RADIO SCIENCE

Radio Science Cologne

Mars Express, Venus Express and ROSETTA

File Naming Convention and File Formats of Higher Science Data Products

Issue: **7**
Revision: **7**
Date: **10.01.2019**
Document: **MEX-MRS-RIU-IS-3050**
VEX-VRA-RIU-IS-5012
ROS-RSI-RIU-IS-3018

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Document Change Record

Issue	Rev	Sec	Date	Changes	author
Draft	0	All	01.12.2004	Draft	mpa
	1	Title	22.12.2004	Document number introduced, title changed	mpa
	2	4	28.12.2004	Introduction of section 4.2	mpa
	3	4 – 7	31.12.2004	Section 4 to 7 reformatted	mpa
	4	3 and 4	11.05.2005	changes in section 3.3 and 4	st
	5	4.4	27.05.2005	undate of refractivity file format	st
	6	4.4 4.5 4.6	02.05.2006	Update of refractivity file format Introduction of logfile format Update of atmosphere file format Introduction of logfile format Update of ionospheric file format	mpa
1	0	All	12.07.07	Update of atmospheric and ionospheric file formats	st
1	1	2.2/4.3	26.07.07	Update of atmospheric file formats	st
1	2	4.2	03.08.07	Update of refractivity file format	st
2	0	All	07.02.08	Update of OCC file formats (level 3 & 4)	st
2	1	3.3	13.05.08	Update of ionospheric data format	st
2a	1	All	14.05.08	change of document format for data workshop	st
2a	2	All	15.05.08	change of document format for data workshop	st
2a	3	All	20.05.08	change of document format for data workshop	st
3a	0	All	27.08.08	change of document format after comments from data workshop	st
4	0	All	04.08.09	Change of document format for new LV4 archive	st
4	1	2.2	19.08.09	Implemented CODMAC level	st
4	2	All	21.10.09	Updated all; changed document number	st
4	3	5	23.11.09	Added new section describing data_set_id and volume_id	LC
5	0	All	28.11.13	Change of document format for new LV4 archive	st
5	1	All	10.12.13	Change of document format for new LV4 archive	st
5	2	All	06.03.14	Small changes	st
5	3	All	18.03.14	Added document section 4.2	jo
5	4	All	25.04.14	Changed document section 4.3 (L04 ionosphere), small changes in other chapters	kp

5	5	All	28.04.14	Small changes	st
5	6	All	05.05.14	Small changes	kp
5	7	All	07.05.14	Small changes	st
5	8	All	07.05.14	Small changes	st
6	0	All	08.08.14	Included comments from team members	st
6	1	All	14.08.14	Included comments from team members	st/kp/jo
6	2	4.3	31.03.15	Completed description for ionosphere part	kp
7	2	4.2	01.04.15	Update of 4.2.2.2 and 4.2.3.2	jo
7	3	All	1.4.15, 4.3	Small changes, implemented L05	St, kp
7	4		29.08.16	Implemented Multipath Profiles	ST
7	5	2.4	26.09.2016	Science data level 2 included in table 2-1	jo
7	6	3.1.1	09.11.16	Updated summary table format	st
7	7	4.3.2.2	10.01.19	Added comments i.) ‘Not calculated for solar zenith angles > 105°’ in lines 12-15/48-59; ii.) added comment in line 14 in table in section 4.3.2.2	kp

59

Page left free

62
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64

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65
66
67

Page left free

ACRONYMS

A/D	Analog/Digital
AGC	Automatic Gain Control
AGVTP	Archive Generation, Validation and Transfer Plan
AOL	Amplitude Open Loop
ATDF	Archival Tracking Data Format
CD-ROM	Compact Disk - Read Only Memory
CL	Closed-Loop
DSN	Deep Space Network
ERT	Earth Received Time
GRT	Ground Received Time
G/S	Ground Station
HGA	High Gain Antenna
IFMS	Intermediate Frequency Modulation System
LCP	Left Circular Polarization
LGA	Low Gain Antenna
LI	Linear interpolation
MaRS	Mars Express Radio Science Experiment
MOLA	Mars Orbiter Laser Altimeter
NAIF	Navigation and Ancillary Information Facility of NASA
OCC	Occultation
ODF	Orbital Data File
OL	Open-Loop
ONED	One-way dual-frequency mode
ONES	One-way single-frequency mode
OWLT	One-way light time
RCP	Right Circular Polarization
RSI	Rosetta Radio Science Investigations
RSR	Radio Science Receiver
RX	Receiver
S/C	Spacecraft
S-TX	S-Band Transmitter
TWOD	Two-way dual-frequency mode
TWOS	Two-way single-frequency mode
VeRa	Venus Express Radio Science Experiment
X-TX	X-band Transmitter

112 Page left free
113

Contents

1 INTRODUCTION 12

1.1 Scope 12

1.2 Applicable Documents 12

1.3 Referenced Documents 12

2 OVERVIEW OF SCIENCE DATA LEVELS 15

2.1 Data Processing Levels 15

2.2 Science Data Processing levels 15

2.3 General File name Format 17

2.4 Data File Names 17

2.5 Descriptive File Names 17

3 LEVEL 3 SCIENCE DATA PRODUCTS 24

3.1 Level 3 Data Products: Occultations 24
3.1.1 Summary Table Occultation Season 24
3.1.2 Occultation measurement refractivity profile file 26
3.1.3 Occultation measurement information file 27

3.2 Level 3 Data Products: Gravity 30

3.3 Level 3 Data Products: Bistatic Radar 30

3.4 Level 3 Data Products: Solar Corona 31

3.5 Level 3 Data Products: Phobos 31

4 LEVEL 4 SCIENCE DATA PRODUCTS 32

4.1 LEVEL 4 Data Products: Neutral Atmospheric Profiles 32
4.1.1 Introduction 32
4.1.2 Atmospheric Information File 32
4.1.3 Atmospheric profiles data file 39

4.2 LEVEL 4 Data Products: Absorptivity profiles and H2SO4 profiles (for Venus only) 41
4.2.1 Introduction 41

4.2.2 Atmospheric Information File 41
4.2.3 Absorptivity and H2SO4 profiles data file 43

4.3 LEVEL 4 Data Products: Ionospheric Electron Density Profiles 43
4.3.1 Introduction 44
4.3.2 Ionospheric information file 44
4.3.3 Electron density profile file 53

4.4 LEVEL 4 Data Products: Gravity 54

4.5 LEVEL 4 Data Products: Bistatic Radar 54

4.6 LEVEL 4 Data Products: Solar Corona 54

4.7 LEVEL 4 Data Products: Phobos 54

5 LEVEL 5 SCIENCE DATA PRODUCTS 54

5.1 LEVEL 5 Data Products: Averaged Atmospheric Profiles 54
5.1.1 Introduction 54
5.1.2 Averaged atmospheric profile file 54

6 VOLUMES AND DATASETS ORGANIZATIONS, FORMATS AND NAME SPECIFICATIONS 56

6.1 Definitions and General Concept 56
6.1.1 Definitions 56

6.2 Data- and Volume Set Organization 57

6.3 VOLUME AND DATASET NAME SPECIFICATION 58
6.3.1 Dataset 58
6.3.2 Dataset Collection 60
6.3.3 Volume 61
6.3.4 Volume Set 64
6.3.5 Volume Series 66

1 INTRODUCTION

1.1 SCOPE

This document defines the file naming convention and the file formats of the science data products beyond data level 2 defined by the Radio Science Team in Cologne.

1.2 APPLICABLE DOCUMENTS

Reference Number	Title	Issue Number	Date
[1]	Radio Science File Naming Convention and Radio Science File Formats	ROS-RSI-IGM-IS-3087_I9_R1_file_naming_convention.doc	07.08.06
[2]	IFMS Doppler Processing and Calibration Software: Level 1a to Level 2 Software Design Specifications	MEX-MRS-IGM-DS-3035_I5_R0_IFMS_Doppler_level1a_level2.doc	26.07.05

1.3 REFERENCED DOCUMENTS

Author	Title	Issue
Fjeldbo, , G., Kliore, A.J., and Eshleman, V.R.	The Neutral Atmosphere of Venus as Studied with the Mariner V Radio Occultation Experiment	*Astron. J.* **76,** 123-140, 1971.
Lipa, B. and Tyler, G.L.	Statistical and computational uncertainties in atmospheric profiles from radio occultation: Mariner 10 at Venus	*Icarus* **39**, 192–208, 1979.
Eshleman, V.R.	The radio occultation method for the study of planetary atmospheres	*Planet. Space Sci*. **21**, 1521–1531, 1973.
Hinson, D.P., Tyler, G.L., Hollingsworth, J.L., and Wilson, R.J.	Initial results from radio occultation measurements with Mars Global Surveyor	*J. Geophys. Res*., **104**, 26, 997-27, 012, 1999.
Schaa, R.	Abel-Inversion von Radio-Okkultationsdaten	Diplomarbeit, Institut für Geophysik und

		Meteorologie, Universität zu Köln, 2005. (*in german*)
Peter, K.	Beobachtungen der Ionosphären- und Ionopausenstrukturen des Mars mit dem Radio Science Experiment MaRS auf Mars Express	Diplomarbeit, Institut für Geophysik und Meteorologie, Universität zu Köln, 2008. (*in german*)
Pätzold, M., Tellmann, S., Häusler, B., Hinson, D., Schaa, R., Tyler, G.L.	A Sporadic Layer in the Ionosphere of Mars	*Science* **310**, **5749**, 837 – 839, 2005.
Pätzold, M., Häusler, B., Bird, M.K., Tellmann, S., Mattei, R., Asmar, S.W., Dehant, V., Eidel, W., Imamura, T, Simpson, R.A., Tyler, G.L.	The structure of Venus' middle atmosphere and ionosphere	*Nature* **450**, 657–660, 2007.
Tellmann, S., Pätzold, M., Häusler, B., Bird, M.K., Tyler, G.L.	The structure of the Venus neutral atmosphere as observed by the Radio Science Experiment VeRa on Venus Express.	*J. Geophys. Res.,114, E00B36, doi: 10.1029/2008JE003204, 2009.*
Tellmann, S., Häusler, B., Hinson, D.P., Tyler, G.L., Andert, T.P., Bird, M.K., Imamura, T., Pätzold, M., and Remus, S.	Small-scale temperature fluctuations seen by the VeRa radio science experiment on Venus Express	*Icarus*, 221, 471 - 480, 2012.
Oschlisniok, J., Häusler, B., Pätzold, M., Tyler, G. L., Bird, M. K., Tellmann, S., Remus, S., Andert, T.	Microwave absorptivity by sulfuric acid in the Venus atmosphere: First results from the Venus Express Radio Science experiment VeRa	*Icarus,* 221, 940 – 948, 2012.
Tellmann, S., Pätzold, M., Häusler, B., Hinson, D.P., and Tyler, G.L.	The structure of the Mars lower atmosphere from Mars Express Radio Science (MaRS) occultation measurements	*J. Geophys. Res.,* 118, 306 - 320, 2013.
Peter, K., Pätzold, M., Molina-Cuberos, G., Witasse, O., González-Galindo, F., Withers, P., Bird, M. K., Häusler, B., Hinson, D. P., Tellmann, S., Tyler, G. L.	The dayside ionospheres of Mars and Venus : Comparing a one-dimensional photochemical model with MaRS (Mars Express) and VeRa (Venus Express) observations	*Icarus, 233, 66 - 82, 2014*

Page left free

2 OVERVIEW OF SCIENCE DATA LEVELS

2.1 DATA PROCESSING LEVELS

This document describes the Radio Science data formats beyond Level 2 (L02). Level 1 (L01) data are raw data recorded at the ESA ground stations in New Norcia (Australia), Cebreros (Spain) or at the NASA Deep Space Network (DSN).
Calibrated received frequencies, predicted frequencies and resulting frequency residuals (observed frequency minus predicted frequency) can be found in L02 data files along with other relevant information about measurement time, measurement geometry and received signal strength.

