Spice kernels, can be identified from the SPICE_FILE_NAME keyword in the PDS labels (Table 2). Ellipsoid dimensions were included in the rotation kernel by LESIA, and may change between shape models.

- The Osiris shape model 7 SPC (SHAP7 v1.8, as distributed by the Osiris team) is the current baseline for the dataset and archive.
Cartesian coordinates are provided in the extended geometry files (produced from July 2016) to remove any ambiguity on longitude/latitude resulting from the concave shape of the nucleus.

Other shape models have been used prior to Jan. 2015, but the corresponding geometry files have normally been superseded and are not expected to circulate outside the VIRTIS team:

- Shape model 1 from OSIRIS observations acquired in July 2014. This is the 500 m resolution model (SHAP1 v3, as collected and distributed by CNES/SONC), which is then transformed into a Digital Shape Kernel (DSK) SPICE file.
- Osiris shape model 2 (SHAP2 v1 with 20 m resolution, as collected and distributed by CNES/SONC). This one was used in the pre-landing phase from mid-August 2014, and up to January 2015.
- Osiris shape model 5 v0.1 with full resolution was used from January 2015 to February 2016. Although using the Cheops frame and aligned with RMOC attitude files, this shape model was very inaccurate in the southern hemisphere that had only been sparsely observed at that time. This was associated to a rotational kernel, which was completed in LESIA based on early information provided by the Osiris team: cg-spc-shap5-v0.1_SJmodified.TPC. The shape model resolution was ~ 20 m in the northern hemisphere.
- Osiris shape model 5 (SHAP5 v1.1, as distributed by the Osiris team) with full resolution was used from February 2016 to June 2019 (completed with shape model 7 from June 2017). All observations have been reprocessed using this shape model in February 2016, including older ones. The zero longitude in this model is aligned with the RMOC comet attitude file, and both use the so-called "Cheops" frame defined by the Osiris team [RD11] as described in Table 1. It is associated to a rotational kernel, which was completed in LESIA based on information provided by the Osiris team: cg-spc-shap5-v1.1_Cedric.TPC. The precession and variation of the nucleus rotation rate are included in the CATT kernels provided by ESA, to the level where they can be detected with the Navcam. The shape model resolution is ~20 m, including in the southern hemisphere. "Extended geometry" files were produced from July 2016 and distributed to the team in addition to the standard ones. They include in particular coordinates in a Cartesian frame, so as to remove any ambiguity on longitude/latitude resulting from the concave shape of the nucleus.

Other shape models were tested at some points but were found to have issues:
- The RMOC model, with limited resolution, was temporarily used in August 2014.
- Osiris shape model 4 (SHAP4 v1.1, as distributed by the Osiris team) with 800 000 facets, had issues related to nucleus orientation.
This was associated to:
- coordinate system ID (SPICE system ID) = "1000012"
- coordinate system name = "67P/C-G_FIXED"
In this situation, the RMOC kernels (trajectory / attitude) and the Osiris shape model may have been poorly consistent. The above ID and name were temporary used with SHAP5 (up to 10/5/2015) – the corresponding files were not properly corrected from variations of rotation rate and have been discarded.

The final geometry cubes are computed using the reconstructed comet positioning provided by ESA one or two weeks after observation. A first version (*.PRE) is computed as the data become available, based on the predicted pointing; when visible, the target limb is often shifted in the FoV by a large amount (tens of M pixels), consistently with the expected pointing accuracy. When a reconstructed version becomes available the regular files are computed and are named *.GEO; the remaining shift is typically less than 5 VIRTIS-M pixels (~0.07°), and often better. New versions may be computed if the reconstruction is further improved in successive kernels.

The accuracy of the projection is limited by the knowledge of the nucleus location and orientation at the time of observation. Owing to the accuracy of the NAC frame and its internal deformations, this is typically on the order of 3 VIRTIS-M pixels. The accuracy of the retrieved longitudes and latitudes, related to the resolution of the shape model, is on the order of 0.05° (i.e., round-off issues may result in errors with this order of magnitude).

Shape model	**Shape model file**	**Associated rotation kernel**	**Radii of associated ellipsoid, km**
SHAP1 v3	RS_GLOBAL_DTM_500m_SHAP1v3.bds	RS_ROT_PARAM_500m_SJmodified.TPC	2.2 1.75

			1.25
SHAP2 v1	RS_GLOBAL_DTM_20m_SHAP2v1.bds	RS_ROT_PARAM_20m_SJmodified.TPC	2.446029 1.565140 1.389072
SHAP5 v0.1	cg-spc-shap5-v0.1-esoc.bds	cg-spc-shap5-v0.1_SJmodified.TPC + ROS_V24.TF	2.2 1.75 1.25
SHAP5 v1.1	cg-spc-shap5-v1.1-cheops.bds	cg-spc-shap5-v1.1_Cedric.TPC + ROS_V25.TF	2.446 1.565 1.389
SHAP7 SPC v1.8	cg-spc-shap7-v1.8-cheops_24-05-2017.bds	rotation ? + ROS_V27.TF	2.40 1.55 1.20

Table 2: Shape models information for 67P

2.2.2 Observations intercepting the surface

The geometry cube planes are listed in Table 3 and illustrated in Fig. 2. The description below applies to Mars, but the same system is used for the Earth, Moon, asteroid flybys and 67P observations with the corresponding topographic models (i.e. DTM or DSK).

All computations are performed in the planetocentric system (i.e., relative to the local vertical) and using eastward longitudes. The geographic frames are those implemented in the SPICE kernels, and defined in the IAU 2006 system [RD1, RD8].

The coordinates of the four pixel footprint corners and of the pixel central point are computed at the intersection of the line of sight with the DTM or shape model. For Mars observations, at such low resolution the difference with a projection on the areoid is significant only on large volcanoes and basins/canyons, or at large emergence angles. The same stands for the Earth and the Moon. However, the difference is very significant in the case of Steins, Lutetia and 67P.

