Interpretation and Use of Binary ODF Data

This document describes and illustrates extraction of values from binary files generated according to the TRK-2-18 Orbit Data File (ODF) Software Interface Specification (SIS). TRK-2-18 is a module within the DSN 820-013 External Interface Specification; 820-013 is also designated JPL D-16765. TRK-2-18 has evolved over more than two decades; but the general structure and content of ODFs have remained much the same. Production of ODFs was discontinued in December 2017; users were encouraged to switch to the TRK-2-34 (TNF) product, which was based on higher precision phase measurements (the ODF was frequency based).

The following versions of the TRK-2-18 document are included in the Planetary Data System (PDS) Radio Science Documentation bundle. Other versions may be added as they become available.

[1] *Document 820-013 (Rev. A), DSN System Requirements, Detailed Interface Design, TRK-2-18, DSN Tracking System Interfaces, Orbit Data File Interface, Mark IVA*, released 1988-01-15.

[2] *Document 820-013 (Rev. A), DSN System Requirements, Detailed Interface Design, TRK-2-18, DSN Tracking System Interfaces, Orbit Data File Interface, Mark IVA*, released 1988-10-15.

[3] *MGSO System Requirements, Detailed Interface Design, SFOC-NAV0-TRK-2-18, MGSO Tracking System Interfaces, Orbit Data File Interface,* released 1996-08-15.

[4] *Document 820-013, Deep Space Mission System (DSMS), External Interface Specifications (JPL D-16765), TRK-2-18, Tracking System Interfaces, Orbit Data File Interface,* released 2000-06-15.

[5] *Document 820-013, Deep Space Network (DSN), External Interface Specification (JPL D-16765), TRK-2-18, Tracking System Interfaces, Orbit Data File Interface,* released 2008-02-29.

File and Record Formats:

Each ODF comprises one or more blocks of 8064 bytes, divided into 36-byte records. When the number of records is not an integer multiple of 224, zero-filled records are used to pad the final block to 8064 bytes. There may be up to six record groups; each group has a 36-byte header record and one or more 36-byte data records (except the End of File Group, which has only a header record):

File Label Group	one header, one data record
Identifier Group	one header, one data record
Orbit Data Group	one header, many data records
Ramp Group	one header, many data records, repeated for each antenna
Clock Offsets Group	one header, one data record , repeated for each antenna
End of File Group	one header

The Ramp Group is not used for VLBI; the Clock Offsets Group is used only by VLBI.

The ODF physical structure is illustrated in Figure 1. The bit-level structure of the different record types is discussed in detail in the documents listed above.