A detailed description of the L01 and L02 data can be found in [1] and [2]. Radio Science L02 files can contain different measurement types:

- gravity measurements
- radio occultation measurements
- solar Corona measurements.
- bistatic radar measurements

The L02 files provide the input data base for the Level 3 (L03), Level 4 (L04) and Level 5 (L05) data files.

2.2 SCIENCE DATA PROCESSING LEVELS

Level 3 (L03) files contain derived science information extracted from the Radio Science L02 data. Different output file types exist depending on the measurement type and geometry. The six different measurement types are:

- Occultation measurements:
  In a first step a refractivity profile is generated for each occultation measurement (L03). Frequency shifts included in the L02 data are used to calculate the ray bending of the radio link in the ionosphere and atmosphere based on geometrical optics [e.g. Fjeldbo et al., 1971]. The refractivity profile, the bending angle and the ray parameter are the main output for Level 3.
- Bistatic Radar measurements:
  Echo power files are generated for X-RCP, X-LCP, S-RCP, and S-LCP. Each is derived from the respective echo power spectra (L02) by integrating over the echo bandwidth after removing the noise pedestal.

There are no L03 files for gravity, Phobos and solar corona measurements.

Level 4 (L04) files contain science products derived from L03 output files. The data processing levels 3 and 4 (L03 and L04) are identical to the CODMAC level 05.

The L03 occultation refractivity profiles are used to generate three different types of L04 occultation (OCC) data:

- Atmospheric profiles of the neutral atmosphere containing vertical profiles of temperature, pressure and neutral number density:
  The neutral number density is directly proportional to the refractivity in the atmosphere. The refractivity profile provided in the L03 data can therefore be used to calculate the neutral number density profile in a first step. The pressure and temperature profiles can be deduced from these density profiles by assuming hydrostatic equilibrium and using the ideal gas law [e.g. Hinson et al., 1999].
- Absorptivity profiles and H_2SO_4 profiles in the neutral atmosphere of Venus (only valid for VeRa data from Venus Express).
- Ionospheric files containing electron density profiles of the planet's ionosphere.

The Bistatic Radar L04 product contains information about the dielectric constant of the surface. L04 BSR files are derived from echo power files by calculating the ratio of RCP to LCP echo power and using the Fresnel power reflection coefficient to extract the dielectric constant at the known specular point incidence angle.

The Phobos, Solar Corona L04 data products are TBD.

Level 5 (L05) files contain averaged science products derived from L04 output files. The data are averaged with regard to the latitude and the local time.

2.3 GENERAL FILE NAME FORMAT

The file names of all higher science products (Level3 and Level4) generated from Level 2 data will follow the following file name format.

rggttttlll_sss_yydddhhmm_qq.eee

For Level 5 (averaged atmospheric profiles), the file name format is

rggttttlll_sss_latlatrrrrqq.eee

See Table 2-1 for explanation.

2.4 DATA FILE NAMES

All tabulated ASCII data files of each processing level will have the extension *eee* = *TAB.*

2.5 DESCRIPTIVE FILE NAMES

Descriptive files contain information in order to support the content of data files. The following file types are defined as descriptive files with extension *eee* =

- *.LBL PDS label files
- *.TXT Information (text) files
- *.LOG additional processing information
- *.INP input information (for L03 only)

Table 2-1: Data file naming convention

Acronym	Description	Examples
r	*Spacecraft (Raumsonde) name* R = Rosetta M = Mars Express V = Venus Express	M
gg	*Ground station ID:* 00 = valid for all ground stations or independent of ground station or not appicable. 99 = averaged over all applicable	00

	groundstations <u>DSN complex 40 Canberra</u> 34 = 34 m BWG 40 = complex 43 = 70 m 45 = 34 m HEF <u>ESA Cebreros antenna:</u> 62 = 35 m <u>ESA Malargüe antenna:</u> 84 = 35 m <u>DSN complex 10 Goldstone:</u> 10 = complex 14 = 70 m 15 = 34 m HEF 24 = 34 m BWG 25 = 34 m BWG 26 = 34 m BWG 27 = 34 m HSBWG <u>ESA Kourou antenna</u> 75 = 15 m <u>DSN complex 60 Madrid:</u> 54 = 34 m BWG 55 = 34 m BWG 60 = complex 63 = 70 m 65 = 34 m HEF <u>ESA New Norcia antenna</u> 32 = 35 m	
tttt	*data source identifier* <u>Level 3 & 4</u> ICL1 = IFMS 1closed loop ICL2 = IFMS 2 closed loop ICL3 = IFMS RS (IFMS 3) closed-loop IOL1 = IFMS 1 open loop IOL2 = IFMS 2 open loop IOL3 = IFMS RS (IFMS 3) open loop ODFX = DSN ODF closed-loop file (X-band) ODFS = DSN ODF closed-loop file (S-band) T000 – T017 = DSN TNF closed-loop file RSR0 = DSN RSR open-loop file	ODF0

	SUMM = summary table Level 5 ICL0 = averaged data from all IFMSs	
lll	*Data processing level* L02 = Level 2 L03 = Level 3 L04 = Level 4 L05 = averaged Level 4 data	L03
sss	*data type* <u>Science data level 2:</u> D1X calibrated Doppler 1 X-band D1S calibrated Doppler 1 S-band D2X calibrated Doppler 2 X-band D2S calibrated Doppler 2 S-band C1X calibrated Doppler 1 X-band including multipath correction C1S calibrated Doppler 1 S-band including multipath correction C2X calibrated Doppler 2 X-band including multipath correction C2S calibrated Doppler 2 S-band including multipath correction <u>Science data level 3:</u> OCx summary table for occultation season x=1,2,3,…. RIX ionospheric and atmospheric refractivity profile for occultation entry (ingress) from X-band RIS ionospheric and atmospheric refractivity profile for occultation entry (ingress) from S-band; only applicable for twoway data (MEX). Not scaled for ionospheric frequency dependent phase shift (please do not use for ionosphere). REX ionospheric and atmospheric refractivity profile for occultation exit (egress) from X-band; only applicable for two way data (MEX). Not scaled for ionospheric frequency dependent phase shift (please do not use for ionosphere).	

	RES ionospheric and atmospheric refractivity profile for occultation exit (egress) from S-band AIX atmospheric refractivity profiles generated from X-band data (ingress measurement) AIS atmospheric refractivity profiles generated from S-band data (ingress measurement) AEX atmospheric refractivity profiles generated from X-band data (egress measurement) AES atmospheric refractivity profiles generated from S-band data (egress measurement) ATX averaged atmospheric profiles (L05) from ingress and egress X-band data CIX atmospheric refractivity profiles including multipath correction generated from X-band OL data (ingress measurement) CIS atmospheric refractivity profiles including multipath correction generated from S-band OL data (ingress measurement) CEX atmospheric refractivity profiles including multipath correction generated from X-band OL data (egress measurement) CES atmospheric refractivity profiles including multipath correction generated from S-band OL data (egress measurement) IIX ionospheric refractivity profile for occultation entry (ingress) from X-band; For twoway data: scaled for ionospheric frequency dependent phase shift on downlink. IIS ionospheric refractivity profile for occultation entry (ingress) from S-	

	band; For twoway data: scaled for ionospheric frequency dependent phase shift on downlink. IID ionospheric refractivity profile for occultation entry (ingress) from differential Doppler. IEX ionospheric refractivity profile for occultation exit (egress) from X-band; For twoway data: scaled for ionospheric frequency dependent phase shift on downlink. IES ionospheric refractivity profile for occultation exit (egress) from S-band; For twoway data: scaled for ionospheric frequency dependent phase shift on downlink. IED ionospheric refractivity profile for occultation exit (egress) from differential Doppler. EYZ Echo power data from bistatic radar measurement, where Y indicates: A: X-band right-circular polarization (X-RCP) B:S-band right-circular polarization (S-RCP) C: X-band left-circular polarizaton (X-LCP) D: S-band left-circular polarizaton (S-LCP) Z is an upper case letter A, B, ... distinguishing between multiple files with the same yydddhhmm. <u>Science data level 4:</u> IIX ionosphere electron density profiles from X-band data (ingress measurement) IIS ionosphere electron density profiles from S-band data (ingress measurement) IID ionosphere electron density profiles from diff. Doppler data (ingress measurement) IIO ionospheric files containing additional information about the geometry of	

	the OCC measurement (ingress) and the data processing IEX ionosphere electron density profiles from X-band data (egress measurement) IES ionosphere electron density profiles from S-band data (egress measurement) IED ionosphere electron density profiles from diff. Doppler data (egress measurement) AIX atmospheric profiles generated from X-band data (ingress measurement) AIS atmospheric profiles generated from S-band data (ingress measurement) AEX atmospheric profiles generated from X-band data (egress measurement) AES atmospheric profiles generated from S-band data (egress measurement) CIX atmospheric profiles including multipath correction generated from X-band data (ingress measurement) CIS atmospheric profiles including multipath correction generated from S-band data (ingress measurement) CEX atmospheric profiles including multipath correction generated from X-band data (egress measurement) CES atmospheric profiles including multipath correction generated from S-band data (egress measurement) PIX Absorptivity and H2SO4 profiles generated from X-band data (ingress measurement) PIS Absorptivity and H2SO4 profiles generated from S-band data (ingress measurement) PEX Absorptivity and H2SO4 profiles generated from X-band data (egress	