The footprint corners are always provided in the same order, which is related to their position in the instrument X-Y plane. Please note that they do not necessarily project in the same order on a surface map (this depends on spacecraft attitude and direction of motion, and on longitude for Cartesian coordinates).

Surface elevation is the value from the DTM or shape model, provided as the altitude above the reference ellipsoid (i.e., shape model radius - ellipsoid radius). It is provided at the pixel center; whenever the pixel center value is missing, a special error code is recorded in the file (the value -20,000 m is used; it is negative and lower than the minimal elevation on Mars).

The other quantities are also computed at the pixel center. The three observing angles (incidence, emergence, phase) are provided in 3 systems: on the DTM (relative to local normal), with respect to the direction of the center of target (center of figure), and relative to the ellipsoid normal. The first set of values is related to surface photometry/shadows, the second one to the airmass. The spacecraft slant distance is computed from the shape model and includes topography. Local time is measured from local midnight. Right ascension and declination of the line of sight are computed for each pixel in all observing modes.

Other instrument-related information is stored in the geometry cubes, including SCET, UTC, and scanning mirror angle for M. SCET are copied directly from the data files, except in the case of H nominal mode where they are reconstructed for each spectrum from acquisition parameters. UTC are the corresponding values recomputed from the SPICE kernels (not using the DDS approximation provided through the EGSE), then translated at mid-exposure (the offset is equal to half the repetition time). UTC is stored on two words, the first one providing the number of day since Jan. 1st, 2000 (starting at 1), the second one providing 10,000 x the number of s on this day, starting at 0h. For H, the slit orientation is provided as the angle between the ellipsoid normal and the longest slit direction (in the plan orthogonal to the line of sight, see Figure 3). For M, the mirror angle is stored as the sine and cosine of this angle (HK parameters are decoded using the adequate transfer function). Whenever these codes are missing in the TM, they are reconstructed using the same algorithm as in the Main Electronics (this may occur for M-IR paquets with no corresponding M-vis paquet). Finally, the Sun direction is provided as the angle from the *spacecraft* boresight and its azimuth in the XY plane, counted from the X axis (Figure 4) – these two parameters have been modified in June 2015 with georos v7.

For H, all quantities are computed on a pixel basis. For M, those which are common to a complete frame are stored in the same plane; they comprise SCET, UTC, sub-S/C coordinates, mirror angle and Sun-boresight direction in the orthogonal plane (10 words, whereas the minimum plane dimension is 64).

All parameters are stored on 4 bytes as long signed integers (Table 4). Angles (coordinates, viewing angles, and α/δ) are stored in degrees and multiplied by 10,000. Distances are stored in meters. Sine and cosine of mirror angle are multiplied by 1000. Local time is stored in units of the target period/24 (local hours) multiplied by 100,000. Parameters based on data or HK which are absent from the TM are replaced by the value -2147483648 (= '80000000' hexa; this actually occurs mainly for mirror angle parameters).

Geometric information that can be considered constant in the time frame of one subsession is also stored in the label of the geometry files, including sub-solar point coordinates at the surface, solar distance, and solar longitude. Solar longitude is computed as the planetocentric longitude of the Sun (L_s), starting from body's North hemisphere spring equinox.

Regular geometry files (.GEO) contain 23 planes for M and 31 for H; extended geometry files contain 100 planes for M and 112 for H and are provided only for 67P. Plane 22 in M files provides quantities common to all pixels acquired at a given time step (along the slit).
Table 1 provides plane numbers for M and H as written in the files. When reading them with the virtispds routine, the plane numbers from H are used for both channels and M planes 23-34 are empty.

M-Plane #	H-Plane #	Parameter description	Comment
0-3	0-3	Longitudes of 4 pixel footprint corner points	Geometrical projection on the DTM
4-7	4-7	Latitudes of 4 pixel footprint corner points	Geometrical projection on the DTM
8-9	8-9	Longitude & latitude of pixel footprint center	Geometrical projection on the DTM
10-12	10-12	Incidence, emergence & phase at footprint center, relative to local normal	Angles relative to the DTM
13-14	13-14	Incidence & emergence at footprint center, relative to the reference ellipsoid	Not accounting for topography. Incidence angle is equal to solar zenith angle.
15-16	15-16	Incidence & emergence at footprint center, relative to target centre direction	
17	17	Surface elevation or distance to surface (footprint center)	Shape model distance to ellipsoid reference (provides local relief), or tangent point distance to shape model (distance in the coma)
18	18	Slant distance	Along the line of sight, from spacecraft to surface or tangent point. Computed from shape model / pixel center at mid-acquisition.
19	19	Local time at footprint center	Relative to ellipsoid
20-21	20-21	Right ascension and declination of pointing direction	J2000 reference frame. Both in degrees.
For M only:			
22		One frame-common plane	Provides several scalar quantities along the frame spatial dimension. The remainder is set to 0.
		0-1 Original data SCET from TM	The first value stores the SCET first two words (integer part), the second one stores the third SCET word (fractional part). This corresponds to the end of acquisition.
		2-3 UTC	Encoded UTC computed at mid-acquisition with Spice (reliable). The first value contains the number of days since Jan. 1st, 2000, the second value contains the time of the day as 10,000 x seconds (starting from 0h)
		4-5 Sub-spacecraft coordinates (longitude/latitude)	Radius can be computed from elements 10-12 in this frame
		6-7 Sine and cosine of M mirror angle	Converted into sin/cos values from HK ("electrical" angle in Virtis documentation)
		Sun direction: 8: angle between Sun direction - spacecraft Z axis; 9: azimuth of Sun direction in spacecraft XY plane (counted from 0° from -X axis).	9 is azimuth: Sun wrt –X axis in XY plane. Radiator is illuminated if < 90° Changed relative to georos v6
		10-12: Sub-spacecraft X/Y/Z coordinates, in m	

