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2) Page 13, Items 11, 12 and 15
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CONCURRENCES:

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TRK-2-18

DSN TRACKING SYSTEM INTERFACES
ORBIT DATA FILE INTERFACE
MARK IVA

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A. PURPOSE

This module specifies the orbit data file (ODF) format of the radio metric data from the Deep Space Network (DSN). The content and formats of the ODF data blocks generated by the Network Operations Control Center (NOCC) Navigation Subsystem (NAV) and either transmitted by the NOCC Support Subsystem (NSS) or provided on magnetic tape are herein defined.

B. REVISION AND CONTROL

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

C. GENERAL INFORMATION

When the ODFs are to be transmitted, 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.

The data will be stored by the NOCC NAV for transmission.

Figure 1 shows the data flow from the DSN Signal Processing Center (SPC) to the Remote Mission Operations Center (RMOC) for the transmitted data and for data provided on magnetic tape.

D. DATA FORMAT AND FIELDS

1. GCF Data Blocks

The ODF data blocks are standard 1200-bit or 4800-bit data blocks that contain radio metric data that have been reformatted from the 820-13, TRK-2-14, TRK-2-15, or TRK-2-20 formats. Figure 2 shows the ODF 1200-bit block format and Figure 3 shows the ODF 4800-bit block format. 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) consisting of 1032 bits for a 1200-bit block, contains three packets (each consisting of nine 32-bit words) described in Tables 1 through 7. The BIF for the 4800-bit block 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 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:

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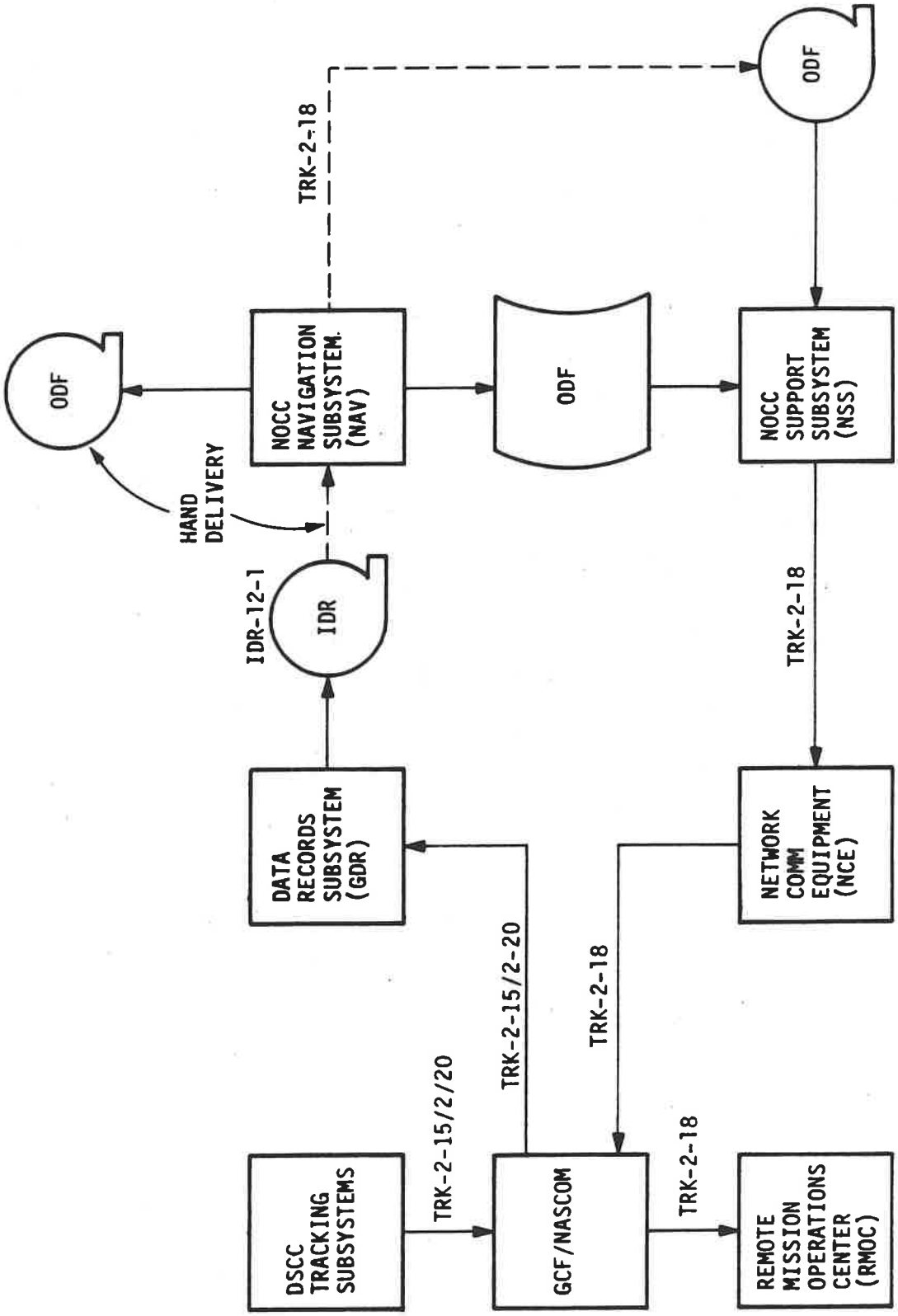