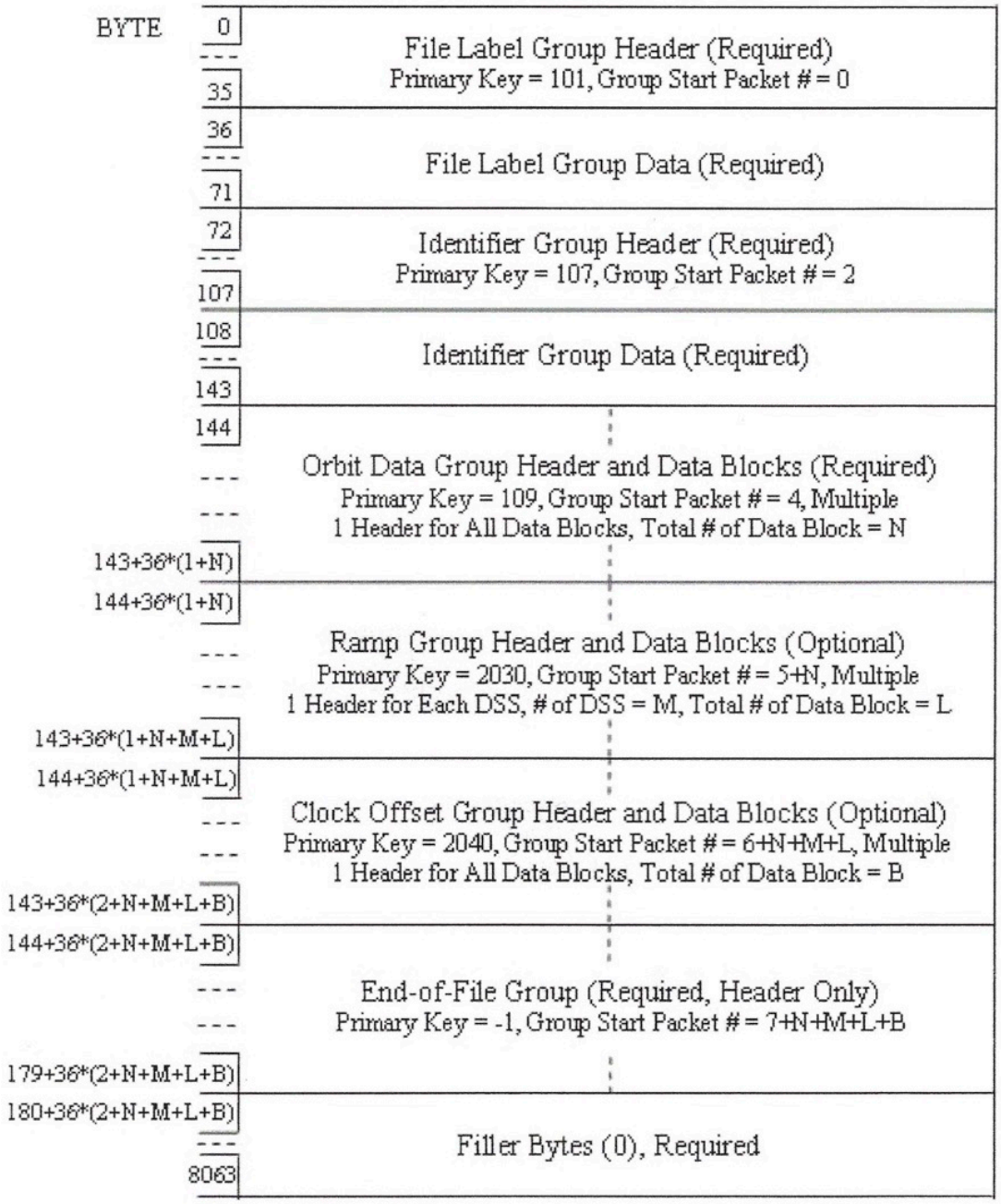

Figure 1. Physical structure of a hypothetical one block ODF (adapted from Figure 3-1 of [5]).

Example Data File:

An example ODF generated during the MESSENGER mission has been included in the Radio Science Documentation bundle. Data were collected at DSN ground stations 14, 43, and 63 over about 35 hours on June 4 and 5 in 2007; values were sampled every 60 s. The logical identifier of the example ODF is

urn:nasa:pds:radiosci_documentation:dsn_trk-2-18:odf07155

A hexadecimal dump of the first 16 records of the example file is shown in Figure 2.

```
0000000    00  00  00  65  00  00  00  00  00  00  00  01  00  00  00  00
0000020    00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00
0000040    00  00  00  00
                           54  44  44  53  20  20  20  20  41  4d  4d  4f
0000060    53  20  20  20  00  00  00  ec  00  10  58  02  00  03  86  01
0000100    01  29  8c  45  00  00  00  00
                                       00  00  00  6b  00  00  00  00
0000120    00  00  00  01  00  00  00  02  00  00  00  00  00  00  00  00
0000140    00  00  00  00  00  00  00  00  00  00  00  00
                                                   54  49  4d  45
0000160    54  41  47  20  4f  42  53  52  56  42  4c  20  46  52  45  51
0000200    2c  41  4e  43  49  4c  4c  41  52  59  2d  44  41  54  41  20

0000220    00  00  00  6d  00  00  00  00  00  00  00  01  00  00  00  04
0000240    00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00
0000260    00  00  00  00
                           6c  02  80  48  00  00  00  00  ff  fa  28  ee
0000300    d8  6f  2b  24  4f  c0  05  c4  02  76  42  17  77  80  8d  e8
0000320    00  00  00  05  dc  00  00  00
                                       6c  02  80  84  00  00  00  00
0000340    ff  fa  29  31  e2  78  95  ed  4f  c0  05  c4  02  76  42  17
0000360    77  80  8d  e8  00  00  00  05  dc  00  00  00
                                                   6c  02  80  c0
0000400    00  00  00  00  ff  fa  29  72  f8  48  f8  6e  4f  c0  05  c4
0000420    02  76  42  17  77  80  8d  e8  00  00  00  05  dc  00  00  00

0000440    6c  02  80  fc  00  00  00  00  ff  fa  29  b2  e8  f4  f5  8c
0000460    4f  c0  05  c4  02  76  42  17  77  80  8d  e8  00  00  00  05
0000500    dc  00  00  00
                           6c  02  81  38  00  00  00  00  ff  fa  29  f1
0000520    cc  26  e0  c4  4f  c0  05  c4  02  76  42  17  77  80  8d  e8
0000540    00  00  00  05  dc  00  00  00
                                       6c  02  81  74  00  00  00  00
0000560    ff  fa  2a  2e  e3  86  7a  e2  4f  c0  05  c4  02  76  42  17
0000600    77  80  8d  e8  00  00  00  05  dc  00  00  00
                                                   6c  02  81  b0
0000620    00  00  00  00  ff  fa  2a  6a  fa  bc  7a  66  4f  c0  05  c4
0000640    02  76  42  17  77  80  8d  e8  00  00  00  05  dc  00  00  00

0000660    6c  02  81  ec  00  00  00  00  ff  fa  2a  a6  e9  33  71  f2
0000700    4f  c0  05  c4  02  76  42  17  77  80  8d  e8  00  00  00  05
0000720    dc  00  00  00
                           6c  02  82  28  00  00  00  00  ff  fa  2a  e1
0000740    e5  67  73  2e  4f  c0  05  c4  02  76  42  17  77  80  8d  e8
0000760    00  00  00  05  dc  00  00  00
                                       6c  02  82  64  00  00  00  00
0001000    ff  fa  2b  1b  fa  03  37  ba  4f  c0  05  c4  02  76  42  17
0001020    77  80  8d  e8  00  00  00  05  dc  00  00  00
                                                   6c  02  82  a0
0001040    00  00  00  00  ff  fa  2b  55  ea  62  f4  53  4f  c0  05  c4
0001060    02  76  42  17  77  80  8d  e8  00  00  00  05  dc  00  00  00
```