	For H only:	13 supplementary planes	
	22-23	Original or reconstructed data SCET	From TM in backup mode, or interpolated for each spectrum in nominal mode. The first plan stores the SCET first two words (integer part), the second one stores the third SCET word (fractional part). In all cases this corresponds to the end of acquisition.
	24-25	UTC	Encoded UTC computed at mid-acquisition with Spice (reliable). The first plan contains the number of days since Jan. 1st, 2000, the second plan contains the time of the day as 10,000 x seconds (starting from 0h)
	26-27	Sub-spacecraft coordinates (longitude/latitude)	Radius can be computed from frames 32-34
	28	Slit orientation (estimate)	Relative to the pixel normal at footprint center (see Fig. 3) – see also frame 31
	29-30	Sun direction: 29: angle between Sun direction - spacecraft Z axis; 30: azimuth of Sun direction in spacecraft XY plane (counted from 0° from -X axis).	(see Fig. 4) 30 is azimuth: Sun wrt –X axis in XY plane. Radiator is illuminated if < 90° Changed relative to georos v6
	31	Angle between H slit and celestial pole direction	
	32-34	Sub-spacecraft X/Y/Z coordinates in m	
New frames for M	New frames for H (also used by M in output of virtispds)	Extended geometry, from v7 and up	
23-34	35-46	Cartesian coordinates of footprint corners (X/Y/Z for corner 1, then 2, 3, 4)	Geometrical projection on the DTM, at mid-acquisition
35-37	47-49	Cartesian coordinates of footprint center (X/Y/Z)	Geometrical projection on the DTM, at mid-acquisition
38-41	50-53	Longitudes of 4 pixel footprint corner points at start of acquisition	Geometrical projection on the DTM
42-45	54-57	Latitudes of 4 pixel footprint corner points at start of acquisition	Geometrical projection on the DTM
46-47	58-59	Longitude & latitude of pixel footprint center at start of acquisition	Geometrical projection on the DTM
48-51	60-63	Longitudes of 4 pixel footprint corner points at end of acquisition	Geometrical projection on the DTM
52-55	64-67	Latitudes of 4 pixel footprint corner points at end of acquisition	Geometrical projection on the DTM
56-57	68-69	Longitude & latitude of pixel footprint center at end of acquisition	Geometrical projection on the DTM
58-61	70-73	Incidence at 4 corners, relative to local normal (same order as 0-3)	Angles relative to the DTM, at mid-acquisition. Provides an estimate of sub-pixel variability
62-65	74-77	Emergence at 4 corners, relative to local normal (same order as 0-3)	Angles relative to the DTM, at mid-acquisition. Provides an estimate of sub-pixel variability
66-69	78-81	Surface elevation at 4 corners (same order as 0-3)	From DTM, at mid-acquisition
70	82	S/C altitude	At mid-acquisition, above shape model – this is constant for a M frame (reserved for future use)
71-75	83-87	Distance from target center to pixel corners & center. If no intercept, measured to tangent point	At mid-acquisition. Offset added to tangent point distance if no intercept (can also be derived from 23-37)
76-80	88-92	“Local local time” (from local incidence at	At mid-acquisition. From corresponding

		corresponding plate, projected in equator plane), at each corner + center	plate (same order as 0-3). Multiplied by 100,000 as the local time in frame 19.
81-82	93-94	Sub-solar long/lat	At mid-acquisition only
83	95	Intercept / shadow binary flags 5 bits encode coma / nucleus intercept (0/1) for each corner & center 5 bits encode shadow/light on nucleus (0/1) for each corner & center – this includes shadowing by other plates	See details below - unclear if 5 first bits (encoding “visibility”) currently provide intercept flag.
84-85	96-97	Angular distance from nucleus center to LoS & azimuth	
86-87	98-99	(alpha, delta) direction of nadir / nucleus center	J2000, degrees
88-89	100-101	Pointing direction provided in body-fixed frame (lon/lat of intercept along pointing direction as seen from comet center)	Similar to 20-21 but provided as lon/lat in degrees (as seen from body center)
90-94	102-106	Radius (distance to shape model center) at 4 pixel corners and center at mid-exposure time, in meters	Can be used together with plans 0-9 to complete spherical coordinates
95-99	107-111	ID of the plate intercepted by the 4 pixel corners and center at mid-exposure	Set to default value -999 if no intercept. Shape model dependent, counted from 1.

Table 3: contents of VIRTIS geometry files, for observations intercepting the surface. Planes are counted from 0 (for handling as IDL array elements). Planes in red and green are added or modified in georos v7 with respect to v6, and are included in 67P files only. Planes in green correspond to the shape model Cartesian coordinates.

Quantity	Unit	Comment
Angles	Degrees * 10,000	
Distances	m	
Sine / cosine	Value * 1000	M scanning mirror only
Local time	Period/24 * 100,000	Period from rotation kernel, from midnight
(all)	-2147483648 = '80000000' hexa	Missing HK parameter
Elevation	+100,000	Offset added to non-intercepting lines of sight (see section 2.2.3)
Elevation	-20,000	Missing value at pixel center
Plate number	-999	No intercept of shape model (corners and center)

Table 4: Encoding and special values used in geometry files

Binary flags in frame 83 (for M) or 95 (for H) provide detailed information about illumination conditions. After conversion to LSB order (Intel platforms), the flags are encoded on the first 2 bytes and look like in the table below.
Flags can be printed under IDL with: `im.qube(95,i), format='(B16.16)'`
Individual bits can be tested under IDL with AND and OR operators (see below).

