820-013
Deep Space Mission System (DSMS)
External Interface Specification
JPL D-16765

TRK-2-18
Tracking System Interfaces
Orbit Data File Interface

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Change Log

Revision	Issue Date	Sections Affected	Change Summary
Initial release	06/15/1983	All	
Change 1	12/15/1998	All	Reformatted. Contains revisions to match the implementation. Uplink and downlink doppler phase have been added. Provides Y2K clarification for the use of two-digit year.
Change 2	01/15/1999	1.1.1, Appendix A	Adds missing text to clarify the calculation for frequency bias.
Change 3	06/15/2000	1.1.1, Table 3-3b.	Deleted Table 3-3b, Item Number 10 values that are not available and will not be provided. Deleted Tables 3-6a and Table 3-6b. Delete all “PRA” since it no longer exists. Table 3-3b, items 9 and 10, delete DSN or GSTDN.

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Appendix

Figures

Tables

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Section 1
Introduction

1.1 Purpose and Scope

This module specifies the Orbit Data File (ODF) format of the radio metric data from the Deep Space Network (DSN). The contents and formats of the ODF data blocks/records generated by the DSN Multimission Navigation (MMNAV) Radio Metric Data Conditioning Team (RMDCT), and either transmitted electronically or provided on magnetic tape, are herein defined.

1.1.1 Applicability of this Release

The 'Change 3' update to this module deletes items that are not available and will not be provided. Other updates to clean-up things that do not exist or are no longer applicable.

The 'Change 2' update to this module adds missing text to clarify the calculation for frequency bias in Appendix A.

The 'Change 1' module update corrects the interface specification to be consistent with revisions approved on 15 August 1996 by the Multimission Ground Support Office (MGSO), and implemented in the Radio Metric Data Conditioning (RMDC) software. Uplink and downlink Doppler phase data have been added to the ODF since the original DSN release.

1.2 Revision and Control

Revisions or changes to information herein presented may be initiated in accordance with the procedures in Section 1 of this document.

1.3 Applicable Documents

820-013	Deep Space Network System Requirements - Detailed Subsystem Interface Design

1.4 Convention

The ODF File Label Record (Table 3-1b) specifies a 2-digit year in the File Createion Date (item number 18). This item has no application to processing any data in the file. However, it is constructed with the premise that values from 50 to 99 shall signify dates with respect to 1900, and values between 00 and 49 shall represent dates with respect 2000.

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Section 2
General Information

The data will be stored by the RMDCT for transmission.

Figure 2-1 shows the data flow from the DSN Signal Processing Center (SPC) to the Project Operations Control Center (POCC) for the transmitted data, and for data provided electronically or on magnetic tape to JPL Projects.

When the ODFs are to be transmitted to a POCC, the Ground Communications Facility (GCF) is assumed to be transparent. The data shall be formatted into 1200-bit or 4800-bit data blocks and transmitted to the user via the Digital Communications Subsystem (GDC) of the GCF.

