RADIO SCIENCE

Radio Science Cologne

Mars Express, Venus Express and ROSETTA

File Naming Convention and File Formats of Higher Science Data Products

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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
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
MaRS	Mars Express Radio Science Experiment
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
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
X-TX	X-band Transmitter

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Contents

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 REFERENCED 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 APPLICABLE 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.*
Pätzold, M., Tellmann, S., Mendillo, M., Withers, P., Häusler, B., Hinson, D.P., Tyler, G.L.	The Martian Ionosphere as seen by Mars Express	*Icarus, in prep.*

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2 OVERVIEW OF SCIENCE DATA LEVEL

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 groundstations in New Norcia (Australia), Cebreros (Spain) or at the NASA Deep Space Network (DSN). L02 data contain the calibrated Radio Science data.

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 data.
- Bistatic Radar

The L02 files build the input data base for the Level 3 (L03) & Level 4 (L04) data files.

2.2 SCIENCE DATA PROCESSING LEVELS

Level 3 (L03) files contain science information extracted from the Radio Science L02 data. Different output file types exists 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). These files contain information about the ray bending of the radio link in the ionosphere and atmosphere. In a next computation step these refractivity profiles are used to produce density, temperature and pressure profiles of the neutral atmosphere and electron density profiles of the ionosphere (Level 4 L04 files). The refractivity profile is the main output for Level 3. It is included in the ionospheric L04 files and it can be easily derived from the atmospheric Level 4 product because the neutral number density in the L04 profiles is directly proportional to the refractivity in the neutral atmosphere. (e.g. see [Hinson et al, 1999] for a description and the proportionality factor).
- Gravity measurements.
- Phobos measurements.
- Atmospheric drag measurements.
- Solar Corona measurements.
- Bistatic Radar measurements.

<u>Level 4 (L04) files</u> contain information calculated using the 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 two different types of L04 occultation (OCC) data:

- Atmospheric profiles of the neutral atmosphere containing vertical profiles of temperature, pressure and neutral number density.
- 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.

The Phobos, Solar Corona and Atmospheric Drag L04 data product are TBD.

2.3 GENERAL FILE NAME FORMAT

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

rggttttlll_sss_yydddhhmm_qq.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

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 feasible to appoint to a specific ground station or complex <u>DSN complex 40 Canberra</u> 34 = 34 m BWG 40 = complex 43 = 70 m 45 = 34 m HEF <u>ESA Cebreros antenna:</u> xx = 35 m	00

	<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> xx = 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 SUMM = summary table	ODF0
lll	*Data processing level* L03 = Level 3 L04 = Level 4	L03
sss	*data type* <u>Science data level 3:</u> OCx summary for occultation season x=1,2,3,…. STC solar corona total electron content data SEC solar corona change of electron content data RIX ionospheric refractivity profile from	AIX

	X-band RIS ionospheric refractivity profile from S-band RNX refractivity profile for neutral atmosphere from X-band RNS refractivity profile for neutral atmosphere from S-band RDX refractivity profile from differential Doppler from X-band RDS refractivity profile from differential Doppler from S-band GRV gravity LOS acceleration data PHB Phobos measurement DRG atmospheric drag measurement PXR bistatic radar echo power X-band, right circular polarized PXL bistatic radar echo power X-band, left circular polarized PSR bistatic radar echo power S-band, right circular polarized PSL bistatic radar echo power S-band, left circular polarized <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) IEO ionospheric files containing additional information about the geometry of the	

	OCC measurement (egress) and the data processing AIX atmospheric profiles generated from X-band data (ingress measurement) AIS atmospheric profiles generated from S-band data (ingress measurement) AIO atmospheric files containing additional information about the geometry of the OCC measurement (ingress) and the data processing AEX atmospheric profiles generated from X-band data (egress measurement) AES atmospheric profiles generated from AEO atmospheric files containing additional information about the geometry of the OCC measurement (egress) and the data processing PHB Phobos measurement DRG atmospheric drag measurement DEX dielectric constant X-band from bistatic radar measurement DES dielectric constant S-band from bistatic radar measurement	
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 for all measurement types except bistatic radar. Set to “N/A” for bistatic radar)	1135
qq	Sequence or version number	01
eee	.TAB ASCII data files .LBL PDS label files .TXT information files .LOG processing information files	TAB

Table 2-1: Data file naming convention

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

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

r00SUMML03_OCx_yyddd0000_qq.TAB

The source identifier is set *to tttt = SUMM*, sss = OCx is for occultation season x = 1, 2, 3, 4, 5, or 6,… respectively. *yyddd* describe the year (*yy*) and the day of year (*ddd*) of the first occultation measurement in the summary table.