	measurement) PES Absorptivity and H2SO4 profiles generated from S-band data (egress measurement) DXZ dielectric constant X-band from bistatic radar measurements. Z is an upper case letter A, B, ... distinguishing between multiple files with the same yydddhhmm. DSZ dielectric constant S-band from bistatic radar measurements. Z is an upper case letter A, B, ... distinguishing between multiple files with the same yydddhhmm.	
yy	Year of the measurement. For the summary tables (*sss = OCx yy* describes the year of the first occultation measurement in the file.)	04
ddd	Day of the year of the measurement. For the summary tables (*sss = OCx ddd* describes the day of year of the first occultation measurement in the file.)	153
hhmm	Sample hour, minute (Start time of Doppler recording at the Ground station)	1135
qq	Sequence or version number (60 stands for Version 6.0) For radio occultation data, *qq* describes software processing version as defined in specification document. For BSR the version number indicates different amounts of time averaging using the same software version.	60
eee	.TAB ASCII data files .LBL PDS label files .TXT information files .LOG processing information files .INP input information for LV3 only	TAB
latlat	Only valid for averaged profiles (Level5): Latlat give the minimum and maximum latitude range for averaging (e.g. 30N50N for 30° North to 50° N)	30N50N
rrrr	Only valid for averaged profiles (Level5): rrrr give the minimum and maximum local time range used for averaging (e.g. 0507 for local times 05:00 - 07:00)	0507

284

3 LEVEL 3 SCIENCE DATA PRODUCTS

3.1 LEVEL 3 DATA PRODUCTS: OCCULTATIONS

3.1.1 Summary Table Occultation Season

One summary table is provided for each occultation season. It contains the basic information relevant for the occultation season.

3.1.1.1 File name format

Each summary table contains a list of occultations for one occultation season. The file name is

INST_OCCNN.pdf

INST = VeRa/MaRS describes the instrument, *NN=01,..* gives the occcultation season number.

3.1.1.2 File format

This file contains some information about the geometrical occultation (OCC) point. The geometrical OCC point is the point where the radio link would disappear behind the planetary disc if the atmospheric and ionospheric bending would be absent. Please note: the geometrical OCC point might differ from the real OCC point due to the atmospheric and ionospheric bending of the radio link, especially for Venus. The radio link can not reach the surface at Venus due to the critical refraction below ~ 32 km. The information given in these files is provided to give the user a first approximation to the location and local time of the measurements. More detailed information about the measurement can be found in the *.TXT files described below. Table 3-1 gives a detailed description of the file format.

Table 3-1: description of the L03 summary tables for occultation measurements

Column	Description	Unit	resolution
1	Occultation number in season x		
2	Orbit number of start of data recording. The actual occultation event might take place in the following orbit.		
3	Archive volume ID		
4	Day of year		
5	Date	dd/mm/yy	
6	Type of occultation measurement: 'I' for ingress measurement, 'E' for egress measurement.		
7	Start time of Doppler recording in hh:mm:ss	[ert]	

8	Stop time of Doppler recording in hh:mm:ss	[ert]	
9	Ground station number		
10	Longitude of occultation coordinate (east) at geometrical occultation point	deg	0.1 deg
11	Latitude of occultation coordinate at geometrical occultation point	deg	0.1 deg
12	Solar longitude at geometrical occultation point	deg	0.01 deg
13	Solar zenith angle at geometrical occultation point	deg	0.1 deg
14	Local time on planet in fraction of hours at geometrical occultation point	hours	0.01 h
15	Local planetary radius at geometrical occultation point. For Mars: based on MOLA model, for Venus: mean radius of 6051.8 km	km	10-2 km
16	Radius of aeroid at geometrical occultation point For Mars: based on MOLA areoid For Venus: mean radius of 6051.8 km	km	10-2 km

Note: no egress observations with MEX.

3.1.2 Occultation measurement refractivity profile file

3.1.2.1 File name format: refractivity profile file (.TAB-file)*

The file name follows the definition of section 2.1 and Table 2-1

rggttttL03_sss_yydddhhmm_qq.TAB

The source identifier is set to tttt = RSR0/ODFX/ODFS or tttt = ICL1/ICL2/ICL3/IOL1/IOL2/IOL3 either the data have been processed through data recorded at the DSN stations or at the ESA stations in closed loop recording (CL) or open loop recording (OL) on the IFMSs 1,2 or 3. The data type identifier is set to *sss* = *RIX*, *RIS,* IIX, IIS, or IID for X-band, S-band for ingress measurements (twoway and oneway), or differential Doppler atmospheric profile data, respectively (s. Table 2-1).

Tab 3-1: File format: refractivity profile file (*.TAB-file)

Line	Description	Unit	Resolution
1	Sample number		
2	UTC time in the format yyyy-mm-ddThh:mm:ss.sss		
3	Ephemeris time	s	10^{-6} s
4	Residual calibrated X-Band frequency shift	Hz	10^{-6} Hz
5	Residual calibrated X-Band frequency shift after baseline fit	Hz	10^{-6} Hz
6	Reconstructed transmit frequency	Hz	10^{-6} Hz
7	Radius	km	10^{-3} m
8	Sigma radius	km	10^{-3} m
9	Bending angle	10^{-6} * radian	10^{-12} * radian
10	Sigma bending angle	10^{-6} * radian	10^{-12} * radian
11	Refractive index		10^{-6}
12	Refractivity		10^{-6}
13	Sigma refractivity		10^{-6}
14	Signal level	Decibel relative to an arbitrary reference (dB)	0.00001 dB
15	Differential Doppler	Hz	10^{-6} Hz
16	Rayparameter	km	10^{-3} km
17	Sigma rayparameter	km	10^{-7} km
18	Longitude	deg	0.01 deg
19	Latitude	deg	0.01 deg
20	Fresnel Radius	km	0.01 km

3.1.3 Occultation measurement information file

3.1.3.1 File name format: information file (.TXT-file)*

The file name follows the definition of section 2.1 and Table 2-1

rggttttL03_sss_yydddhhmm_qq.TXT

The source identifier is set to tttt = RSR0/ODFX/ODFS or tttt = ICL1/ICL2/ICL3/IOL1/IOL2/IOL3 either the data have been processed through data recorded at the DSN stations or at the ESA stations in closed loop recording (CL) or open loop recording (OL) on the IFMSs 1,2 or 3. The data type identifier is set to *sss = AIX*, *AIS, RID*, or *IIX, IIS, IID* for X-band, S-band, or Differential Doppler atmospheric ingress profile data, respectively (s. Table 2-1). The corresponding file names for egress measurements are *sss = AEX, IIX,* etc. .

357
358 ***3.1.3.2 Tab 3-1: File format: L03 information file (*.TXT-file)***
359

Line	Description	Unit	Resolution
1	Start time: Earth Received Time (ERT) at which the first radio occultation data sample was acquired.		
2	Stop time: ERT at which the last radio occultation data sample was acquired.		
3	Orbit number		
4	ground station DSS number		
5	PCK file name: file name of the NAIF Planetary Constants file used in this retrieval.		
6	SPK file name: file name of the NAIF Spacecraft dealing with ephemeris data.		
7	Comment line		
8	Comment line		
9	Comment line		
10	Occultation time at geometrical OCC point in spacecraft time in the format yyy-mm-ddThh:mm:ss.sss		
11	Occultation time at geometrical OCC point in Earth received time in the format yyy-mm-ddThh:mm:ss.sss		
12	Ray path direction: The angle between local north and the tangent to the ray path at occultation point, measured positive from local north to local east. The tangent to the ray path indicates the direction of signal propagation. A signal travelling from west toward east as it grazed the surface would have a ray-path-direction of 90°.	deg	0.01 deg
13	Angle from diametric: Angle at which the spacecraft rises or	deg	0.01 deg

	sets behind the planet limb, measured clockwise from the planet radial direction as viewed from Earth. An angle-from-diametric equal to zero indicates a diametric occultation with motion of the ray away from the surface (e.g. occultation egress). A value of 180° is a nearly diametric ingress occultation.		
14	Latitude at surface	Deg	0.01 deg
15	Longitude at surface at geometrical OCC point	Deg	0.01 deg
16	Sub-solar latitude of geometrical OCC point	Deg	0.01 deg
17	Sub-solar longitude at geometrical OCC point	Deg	0.01 deg
18	Solar longitude. The solar longitude is the planet-Sun angle, measured from the Northern Hemisphere spring equinox where Ls=0.Ls=90 thus corresponds to summer solstice, just as Ls=180 marks the autumn equinox and Ls=270 the winter solstice (all relative to the northern hemisphere).	Deg	0.01 deg
19	MOLA radius at surface at geometrical OCC point for MEX; mean radius at surface for VEX	Km	0.01 km
20	Radius of last sample before geometrical OCC	Km	0.01 km
21	S/C to limb distance at geometrical OCC point	Km	km
22	S/C to G/S distance at geometrical OCC point	10^6 km	Km
23	Local true solar time (LTST) at geometrical OCC point	hours	0.01 hours
24	Solar zenith angle at geometrical OCC point	Deg	0.01 deg
25	Sun-Earth-S/C angle at geometrical OCC point	Deg	0.01 deg
26	G/S elevation angle at geometrical OCC point	Deg	0.01 deg

27	Comment line		
28	Comment line		
289	Comment line		
30	Measurement time of lowest sample in S/C time in the format yyy-mm-ddThh:mm:ss.sss		
31	Measurement time of lowest sample in ERT in the format yyy-mm-ddThh:mm:ss.sss		
32	Latitude of lowest sample	deg	0.01 deg
33	Longitude of lowest sample	deg	0.01 deg
34	Sub-solar latitude of lowest sample	deg	0.01 deg
35	Sub-solar longitude of lowest sample	deg	0.01 deg
36	MOLA radius at surface at the position of the lowest sample for MEX; mean radius for VEX	km	0.01 km
37	Radius of the lowest sample	km	0.01 km
38	S/C to limb distance at the lowest sample	km	km
39	S/C to G/S distance at the lowest sample	10^6 km	km
40	Local true solar time at lowest sample	hours	0.01 hours
41	Solar zenith angle	deg	0.01 deg
42	Sun-Earth-S/C angle at lowest samples	deg	0.01 deg
43	G/S elevation angle	deg	0.01 deg
44	Radius of first Fresnel zone of lowest sample	km	0.01 km
45	Comment line		
46	Comment line		
47	Comment line		
48	Radius of first Fresnel zone at a fixed altitude level.	km	0.01 km