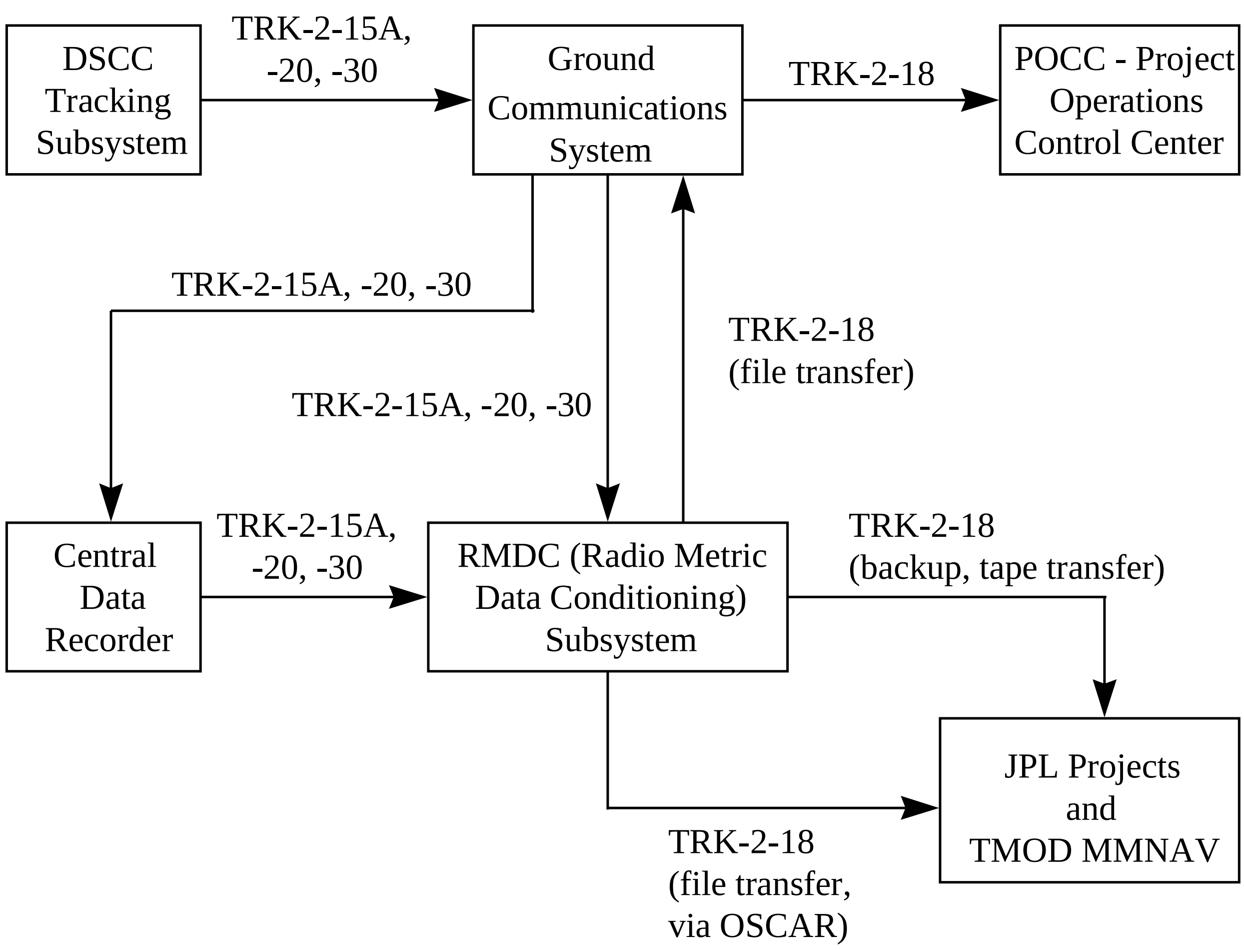

Figure 2-1. Data Flow for Orbit Data File Interface

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Section 3
Data Format and Fields

3.1 GCF Data Blocks

The ODF data blocks are standard 1200-bit or 4800-bit data blocks which contain radio metric data that have been generated from the 820-13, TRK-2-15A, TRK-2-20, and TRK-2-30 formats. The first 120 bits of the block form the block header and provide information common to all data in the block. The Block Information Field (BIF) consists of 1032 bits for a 1200-bit block and contains three packets (each consisting of nine 32-bit words) described in Tables 3-1 through 3-8. The BIF for 4800-bit blocks consists of 4632 bits and contains 16 packets of data. The last 48 bits of the data block contain the GCF error detection and correction data, the Error Status Code (ESC), and the Error Polynomial Code (EPC). The ODF data blocks will be ordered by block header time and date. Detailed descriptions of the header, BIF, and block ending are provided in the following paragraphs:

WORD 1 THRU WORD 8, BIT 8

Standard DSN Block Header as described in module OPS-6-8 of this document, with the following code assignments:

Source Code = AF_{16} (257_8 = DSN MMNAV)

UDT Code = 15_{16} (025_8)

DDT Code = 14_{16} (024_8)

WORD 8, BITS 9 THRU 16

Set to zeros

WORD 9 THRU WORD 72/WORD 297

BIF - ODF data with the following constraints:

(1) Each complete ODF will span several blocks.

