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DSN ODF (Orbit Data File) Processing Package:
Level 1a to Level 1b
Software Design Specifications

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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
DDS	Data Delivery System
DSN	Deep Space Network
DVD	Digital Versatile Disk
ESA	European Space Agency
ESOC	European Space Operation Center
ESTEC	European Space Technology Center
FOL	Frequency Open Loop
G/S	Ground Station
HGA	High Gain Antenna
IFMS	Intermediate Frequency Modulation System
JPL	Jet Propulsion Laboratory
LCP	Left Circular Polarization
LGA	Low Gain Antenna
LOS	Line Of Sight
MaRS	Mars Express Radio Science Experiment
MGA	Medium Gain Antenna
MGS	Mars Global Surveyor
NASA	National Aeronautics and Space Administration
ODF	DSN Original Data File
ODR	Original Data Record
OL	Open-Loop
ONED	one-way dual-frequency mode
ONES	One-way single-frequency mode
PDS	Planetary Data System
POL	Polarization Open Loop
RCP	Right Circular Polarization
RSR	Radio Science Receiver
RX	Receiver
S/C	Spacecraft

SIS	Software Interface Specification
S-TX	S-Band Transmitter
SPICE	Space Planet Instrument C-Matrix Events
TBC	To Be Confirmed
TBD	To Be Determined
TWOD	Two-way dual-frequency mode
TWOS	Two-way single-frequency mode
USO	Ultra Stable Oszillator
X-TX	X-band Transmitter

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1 INTRODUCTION

1.1 SCOPE

This document specifies the requirements for the development of the DSN Orbit Data File (ODF) processing software, transferring Level 1a ODF data towards Level 1b. The software shall analyze radio Doppler and range tracking data recorded at the DSN ground stations.

1.2 REFERENCED DOCUMENTS

	Reference Number	Title
[1]	ROS-RSI-IGM-IS-3087	Radio Science File naming Convention
[2]	TRK-2-18	Orbit Data File Interface

1.3 SOFTWARE CONFIGURATION CONTROL

This document addresses the software package

DSN_ODF_PROC_PCK_L1A_TO_L1B
Version 1.0

After release, the software is under configuration control which will be documented in this section.

Version number	Changes/Action	New version	Release date

1.4 ACTION ITEM LIST

Action item	Description	Due date	actioneer	closed
1	New L1a file name not copied to original file	04.04.2005	AG	
2	No *.DAT extension of L1a file	04.04.2005	AG	
3	Label file: copy Stanford ODF description into Label file	04.04.2005	AG	
4	Accept “0” as station ID in Label file for L1a	04.04.2005	AG	
5	No pointers in Label L1a file	04.04.2005	AG	
6	Processing_level_ID must be “1”	04.04.2005	AG	
7	In L1b output: resolution of “fraction of DOY” is 1E-10	04.04.2005	AG	
8	Observe new range output format	04.04.2005	AG	
9	Ramp output file: sample starts with “1”	04.04.2005	AG	
10	No format descriotion of ramp file in Label file	04.04.2005	AG	
11	No processing and output for weather file	04.04.2005	AG	

2 SHORT FORMAT DESCRIPTION OF LEVEL 1A DSN ODF TAPES

2.1 BLOCK STRUCTURE

The ODF data are provided in disk files. Each ODF block or physical record consists of 2016 32-bit-words, for a total length of 64512 bits. Each ODF block contains 224 9-word (288 bits = 9 words x 32 bit) logical records. [2]
These logical records are grouped in two records with a group header record (9 words x 32 bit) and a group data record (9 words x 32 bit).

2.2 BLOCK CONTENT

A complete ODF may consist of several blocks or physical records.

A complete ODF may consist of the following records:

- File Label Group – one per ODF; consists of File Label Group Header Record and File Label data Group Record
- Identifier Group – one per ODF; consists of Identifier Group Header Record and identifier Group Data Record
- Orbit Data Group – multiple record groups, time ordered; each record group consists of sequential Orbit Data Group Header Record and Orbit Data Group Data Record
- Ramp groups – optional
- Clock offset groups – optional
- Data summary group – optional
- End-of-File (EOF) group – one per ODF; consists of EOF Group Record only

The description of the block content is given in [2] and attached as Annex A.