3.2 LEVEL 3 DATA PRODUCTS: GRAVITY

TBD

3.3 LEVEL 3 DATA PRODUCTS: BISTATIC RADAR

TBD

3.4 LEVEL 3 DATA PRODUCTS: SOLAR CORONA

TBD

3.5 LEVEL 3 DATA PRODUCTS: PHOBOS

TBD

4 LEVEL 4 SCIENCE DATA PRODUCTS

4.1 LEVEL 4 DATA PRODUCTS: NEUTRAL ATMOSPHERIC PROFILES

4.1.1 Introduction

Vertical profiles of number density, pressure and temperature of the neutral atmosphere are derived from the L03 refractivity data file. The data products are

- a TXT-file containing background information about measurement location, solar and geometrical conditions, and file names of relevant used SPICE files.
- the atmospheric profiles (*.TAB-files).
- the lable files (*.LBL-files)

4.1.2 Atmospheric Information File

4.1.2.1 File Name Information File (.TXT-file)*

The file name follows the definition of section 2.3 and Table 2.1

rggttttL04_sss_yydddhhmm_qq.TXT

The source identifier is set to tttt = RSR0/ODFX/ODFS or tttt = ICL1/ICL2/ICL3/IOL1/IOL2/IOL3 either the data have been processed through data recorded at the DSN stations or at the ESA stations in closed loop recording (CL) or open loop recording (OL) on the IFMSs 1,2 or 3. The data type identifieris set to *sss = AIX/AEX, AIS/AES, CIX/CEX, CIS/CES* for X-band or S-band atmospheric profile data (I=ingress, E=egress), respectively. The files with *sss = AIX/AEX, AIS/AES* contain no multipath correction, while the files with the data type identifier *sss = AIX/AEX, AIS/AES* contain a multipath correction in the cloud layer (only applicable for Venus).
The *.TXT files are different for MEX and for VEX. The MEX file contains some information about the MOLA radius at the surface while the VEX file contains some information about the 1bar-level.

4.1.2.2 File format information file for MEX (.TXT-file)*

Line	Description	Unit	Resolution
1	Profile file name: Name of the corresponding atmospheric profile file		
2	Start time: The Earth Receive Time (GRT) at which the first radio occultation data sample in the corresponding profile file was acquired.		
3	Stop time: The Earth Receive Time (GRT) at which the last radio occultation data sample in the corresponding profile file was acquired.		

4	Orbit number		
5	G/S antenna number		
6	Ray path direction: The angle between local north and the tangent to the ray path at occultation point, measured positive from local north toward local east. The tangent to the ray path indicates the direction of signal propagation. A signal travelling from west toward east as it grazed the surface would have a ray-path-direction of 90 degrees.	Deg	0.01 deg
7	Angle from diametric: Angle at which the spacecraft rises or sets behind the planet limb, measured clockwise from the planet radial direction as viewed from Earth. An angle-from-diametric equal to zero indicates a diametric occultation with motion of the ray away from the surface (e.g., occultation egress). A value of 180 degress is a nearly diametric ingress occultation.	Deg	0.01 deg
8	Solar Longitude. The solar longitude is the planet-Sun angle, measured from the Northern Hemisphere spring equinox where Ls=0.Ls=90 thus corresponds to summer solstice, just as Ls=180 marks the autumn equinox and Ls=270 the winter solstice (all relative to the northern hemisphere).	Deg	0.01 deg
9	PCK file name: file name of the NAIF Planetary Constants file used in this retrieval.		
10	SPK file name: file name of the NAIF Spacecraft dealing with ephemeris data.		
11	Gravity field model		
12	Upper boundary condition for	K	0.01 K

	Temperature: lowest value		
13	Upper boundary condition for Temperature: medium value	K	0.01 K
14	Upper boundary condition for Temperature: upper value	K	0.01 K
15	Comment line		
16	Comment line		
17	Comment line		
18	Measurement time of lowest acceptable sample in Earth received time		
19	Measurement time of lowest acceptable sample in Earth received time minus oneway light time.		
20	Latitude (North) of lowest acceptable sample	Deg	0.01 deg
21	Longitude (East) of lowest acceptable sample	Deg	0.01 deg
22	Sub-solar latitude of lowest acceptable sample (North)	Deg	0.01 deg
23	Sub-solar longitude of lowest acceptable sample (East)	Deg	0.01 deg
24	Radius of lowest acceptable sample	Km	0.01 km
25	MOLA radius: Radius at latitude and longitude of lowest acceptable measurement point taken from a 0.25 x 0.25 grid. The given value is the radius at the grid point closest to the measurement point.	Km	0.01 km
26	MOLA areoid: Radius of areoid at latitude and longitude of lowest acceptable measurement point taken from a 0.25 x 0.25 grid. The given value is the radius at the grid point closest to the measurement point.	Km	0.01 km
27	Sigma Radius	Km	0.01 km
28	Pressure of lowest sample	Pa	0.01 Pa
29	Sigma Pressure of lowest sample	Pa	0.01 Pa

30	Temperature of lowest sample	K	0.01 K
31	Sigma Temperature of lowest sample	K	0.01 K
32	Spacecraft to Limb Distance at measurement time of lowest acceptable sample	Km	1 km
33	Spacecraft to Groundstation Distance at measurement time of lowest acceptable sample	10^6 km	1 km
34	Local True Solar Time of Occultation (LTST) at geolocation of lowest acceptable sample	hour	0.01 hour
35	Solar Zenith Angle at geolocation of lowest acceptable sample	Deg	0.01 deg
36	Sun-Earth-Spacecraft-Angle at measurement time of lowest acceptable sample: Approximate angle between Sun and spacecraft as viewed from Earth during experiment.	Deg	0.01 deg
37	Groundstation elevation angle at measurement time of lowest acceptable sample	Deg	0.01 deg
38	Fresnel radius at lowest acceptable sample	Km	0.01km
39	Comment line		
40	Comment line		
41	Comment line		
42	Fresnel radius at 50 km altitude above surface	Km	0.01 km

405
406 ***4.1.2.3 File format information file for VEX (*.TXT-file)***

Line	Description	Unit	Resolution
1	Profile file name: Name of the corresponding atmospheric profile file		
2	Start time: The Earth Receive Time (GRT) at which the first radio occultation data sample in the corresponding profile file was acquired.		
3	Stop time: The Earth Receive Time (GRT) at which the last		

	radio occultation data sample in the corresponding profile file was acquired.		
4	Orbit number		
5	G/S antenna number		
6	Ray path direction: The angle between local north and the tangent to the ray path at occultation point, measured positive from local north toward local east. The tangent to the ray path indicates the direction of signal propagation. A signal travelling from west toward east as it grazed the surface would have a ray-path-direction of 90 degrees.	Deg	0.01 deg
7	Angle from diametric: Angle at which the spacecraft rises or sets behind the planet limb, measured clockwise from the planet radial direction as viewed from Earth. An angle-from-diametric equal to zero indicates a diametric occultation with motion of the ray away from the surface (e.g., occultation egress). A value of 180 degress is a nearly diametric ingress occultation.	Deg	0.01 deg
8	Solar Longitude. The solar longitude is the planet-Sun angle, measured from the Northern Hemisphere spring equinox where Ls=0.Ls=90 thus corresponds to summer solstice, just as Ls=180 marks the autumn equinox and Ls=270 the winter solstice (all relative to the northern hemisphere).	Deg	0.01 deg
9	PCK file name: file name of the NAIF Planetary Constants file used in this retrieval.		
10	SPK file name: file name of the NAIF Spacecraft dealing		

	with ephemeris data.		
11	Gravity field model		
12	Upper boundary condition for Temperature: lowest value	K	0.01 K
13	Upper boundary condition for Temperature: medium value	K	0.01 K
14	Upper boundary condition for Temperature: upper value	K	0.01 K
15	Comment line		
16	Comment line		
17	Comment line		
18	Measurement time of lowest acceptable sample in ground received time		
19	Measurement time of lowest acceptable sample in ground received time minus oneway light time.		
20	Latitude (North) of lowest acceptable sample	Deg	0.01 deg
21	Longitude (East) of lowest acceptable sample	Deg	0.01 deg
22	Sub-solar latitude of lowest acceptable sample (North)	Deg	0.01 deg
23	Sub-solar longitude of lowest acceptable sample (East)	Deg	0.01 deg
24	Radius of lowest acceptable sample	Km	0.01 km
25	Sigma Radius	Km	0.01 km
26	Pressure of lowest sample	Pa	0.01 Pa
27	Sigma Pressure of lowest sample	Pa	0.01 Pa
28	Temperature of lowest sample	K	0.01 K
29	Sigma Temperature of lowest sample	K	0.01 K
30	Spacecraft to Limb Distance at measurement time of lowest acceptable sample	Km	1 km
31	Spacecraft to Groundstation Distance at measurement time of lowest acceptable sample	10^6 km	1 km
32	Local True Solar Time of Occultation (LTST) at geolocation of lowest acceptable sample	hour	0.01 hour
33	Solar Zenith Angle at	Deg	0.01 deg

	geolocation of lowest acceptable sample		
34	Sun-Earth-Spacecraft-Angle at measurement time of lowest acceptable sample: Approximate angle between Sun and spacecraft as viewed from Earth during experiment.	Deg	0.01 deg
35	Groundstation elevation angle at measurement time of lowest acceptable sample	Deg	0.01 deg
36	Fresnel radius at lowest acceptable sample	Km	0.01km
37	Comment line		
38	Comment line		
39	Comment line		
40	Fresnel radius at 100 km radius above surface	Km	0.01 km
41	Comment line		
42	Comment line		
43	Comment line		
44	Measurement time at the 1bar-level in ground received time		
45	Measurement time at the 1bar-level in ground received time minus oneway light time		
46	Latitude (North) at the 1bar-level	Deg	0.01 deg
47	Longitude (East) at the 1bar-level	Deg	0.01 deg
48	Radius at the 1bar-level	Km	0.01 km
49	Sigma Radius	Km	0.01 km
50	Temperature at the 1bar-level	K	0.01 K
51	Sigma Temperature at the 1bar-level	K	0.01 K
52	Local true solar time at the 1bar-level	Hours	0.01 h
53	Solar zenith angle at the 1bar-level	deg	0.01 deg
54	Fresnel radius at the 1bar-level	km	0.01 km

407

4.1.3 Atmospheric profiles data file

4.1.3.1 File name format: Atmospheric profiles data file (.TAB-file)*

The file name follows the definition of section 3.1 and Table 3.1

rggttttL04_sss_yydddhhmm_qq.TAB

The source identifier is set to tttt = RSR0/ODFX/ODFS or tttt = ICL1/ICL2/ICL3/IOL1/IOL2/IOL3 either the data have been processed through data recorded at the DSN stations or at the ESA stations in closed loop recording (CL) or open loop recording (OL) on the IFMSs 1,2 or 3. The data type identifier is set to *sss = AIX/AEX* or *AIS/AES, CIX/CEX, CIS/CES* for X-band or S-band atmospheric profiles data (I=ingress, E=egress), respectively. The files with *sss = AIX/AEX, AIS/AES* contain no multipath correction, while the files with the data type identifier *sss = AIX/AEX, AIS/AES* contain a multipath correction in the cloud layer (only applicable for Venus).