(2) A complete ODF will consist of the following data presented in order of transmission:

a) File Label group - one per ODF (Tables 3-la and 3-lb); required

b) Identifier group - one per ODF (Tables 3-2a and 3-2b); required

c) Orbit Data group - multiple records, time ordered (Tables 3-3a and 3-3b); required

d) Ramp groups - one group for each DSS, multiple records, time ordered (Tables 3-4a and 3-4b); optional

e) Clock Offsets group - multiple records, time ordered (Tables 3-5a and 3-5b); optional

f) (Note. Tables 3-6a and 3-6b have been deleted.)

g) Data Summary group - multiple records, ordered by station, band, and data type (Tables 3-7a and 3-7b); optional

h) End-of-File group - one per ODF (Table 3-8); required

(3) Each ODF consists of the radio metric data for one spacecraft, zero or more quasars, and one or more stations.

(4) Character data are 8-bit, ASCII-equivalent integer values.

(5) Times, except as noted, are given as seconds past zero hours UTC of January 1, 1950.

(6) For 1200-bit blocks, Words 63 through 72 always consist of filler bits (repetitive 1000). For 4800-bit blocks, Word 297 will always be filler. Unused portions of any BIF will be filler.

(7) The ODF data words are 32 bits in length.

(8) The 5th and 6th data words of an ODF packet/record are always zero (0) for a group header record, and are always non-zero for a data record.

(9) The parameter field pack format conventions used herein are as follows:

Ix = unsigned integer, x bits in length
Sx = signed integer, x bits in length, two's complement

(10) Most data parameters will be provided as binary integers; two's complement will be used for all fields that may have negative values.

(11) Single-bit status parameters will be set to one (1) for no, bad, off, out of tolerance, etc.; and will be set to zero (0) for yes, good, on, in tolerance, etc.

WORD 73 THRU WORD 75/WORD 298 THRU WORD 300

Standard DSN block ending as described in module OPS-6-8 of this document.

3.2 Electronic and Magnetic Tape Interfaces

The ODF data are provided in disk files or on unlabeled, 9-track, 1600-bits/inch magnetic tapes. 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-bit) logical records. These records are described in Tables 3-1 through 3-8.

Table 3-1a. ODF File Label Group Header Format

Item Number	Pack Format	Data Word	Description
1	S32	1	Primary Key = 101
2	I32	2	Secondary Key = 0
3	I32	3	Logical Record Length (in packets) = 1
4	I32	4	Group Start Packet Number (= 0)
5-9	5*I32	5-9	0

Table 3-1b. ODF File Label Group Data Format

Item Number	Pack Format	Data Word	Description
1-8	8*I8	1-2	System ID - 8 ASCII "Characters" (e.g., "AXP2300 ")
9-16	8*I8	3-4	Program ID - 8 ASCII "Characters" (e.g., "ODE V2.0")
17	I32	5	Spacecraft ID Number
18	I32	6	File Creation Date (YYMMDD)
19	I32	7	File Creation Time (hhmmss)
20	I32	8	File Reference Date (YYYYMMDD)*
21	I32	9	File Reference Time (HHMMSS)*

* Currently the ODF data timetags are referenced to EME50. Hence, these two items are set to 19500101 (date) and 000000 (time) respectively. Older ODFs which have file reference date and time both equal to zero will be assumed to be EME50.