Unused						Shadow flags					Visibility flags				
0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x

The shadow and visibility flags are ordered as [corner1-4, center]. Shadow flags are set to 0 if the point is not illuminated or in the coma. Visibility flags are set to 0 if the point is hidden from the observer or in the coma; this is intended to identify pixels straddling the limb, or pixels partly masked by other facets. However, the Spice routine used are still in beta version, and inconsistent information may be returned very close to the limbs (e. g., shadow flag set to 1 and visibility flag set to 0); these pixels usually have an emergence angle > 90°.
The suggested practice is to use the shadow flags to identify illumination conditions:

```
(im.qube(83,128,30) and '0000001111100000'b) EQ 1      ; true if entirely illuminated
```

and to use the last planes to check if the FoV corners intercept the nucleus:

```
product(geomm.Qube(95:99,128,30)) NE -999               ; true if entirely on nucleus
```

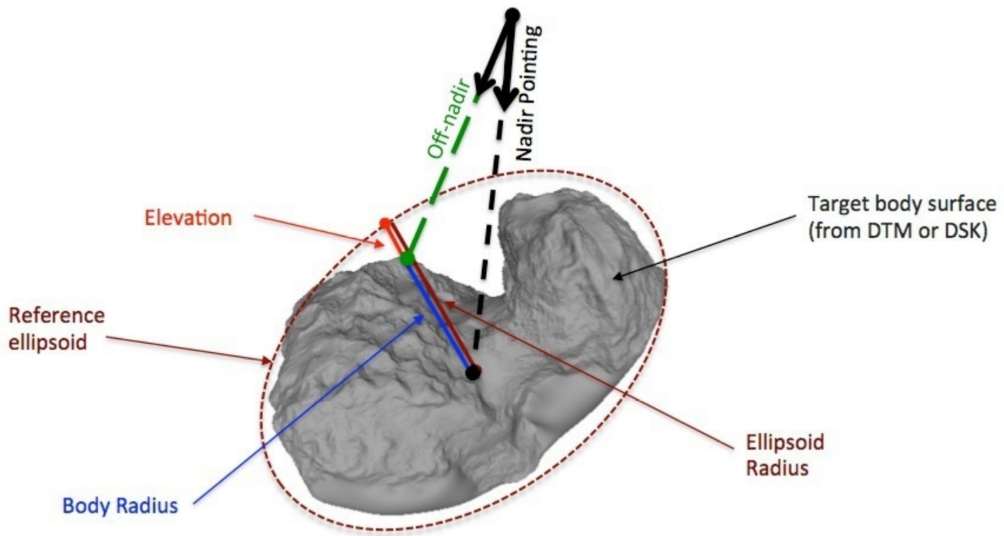

Figure 2: Observations intercepting the surface
(for planets, the reference ellipsoid is in general inside the DTM)

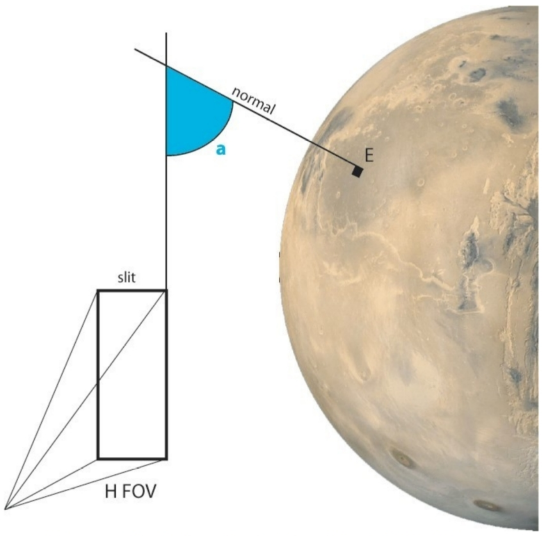

Figure 3: Slit orientation for Virtis-H

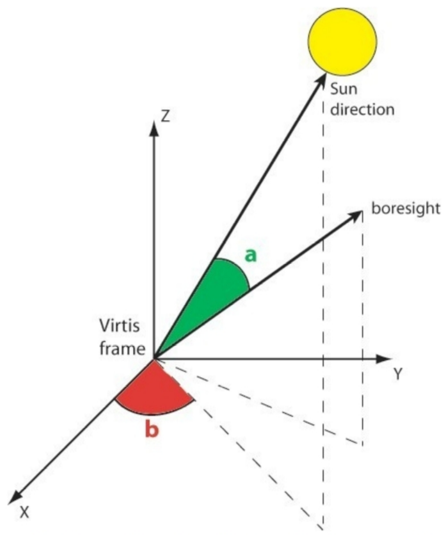

Figure 4: Sun direction in the instrument frame

2.2.3 Limb observations and other geometries

Whenever the line of sight does not intercept the surface, the above quantities are replaced by specific information (Figure 5). The tangent point is always defined as the point along the line of sight that is closest to the surface of the target. For planets, this is also the point closest to the target center. On 67P, because of target concavity the tangent point is computed along the line of sight to search for the minimum distance to the shape model; a secondary maximum may be present on the other lobe, and is not documented in the files.
Note: in the current phase, defining the tangent point this way is prohibitive in terms of computing time for 67P. For the time being, the tangent point on 67P observations is therefore defined as the closest point to the ellipsoid. This will be improved in the future.

• During limb observations surface elevation (plane 17, counting from 0) is replaced by the tangent altitude (impact parameter above the surface, counted from the shape model or DTM) with the addition of a large offset (100,000 m, see Table 4). This offset is intended to select or filter limb observations easily. The 100,000 m offset must be subtracted from plane 17 to retrieve the tangent altitude.
• Angles, local time, and slant distance are computed at the intersection with the vector passing through the center of the target (tangent point).
• The H slit orientation cannot be retrieved from surface coordinates, but is available in plane 28 for H.

inside the pixel displaying the shorter distance to the target (which is measured from pixel center).