3 SPECIFICATIONS FOR LEVEL 1A TO LEVEL 1B PROCESSING

3.1 GENERAL SPECIFICATION

ODF-SPEC-3110: The software shall
- read the binary DSN ODF_FILE,
- process the data according to this specification,
- create ASCII data output files according to this specification and
- create a PDS conform label file Level 1a, for the original ODF_FILE and Level 1b label files for the output files.

ODF-SPEC-3120: The software language is FORTRAN and PERL

3.2 INPUT FILES

3.2.1 Data file types

ODF-SPEC-3210: the following table defines the input file types and the logical file names used in this specification and within the software:

File Description	Logical name within program
DSN Orbit data file (ODF); binary	ODF_FILE
DSN meteorological file	DSN_MET

3.2.2 File names

ODF-SPEC-3220: The incoming DSN ODF_FILE (Level 1a) will be renamed. Level 1a file names are defined as (see also [1] section 4.1)

r00ODF0L1A_ODF_yydddhhmm_qq.DAT

The time information in the file name will be the reference time given in ODF_HEADER and is typically the start date of the file. A DSN ODF file contains usually data covering several days and from different ground stations. Therefore, a general apointement to a specific ground station cannot be done and *gg=00*.

Table 3-1: file name parameter

Acronym	Description	Examples
r	Spacecraft (Raumsonde) name R = Rosetta M = Mars Express V = Venus Express	M
gg	Ground station ID: 00 = independent of ground station, various ground stations or not feasible to appoint to a specific ground station or complex DSN complex 40 Canberra 34 = 34 m BWG 40 = complex 40 43 = 70 m 45 = 34 m HEF DSN complex 10 Goldstone: 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 DSN complex 60 Madrid: 54 = 34 m BWG 55 = 34 m BWG 60 = complex 63 = 70 m 65 = 34 m HEF	43
tttt	data source identifier Level 1a and 1b ODF0 = ODF closed loop	ODF0
lll	Data archiving level L1A = Level 1A	L1A
sss	data type DSN data files level 1a: ODF original orbit files (closed-loop)	
yy	Year	04
ddd	Day of the year	153
hhmm	Sample hour , minute (Start time)	1135
qq	Sequence or version number	01

eee	.DAT binary data files (Level 1a)	DAT

ODF-SPEC-3230: A Level 1a label file will be generated according to PDS standards. The level 1a label file name is defined in ODF-SPEC-3220 with the extension *.LBL (see also [1] section 4.2).

r00ODF0L1A_ODF_yydddhhmm_qq.LBL

3.2.3 File formats

ODF-SPEC-3240: ODF_FILE formats are defined in [2] Tables 3-1 to Tables 3-8. A copy of these Tables can be found in Annex 1.

3.3 LEVEL 1A TO LEVEL 1B PROCESSING SOFTWARE SPECIFICATIONS

ODF-SPEC-3320: the different groups or record types will be identified by the first word (item 1) in the relevant Group Header Record called “Primary Key”:

Group Header Record	Item number	Data word	Numerical value of “Primary Key”	Table Number in [2] (see also Annex 1)
File Label	1	1	101	Table 3-1°
Identifier	1	1	107	Table 3-2a
Orbit Data	1	1	109	Table 3-3a
Ramp	1	1	2030	Table 3-4a
Clock Offsets	1	1	2040	Table 3-5a
Data Summary	1	1	105	Table 3-7a
EOF	1	1	-1	Table 3-8

ODF-SPEC-3330: the observables are defined by item 10 in the Orbit Data Group Data Record.