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. 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 approximate information about the location and local time of the measurements. More detailed information about the measurement can be found in the *.TXT files described below.

Column	Description	Unit	resolution
1	Occultation number in season x		
2	Orbit number		
3	Day of year		
4	Date	dd/mm/yy	
5	Start time of Doppler recording in hh:mm:ss	[grt]	
6	Stop time of Doppler recording in hh:mm:ss	[grt]	
7	Ground station		
8	Longitude of occultation coordinate (east) at ingress	deg	0.1 deg
9	Longitude of occultation coordinate (west) at ingress	deg	0.1 deg
10	Latitude of occultation coordinate at ingress	deg	0.1 deg
11	Solar longitude at ingress	deg	0.01 deg
12	Solar elevation at ingress	deg	0.1 deg
13	Solar zenith angle at ingress	deg	0.1 deg
14	Local time on planet in fraction of hours at ingress	hours	0.01 h
15	Local radius based on For Mars: the MOLA model at ingress location	km	10^{-2} km

	For Venus: mean radius of 6051.8 km used		
16	Topographic elevation at ingress	km	10^{-2} km
17	Longitude of occultation coordinate (east) at egress	deg	0.1 deg
18	Longitude of occultation coordinate (west) at egress	deg	0.1 deg
19	Latitude of occultation coordinate at egress	deg	0.1 deg
20	Solar longitude at egress	deg	0.1 deg
21	Solar elevation at egress	deg	0.1 deg
22	Solar zenith angle at egress	deg	0.1 deg
23	Local time on planet in fraction of hours at egress	hours	0.01 h
24	Local radius based on For Mars: the MOLA model at egress location For Venus: mean radius of 6051.8 km used	km	10^{-2} km
25	Topographic elevation at egress	km	10^{-2} km

Note: no egress observations with MEX. Egress columns for MEX are not included.

3.1.2 Occultation measurement information file

3.1.2.1 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 = RIX* or *RIS* for X-band or S-band atmospheric profile data, respectively.

3.1.2.2 File format: information file (.TXT-file)*

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	Occultation time: time at the planet when the geometrical ray path grazed the limb. This is computed by substracting the limb-to-Earth light time from the appropriate ERT.		
4	Orbit number		
5	ground station DSS 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 degrees is a nearly diametric ingress occultation.	deg	0.01 deg
8	Latitude at surface (North)	deg	0.01 deg
9	Longitude at surface (East)	deg	0.01 deg

10	Sub-solar latitude	deg	0.01 deg
11	Sub-solar longitude	deg	0.01 deg
12	Solar Longitude	deg	0.01 deg
13	For Mars: MOLA radius: Radius at Occultation 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. For Venus: mean planetary radius of 6051.8 km used	km	0.01 km
14	Spacecraft to Limb Distance	km	1 km
15	Spacecraft to ground station Distance	10^6 km	1 km
16	Local True Solar Time of Occultation (LTST)	hour	0.01 hour
17	Solar Zenith Angle	deg	0.01 deg
18	Sun-Earth-Spacecraft-Angle: Approximate angle between Sun and spacecraft as viewed from Earth during experiment.	deg	0.01 deg
19	ground station elevation angle	deg	0.01 deg
20	PCK file name: file name of the NAIF Planetary Constants file used in this retrieval.		
21	SPK file name: file name of the NAIF Spacecraft dealing with ephemeris data.		

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: ATMOSPHERIC DRAG

TBD

3.6 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).

4.1.2 Atmospheric information file

4.1.2.1 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* = *AIO/AEO* for X-band or S-band atmospheric profile data (I=ingress, E=egress), respectively.