Table 3-2a. ODF Identifier Group Header Format

Item Number	Pack Format	Data Word	Description
1	S32	1	Primary Key = 107
2	I32	2	Secondary Key = 0
3	I32	3	Logical Record Length (in packets) = 1
4	I32	4	Group Start Packet Number (= 2)
5-9	5* I32	5-9	0

Table 3-2b. ODF Identifier Group Data Format

Item Number	Pack Format	Data Word	Description
1-8	8*I8	1-2	"TIMETAG" - 8 ASCII "Characters"
9-16	8*I8	3-4	"OBSRVBL" - 8 ASCII "Characters"
17-36	20*I8	5-9	"FREQ, ANCILLARY-DATA" - 20 ASCII "Characters"

Table 3-3a. ODF Orbit Data Group Header Format

Item Number	Pack Format	Data Word	Description
1	S32	1	Primary Key = 109
2	I32	2	Secondary Key = 0
3	I32	3	Logical Record Length (in packets) = 1
4	I32	4	Group Start Packet Number (= 4)
5-9	5* I32	5-9	0

Table 3-3b. ODF Orbit Data Group Data Format

Item Number	Pack Format	Data Word	Data Units	Parameters Description
1	I32	1	sec	Record Time Tag, integer part
2	I10	2	msec	Record Time Tag, fractional part
3	I22		nsec	[Primary] Receiving Station Downlink Delay
4	S32	3	*	Observable, integer part
5	S32	4	*	Observable, fractional part (10^{-9})
6	I3	5	n/a	Format ID = 2
7	I7		n/a	[Primary] Receiving Station ID Number
8	I7		n/a	Transmitting Station ID Number (0 if quasar VLBI, 1-way [Doppler, phase, or range], or angles data)
9	I2		n/a	Network ID for Transmitting Station: 0 = DSN, Block V Exciter 1 = Other 2 = OTS 3 = NSP

Item Number	Pack Format	Data Word	Data Units	Parameters Description
10	I6		n/a	Data Type ID: 01 = Narrowband spacecraft VLBI, Doppler mode; cycles 02 = Narrowband spacecraft VLBI, phase mode; cycles 03 = Narrowband quasar VLBI, Doppler mode; cycles 04 = Narrowband quasar VLBI, phase mode; cycles 05 = Wideband spacecraft VLBI; nanoseconds 06 = Wideband quasar VLBI; nanoseconds 11 = 1-Way Doppler; Hertz 12 = 2-Way Doppler; Hertz 13 = 3-Way Doppler; Hertz 36 = NSP Pseudo-Noise Range; range units 37 = DSN SRA or NSP Sequential Range; range units 41 = RE Range; nanoseconds 51 = Azimuth Angle; degrees 52 = Elevation Angle; degrees 53 = Hour Angle; degrees 54 = Declination Angle; degrees 55 = X Angle (where +X is East); degrees 56 = Y Angle (where +X is East); degrees 57 = X Angle (where +X is South); degrees 58 = Y Angle (where +X is South); degrees
11	I2		n/a	Downlink Band ID (Receiving Station): 0 = not applicable if angle data, = Ku-Band otherwise 1 = S-Band 2 = X-Band 3 = Ka-Band
12	I2		n/a	Uplink Band ID (Transmitting Station): 0 = not applicable if angle or 1-way data, = Ku-Band otherwise 1 = S-Band 2 = X-Band 3 = Ka-Band
13	I2		n/a	Exciter Band ID (Receiving Station): 0 = not applicable if angle data, = Ku-Band otherwise 1 = S-Band 2 = X-Band 3 = Ka-Band
14	I1		n/a	Data Validity Indicator (0 = good, 1 = bad)