4.1.3.2 File format: Atmospheric Profiles data file (.TAB-file)*

Column	Description	Unit	resolution
1	Sample Number	-	-
2	UTC Time	-	-
3	Ephemeris Seconds	s	10^{-6} s
4	Radius	km	10^{-3} km
5	Latitude	deg	0.01 deg
6	Longitude (East)	deg	0.01 deg
7	Geopotential: Geopotential at measurement location (RADIUS, LATITUDE, LONGITUDE). A reference value (GEOPOTENTIAL REFERENCE in TXT-file) has been subtracted.	m^2/s^2	1 m^2/s^2
8	Geopotential height calculated from column 4 using a reference radius of 3396.0 km (for Mars) or 6051.8 km for Venus.	km	0.001 km
9	Pressure with lowest upper boundary condition	Pa	0.001 Pa
10	Sigma pressure with lowest upper boundary condition	Pa	0.001 Pa
11	Pressure with medium upper boundary condition	Pa	0.001 Pa
12	Sigma pressure with medium upper boundary condition	Pa	0.001 Pa
13	Pressure with highest upper boundary condition	Pa	0.001 Pa
14	Sigma pressure with highest upper boundary condition	Pa	0.001 Pa
15	Temperature with lowest upper boundary condition	K	0.001 K
16	Sigma temperature fit with lowest upper boundary condition	K	0.001 K
17	Temperature with medium upper boundary condition	K	0.001 K
18	Sigma temperature fit with medium upper boundary condition	K	0.001 K
19	Temperature with highest upper boundary condition	K	0.001 K

20	Sigma temperature fit with highest upper boundary condition	K	0.001 K
21	Number Density	m^{-3}	m^{-3}
22	Sigma Density	m^{-3}	m^{-3}
23	Rayparameter	km	10^{-3} km
24	Bending angle	$*10^{-6}$ radian	$*10^{-12}$ radian
25	Signal Level (AGC) relative to an arbitrary unit (dB)	dB	0.00001 dB
26	Fresnel Radius	Km	0.01 km

426
427

4.2 LEVEL 4 DATA PRODUCTS: ABSORPTIVITY PROFILES AND H2SO4 PROFILES (FOR VENUS ONLY)

4.2.1 Introduction

Vertical profiles of atmospheric absorptivity and vertical H2SO4 profiles are derived from the L03 refractivity data file and atmospheric profiles data file. The data products are

- a TXT-file containing background information about measurement location, solar and geometrical conditions, and file names of relevant used SPICE files.
- The absorptivity and H2SO4 profile (*.TAB)
- the label file (*.LBL)

4.2.2 Atmospheric Information File

4.2.2.1 File name information file (.TXT-file)*

The file name follows the definition of section 3.1 and Table 3.1

rggttttL04_sss_yydddhhmm_qq.TXT

The source identifier is set to tttt = RSR0/ODFX/ODFS or tttt = ICL1/ICL2/ICL3/IOL1/IOL2/IOL3 either the data have been processed through data recorded at the DSN stations or at the ESA stations in closed loop recording (CL) or open loop recording (OL) on the IFMSs 1,2 or 3. The data type identifier is set to *sss = PIX/PEX* or *PIS/PES* for X-band or S-band absorptivity and H2SO4 profiles data (I=ingress, E=egress), respectively.

4.2.2.2 File format information file (.TXT-file)*

Line	Description	Unit	Resolution
1	Profile file name: Name of the corresponding atmospheric profile file		
2	Start time: The Earth Receive Time (GRT) at which the first radio occultation data sample in the corresponding profile file was acquired.		
3	Stop time: The Earth Receive Time (GRT) at which the last radio occultation data sample in the corresponding profile		

	file was acquired.		
4	Orbit number		
5	DSN antenna number		
6	PCK file name: file name of the NAIF Planetary Constants file used in this retrieval.		
7	SPK file name: file name of the NAIF Spacecraft dealing with ephemeris data.		
8	Measurement time (at 1 bar level): The Spacecraft Time (GRT) at which the data sample at the 1 bar level in the corresponding profile file was acquired.		
9	Latitude at 1 bar level (North)	deg	0.01 deg
10	Longitude at 1 bar level (East)	deg	0.01 deg
11	Radius at 1 bar level	km	0.001 km
12	Sigma Radius	km	0.001 km
13	Absorptivity at 1 bar level	dB/km	10^{-5} dB/km
14	Sigma absorptivity at 1 bar level	dB/km	10^{-5} dB/km
15	Sulfuric acid vapor mixing ratio at 1 bar level	ppm	0.01 ppm
16	Sigma sulfuric acid vapor mixing ratio at 1 bar level	ppm	0.01 ppm
17	Local True Solar Time at 1 bar level	hour	0.01 hour
18	Solar zenith angle	deg	0.01 deg
19	Measurement time (lowest sample): The Spacecraft Time (GRT) at which the lowest acceptable radio occultation data sample was acquired.		
20	Latitude of lowest acceptable sample (North)	deg	0.01 deg
21	Longitude of lowest acceptable sample (East)	deg	0.01 deg
24	Radius of the lowest acceptable measurement point	km	0.001 km
25	Sigma Radius	km	0.001 km
26	Absorptivity of lowest acceptable sample	dB/km	10^{-5} dB/km
27	Sigma absorptivity of lowest acceptable sample	dB/km	10^{-5} dB/km
28	Sulfuric acid vapor mixing	Ppm	0.01 ppm

	ratio of lowest acceptable sample		
29	Sigma sulfuric acid vapor mixing ratio of lowest acceptable sample	Ppm	0.01 ppm
30	Local True Solar Time of lowest acceptable sample	hour	0.01 hour
31	Solar zenith angle of lowest acceptable sample	Deg	0.01 deg

4.2.3 Absorptivity and H2SO4 profiles data file

4.2.3.1 File name format: Atmospheric profiles data file (.TAB-file)*

The file name follows the definition of section 3.1 and Table 3.1

rggttttL04_sss_yydddhhmm_qq.TAB

The source identifier is set to tttt = RSR0/ODFX/ODFS or tttt = ICL1/ICL2/ICL3/IOL1/IOL2/IOL3 either the data have been processed through data recorded at the DSN stations or at the ESA stations in closed loop recording (CL) or open loop recording (OL) on the IFMSs 1,2 or 3. The data type identifier is set to *sss* = *PIX/PEX* or *PIS/PES* for X-band or S-band atmospheric profiles data (I=ingress, E=egress), respectively.

4.2.3.2 File format: Atmospheric Profiles data file (.TAB-file)*

Column	Description	Unit	resolution
1	Sample Number	-	-
2	UTC Time	-	-
3	Ephemeris Seconds	s	10^{-6} s
4	Radius	km	10^{-3} km
5	Latitude	deg	0.01 deg
6	Longitude (East)	deg	0.01 deg
7	Signal attenuation	dB	10^{-5} dB
8	Defocussing loss	dB	10^{-5} dB
9	Absorptivity	dB/km	10^{-5} dB/km
10	Sigma absorptivity	dB/km	10^{-5} dB/km
11	Sulfuric acid vapor mixing ratio	ppm	0.01 ppm
12	Sigma sulfuric acid vapor mixing ratio	ppm	0.01 ppm

4.3 LEVEL 4 DATA PRODUCTS: IONOSPHERIC ELECTRON DENSITY PROFILES

4.3.1 Introduction

Vertical profiles of electron density of the ionosphere are derived from the L03 refractivity data file. The data products are

- a TXT-file containing background information about measurement location, solar and geometrical conditions, and file names of relevant used SPICE files.
- The ionospheric electron density profile (*.TAB)
- the label file (*.LBL)

4.3.2 Ionospheric information file

4.3.2.1 File Name Information file (.TXT-file)*

The file name follows the definition of section 2 and Table 2.1

rggttttL04_sss_yydddhhmm_qq.TXT

The source identifier is set to tttt = RSR0/ODFX/ODFS or tttt = ICL1/ICL2/ICL3/IOL1/IOL2/IOL3 either the data have been processed through data recorded at the DSN stations or at the ESA stations in closed loop recording (CL) or open loop recording (OL) on the IFMSs 1,2 or 3. The data type identifier is set to *sss = IIX/IEX/IIS/IES/IID/IED* for X-band, S-band and diff. Doppler ionospheric profile data (I=ingress, E=egress), respectively.

4.3.2.2 File format information file (.TXT-file)*

Line references are given in curly brackets, e.g. a parameter in line 3 is referenced as {3}. Parameters, which are calculated by linear interpolation between two values are marked with (LI). The values for 130 km altitude are derived by the following method: The aeroid radius for every observation latitude (column 6) and longitude (column 7) in L04*.TAB is derived (see description line 40 of L04*.TXT for details) and subtracted from the actual ray periapsis (column 4). The residual altitudes are linear interpolated to 130 km altitude. The linear scaling factor gained in this process is used to compute the other given parameters for 130 km altitude. No parameters are calculated, when the electron density profile stops above 3389.5 km + 110 km for Mars and 6051.8 km + 120 km for Venus.