Figure 1. Data Flow for Orbit Data File Interface

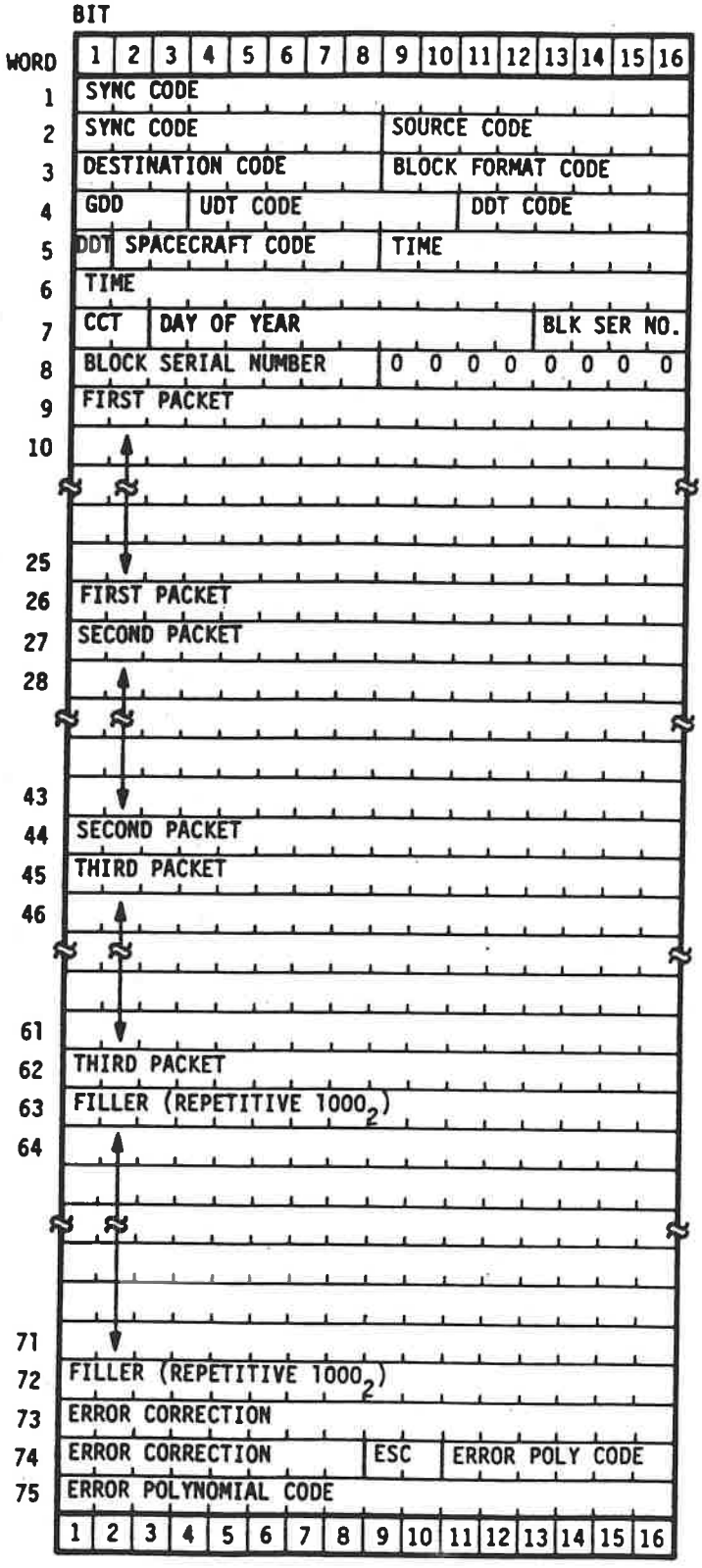

Figure 2. Orbit Data File 1200-Bit Data Block Format

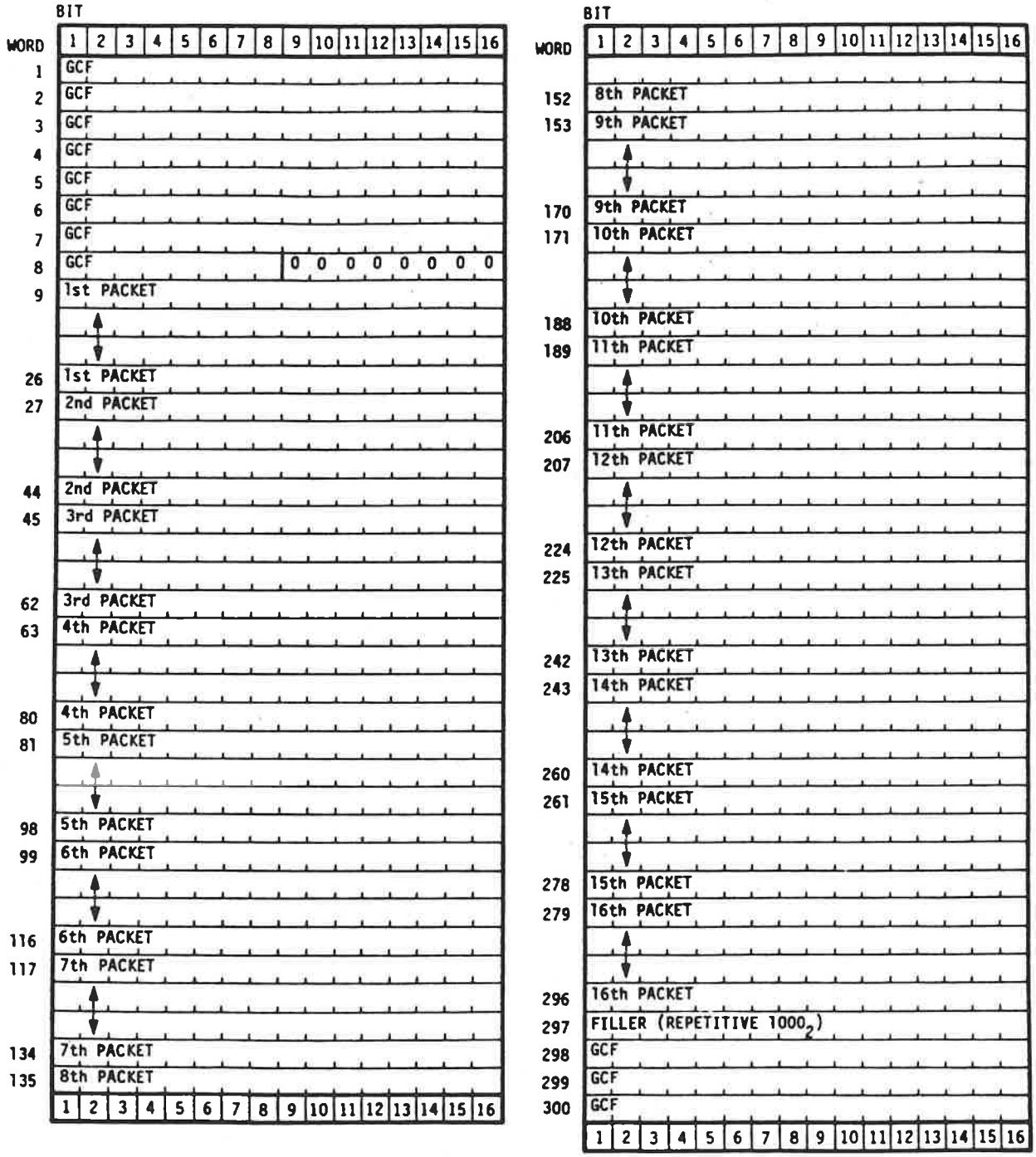

Figure 3. Orbit Data File 4800-Bit Data Block Format

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

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

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 1a and 1b)

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

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

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

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

f) Data Summary group - multiple records, ordered by station, band, and data type (Tables 6a and 6b)

g) End-of-File group - one per ODF (Table 7)

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

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(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 will always contain filler (repetitive 1000_2). For 4800-bit blocks, Word 297 will always contain filler. Unused portions of any BIF will contain filler.