Identification of observable	Item number	Data word	Numerical value of “Data Type ID”
One-way Doppler	10	5	11
Two-way Doppler	10	5	12
Three-way Doppler	10	5	13
NSP Pseudo noise Range	10	5	36
DSN sequential Range	10	5	37
RE Range	10	5	41

ODF-SPEC-3335: DSN station ID, *uplink/downlink band flag; data validity indicator*
These info are defined in the Orbit Data Group Data Record:

Identification	Item number	Data word	value
Uplink band	12	5	0 = one-way 1 = S-band 2 = X-band 3 = Ka-band
Downlink band	11	5	0 = one-way 1 = S-band 2 = X-band 3 = Ka-band
DSN station ID	8	5	Station ID number
Data validity flag	14	5	0 = good data 1 = bad data

ODF-SPEC-3340: the observables are stored as item 4 and item 5 in Orbit Data Group Data Record and formatted as

observable	Item numbers	Data words	Format	Units
One-way Doppler	4,5	3,4	S32	Hz
Two-way Doppler	4,5	3,4	S32	Hz
Three-way Doppler	4,5	3,4	S32	Hz
Range	4,5	3,4	S32	Range units
Range	4,5	3,4	S32	Range units
Range	4,5	3,4	S32	nsec

ODF-DEF-3360: The time tag unit is seconds past zero hours UTC of 1st January 1950.

ODF-DEF-3370: The number of seconds including leap seconds between 1st January 1950 00:00 UTC and 1st January 2003 00:00 UTC is:

Modified Julian date 1st January 1950 00:00 UTC	0
Modified Julian Date 1st January 2003 00:00 UTC	19,358
Number of standard days	19,358
Number of standard seconds	1,672,531,200
Number of leap seconds between 1972 and 31.12.2003	22

(last leap second was introduced on 31st Dec 1999)	
Total number of seconds	1,672,531,222

ODF-SPEC-3350: the time tag of the observable (record time tag) is stored in item 1 and item 2 of the Orbit Data Group data Record.

Time tag	Item numbers	Data words	Format	Units
Time tag integer part	1	1	I32	sec
Time tag fractional part	2	2 bit1 – bit10	I10	msec

The time tag relative to 1st January 2003 00:00 UTC in seconds is:

$$time\_tag\left[\sec onds\right] = float(item1) + float(item2)\cdot 10^{-3} - 1{,}672{,}531{,}222$$

$$item2 = word2.AND.(2^{10} - 1)$$

ODF-SPEC-3355: Leap seconds have to be added to time_tag[seconds] if "Leap Second Alert" will occur after 31st December 2003.

ODF-SPEC-3360: number of days since 1st January 2003 00:00 UTC is :

$$time\_tag\left[days\right] = \frac{time\_tag\left[\sec onds\right]}{86{,}400}$$

year	Number of days	Cumulative number of days since 01.01.2003
2003	365	365
2004	366	731
2005	365	1096
2006	365	1461
2007	365	1826
2008	366	2192
2009	365	2557

ODF-SPEC-3370: *time_tag*
is to be transformed into

- ISO format
- Fractions of day of year
- Ephemeris time in seconds since 1st January 2000, 00:00 UTC

ODF_SPEC_3400: *uplink frequency*
The uplink frequency may be reconstructed from the Ramp Group Data Format.

$$uplink\_frequency(t) = start\_frequency(t_0) + ramp\_rate(t_0) \cdot (t - t_0) \qquad (1.1)$$

Where

Variable	description	Item#	Data word	format
start_frequency	Ramp start frequency, integer GHz	5	5	I22
	Ramp start frequency, integer part (mod 10^9)	7	6	I32
	Ramp start frequency, fractional part (10^{-9})	8	7	I32
Ramp_rate	Ramp rate, integer part (two´s complement)	3	3	S32
	Ramp rate, fractional part (two´s complement, 10^{-9})	4	4	S32
t_0	Ramp start time, integer part	1	1	I32
	Ramp start time, fractional part (10^{-9})	2	2	I32
t	Time stamp of observable $t \geq t_0$			

4 DSN METEOROLOGICAL FILE FOR TROPOSPHERIC CALIBRATION

ODF-SPEC-4010: The original DSN meteorological file DSN_MET will be renamed to

rggDSN0L1A_MET_yydddhhmm_qq.AUX

The file name format is specified in [1] section 4.1.