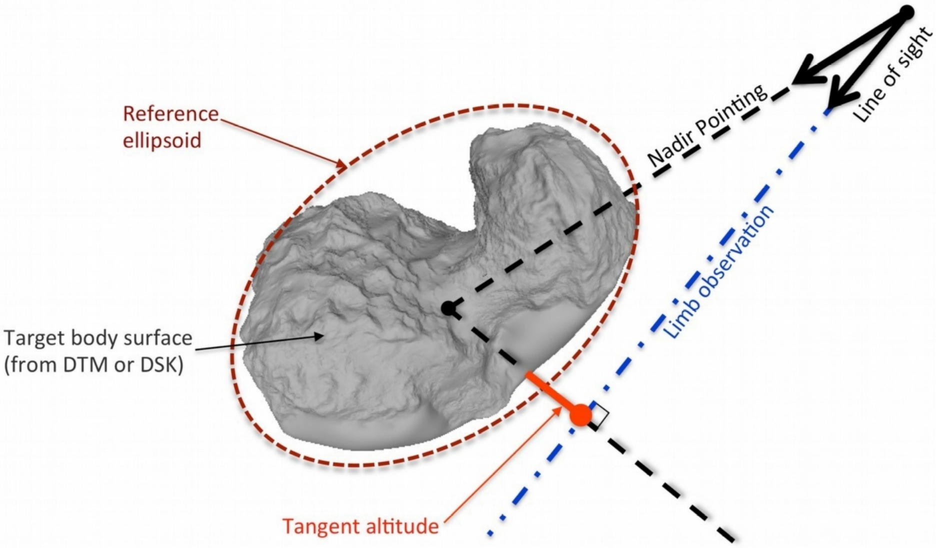

Figure 5: Limb/coma observations

2.3 Geometry file labels

An example of PDS label for the geometry cubes is given in Table 5 for Virtis-H. This is essentially a shortened version of the raw data files labels. Four new keywords provide extra geometric information not available in the data file labels: solar distance, season, and sub-solar point coordinates (lines in blue in Table 5).

Solar distance, solar longitude, and sub-solar point coordinates are computed at start of acquisition, and are about constant during a session. Slant distance is the average value encountered during observation. The other values are either minimum/maximum values (for coordinates) or start/stop values (for times).

Four extra keywords are present in the Virtis-M geometry files. They are all related to the scanning mode, and are identical to those present in the data file labels.

Keyword	SSE	Type	Possible values / range	Description
PDS_VERSION_ID	SC	ID	PDS3	Version of PDS standard used, constant
LABEL_REVISION_NOTE	SC	CHAR	"SE-MTC, 7/06/2013"	ID of label version
(blank line)				
/* File format and length */				
PRODUCT_ID	SC	CHAR	"xxx.GEO"	Current file name with extension
ORIGINAL_PRODUCT_ID	SC	CHAR	"xxx.QUB"	Original data file name with

				extension (ie: PI72P331.QUB)
RECORD_TYPE	SC	ID	FIXED_LENGTH	File formatting info
RECORD_BYTES	SC	INT	512	Record length in bytes, constant
FILE_RECORDS	SC	INT	nn1	Total file length / RECORD_BYTES (closest integer greater than or equal to this value)
LABEL_RECORDS	SC	INT	10	Smallest integer large enough to accommodate the label up to the END keyword (ie., label length in byte ≤ LABEL_RECORDS * 512)
FILE_STATE	SC	ID	CLEAN	Flag for incomplete files, constant
(blank line)				
/* Pointers to data objects */				
^QUBE	SC	PT	nn2	LABEL_RECORDS + 1
(blank line)				
/* Producer information */				
PRODUCER_ID	SC	ID	ROSETTA_VIRTIS_TEAM	(constant)
PRODUCER_FULL_NAME	SC	CHAR	"CORADINI"	(constant)
PRODUCER_INSTITUTION_NAME	SC	CHAR	"OBSERVATOIRE DE PARIS-LESIA"	(constant)
PRODUCT_CREATION_TIME	SC	TIME	yyyy-mm-ddThh:mm:ss.fff	Time when the PDS file is written
TELEMETRY_SOURCE_ID	SC	CHAR	"VIRTIS_EGSE<n>"	EGSE ID (<n> is the version number of EGSE itself = 3)
SOFTWARE_VERSION_ID	SET	CHAR	{"VirtisROS SW v.4.10", "EGSE_SOFT_<n>", "PDS_CONVERTER_<p>", "EGSE2PSA_CONVLABEL_1.2.2", "GEOROS_<q>", "V_GEOLABEL_6"}	Versions ID of software used to process this file, including on-board software and conversion routines. <n>, <p> and <q> are the version numbers of EGSE (generating the data) and GEOROS (computing the geometry) software. v_geolabel is the routine writing the files.
(blank line)				
/* Data description parameters */				
DATA_SET_NAME	SC	CHAR	"xxx"	(Same as raw data)
DATA_SET_ID	SC	CHAR	"xxx "	(Same as raw data)
PRODUCT_TYPE	SC	ID	EDR	(constant)
PROCESSING_LEVEL_ID	SC	INT	2	As in DATA_SET_ID
STANDARD_DATA_PRODUCT_ID	SC	CHAR	"VIRTIS GEOMETRY"	Identifies data versus geometry
MISSION NAME	SC	CHAR	"INTERNATIONAL ROSETTA MISSION"	(constant)
MISSION_ID	SC	ID	ROSETTA	(constant)
INSTRUMENT_HOST_NAME	SC	ID	"ROSETTA-ORBITER"	(constant)
INSTRUMENT_HOST_ID	SC	ID	RO	(constant)
MISSION_PHASE_NAME	SC	CHAR	"xxx”	String, as defined by PSA MTP # for 67P
PI_PDS_USER_ID	SC	CHAR	"CORADINI"	(constant)
INSTRUMENT_NAME	SC	CHAR	"VISIBLE AND INFRARED THERMAL IMAGING SPECTROMETER"	(constant)
INSTRUMENT_ID	SC	ID	"VIRTIS"	(constant)
INSTRUMENT_TYPE	SC	CHAR	"IMAGING SPECTROMETER"	(constant)
^INSTRUMENT_DESC	SC	PT	"RO_VIRTIS_EAICD.ASC"	(constant)
ROSETTA:CHANNEL_ID	SC	ID	"VIRTIS_H"	(constant)