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

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

WORD 73 THRU WORD 75/WORD 298 THRU WORD 300

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

2. Magnetic Tape Interface

The ODF data are provided on unlabeled, 9-track, 1600-b/in. magnetic tapes. Each ODF block (or physical record) consists of 2016 32-bit words, for a total length of 64,512 bits. Each block contains 224 9-word (288-bit) logical records. These records are described in Tables TRK-2-18-1 through -7.

Table 1a. ODF File Label Group Header Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1	1-32	32	1	Primary Key = 101
2	33-64	32	2	Secondary Key = 0
3	65-96	32	3	Logical Record Length (in packets) = 1
4	97-128	32	4	Group Start Packet Number (= 0)
5-9	129-288	5*32	5-9	0

Table 1b. ODF File Label Group Data Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1	1-8	8	1	1st ASCII "Character" of System ID
2	9-16	8		2nd ASCII "Character" of System ID
3	17-24	8		3rd ASCII "Character" of System ID
4	25-32	8		4th ASCII "Character" of System ID
5	33-40	8	2	5th ASCII "Character" of System ID
6	41-48	8		6th ASCII "Character" of System ID
7	49-56	8		7th ASCII "Character" of System ID
8	57-64	8		8th ASCII "Character" of System ID
9	65-72	8	3	1st ASCII "Character" of Program ID
10	73-80	8		2nd ASCII "Character" of Program ID
11	81-88	8		3rd ASCII "Character" of Program ID
12	89-96	8		4th ASCII "Character" of Program ID
13	97-104	8	4	5th ASCII "Character" of Program ID
14	105-112	8		6th ASCII "Character" of Program ID
15	113-120	8		7th ASCII "Character" of Program ID
16	121-128	8		8th ASCII "Character" of Program ID
17	129-160	32	5	Spacecraft ID Number
18	161-192	32	6	File Creation Time (YYMMDD)
19	193-224	32	7	File Creation Time (hhmmss)
20	225-256	32	8	0 (Spare)
21	257-288	32	9	0 (Spare)

Table 2a. ODF Identifier Group Header Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1	1-32	32	1	Primary Key = 107
2	33-64	32	2	Secondary Key = 0
3	65-96	32	3	Logical Record Length (in packets) = 1
4	97-128	32	4	Group Start Packet Number (= 2)
5-9	129-288	5*32	5-9	0

Table 2b. ODF Identifier Group Data Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1-8	1-64	8*8	1-2	"TIMETAG" - 8 ASCII "Characters"
9-16	65-128	8*8	3-4	"OBSRVBL" - 8 ASCII "Characters"
17-28	129-224	12*8	5-7	"OD-SAMPL-ID" - 12 ASCII "Characters"
29-36	225-288	8*8	8-9	"FRQ RSD" - 8 ASCII "Characters"

Table 3a. ODF Orbit Data Group Header Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1	1-32	32	1	Primary Key = 109
2	33-64	32	2	Secondary Key = 0
3	65-96	32	3	Logical Record Length (in packets) = 1
4	97-128	32	4	Group Start Packet Number (= 4)
5-9	129-288	5*32	5-9	0

Table 3b. ODF Orbit Data Group Data Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1	1-32	32	1	Record Time Tag, integer part
2	33-64	32	2	Record Time Tag, fractional part (10^{-9})
3	65-96	32	3	Observable, integer part (two's complement)*†
4	97-128	32	4	Observable, fractional part (two's complement, 10^{-9})**†
5	129-131	3	5	Format ID (= 1)
6	132-138	7		• Receiving Station ID Number, if tracking data • 1st Receiving Station ID Number, if VLBI data
7	139-145	7		Transmitting Station ID Number
8	146-147	2		Network ID Number for Receiving Station: 1 = DSN
9	148-149	2		Downlink Band ID: 0 = Not applicable 1 = S-band 2 = X-band 3 = L-band
10	150-155	6		Data Type ID Number: 01 = Narrowband spacecraft VLBI, mode 02 = Narrowband spacecraft VLBI, phase mode 03 = Narrowband quasar VLBI, Doppler mode

* For Goddard nanosecond range (DT 41), this item will contain the integer nanoseconds of range.