ODF-SPEC-4020: The original DSN meteorological file DSN_MET has the following file format:

The file has a header line:

DATE: yymmdd DOY: ddd DSS gg *(= ground station complex)*

And six columns with meteorological information for every 30 minutes

column	description	unit
1	time	hhmm
2	dew p temperature	degree Celsius
3	temperature	degree Celsius
4	pressure	mbar
5	H2O partial pressure	mbar
6	relative humidity	%

The format repeats for each day of the year. There is one meteorological file for each DSN compex 10, 40 and 60.

ODF-SPEC-4030: The original DSN meteorological file DSN_MET will be modified to match the file format of the IFMS meteorological file. One output files for each DSN complex will be generated.

5 OUTPUT FILES

5.1 DATA OUTPUT FILE TYPES

ODF-SPEC-5110: the following table defines the output file types and the logical file names used in this specification and within the software:

File Description	Logical name within program
Processed DSN Orbit data file (ODF); ASCII	ODF_DOP_S ODF_DOP_X ODF_RNG_S ODF_RNG_X
Uplink frequency reconstruction file	ODF_RAMP
Modified DSN meteorological file	DSN_MET_MOD

5.2 FILE NAMES

ODF-SPEC-5220: The level 1b file name of ODF_DOP-S, ODF_DOP_X, ODF_RNG_S, ODF_RNG_X , ODF_RAMP and ODF_MET_MOD are defined (see also [1] section 4.1) as:

r00tttL1B_sss_yydddhhmm_qq.TAB

The time information in the file name is taken as the reference time. and is typically the start date of the file. A DSN ODF file contains usually data covering several days and from different ground stations. Therefore, a general apointement to a specific ground station cannot be done and gg=00.

Table 5-1: file name parameter

Acronym	Description	Examples
r	Spacecraft (Raumsonde) name R = Rosetta M = Mars Express V = Venus Express	M
gg	Ground station ID: 00 = independent of ground station, various ground stations or not feasible to appoint to a specific ground station or complex	43
tttt	data source identifier Level 1a and 1b ODF0 = ODF closed loop DSN0 = DSN ancillary file (meteo file)	ODF0
lll	Data archiving level L1B = Level 1B	L1B
sss	data type DSN data files level 1b: DPS S-band Doppler DPX X-band Doppler RNS uncalibrated S-band ranging file RNX uncalibrated X-band ranging file RMP uplink frequency ramp rate file DSN ancillary files level 1b: MET modified DSN meteorological file	DPS
yy	Year	04
ddd	Day of the year	153
hhmm	Sample hour , minute (Start time)	1135
qq	Sequence or version number	00
eee	.TAB ASCII data files	

5.3 FILE FORMATS

5.3.1 ODF Doppler and Ranging file formats Level 1b

ODF-SPEC-5350: The file format of ODF_DOP_S, ODF_DOP_X, ODF_RNG_S and ODF_RNG_X are defined in Table 5-2, 5-3, 5-4, 5-5.

, respectively.

Table 5-2 File format of ODF_DOP_S

Column	Format	Description	Unit	Resolution
1		Sample number		
2		Time in ISO format		
3		Time in fractions of day of year	Days	10^{-10}
4		Ephemeris time since 01.01.2000	Sec	μsec
5	I2	Spacecraft ID		
6	I2	DSN station ID		
7	I1	1 = One-way 2 = two-way		
8	I1	Uplink frequency flag 0 = one-way 1 = S-band 2 = X-band 3 = Ka-band		
9	I1	Downlink frequency flag 1 = S-band 2 = X-band 3 = Ka-band		
10	I1	Data validity indicator 0 = data invalid 1 = data valid		
11		Observed S-band Doppler	Hz	nHz

Table 5-3: File format of ODF_DOP_X

Column	Format	Description	Unit	Resolution
1		Sample number		
2		Time in ISO format		
3		Time in fractions of day of year	Days	10^{-9}
4		Ephemeris time since 01.01.2000	Sec	μsec
5	I2	Spacecraft ID		
6	I2	DSN station ID		
7	I1	1 = One-way 2 = two-way		
8	I1	Uplink frequency flag 0 = one-way 1 = S-band 2 = X-band 3 = Ka-band		
9	I1	Downlink frequency flag 1 = S-band 2 = X-band 3 = Ka-band		
10	I1	Data validity indicator 0 = data invalid 1 = data valid		
11		Observed X-band Doppler	Hz	nHz