DATA_QUALITY_ID	SC	INT	0 1 "NULL"	0 if TM datapaquets are missing when writing PDS data 1 otherwise "NULL" is no diagnostic (may be used to store other error codes)
DATA_QUALITY_DESC	SC	CHAR	"0:INCOMPLETE ; 1:COMPLETE"	(constant)
(blank line)				
/* Science operations information */				
TARGET_TYPE	SC	CHAR	"PLANET" "CALIBRATION" "SKY" "ASTEROID" "COMET"	As defined by PSA
TARGET_NAME	SC	CHAR	"EARTH" "MARS" "CALIBRATION" "SKY" "2867 STEINS" "21 LUTETIA" "67P/<etc>"	As defined by PSA
START_TIME	SC	TIME	yyyy-mm-ddThh:mm:ss.fff	UTC of first acquisition
STOP_TIME	SC	TIME	yyyy-mm-ddThh:mm:ss.fff	UTC of last acquisition
SPACECRAFT_CLOCK_START_COUNT	SC	CHAR	"n/ssssssssss.fffff"	Formatted, from TM packet data field header. n is increased after each resynchronization of the S/C clock, starting from 1
SPACECRAFT_CLOCK_STOP_COUNT	SC	CHAR	"n/ssssssssss.fffff"	Formatted, from TM packet data field header. n is increased after each resynchronization of the S/C clock, starting from 1
ORBIT_NUMBER	SC	INT	"N/A"	Reserved, unused during cruise
OBSERVATION_TYPE	SC	CHAR	"xxx"	Reserved for future use
SC_SUN_POSITION_VECTOR	VEC	REAL	(x,x,x)	Provides sun direction in J2000 frame
SC_TARGET_POSITION_VECTOR	VEC	REAL	(x,x,x)	Provides target direction in J2000 frame
SC_TARGET_VELOCITY_VECTOR	VEC	REAL	(x,x,x)	Provides target velocity in J2000 frame
COORDINATE_SYSTEM_ID	SC	PT	"xxx"	Spice code of body-fixed reference frame in use
COORDINATE_SYSTEM_NAME	SC	PT	"xxx"	Spice name of body-fixed reference frame in use
DECLINATION	SC	REAL	0.0	J2000 coordinate
RIGHT_ASCENSION	SC	REAL	0.0	J2000 coordinate
MAXIMUM_LATITUDE	SC	REAL	000.000	In decimal degrees
MINIMUM_LATITUDE	SC	REAL	000.000	In decimal degrees
EASTERNMOST_LONGITUDE	SC	REAL	000.000	In decimal degrees, Eastward longitudes
WESTERNMOST_LONGITUDE	SC	REAL	000.000	In decimal degrees, Eastward longitudes
SPACECRAFT_ALTITUDE	SC	REAL	0000.000	Average value above ellipsoid in km
PHASE_ANGLE	SC	REAL	0000.000	In decimal degrees
SUB_SPACECRAFT_LATITUDE	SC	REAL	0000.000	In decimal degrees

SUB_SPACECRAFT_LONGITUDE	SC	REAL	0000.000	In decimal degrees, eastward
SLANT_DISTANCE	SC	REAL	0000.000	Average value in km
SOLAR_DISTANCE	SC	REAL	0000.000	Sun-target distance in km
SOLAR_LONGITUDE	SC	REAL	0000.000	Ls, counted from vernal equinox, in decimal degrees
SUB_SOLAR_LONGITUDE	SC	REAL	0000.000	Longitude of sub-solar point, in decimal degrees
SUB_SOLAR_LATITUDE	SC	REAL	0000.000	Latitude of sub-solar point, in decimal degrees
NOTE			"bla-bla"	Information note requested by the PSA, should not include "=" sign
(blank line)				
/* Instrument status */				(constant)
INSTRUMENT_MODE_ID	SC	INT	1 H_Off 2 H_Cool_Down 3 H_Idle 4 H_Annealing 5 H_PEM_On 6 H_Test 7 H_Calibration 8 H_Nominal_Simulation 9 H_Science_Maximum_Data_Rate 10 H_Science_Nominal_Data_Rate 11 H_Science_Minimum_Data_Rate 12 (deleted) 13 H_Science_Backup 14 H_User_Defined 15 (deleted) 16 (deleted) 17 (deleted) 18 H_Spectral_Calibration_Simulation 19 H_Degraded 63 H_ME_Test	H channel functioning mode, M counterparts are different
^INSTRUMENT_MODE_DESC	SC	CHAR	"RO_VIRTIS_EAICD.ASC"	(constant)
(blank line)				
/* Pointer to navigation data files*/				
SPICE_FILE_NAME	SET	CHAR	{"xxx", ...,"xxx"} or "NULL"	List of Spice kernels used in computation. The last entries provide the names of the DSK or DTM describing the surface.
(blank line)				
/* Cube keywords */				
OBJECT	SC	ID	QUBE	(constant)
AXES	SC	INT	3	(constant)
AXIS_NAME	EN	ID	(BAND,SAMPLE,LINE)	(constant, provides data organization)
CORE_ITEMS	EN	INT	(x,y,z)	Cube dimensions: y, z same as data cube. x constant (# of geometrical values stored)
CORE_ITEM_BYTES	SC	INT	4	(constant)
CORE_ITEM_TYPE	SC	ID	MSB_INTEGER	(constant)
CORE_BASE	SC	REAL	0.0	(constant)
CORE_MULTIPLIER	SC	REAL	1.0	(constant)
CORE_VALID_MINIMUM	SC	INT	-2147483648	(constant)
CORE_NULL	SC	INT	-2147483648	(constant) '80000000' hexa
CORE_LOW_REPR_SATURA	SC	INT	-2147483648	(constant)

TION				
CORE_LOW_INSTR_SATURATION	SC	INT	-2147483648	(constant)
CORE_HIGH_REPR_SATURATION	SC	INT	2147483647	(constant)
CORE_HIGH_INSTR_SATURATION	SC	INT	2147483647	(constant)
CORE_NAME	SC	ID	"GEOMETRIC PARAMETERS"	(constant)
CORE_UNIT	SC	ID	"UNK"	(constant) Depends on parameter
CORE_DESC	SC	CHAR	"Parameters are defined in EAICD"	(constant)
(blank line)				
SUFFIX_BYTES	SC	INT	4	(constant)
SUFFIX_ITEMS	EN	INT	(0, 0 ,0)	No suffix present
END_OBJECT	SC	ID	QUBE	(constant)
(blank line)				
END	SC	ID		

Table 5: Label for Virtis-H on Rosetta. Extra or modified lines relative to the raw data labels are outlined in blue (several lines present in the data labels are also removed).