Line	Description	Unit	Resolution
1	Profile file name: Name of the corresponding ionospheric profile file		
2	Start time: ERT at which the highest radio occultation data sample in the corresponding profile file was acquired.	yyyy-mm-dd Thh:mm:ss.sss	
3	Stop time: ERT at which the lowest radio occultation data sample in the corresponding profile file was acquired.	yyyy-mm-dd Thh:mm:ss.sss	
4	Orbit number Default value: -99999		
5	Antenna number Default value: -99		
6	PCK file name: file name of the NAIF Planetary Constants kernel file used in this retrieval.		
7	SPK file name: file name of the NAIF Spacecraft orbit kernel file dealing with ephemeris data.		
8	Gravity field model: JGM75C01.SHA: MGS75C Spherical Harmonic model for Mars shgj120p.TAB: MGNP120PSAAP Spherical Harmonic model for Venus		
9	Geopotential reference: Reference value for geopotential reference geoid has mean equatorial radius of 3396 km for Mars and 6051.8 km for Venus.	m^2/s^2	1 m^2/s^2
10	Noise level of the profile: The noise level of an electron density profile is defined as the standard deviation of the electron density above 3389.5 km + 800 km	10^6 m^{-3}	10^4 m^{-3}

	for Mars and 6051.8km + 400 km for Venus. If no 50 data points are available above this border, the noise level is calculated from either the electron density above the ionopause or from the highest 50 data points of the profile, detrended with a linear fit. No noise level is calculated, when the profile stops above 3389.5 km + 300 km for Mars and 6051.8 km + 300 km for Venus. Default value: -99999.99		
11	Offset correction of the profile: The upper part of an ionospheric profile should be undisturbed by the influence of the neutral atmosphere and ionosphere of the planet. Therefore the calculated mean of the undisturbed part of the profile (see {10} for calculation range) should be zero. This is accomplished by calculating the mean of the undisturbed part of the electron density profile and shifting the whole profile by the value given in this line. This parameter is set to the default value and no shift of the L04.TAB electron density profile is done, when detrending is necessary in {10}. No offset correction is done and the offset value is set to 0.0, when the highest data point of the data set lies below 3389.5km+1000.0 km for Mars and 6051.8 km+1000.0 km for Venus. Default value: -9999.99	10^6 m^{-3}	10^4 m^{-3}
12	Upper noise level altitude (LI): Distance of the ray periapsis to the planet center where the observed electron density rises from the noise level {10}. Not calculated for solar zenith angles > 105°. Default value: -9999.999	km	0.001 km
13	Fresnel radius at upper noise level altitude {12} (LI). The Fresnel radius is SQRT(lambda·D), where lambda is the S/C wavelength and D is the S/C to limb distance. For details see Hinson et al. 1999, JGR Vol. 104, NO. E11, 1999, Initial results from radio occultation measurements with Mars Global Surveyor Not calculated for solar zenith angles > 105°. Default value: -9.99	km	0.01 km
14	Lower noise level altitude (LI): Distance of the ray periapsis to the planet	km	0.001 km

	center where the observed electron density falls below the noise level {10} for the first time. If {10} is not reached (e.g. when the ionospheric profile is not complete) or if {10} is found below 50 km altitude, the parameter is set to the default value. Not calculated for solar zenith angles > 105°. Default value: -9999.999		
15	Fresnel radius at lower noise level altitude {14} (LI). If {14} contains a default value, this parameter is set to the default value. Not calculated for solar zenith angles > 105°. Default value: -9.99	km	0.01 km
16	Lowest valid altitude of ionospheric profile: Profiles derived from X-band (IEX/IIX): Distance of the ray periapsis to the planet center, where the electron density falls below –3·{10} (or -2.0E10, depending on which value is closer to zero) due to the influence of the neutral atmosphere. If this electron density value is not reached or if the derived valid altitudes is not in the range from 60 km + {40} to 120 km + {40},the parameter is set to the default value. Profiles derived from diff. Doppler (IED/IID): Altitude is taken from the L04 I*X .TXT file if available, otherwise this parameter is set to the default value. Default value: -9999.999	km	0.001 km
17	Fresnel radius at lowest valid altitude {16}: If {16} contains a default value, this parameter is set to the default value. Default value: -9.99	km	0.01 km
18	Comment line		
19	Comment line		
20	Comment line		
21	Occultation time: Time of the geometrical occultation at ground station. Default value: NOT-AVAILABLE	yyyy-mm-dd Thh:mm:ss.sss	
22	Occultation time: Time of the geometrical occultation at S/C position. Default value: NOT-AVAILABLE	yyyy-mm-dd Thh:mm:ss.sss	
23	Ray path direction at geometrical occultation point at {22}:	Deg	0.01 deg

	The angle between local north and the tangent to the ray path at occultation point, measured positive from local north toward local east. The tangent to the ray path indicates the direction of signal propagation. A signal travelling from west toward east as it grazed the surface would have a ray-path-direction of 90 degrees. If {22} contains a default value, this parameter is set to the default value. Default value: -999.99		
24	Angle from diametric at geometrical occultation point at {22}: Angle at which the spacecraft rises or sets behind the planet limb, measured clockwise from the planet radial direction as viewed from Earth. An angle-from-diametric equal to zero indicates a diametric occultation with motion of the ray away from the surface (e.g., occultation egress). A value of 180 degree is a nearly diametric ingress occultation. If {22} contains a default value, this parameter is set to the default value. Default value: -999.99	deg	0.01 deg
25	S/C to limb distance at geometrical occultation point at {22}. If {22} contains a default value, this parameter is set to the default value. Default value: -99999.	Km	Km
26	S/C to G/S distance at geometrical occultation point at {22}. If {22} contains a default value, this parameter is set to the default value. Default value: -9999.999	10^6 km	10^3 km
27	Sun-Earth-S/C-angle at geometrical occultation point at {22}. If {22} contains a default value, this parameter is set to the default value. Default value: -999.99	Deg	0.01 deg
28	Antenna elevation angle at geometrical occultation point at {22}. If {22} contains a default value, this parameter is set to the default value. Default value: -999.99	Deg	0.01 deg
29	Comment line		
30	Comment line		
31	Comment line		

32	Measurement time (130 km) at ground station in ERT (LI): Time at G/S, when the spacecraft ray periapsis reaches 130 km altitude above {40}. The parameter is set to the default value, when the altitude of 130 km above {40} is not covered by the measurement. Default value: NOT-AVAILABLE	yyyy-mm-dd Thh:mm:ss.sss	
33	Measurement time (130 km) at S/C at {32}-OWLT (one way light time between S/C and G/S): The parameter is set to the default value, when the altitude of 130 km above {40} is not covered by the measurement. Default value: NOT-AVAILABLE	yyyy-mm-dd Thh:mm:ss.sss	
34	Solar Longitude (130 km) at {33}: The solar longitude is the planet-Sun angle, measured from the Northern Hemisphere spring equinox where Ls=0.Ls=90 thus corresponds to summer solstice, just as Ls=180 marks the autumn equinox and Ls=270 the winter solstice (all relative to the northern hemisphere). If {33} contains a default value, this parameter is set to the default value. Default value: -999.99	Deg	0.01 deg
35	Planet to Sun distance (130 km) at {33}: If {33} contains a default value, this parameter is set to the default value. Default value: -9999.999	10^6 km	10^3 km
36	North planetary latitude (130 km) of the ray periapsis at {33} (LI): If {33} contains a default value, this parameter is set to the default value. Default value: -99.99	Deg	0.01 deg
37	East planetary longitude (130 km) of the ray periapsis at {33} (LI): If {33} contains a default value, this parameter is set to the default value. Default value: -999.99	Deg	0.01 deg
38	Sub-solar north planetary latitude (130 km) of the ray periapsis at {33}: If {33} contains a default value, this parameter is set to the default value. Default value: -99.99	Deg	0.01 deg
39	Sub-solar east planetary longitude (130 km) of the ray periapsis at {33}: If {33} contains a default value, this	Deg	0.01 deg

	parameter is set to the default value. Default value: -999.99		
40	Aeroid radius (130 km) at {36}, {37} (LI): Mars: The areoid radius is derived with the heights.f routine of the Mars Climate Database, which is based on the MGM 1025 spherical harmonics gravity field (an update of the Goddard Mars Model 2B in combination with the IAU2000 rotation model and cartographic frame). Venus: mean planetary radius of 6051.8 km If {33} contains a default value, this parameter is set to the default value. efault value: -9999.999	Km	0.001 km
41	MOLA radius (130 km) at {36}, {37} (LI): Mars: The MOLA radius is derived with the heights.f routine of the Mars Climate Database. Venus: set to the default value. If {33} contains a default value, this parameter is set to the default value. Default value: -9999.999	Km	0.001 km
42	Local true solar time (130 km) at {33}, {36}, {37}: If {33} contains a default value, this parameter is set to the default value. Default value: -99.99	hours	0.01 hour
43	Solar zenith angle (130 km) at {33}, {36}, {37} (LI) at ray periapsis altitude: If {33} contains a default value, this parameter is set to the default value. Default value: -999.99	Deg	0.01 deg
44	Electron Density (130 km) (LI): Electron density at 130 km altitude + {40}. If {33} contains a default value, this parameter is set to the default value. If the available electron density is lower than {10}, this parameter is set to the default value. Default value: -99999.99	10^6 m^{-3}	10^4 m^{-3}
45	Comment line		
46	Comment line		
47	Comment line		
48	Measurement time at the ground station in ERT, when the spacecraft ray periapsis reaches the maximum electron density of the profile. Not calculated for solar zenith angles > 105°.	yyyy-mm-dd Thh:mm:ss.sss	