Table 5-4: File format of ODF_RNG_S

Column	Format	Description	Unit	Resolution
1		Sample number		
2		Time in ISO format		
3		Time in fractions of day of year	Days	10^{-9}
4		Ephemeris time since 01.01.2000	Sec	μsec
5	I2	Spacecraft ID		
6	I2	DSN station ID		
7	I1	1 = One-way 2 = two-way		
8	I1	Uplink frequency flag 0 = one-way 1 = S-band 2 = X-band 3 = Ka-band		
9	I1	Downlink frequency flag 1 = S-band 2 = X-band 3 = Ka-band		
10	I1	Data validity indicator 0 = data invalid 1 = data valid		
11	I2	Data type (item 10)		
12		Observed S-band range	Range units or nsec	
13		Item 18 plus item 19		
14		Item 20		
15		Item 21		
16		Item 22		

Table 5-5: File format of ODF_RNG_X

Column	Format	Description	Unit	Resolution
1		Sample number		
2		Time in ISO format		
3		Time in fractions of day of year	Days	10^{-9}
4		Ephemeris time since 01.01.2000	Sec	μsec
5	I2	Spacecraft ID		
6	I2	DSN station ID		
7	I1	1 = One-way 2 = two-way		
8	I1	Uplink frequency flag 0 = one-way 1 = S-band 2 = X-band 3 = Ka-band		
9	I1	Downlink frequency flag 1 = S-band 2 = X-band 3 = Ka-band		
10	I1	Data validity indicator 0 = data invalid 1 = data valid		
11	I2	Data type (item 10)		
12		Observed X-band range	Range units or nsec	
13		Item 18 plus item 19		
14		Item 20		
15		Item 21		
16		Item 22		

5.3.2 ODF Ramp RATE File Format

ODF-SPEC-5360: The file format of ODF_RAMP is defined in Table 5-6.

Table 5-6: file format of ODF_RAMP

Column	Format	Description	Unit	Resolution
1		Sample number		
2		Ramp start time Time in ISO format		
3		Ramp start time Time in fractions of day of year	Days	10^{-10}
4		Ramp start time Ephemeris time since 01.01.2000	Sec	μsec
5		Ramp stop time Time in ISO format		
6		Ramp stop time Time in fractions of day of year	Days	10^{-10}
7		Ramp stop time Ephemeris time since 01.01.2000	Sec	μsec
8		DSN Station ID		
9		Ramp Rate	Hz/s	10^{-6} Hz/s
10		Ramp Start Frequency	Hz	10^{-6} Hz

5.3.3 DSN modified meteorological file

ODF-SPEC-5370: the output file names are specified as

rggDSN0L1B_MET_yydddhhmm_qq.TAB

with *gg* = DSN complex.

ODF-SPEC-5372: The output format is specified in ODF-SPEC-5373.

ODF-SPEC-5373: The file format of ODF_MET_MOD is defined in Table 5-7. Three output files are generated, one for each DSN complex.

Table 5-7: file format of ODF_MET_MOD

Column	description	Unit
1	Sample number	
2	Ground received time as UTC in ISO format	
3	Ground received time as UTC in fractions of day of year starting with the first day of the year the data was recorded in at 00:00.000	days
4	Ground received time as Ephemeris time beginning at 12:00 01.01.2000 UTC	s
5	Humidity	0.1 %
6	Pressure	0.1 hecto Pascal
7	Temperature	0.1° C

5.4 LABEL FILES

ODF-SPEC-5470: Level 1b label files will be generated according to PDS standards.

ODF-SPEC-5480: The level 1b label file name is defined in ODF-SPEC-5220 and 5370 with the extension *.LBL (see also [1] section 4.2).

rggODF0L1B_sss_yydddhhmm_qq.LBL