** For Goddard nanosecond range (DT 41), this item will contain the fractional nanoseconds of range.

† See Appendix A for description of the Doppler and Range observables.

Table 3b. ODF Orbit Data Group Data Format (Contd)

Item Number	Bit Number	Length (Bits)	Data Word	Description
10 (Contd)				04 = Narrowband quasar VLBI, phase mode 05 = Wideband spacecraft VLBI 06 = Wideband Quasar VLBI 07 = Narrowband ΔDOR 08 = Wideband ΔDOR 11 = One-way Doppler 12 = Two-way Doppler 13 = Three-way Doppler 14 = Three-way coherent Doppler 26 = DRVID using PRA ranging 27 = DRVID using SRA ranging 28 = DRVID using MU2 ranging 36 = Planetary operational discrete spectrum range (PRA) 37 = Planetary operational discrete spectrum range (SRA) 38 = Discrete spectrum range (MU2) 41 = Goddard nanosecond range (GSTDN) 51 = Azimuth 52 = Elevation 53 = Hour angle 54 = Declination 55 = X angle (where +X is East) 56 = Y angle (where +X is East) 57 = X angle (where +X is South) 58 = Y angle (where +X is South)
11	156-159	4		• Highest Ranging Component, if range data

Table 3b. ODF Orbit Data Group Data Format (Contd)

Item Number	Bit Number	Length (Bits)	Data Word	Description
11 (Contd)				• Channel ID Number, if n/b VLBI data • Mode ID Number, if w/b VLBI data • 0, otherwise
12	160	1 } 8		
	161-167	7 }	6	• 0, if VLBI quasar data • Spacecraft ID Number, otherwise
13	168-177	10		• Pass ID Number, if tracking data • Quasar ID Number, if VLBI quasar data • 0, otherwise
14	178-179	2		• Split Pass ID Number, if tracking data • Modulus indicator, if wideband VLBI data • 0, otherwise
15	180-186	7		• 2nd Receiving Station ID Number, if VLBI data • 4-bit spare (0), 2-bit Exciter band ID (see item 16 for codes), and 1-bit Receiver/Exciter Independent Flag (0 = no, 1 = yes) otherwise
16	187-188	2		Uplink Band ID: 0 = Not applicable 1 = S-band 2 = X-band 3 = C-band
17	189-192	4 } 11		• Power/Noise Ratio, if range or DRVID data (10^{-1}, two's complement)
	193-199	7 }	7	• Modulus integer part, if wideband VLBI data • 0, otherwise

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Table 3b. ODF Orbit Data Group Data Format (Contd)

Item Number	Bit Number	Length (Bits)	Data Word	Description
18	200	1		Data Validity (0 = good, 1 = bad)
19	201-224	24		• Compression Time (hundredths of seconds), if Doppler or narrow-band VLBI data • 18-bit Downlink Ranging Transmitter Coder In-Phase offset from Sample Timetag (seconds), and 6-bit Lowest Ranging component, if range data • Modulus fractional part (10^{-7}), if wideband VLBI data • Integer seconds of range, if Goddard nanosecond range.* • 0, otherwise
20	225-256	32	8	Frequency, part 1 (tens of Hz)**
21	257-264	8	9	Frequency, part 2 (tenths of Hz)**
22	265-288	24		• Residual (10^{-3}, two's complement), if Doppler data • 18-bit Uplink Ranging Transmitter Coder In-Phase offset from Sample Timetag (seconds), and 6-bit spare (0), if range data • 0(spare), otherwise

*Item 19 must be combined with items 3 and 4 to arrive at the observable range value.

**Transponder frequency, if 1-way doppler; receiver frequency, if ramped and not 1-way; transmitter frequency, otherwise.