	If {53} contains a default value, this parameter is set to the default value. Default value: NOT-AVAILABLE		
49	Measurement time at S/C at {48}-OWLT (one way light time between S/C and G/S) Not calculated for solar zenith angles > 105°. If {53} contains a default value, this parameter is set to the default value. Default value: NOT-AVAILABLE	yyyy-mm-dd Thh:mm:ss.sss	
50	North planetary latitude (max) of the ray periapsis at {49}: Not calculated for solar zenith angles > 105°. If {53} contains a default value, this parameter is set to the default value. Default value: -99.99	deg	0.01 deg
51	East planetary longitude (max) of the ray periapsis at {49}: Not calculated for solar zenith angles > 105°. If {53} contains a default value, this parameter is set to the default value. Default value: -999.99	deg	0.01 deg
52	Solar zenith angle (max) at {49}, {50}, {51} at ray periapsis altitude: Not calculated for solar zenith angles > 105°. If {53} contains a default value, this parameter is set to the default value. Default value: -999.99	deg	0.01 deg
53	Maximum of electron density (max): Maximum electron density of the ionospheric profile. The parameter is set to the default value, when i.) the maximum electron density of the ionosphere hasn't been reached during the observation (lowest data sample contains the highest electron density); ii.) the maximum electron density cannot be found in the altitude range of 90 km + radius to 400 km + radius (radius = 3389.5 km for Mars and 6051.8 km for Venus); iii.) the maximum electron density is lower than 3*{10}. Not calculated for solar zenith angles > 105°. Default value: -99999.99	10^6 m^{-3}	10^4 m^{-3}
54	Radius of maximum electron density (max) {53}: Distance between the altitude, where the ray periapsis is measuring the maximum electron density and the center of the planet. Not calculated for solar zenith angles > 105°. If {53} contains a default value, this	km	0.001 km

	parameter is set to the default value. Default value: -9999.999		
55	Aeroid radius (max) of maximum electron density {53} at {50}, {51}: Mars: The areoid radius is derived with the heights.f routine of the Mars Climate Database, which is based on the MGM 1025 spherical harmonics gravity field (an update of the Goddard Mars Model 2B in combination with the IAU2000 rotation model and cartographic frame). Venus: mean planetary radius of 6051.8 km Not calculated for solar zenith angles > 105°. If {53} contains a default value, this parameter is set to the default value. Default value: -9999.999	km	0.001 km
56	MOLA radius (max) of maximum electron density {53} at {50}, {51}: Mars: The MOLA radius is derived with the heights.f routine of the Mars Climate Database. Venus: set to the default value. Not calculated for solar zenith angles > 105°. If {53} contains a default value, this parameter is set to the default value. Default value: -9999.999	km	0.001 km
57	Altitude above ref. aeroid (max) {55} of the electron density maximum {53}: Not calculated for solar zenith angles > 105°. If {53} contains a default value, this parameter is set to the default value. Default value: -9999.999	km	0.001 km
58	Geopotential (max) at {55}. Not calculated for solar zenith angles > 105°. If {53} contains a default value, this parameter is set to the default value. Default value: -9999999.	m^2/s^2	1 m^2/s^2
59	Geopotential height (max) of maximum electron density {53}: Not calculated for solar zenith angles > 105°. If {53} contains a default value, this parameter is set to the default value. Default value: -99999.999	km	0.001 km

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4.3.3 Electron density profile file

4.3.3.1 File name format: electron density profile (.TAB)*

The file name follows the definition of section 2 and Table 2.1

rggttttL04_sss_yydddhhmm_qq.TAB

The source identifier is set to tttt = RSR0/ODFX/ODFS or tttt = ICL1/ICL2/ICL3/IOL1/IOL2/IOL3 either the data have been processed through data recorded at the DSN stations or at the ESA stations in closed loop recording (CL) or open loop recording (OL) on the IFMSs 1,2 or 3. The data type identifier is set to *sss* = *IIX*/IEX or *IIS*/IES for X-band or S-band ionospheric profile data (I=ingress, E = egress), respectively, or *sss* = *IID/IED* for differential Doppler data.

4.3.3.2 File format: electron density profile (.TAB)*

Column	Description	Unit	Resolution
1	Sample number		
2	Earth received time in ISO format (yyyy-mm-ddThh-mm-ss.sss)		
3	Earth received time from column 2 in ephemeris time	sec	10^{-6} sec
4	Radius (distance to planet center of mass) Default value: -9999.999	km	10^{-3} km
5	Geopotential height Default value: -9999.999	km	10^{-3} km
6	North planetary latitude Default value: -99.999	deg	0.001 deg
7	East planetary longitude Default value: -99.999	deg	0.001 deg
8	Refractivity Default value: -999.999999		10^{-6}
9	Received signal power level Default value: -999.99999	dBm	0.00001 dBm
10	Electron Density Default value: -9999999.99	10^{6} m^{-3}	10^{4} m^{-3}
11	Noise level electron density: Detailed description see chapter 4.3.2.2 table column 10. Default value: -99999.99	10^{6} m^{-3}	10^{4} m^{-3}
12	Solar zenith angle at ray periapsis altitude Default value: -999.99	deg	0.01 deg
13	Fresnel radius SQRT(lambda*D), where lambda is the S/C wavelength and D is the S/C to limb distance. For details see Hinson et al. 1999, JGR Vol. 104, NO.	km	10^{-2} km

	E11, 1999, Initial results from radio occultation measurements with Mars Global Surveyor Default value: -9.99		

4.4 LEVEL 4 DATA PRODUCTS: GRAVITY

TBD

4.5 LEVEL 4 DATA PRODUCTS: BISTATIC RADAR

TBD

4.6 LEVEL 4 DATA PRODUCTS: SOLAR CORONA

TBD

4.7 LEVEL 4 DATA PRODUCTS: PHOBOS

TBD

5 LEVEL 5 SCIENCE DATA PRODUCTS

5.1 LEVEL 5 DATA PRODUCTS: AVERAGED ATMOSPHERIC PROFILES

5.1.1 Introduction

Averaged vertical profiles of number density, pressure and temperature of the neutral atmosphere are derived from the single L04 atmospheric data files. The data products are

- the atmospheric profiles (*.TAB-files).
- the lable files (*.LBL-files)

5.1.2 Averaged atmospheric profile file

5.1.2.1 File name format: atmospheric profile (.TAB)*

The file name follows the definition of section 2 and Table 2.1

rggttttL05_sss_latlatrrrrqq.TAB

The source identifier is set to tttt = ICL0 for data processed from Closed loop recordings of the IFMSs 1,2 or 3. The data type identifier is set to *sss = ATX* for X-band atmospheric profile data from ingress and egress. latlat give the minimum and maximum latitude boundary for averaging and rrrr give the minimum and maximum

local time boundary for averaging. The *.TAB file format is identical to the one for the atmospheric single profile files (s. Section 4.1.2).

6 VOLUMES AND DATASETS ORGANIZATIONS, FORMATS AND NAME SPECIFICATIONS

6.1 DEFINITIONS AND GENERAL CONCEPT

6.1.1 Definitions

6.1.1.1 Data Product

A data product is a labelled grouping of data resulting from a scientific observation. Examples of data products include spectrum tables, and time series tables. A data product is a component of a data set.

6.1.1.2 Data Set

The accumulation of data products, secondary data, software, and documentation, that completely document and support the use of those data products. A data set is part of a data set collection.

6.1.1.3 Data Set Collection

A data set collection consists of data sets that are related by observation type, discipline, target, or time, and therefore are treated as a unit, archived and distributed as a group (set) for a specific scientific objective and analysis.

6.1.1.4 Volume

A physical unit used to store or distribute data products (e.g. a CD_ROM disk or On-Line Magnetic disc) which contain directories and files. The directories and files include documentation, software, calibration and geometry information as well as the actual science data. A volume is part of a volume set.

6.1.1.5 Volume Set

A volume set consists of one or more data volumes containing a single data set or collection of related data sets. In certain cases, the volume set can consists of only one volume.

6.2 DATA- AND VOLUME SET ORGANIZATION

The general concept for the MaRS, RSI and VeRa Data- and Volume Set Design is shown in Figure 1:

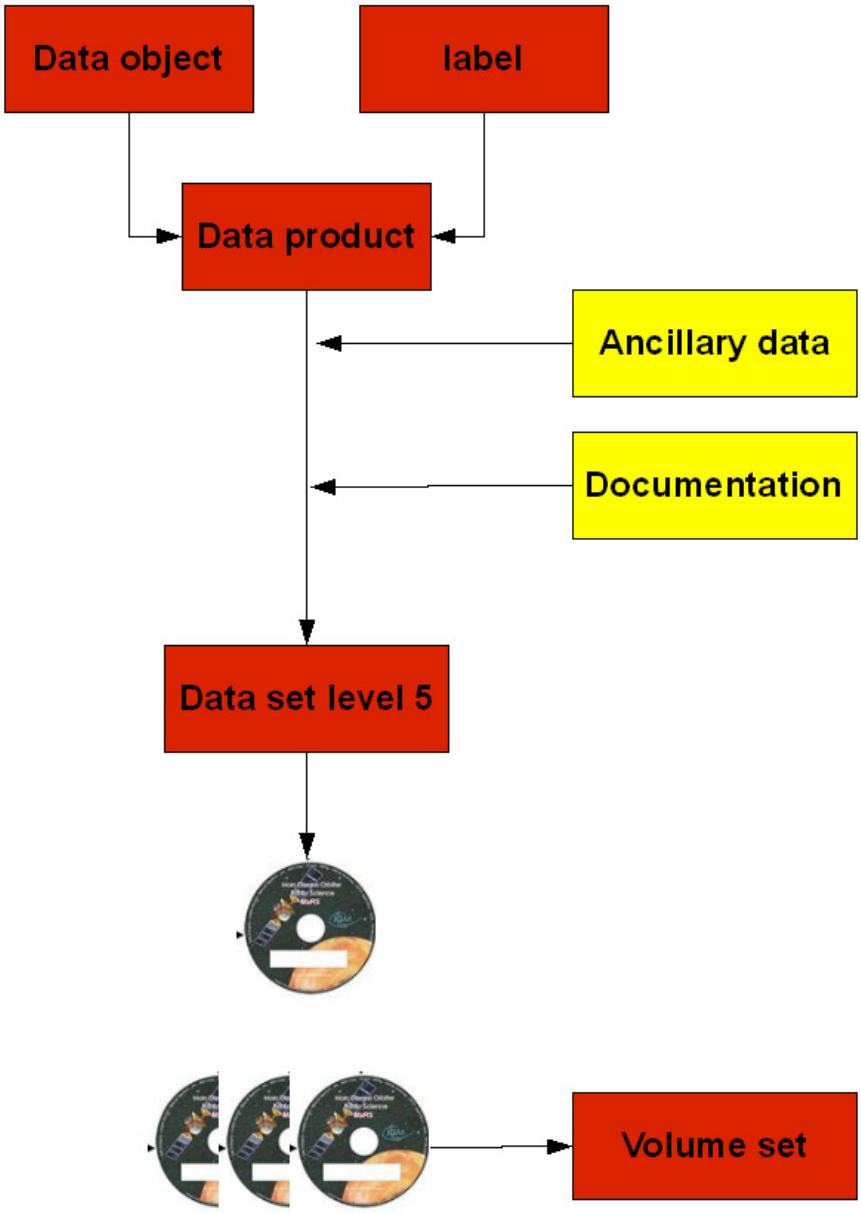

Figure 1: **Data Set Collection, Data Set and Data Product**

6.3 VOLUME AND DATASET NAME SPECIFICATION

6.3.1 Dataset

6.3.1.1 Dataset ID

The Data Set ID is a unique alphanumeric identifier for the MaRS, VeRa and RSI data products. One data set corresponds to one physical data volumeand both have a four digit sequence number. For higher science data, both volume and data set, have the same sequence number (see 6.3.3.1).For more information on the dataset ID see Table 6-1.