Appendix-A FOV definitions

The data provided here are copied from the latest Spice kernels provided by ESA, and partly come from documents AD3 and RD7. Virtis offsets in Table 6 have been derived from analysis of Mars fly-by data and star pointing during PC6.

Both Virtis channels have their slit in the Y direction.

For Virtis-M (both visible and IR imaging channels):
• IFOV (pixel size) is ~ 0.000250x0.000250 rad = 0.0143x0.0143°
• FOV is elongated in the Y direction by 256 pixels: 0.064 rad = 3.67°
The FOV corresponds to the detector column that is acquired at each time step.

For Virtis-H (high resolution point spectrometer channel):
• IFOV (pixel size) is ~ 0.000583x0.000583 rad = 0.0334x0.0334°
• FOV is elongated in the Y direction by 3 pixels: 0.001749 rad = 0.1002°
The FOV corresponds to the 3-pixel wide area on which the signal has to be integrated; in nominal mode, this integration is performed on-board by the ME.

FOV centers are slightly offset from the spacecraft bore sight. The exact positions are given in terms of offset in document AD3 (but are given in terms of rotations around the axes in the Spice kernels). The figures are provided in Table 6, and are used in Fig. 6 to overplot the various instruments' FOV.
Table 7 provides a tentative estimate of the location of Virtis boresight in the Osiris images (as stated in RD7).

	X	Y
M_IR-offsets	dx = -0.071619724°	dy = -0.025926340°
M_IR-rotations	Rx = -0.025926340°	Ry = 0.071619724°
M_vis-offsets	dx = -0.071619724°	dy = 0.032945073°
M_vis-rotations	Rx = 0.032945073°	Ry = 0.071619724°
H-offsets	dx = -0.0936°	dy = 0.0027°
H-rotations	Rx = 0. 0027°	Ry = 0.0936°

Table 6: Virtis FOV centers relative to spacecraft boresight

	X/Y NAC pixels	X/Y WAC pixels
M_IR boresight	992 / 980	1043/ 946
H boresight	1013/ 963	1039/ 943

Table 7: Virtis FOV centers projection on Osiris frames

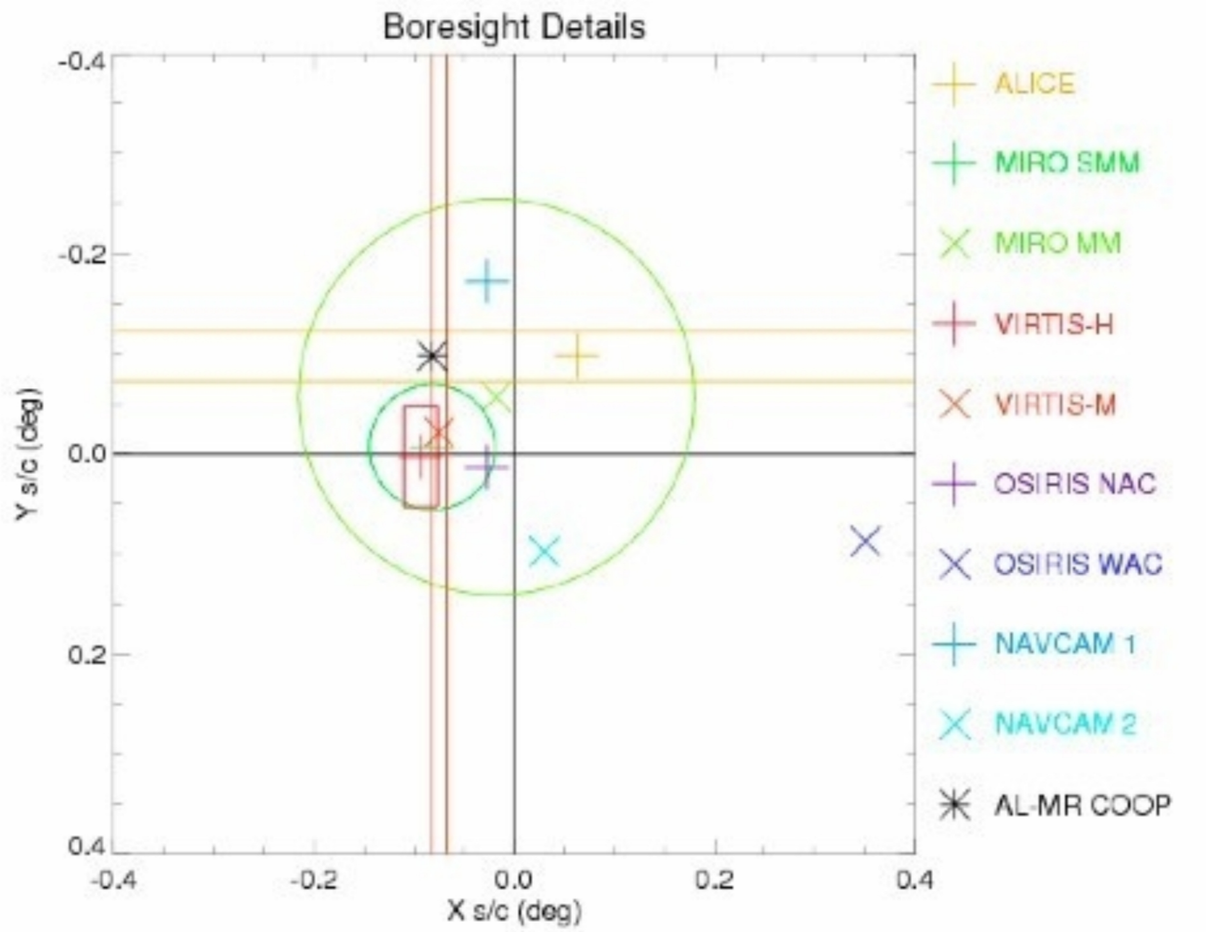

Figure 6: Details of Rosetta instruments' FOV in the spacecraft X/Y frame. Zs/c points into the page, +Xs/c points to the right, and +Ys/c points down *(figure from AD3)*