Item Number	Pack Format	Data Word	Data Units	Parameters Description
15	I7	6-7	n/a n/a sec n/a n/a	2nd Receiving Station ID Number if VLBI data; Lowest (Last) Component if DSN SRA or NSP Sequential range data; Integer Seconds of Observable if RE range data; Channel Number if Doppler or phase data; 0 otherwise
16	I10		n/a n/a	Quasar ID if VLBI quasar data; Spacecraft ID otherwise
17	I1		n/a n/a n/a n/a	Modulus indicator if wideband VLBI data; Phase Point indicator if narrowband VLBI data; Receiver/Exciter independent flag if Doppler, phase, or range data (0 = no, 1 = yes); 0 otherwise
18	I22**		mHz	Reference Frequency, H/P (0 if angles or phase data)***
19	I24**		mHz	Reference Frequency, L/P (0 if angles or phase data)***
20	S20	8-9	n/a 10^{-1} nsec mdeg sec 10^{12} cycles n/a	(Phase Calibration Flag minus 1) times 100000, plus Channel ID times 10000 if narrowband VLBI data; (Channel Sampling Flag minus 1) times 100000, plus Mode ID times 10000, plus Modulus H/P if wide-band VLBI data; Train Axis Angle if OTS Doppler data; Uplink Ranging Transmitter Coder In-Phase Time Offset from Sample Timetag if SRA range data; Teracycles of observable it Total-Count Phase data; 0 otherwise
21	I22		10^{-7} nsec 0.01 sec sec n/a	Modulus L/P if wideband VLBI data; Compression Time if Doppler, phase, or narrowband VLBI data; Highest (First) Component times 100000, plus Downlink Ranging Transmitter Coder In-Phase Time Offset from Sample Timetag if SRA range data; 0 otherwise
22	I22		nsec nsec n/a	2nd Receiving Station Downlink Delay if VLBI data; Transmitting Station Uplink Delay if Doppler, phase, or range data; 0 otherwise

* Units are specified by item 10 (Data Type ID)

** Actually I46, but may be split as necessary for specific computers

*** Transponder frequency if 1-way Doppler or phase; 0 (zero) if NSP (Network ID = 3) and not 1-way; receiver frequency if ramped and not 1-way; transmitter frequency otherwise.

Table 3-4a. ODF Ramp Groups Header Format

Item Number	Pack Format	Data Word	Description
1	S32	1	Primary Key = 2030
2	I32	2	Secondary Key = Station ID Number
3	I32	3	Logical Record Length (in packets) = 1
4	I32	4	Group Start Packet Number
5-9	5*I32	5-9	0

Table 3-4b. ODF Ramp Groups Data Format

Item Number	Pack Format	Data Word	Description
1	I32	1	Ramp Start Time, integer part
2	I32	2	Ramp Start Time, fractional part (10^{-9})
3	S32	3	Ramp Rate, integer part (two’s complement)
4	S32	4	Ramp Rate, fractional part (two’s complement, 10^{-9})
5	I22	5	Ramp Start Frequency, integer GHz *
6	I10		Transmitting/Receiving Station ID Number
7	I32	6	Ramp Start Frequency, integer part cont. (modulo 10^{9})
8	I32	7	Ramp Start Frequency, fractional part (10^{-9})
9	I32	8	Ramp End Time, integer part
10	I32	9	Ramp End Time, fractional part (10^{-9})

* If non-zero, ramp start frequency and ramp rate are at sky level

Table 3-5a. ODF Clock Offsets Group Header Format

Item Number	Pack Format	Data Word	Description
1	S32	1	Primary Key = 2040
2	I32	2	Secondary Key = 0
3	I32	3	Logical Record Length (in packets) = 1
4	I32	4	Group Start Packet Number
5-9	5*I32	5-9	0

Table 3-5b. ODF Clock Offsets Group Data Format

Item Number	Pack Format	Data Word	Description
1	I32	1	Start Time, integer part
2	I32	2	Start Time, fractional part (10^{-9})
3	S32	3	Clock Offset, integer part (two's complement)
4	S32	4	Clock Offset, fractional part (two's complement, 10^{-9})
5	I32	5	Primary Station ID Number
6	I32	6	Secondary Station ID Number
7	I32	7	0 (spare)
8	I32	8	0 (reserved for End Time, integer part)
9	I32	9	0 (reserved for End Time, fractional part)