XXX-Y-ZZZ-U-VVV-NNNN-WWW

Acronym	Description	Example
XXX	Instrument Host ID	MEX RO VEX
Y	Target ID	M (Mars) V (Venus) C (Comet Churyumov-Gerasimenko) L (asteroid Lutetia) S (asteroid Steins) X (for others i.e. Sun)
ZZZ	Instrument ID	MRS RSI VRA
U	Data level[1] (CODMAC Level)	5 derived higher science data
VVV	For higher Sience data the measurement type	OCC Occultation
NNNN	A 4 digit sequence number	0123
WWW	Version number	V1.0

Table 6-1: Dataset ID

[1] In all keywords in the labels the CODMAC-levels are used instead of PSA-level. In the file names and documents we keep PSA-level.

Examples:

MEX-M-MRS-5-OCC-9101-V1.0

6.3.1.2 Dataset Name

The dataset name is the full name of the dataset already identifiable by a dataset id. Dataset names shall be at most 60 characters in length and must be in upper case. See Table 6-2 for more information.

Description	Example
Instrument Host Name	MARS EXPRESS ROSETTA ORBITER VENUS EXPRESS
Target name	MARS VENUS 67P (for Comet Churyumov-Gerasimenko) CHECKOUT (commissioning Rosetta) LUTETIA STEINS SKY (commissioning VEX)
Instrument id	MRS RSI VRA
data processing level number in CODMAC level	1/2/3
mission phases (MaRS misson phases can deviate from the MEX official phase names. See above) For higher science data: Measurement type	MISSION COMMISSIONING CRUISE 1 PRIME MISSION EXTENDED MISSION OCCULTATION
A 4 digit sequence number which is identical to the sequence number in the corresponding volume's Radio Science VOLUME_ID	0123
Version number	V1.0

Table 6-2: Dataset name

Examples:

MARS EXPRESS MARS MRS 1/2/3 MISSION COMISSIONING 0123 V1.0
VENUS EXPRESS VENUS VRA 1/2/3 PRIME MISSION 0099 V2.0
ROSETTA ORBITER 67P RSI 1/2/3 CRUISE 1 1144 V3.0
MARS EXPRESS MARS MRS 5 OCCULTATION 9101 V2.0

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6.3.2 Dataset Collection

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6.3.2.1 Dataset Collection ID

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The data set collection ID element is a unique alphanumeric identifier for a collection of related data sets or data products. The data set collection is treated as a single unit, whose components are selected according to a specific scientific purpose. Components are related by observation type, discipline, target, time, or other classifications. See Table 6-3 for more information.

657

XXX_Y_ZZZ_U_VVV_IIIIIIIII_TTT

Acronym	Description	Example
XXX	Instrument Host ID	MEX RO VEX
Y	Target ID	M (Mars) V (Venus) C (Comet 67P/Churyumov-Gerasimenko tbc) L (asteroid Lutetia tbc) S (asteroid Steins tbc)
ZZZ	Instrument ID	MRS RSI VRA
U	Data Level In the keyword DATA_COLLECTION_ID the CODMAC-levels are used instead of PSA-level. In all other file names and documents we keep PSA-level.	1 (Raw Data of level 1a and 1b) 2 (Calibrated Data) 5 (Higher Level Data) 1/2/3 (Data set contains raw and calibrated data)
VVV	Data Description (Acronym)	MCO commissioning CR1 cruise first part PRM prime mission ENT extended mission
IIIIIIIII	Data Description (Detailed)	ROCC Occulation Profiles GRAV Gravity Data RANG Apocenter Ranging BSR Bistatic Radar Spectra PHOBOS Phobos Flyby SUPCON superior solar conjunction INFCON inferior solar conjunction
TTT	Version Number	V1.0

659 **Table 6-3: Dataset Collection ID**

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6.3.3 Volume

6.3.3.1 Volume ID

The Volume ID provides a unique identifier for a single MaRS, RSI or VeRa data volume, typically a physical CD_ROM disk or On-Line Magnetic disc. The volume ID is also called "volume label" by the various CD-ROM recording software packages. The Volume ID is formed using a mission identifier, an instrument identifier of 3 characters, followed by an underscore character, followed by a 4 digit sequence number. For higher science data in the 4-digit number, the first two digits UU represent the volume set, the remaining digits define the range of volumes in the volume set.

Important note: the here defined ESA PSA Volume_Id is not identical with the Radio Science Volume_Id. The Radio Science Volume_Id is a number which is incremented measurement by measurement, independent what kind of measurement was conducted. The Radio Science Volume_Id belonging to one single measurement can be found in the Logbook, located in the folder DOCUMENT/MRS_DOC (or RSI_DOC or VRA_DOC). The ESA PSA Volume_Id in contrast is incremented by measurement types. MEXMRS_9121, for example, denotes the 21th archived higher science occultation volume archived by the Mars Express MRS team since implementation of this guideline.

For higher science data, i.e. level 3 and 4 data, the first digit in the sequence number is set to 9. The second digit represents the type of measurement. The remaining digits define the range of volumes in the higher science volume set.

UU:

- 90: Higher science data Commissioning
- 91: Higher science data occultation
- 92: Higher science data gravity
- 93: Higher science data solar conjunction
- 94: Higher science data bistatic radar
- 95: Higher science data checkout
- 96: Higher science data swing by
- 97: Higher science data cometary coma

XXXXXX_UUZZ

Acronym	Description	Example
XXXXXX	Missionhost and Instrument ID	MEXMRS RORSI VEXVRA
ZZZZ	4 digit sequence number	9101

Table 6-4: Volume ID

Examples:

MEXMRS_1001

703 RORSI_2999
704 VEXVRA_3508
705 MEXMRS_9101
706

6.3.3.2 Volume Version ID

There can be several version of the same volume, if for example the archiving software changed during the archiving process or errors occurred during the initial production. This is indicated by the Volume Version ID, a string, which consists of a 'V' for Version followed by a sequence number indicating the revision number.

VV.V

Acronym	Description	Example
VV.V	Volume Version ID	V1.0

Table 6-5: Volume Version ID

If a volume is redone because of errors in the initial production or because of a change in the archiving software during the archiving process, the volume ID remains the same, and the Volume Version ID will be incremented.

6.3.3.3 Volume Name

The VOLUME NAME (formatted according to Table 5-6) contains the name of the data volume (typically a CD_ROM disk or On-Line Magnetic disc) already identifiable by its VOLUME ID.
Note that the volume naming for higher science data deviates from the volume naming of level 1/2/3 (CODMAC level) i.e. level 1a/1b/2 (ESA PSA level) data volumes (See document MEX_MRS_IGM_IS_3016 for more detail).

xxxxxx_zzzz_vv.v

Acronym	Description	Example
xxxxxx	Missionhost and Instrument ID	MEXMRS RORSI VEXVRA
zzzz	ESA PSA volume id for CODMAC data level 5	0001
vv.v	Volume Version ID	V1.0

Table 5-6: Volume name definition

Examples:

MEXMRS_9101_V1.0
RORSI_0999_V1.0
VEXVRA_9108_V1.0

6.3.4 Volume Set

A volume set consists of a number of volumes.

6.3.4.1 Volume Set ID

The VOLUME SET ID identifies a data volume or a set of volumes. Volume sets are considered as a single orderable entity. VOLUME SET ID shall be at most 60 characters in length must be in upper case and separated by underscores. See Table 6-7 for more information.

XXX_YYYY_ZZZ_WWW_UVVV

Acronym	Description	Example
XXX	Abbreviation of the country of origin	GER USA
YYYY	The government branch	UNIK NASA
ZZZ	Discipline within branch	RIU (new, since 15.8.2007) IGM (old)
WWW	Mission and Instrument ID	MEXMRS RORSI VEXVRA
UVVV	For Mex: A 4 digit sequence identifier The “U” digit is be used to represent the volume set Only MEX: U = 0 commissioning / cruise = 1 flybys = 2 prime missions = 3 extended missions For ROS/VEX see chapter 6.3.3.1 the trailing “V”s are wildcards that represent the range of volumes in the set and are set to X as long as the number of volumes is not fixed	0099

Table 6-7: Volume Set ID

Examples:

GER_UNI_RIU_MEXMRS_91xx
USA_NASA_JPL_MEXMRS_0098

6.3.4.2 Volume Set Name

The VOLUME SET NAME provides the full, formal name of a group of data volumes containing a data set or a collection of related data sets. Volume set names shall be at most 60 characters in length and must be in upper case. Volume sets are considered as a single orderable entity. In certain cases, the volume set name can be the same as the volume name, such as when the volume set consists of only one volume.

Spacecraft	Example
Mars Express	MEX: RADIO SCIENCE OCCULTATION MEX: RADIO SCIENCE GLOBAL GRAVITY MEX: RADIO SCIENCE TARGET GRAVITY MEX: RADIO SCIENCE SOLAR CONJUNCTION MEX: RADIO SCIENCE PHOBOS FLYBY MEX: RADIO SCIENCE BISTATIC RADAR MEX: RADIO SCIENCE OCCULTATION HIGHER SCIENCE MEX: RADIO SCIENCE GLOBAL GRAVITY HIGHER SCIENCE MEX: RADIO SCIENCE TARGET GRAVITY HIGHER SCIENCE MEX: RADIO SCIENCE SOLAR CONJUNCTION HIGHER SCIENCE MEX: RADIO SCIENCE PHOBOS FLYBY HIGHER SCIENCE MEX: RADIO SCIENCE BISTATIC RADAR HIGHER SCIENCE
Venus Express	VEX: RADIO SCIENCE OCCULTATION
Rosetta	RO: RADIO SCIENCE COMMISSIONING

Table 6-8: Volume Set Name

Examples:

MEX: RADIO SCIENCE OCCULTATION
MEX: RADIO SCIENCE GLOBAL GRAVITY

6.3.5 Volume Series

A volume series consists of one or more volume sets that represent data from one or more missions or campaigns.

6.3.5.1 Volume Series Name

The volume_series_name element provides a full, formal name that describes a broad categorization of data products or data sets related to a planetary body or a research campaign. See Table 6-9 for details.

Spacecraft	Example
Mars Express	MISSION TO MARS
Venus Express	MISSION TO VENUS
Rosetta	MISSION TO SMALL BODIES

Table 6-9: Volume Series Name

Examples:

MISSION TO MARS
MISSION TO VENUS
MISSION TO SMALL BODIES