4.1.2.2 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	Measurement time (lowest sample): The Spacecraft Time (GRT-OWLT) at which the lowest acceptable radio occultation data sample was acquired.		
5	Orbit number		
6	DSN antenna number		

7	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
8	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
9	Latitude of lowest acceptable sample (North)	deg	0.01 deg
10	Longitude of lowest acceptable sample (East)	deg	0.01 deg
11	Sub-solar latitude of lowest acceptable sample (North)	deg	0.01 deg
12	Sub-solar longitude of lowest acceptable sample (East)	deg	0.01 deg
13	Solar Longitude at lowest acceptable sample	deg	0.01 deg
14	For Mars: 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. For Venus: mean planetary radius of 6051.8 km used	km	0.01 km
15	For Mars:	km	0.01 km

	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. For Venus: set to -9999.99		
16	Radius of the lowest acceptable measurement point	km	0.01 km
17	Sigma Radius	km	0.01 km
18	Pressure of lowest sample	Pa	0.01 Pa
19	Sigma Pressure of lowest sample	Pa	0.01 Pa
20	Temperature of lowest sample	K	0.01 K
21	Sigma Temperature of lowest sample	K	0.01 K
22	Upper boundary condition for Temperature: lowest value	K	0.01 K
23	Upper boundary condition for Temperature: medium value	K	0.01 K
24	Upper boundary condition for Temperature: upper value	K	0.01 K
25	Spacecraft to Limb Distance at measurement time of lowest acceptable sample	km	1 km
26	Spacecraft to Groundstation Distance at measurement time of lowest acceptable sample	10^6 km	1 km
27	Local True Solar Time of Occultation (LTST) at geolocation of lowest acceptable sample	hour	0.01 hour
28	Solar Zenith Angle at geolocation of lowest acceptable sample	deg	0.01 deg
29	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
30	Groundstation elevation angle at measurement time of lowest acceptable sample	deg	0.01 deg
31	Gravity field model		

32	Geopotential reference: Reference value for geopotential. Reference geoid has mean equatorial radius of 3396 km.	m^2/s^2	1 m^2/s^2
33	PCK file name: file name of the NAIF Planetary Constants file used in this retrieval.		
34	SPK file name: file name of the NAIF Spacecraft dealing with ephemeris data.		

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* for X-band or S-band atmospheric profiles data (I=ingress, E=egress), respectively.

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 substracted.	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	Pa	0.001 Pa

	condition		
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}

4.2 LEVEL 4 DATA PRODUCTS: IONOSPHERIC ELECTRON DENSITY PROFILES

4.2.1 Introduction

Vertical profiles of electron density of the ionosphere are derived from the 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)

4.2.2 Electron density profile file

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

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 = 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.

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

Column	Description	Unit	resolution
1	Sample number		
2	Time in ISO format		
3	Ephemeris time	sec	10^{-6} sec
4	Radius	km	10^{-3} km
5	Geopotential height	km	10^{-3} km
6	Latitude	deg	0.01 deg
7	Longitude East	deg	0.01 deg
8	Refractivity times 10^{6}		10^{-6}
9	Received signal power level	dBm	0.1 dBm
10	Electron Density	$10^{6}m^{-3}$	10^{-2} m^{-3}
11	Uncertainty electron density	$10^{6}m^{-3}$	10^{-2} m^{-3}

4.2.3 Ionospheric information file

4.2.3.1 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 = IIO/IEO* for X-band or S-band ionoospheric profile data (I=ingress, E=egress), respectively.

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

Line	description	Unit	Resolution
1	Profile file name: Name of the corresponding ionospheric 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	Measurement time of the sample with a ray periapsis of 100 km above MOLA surface given in Earth Receive Time (GRT).		
5	Measurement time of the sample with a ray periapsis of 100 km above MOLA surface given in Spacecraft Time (GRT - OWLT).		
6	Orbit number		
7	DSN antenna number		
8	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
9	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	deg	0.01 deg

	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.		
10	Solar Longitude of geometrical OCC point.	deg	0.01 deg
11	Latitude (North) of the sample with a ray periapsis of 100 km above MOLA surface for Mars and 115 km above mean radius of 6051.8 km for Venus.	deg	0.01 deg
12	Longitude (East) of the sample with a ray periapsis of 100 km above MOLA surface for Mars and 115 km above mean radius of 6051.8 km for Venus..	deg	0.01 deg
13	Sub-solar latitude (North) of the sample with a ray periapsis of 100 km above MOLA surface and 115 km above mean radius of 6051.8 km for Venus.	deg	0.01 deg
14	Sub-solar longitude (East) of the sample with a ray periapsis of 100 km above MOLA surface and 115 km above mean radius of 6051.8 km for Venus.	deg	0.01 deg
15	For Mars: MOLA radius: Radius at latitude and longitude (given in line 11 and 12) taken from a 0.25 x 0.25 grid. The given value is the radius at the grid point closest to the measurement point. For Venus: mean planetary radius of 6051.8 km used	km	0.01 km
16	For Mars: MOLA areoid: Radius of areoid at latitude and longitude (given in line 11 and 12) taken from a 0.25 x 0.25 grid. The given value is the	km	0.01 km