Table 3-7a. ODF Data Summary Group Header Format

Item Number	Pack Format	Data Word	Description
1	S32	1	Primary Key = 105
2	I32	2	Secondary Key = 0
3	I32	3	Logical Record Length (in packets) = 1
4	I32	4	Group Start Packet Number
5-9	5*I32	5-9	0

Table 3-7b. ODF Data Summary Group Data Format

Item Number	Pack Format	Data Word	Description
1	I32	1	First Sample Time, integer part
2	I32	2	First Sample Time, fractional part (10^{-9})
3	I32	3	Receiving Station ID Number
4	I32	4	Doppler Channel Number (0 if VLBI, Range, or Angles summary)
5	I32	5	Downlink Band ID Number
6	I32	6	Data Type ID Number
7	I32	7	Number of Samples (in ODF)
8	I32	8	Last Sample Time, integer part
9	I32	9	Last Sample Time, fractional part (10^{-9})

Table 3-8. ODF End-of-File Group Format

Item Number	Pack Format	Data Word	Description
1	S32	1	Primary Key = -1
2	I32	2	Secondary Key = 0
3	I32	3	Logical Record Length (in packets) = 0
4	I32	4	Group Start Packet Number
5-9	5*I32	5-9	0

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Appendix A

A.1. *Doppler and Range Observables*

Doppler and range observables, rather than the actual measurements made at the Deep Space Stations are provided in the ODF Orbit Data Group (see Table 3b, items 4 and 5).

The Doppler observable (in Hertz) is computed according to the following equation. The time tag is at the mid-point of the compression interval, t_i to t_j.

$$\text{Observable} = (B / |B|) * [(N_j - N_i) / (t_j - t_i) - | F_b * K + B|]$$

where:

- B = Bias placed on receiver
- N_i = Doppler count at time t_i
- N_j = Doppler count at time t_j
- t_i = start time of interval
- t_j = end time of interval
- F_b = frequency bias
- K = 1 for S-band receivers (Table 3b, Item 11)
  - = 11/3 for X-band receivers
  - = 176/27 for Ku-band receivers
  - = 209/15 for Ka-band receivers

NOTE: Future spacecraft transponders may require different turnaround ratios (e.g., the value of K may vary)

$$F_b = (X_1 / X_2) * (X_3 * F_r + X_4) - F_{sc} + R_3 \qquad \text{for 1-way Doppler}$$

$$F_b = (X_1 / X_2) * (X_3 * F_r + X_4) - (T_1 / T_2) \times (T_3 * F_t + T_4) \qquad \text{for all other Doppler}$$

where:

F_r = Receiver (VCO) frequency at time t_r

F_{sc} = Spacecraft (beacon) frequency

F_t = Transmitter frequency at time t_{r-RTLT}

R_3 = 0 for S-band receivers
= 0 for X-band receivers
= 0 for Ku-band receivers
= 0 for Ka-band receivers

T_1 = 240 for S-band transmitters (Table 3b, Item 12)
= 240 for X-band transmitters
= 142 for Ku-band transmitters
= 14 for Ka-band transmitters

T_2 = 221 for S-band transmitters
= 749 for X-band transmitters
= 153 for Ku-band transmitters
= 15 for Ka-band transmitters

T_3 = 96 for S-band transmitters
= 32 for X-band transmitters
= 1000 for Ku-band transmitters
= 1000 for Ka-band transmitters

T_4 = 0 for S-band transmitters
= 6,500,000,000 for X-band transmitters
= -7,000,000,000 for Ku-band transmitters
= 10,000,000,000 for Ka-band transmitters

X_1 to X_4 have the same values as T_1 to T_4 but are dependent on the exciter band (Table 3b, Item 13) at the receiving station.

NOTE: When the reference frequency (Table 3b, items 18 and 19) is provided at sky level, T_3 and X_3 are 1 for all bands, and T_4 and X_4 are 0 for all bands.

For range data, the observable is computed as follows:

Observable = R - C + Z - S

where:
R = range measurement
C = station delay calibration
Z = Z-height correction
S = spacecraft delay