Table 4a. ODF Ramp Groups Header Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1	1-32	32	1	Primary Key = 2030
2	33-64	32	2	Secondary Key = Station ID Number
3	65-96	32	3	Logical Record Length (in packets) = 1
4	97-128	32	4	Group Start Packet Number
5-9	129-288	5*32	5-9	0

Table 4b. ODF Ramp Groups Data Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1	1-32	32	1	Ramp Start Time, integer part
2	33-64	32	2	Ramp Start Time, fractional part (10^{-9})
3	65-96	32	3	Ramp Rate, integer part (two's complement)
4	97-128	32	4	Ramp Rate, fractional part, (two's complement, 10^{-9})
5	129-160	32	5	Receiving/Transmitting Station ID Number
6	161-192	32	6	Ramp Start Frequency, integer part
7	193-224	32	7	Ramp Start Frequency, fractional part (10^{-9})
8	225-256	32	8	Ramp End Time, integer part
9	257-288	32	9	Ramp End Time, fractional part (10^{-9})

Table 5a. ODF Clock Offsets Group Header Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1	1-32	32	1	Primary Key = 2040
2	33-64	32	2	Secondary Key = 0
3	65-96	32	3	Logical Record Length (in packets) = 1
4	97-128	32	4	Group Start Packet Number
5-9	129-288	5*32	5-9	0

Table 5b. ODF Clock Offsets Group Data Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1	1-32	32	1	Start Time, integer part
2	33-64	32	2	Start Time, fractional part (10^{-9})
3	65-96	32	3	Clock Offset, integer part (two's complement)
4	97-128	32	4	Clock Offset, fractional part, (two's complement, 10^{-9})
5	129-160	32	5	Primary Station ID Number
6	161-192	32	6	Secondary Station ID Number
7	193-224	32	7	0 (spare)
8	225-256	32	8	0 (reserved for End Time, integer part)
9	257-288	32	9	0 (reserved for End Time, fractional part)

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Table 6a. ODF Data Summary Group Header Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1	1-32	32	1	Primary Key = 105
2	33-64	32	2	Secondary Key = 0
3	65-96	32	3	Logical Record Length (in packets) = 1
4	97-128	32	4	Group Start Packet Number
5-9	129-288	5*32	5-9	0

Table 6b. ODF Data Summary Group Data Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1	1-32	32	1	First Sample Time, integer part
2	33-64	32	2	First Sample Time, fractional part (10^{-9})
3	65-96	32	3	Station ID Number
4	97-128	32	4	Network ID Number
5	129-160	32	5	Band ID Number
6	161-192	32	6	Data Type ID Number
7	193-224	32	7	Number of Samples (in ODF)
8	225-256	32	8	Last Sample Time, integer part
9	257-288	32	9	Last Sample Time, fractional part (10^{-9})

Table 7. ODF End-of-File Group Format

Item Number	Bit Number	Length (Bits)	Data Word	Description
1	1-32	32	1	Primary Key = -1
2	33-64	32	2	Secondary Key = 0
3	65-96	32	3	Logical Record Length (in packets) = 0
4	97-128	32	4	Group Start Packet Number
5-9	129-288	5*32	5-9	0

APPENDIX A

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 3 and 4).

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.

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

where:

B = Bias frequency of measured Doppler
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

K = 1 for S-band receivers (Table 3b, Item 9)
11/3 for X-band receivers
1 for L-band receivers

$$F_b = \frac{240}{221} \times (96 \times F_r) - F_{SC} + R_3 \quad \text{for 1-way doppler}$$

$$= \frac{X_1}{X_2} \times (X_3 \times F_r + X_4) - \frac{T_1}{T_2} \times (T_3 \times F_t + T_4) \quad \text{for all other doppler}$$

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
= -620,000,000 for L-band receivers

T_1 = 240 for S-band transmitters (Table 3b, Item 16)
= 240 for X-band transmitters
= 228 for C-band transmitters

T_2 = 221 for S-band transmitters
= 749 for X-band transmitters
= 681 for C-band transmitters

T_3 = 96 for S-band transmitters
= 32 for X-band transmitters
= 232 for C-band transmitters

T_4 = 0 for S-band transmitters
= 6,500,000,000 for X-band transmitters
= 0 for C-band transmitters

X_1 to X_4 have the same values at T_1 to T_4 but are dependent on the exciter band (Table 3b, Item 15, 2nd subitem).

For Doppler data, the residual is computed as the average of the measured residuals at the end points of the compression interval (so that its time tag is the same as that of the Doppler observable):

$$\text{Residual} = (R_j + R_i)/2$$

For range data, the observable is computed as follows:

$$\text{Observable} = R - C + Z - S$$

where: R = range
C = Station delay calibration
Z = Z correction
S = Spacecraft delay

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