Appendix-B Code history

- Dec 2006: Written by K. Garceran (from geovirtis, for VEx)
- March-2007, S. Erard: Quick & dirty adaptation/merging of geovirtis and geomeg to Rosetta Mars flyby (functional but uses different routines for M and H, to be cleaned and checked later)
- Modified to compute geometry cube for Earth and Mars swing-by, P.Lambert
- 17-OCT-2007, P.Lambert: adapted for VIRTIS/ROSETTA, MARS FLY-BY.
- 23-OCT-2007, P.Lambert: adapted for new new EGSE, VIRTIS/ROSETTA
  H OK (to process old egse data -> specify /OLD)
- 26-OCT-2007, P.Lambert: /UP no more available. /UP is in charge at Rome
  The raw qubes to process are already updated at Rome
- 17-DEC-2007, P.Lambert: from georosmars & georosearth, georos deals with the different target, EARTH (ESB1,ESB2) and Mars.
- 10-SEP-2008, S.Erard: Quick update for Steins flyby
- 28-APR-2009, F.Henry: /ESB1, /ESB2, MSB, /AFB1 options are no longer available
  The target is guessed from the database
- 30-APR-2009, F.Henry: options /ESB1, /ESB2, MSB, /AFB1 are back in order to be able to use GEOROS without the database
- 22-MAY-2009, X.Bonnin: The Moon observation geometry files during the two Earth swing-by (ESB1, ESB2) are now computed correctly (Using TARGET_NAME in file label)

Version 4.2
- 10-JUN-2009, X.Bonnin: The computation of the geometry files for the Steins fly-by (AFB1) is now done with the Digital Shape kernels (DSK) when DTM keyword is set.
  The dynamically loadable module library (DLM) DSKPLTLIB must be loaded to use DSK files in georos.
- 25-NOV-2009, F. Henry; Added the /ESB3 ans /AFB2 flags
- 10-DEC-2009, X. Bonnin; Added the LESIA_CKM flag to load the SPICE CK mirror position files produced by the LESIA

Version 4.3
- 14-JAN-2010, X.Bonnin: Added DTM for the Earth (GLOBE data) and Moon (CLEMENTINE/LIDAR data).

Version 4.4
-21-DEC-2011, S.Jacquinod: The computation of the geometry file for the Lutetia fly-by (AFB2) is now done with the Digital Shape kernels (DSK) when DTM keyword is set.
The dynamically loadable module library (DLM) DSKPLTLIB must be loaded to use DSK files in georos.

Version 5.0
- 04-JUL_2013, S.Jacquinod: Added the computation of the geometric label parameters
  Use the keyword /up to updated original RAW files
  Added a new routine in the pipeline: eastwestlon.pro to compute easternmost & westernmost longitudes in the geometric labels
  Extract the INSTRUMENT_MODE_ID with no quotes

Version 5.1
-08-JUL-2013, S.Jacquinod: read the DATA_QUALITY_ID keyword as a string instead of a float.
  give it as a string to the structure CatArg for the update of the label

Version 5.2
-23-JUL-2013, S. Jacquinod:
  Added the computation of the reference frame ID and the definition of the system variable !BODY_FRAME_ID (georos_body_setup.pro)
  Added the computation of the mean slant distance for geometric labels
  Added error line display on prompt and writing in the logfile

Version 5.3
- 18-NOV-2013, S. Jacquinod:
  suppressed the keywords option ESB1, ESB2, ESB3, MSB, AFB1, AFB2 because the name of the mission phases has changed
  Added the new keyword parameter PHASE_NAME.
  See the sections "keyword parameters" and "example" hereabove for use

Version 5.4
- 26-NOV-2013, S. Jacquinod:
  correct a bug with the definition of the system variable !COMPUTE_DSK for AST1 and AST2

Version 6.0

- 08-JUL-2014, S. Jacquinod:
multiple changes to adapt the routines with the SPICE Version 65 Library
- 09-JUL-2014, F. HENRY, S. Jacquinod:
added LOAD_MK in order to manually load meta-kernels .ker (in MK/ SPICE_KERNELS directory). This META kernels contains all the names of the kernels that have to be loaded
added OFFLINE option to compute geometry with no internet connection
added SONC option for the VIRTIS_Coma_products output in ASCII format ('txt' option) or VOtable ('votable')
- 15-JUL-2014, S. Jacquinod:
correction of a bug for Nominal files where the size is 1*64. The search for the dimension [2] of size(scstr) was false because in this case scstr is a 1D array.
correction of a bug: basename doesn't exist, it's the function file_basename in IDL
- 08-AUG-2014, S. Jacquinod: replace MTP case by STP case because data are stored by STP on Otarie now
- 15-SEP-2015; F. Henry: - .PRE files are created when the RORB kernel file has a predicted start date later than the beginning of the start of the observation. .GEO are created otherwise
- 17-JAN-2015; S. Jacquinod : Shape 5
Version 6.1
- 26-JAN-2015; FH + SJ: modification of georos_interp to fix the bug when h_frame_summing > 1
- 12-MAR-2015; FH: modification of the DATA_SET_NAME and DATA_SET_ID for GEO products
(data level should be 3 for GEO and 2 for QUB)
Version 6.2
- 08-MAY-2015; SJ: correction of the bug concerning the loading of the CATT file and the PCK associated to SHAPE 5 with the good reference frame in order to use the good rotation period of the nucleus
• 67P dataset recomputed on May 12 with proper rotation variations, supersedes all previous versions.
- JAN-2016: now uses shape model 5 v1.1

Version 7.0
- New, extended geometry implemented for 67P.
- July 2016: same code now handles both versions, 6 and 7.