	radius at the grid point closest to the measurement point. For Venus: set to -9999.99		
17	Electron density at 100 km above MOLA surface and 115 km above mean radius of 6051.8 km for Venus.	10^6 m^{-3}	10^4 m^{-3}
18	Sigma electron density at 100 km above MOLA surface and 115 km above mean radius of 6051.8 km for Venus.	10^6 m^{-3}	10^4 m^{-3}
19	Local True Solar Time of Occultation (LTST) at 100 km above MOLA surface and 115 km above mean radius of 6051.8 km for Venus.	hour	0.01 hour
20	Solar Zenith Angle at 100 km above MOLA surface and 115 km above mean radius of 6051.8 km for Venus.	deg	0.01 deg
21	Latitude (North) of the sample with maximum of electron density.	deg	0.01 deg
22	Longitude (East) of the sample with maximum of electron density.	deg	0.01 deg
23	Sub-solar latitude (North) of the sample with maximum of electron density.	deg	0.01 deg
24	Sub-solar longitude (East) of the sample with maximum of electron density.	deg	0.01 deg
25	For Mars: MOLA radius: Radius at latitude and longitude (given in line 21 and 22) taken from a 0.25 x 0.25 grid. The given value is the radius at the grid point closest to the measurement point. For Venus: mean planetary radius of 6051.8 km used	km	0.01 km
26	For Mars: MOLA areoid: Radius of areoid at latitude and longitude (given in line 21 and 22) taken from a 0.25 x 0.25 grid. The given value is the	km	0.01 km

	radius at the grid point closest to the measurement point. For Venus: set to -9999.99		
27	Maximum of electron density	10^6 m^{-3}	10^4 m^{-3}
28	Sigma maximum of electron density	10^6 m^{-3}	10^4 m^{-3}
29	Radius of maximum of electron density	km	0.01 km
30	Geopotenial height of electron density maximum	km	0.01 km
31	Altitude above reference areoid of electron density maximum	km	0.01 km
32	Solar Zenith Angle at geolocation of electron density maximum	deg	0.01 deg
33	Distance between Planet and Sun	10^6 km	1 km
34	Gravity field model		
35	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
36	PCK file name: file name of the NAIF Planetary Constants file used in this retrieval.		
37	SPK file name: file name of the NAIF Spacecraft dealing with ephemeris data.		

4.3 LEVEL 4 DATA PRODUCTS: GRAVITY

TBD

4.4 LEVEL 4 DATA PRODUCTS: BISTATIC RADAR

TBD

4.5 LEVEL 4 DATA PRODUCTS: SOLAR CORONA

TBD

4.6 LEVEL 4 DATA PRODUCTS: ATMOSPHERIC DRAG

TBD

4.7 LEVEL 4 DATA PRODUCTS: PHOBOS

TBD

5 VOLUMES AND DATASETS ORGANIZATIONS, FORMATS AND NAME SPECIFICATIONS

5.1 DEFINITIONS AND GENERAL CONCEPT

5.1.1 Definitions

5.1.1.1 Data Product

A data product is a labeled 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.

5.1.1.2 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.

5.1.1.3 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.

5.1.1.4 Volume

A physical unit used to store or distribute data products (e.g. a CD_ROM or DVD disk) 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.

5.1.1.5

5.1.1.6 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.

5.2 DATA- AND VOLUME SET ORGANIZATION

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

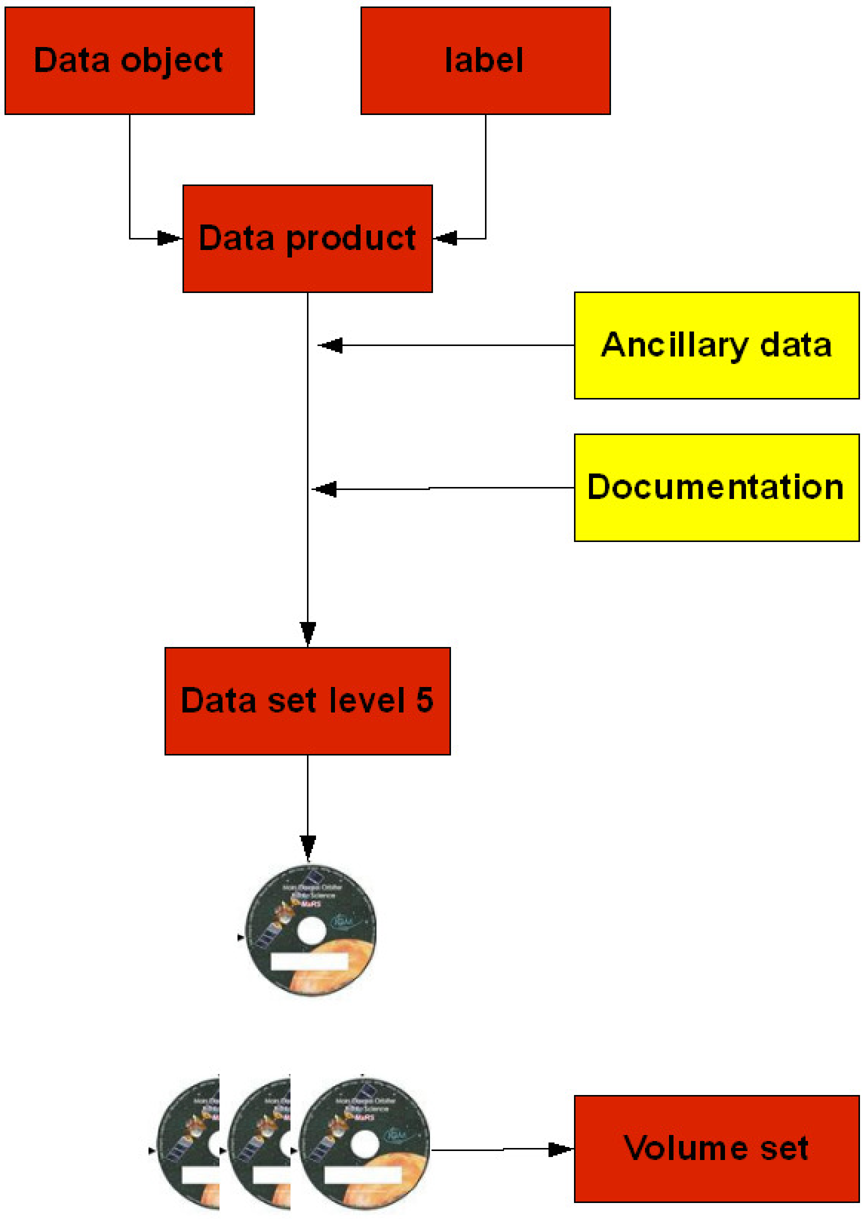

Figure 1: Data Set Collection, Data Sets and Data Products

5.3 VOLUME AND DATASET NAME SPECIFICATION

5.3.1 Dataset

5.3.1.1 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 volume and both have a four digit sequence number. For higher science data, both volume and data set, have the same sequence number (see 5.3.3.1).For more information on the dataset ID see Table 5-1.

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 5-1: 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

5.3.1.2 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 5-2 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 5-2: 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

5.3.2 Dataset Collection

5.3.2.1 Dataset Collection ID

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 5-3 for more information.

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

Table 5-3: Dataset Collection ID

5.3.3 Volume

5.3.3.1 Volume ID

The Volume ID provides a unique identifier for a single MaRS, RSI or VeRa data volume, typically a physical CD-ROM or DVD. 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 5-4: Volume ID

Examples:

MEXMRS_1001
RORSI_2999
VEXVRA_3508
MEXMRS_9101

5.3.3.2 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 5-5: 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.

5.3.3.3 Volume Name

The VOLUME NAME (formatted according to Table -6) contains the name of the physical data volume (typically a CD-ROM or DVD) 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 -6: Volume name definition

Examples:

MEXMRS_9101_V1.0
RORSI_0999_V1.0
VEXVRA_9108_V1.0

5.3.4 Volume Set

A volume set consists of a number of volumes.

5.3.4.1 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 5-7 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 5.3.3.1 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 5-7: Volume Set ID

Examples:

GER_UNI_RIU_MEXMRS_91xx
USA_NASA_JPL_MEXMRS_0098

5.3.4.2 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 5-8: Volume Set Name

Examples:

MEX: RADIO SCIENCE OCCULTATION
MEX: RADIO SCIENCE GLOBAL GRAVITY

5.3.5 Volume Series

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

5.3.5.1 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 5-9 for details.

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

Table 5-9: Volume Series Name

Examples:

MISSION TO MARS
MISSION TO VENUS
MISSION TO SMALL BODIES