Figure 2. Hexadecimal dump of the first 16 records of the example data file. Byte addresses (in octal) are in the left column. Line breaks have been inserted to mark record boundaries. The dump was created using the unix command *od -t x1 odf07155.dat*

The first six records may be unpacked as shown in Tables 1-3. Records 1-4 are unpacked following the specification in Tables 3-1, 3-2, 3-1, and 3-3 [5], respectively.

Table 1. Unpacking Records 1-4

Record	Bytes	Hex	Description	Unpacked Value
1	0-3	00 00 00 65	Primary Key	101
1	4-7	00 00 00 00	Secondary Key	0
1	8-11	00 00 00 01	Logical Record Length	1
1	12-15	00 00 00 00	Group Start Packet Number	0
1	16-19	00 00 00 00	Not used	N/A
1	20-23	00 00 00 00	Not used	N/A
1	24-27	00 00 00 00	Not used	N/A
1	28-31	00 00 00 00	Not used	N/A
1	32-35	00 00 00 00	Not used	N/A
2	0-7	54 44 44 53 20 20 20 20	System ID	'TDDS' + 4 <SP>
2	8-15	41 4d 4d 4f 53 20 20 20	Program ID	'AMMOS' + 3 <SP>
2	16-19	00 00 00 ec	Spacecraft Number	236
2	20-23	00 10 58 02	File Creation Date (YYMMDD format*)	1071106
2	24-27	00 03 86 01	File Creation Time (HHMMDD format)	230913
2	28-31	01 29 8c 45	File Reference Date (YYYYMMDD)	19500101
2	32-35	00 00 00 00	File Reference Time (HHMMDD)	000000
3	0-3	00 00 00 6b	Primary Key	107
3	4-7	00 00 00 00	Secondary Key	0
3	8-11	00 00 00 01	Logical Record Length	1
3	12-15	00 00 00 02	Group Start Packet Number	2
3	16-19	00 00 00 00	Not used	N/A
3	20-23	00 00 00 00	Not used	N/A
3	24-27	00 00 00 00	Not used	N/A
3	28-31	00 00 00 00	Not used	N/A
3	32-35	00 00 00 00	Not used	N/A
4	0-7	54 49 4d 45 54 41 47 20	Identifier 1	'TIMETAG' + 1 <SP>
4	8-15	4f 42 53 52 56 42 4c 20	Identifier 2	'OBSRVBL' + 1 <SP>
4	16-35	46 52 45 51 2c 41 4e 43 49 4c 4c 41 52 59 2d 44 41 54 41 20	Identifier 3	'FREQ,' + 'ANCIL' + 'LARY-' + 'DATA' + 1 <SP>

* Table 3-2 [5] states that File Creation Date will be in YYMMDD format and that values 50 ≤ YY ≤ 99 are with respect to 1900, while values 00 ≤ YY ≤ 49 are with respect to 2000. In fact, we have found that all File Creation Dates are with respect to 1900 and that YY for years starting in 2000 has values greater than or equal to 100. In this example YY = 107 for year 2007.

Record 5 is unpacked following the specification in Table 3-1 [5].

Table 2. Unpacking Record 5

Record	Bytes	Hex	Description	Unpacked Value
5	0-3	00 00 00 6d	Primary Key	109
5	4-7	00 00 00 00	Secondary Key	0
5	8-11	00 00 00 01	Logical Record Length	1
5	12-15	00 00 00 04	Group Start Packet Number	4
5	16-19	00 00 00 00	Not used	N/A
5	20-23	00 00 00 00	Not used	N/A
5	24-27	00 00 00 00	Not used	N/A
5	28-31	00 00 00 00	Not used	N/A

Record 6 bits 1-160 is unpacked using the specification in Table 3-4a [5] while bits 161-288 are unpacked using the specification in Table 3-4d [5].

The Record Time Tag is reconstructed by summing integer values in bits 1-32 with the fractional component (to the right of the decimal point) in bits 33-42 to give 1812103240.0 seconds.

The Data Type of the observable in this record is 11 (one-way Doppler), as given by bits 148-153. The value of one-way Doppler is -382738.663803100 Hz from the combination of bits 65-96 and bits 97-128.

The Reference Frequency (bits 179-224) is $137097*2^{24} + 8424936 = 2299812417000$ mHz. The Compression Time (bits 245-266) is 60.00 s.

All of the unpacked values, including values from the Ramp Group and End of File Group, are given in associated file *odf071255.txt*. There is no Clock Offset Group in this ODF.

Two-way Doppler (Data Type 12) is plotted versus Record Time Tag in Figure 3.

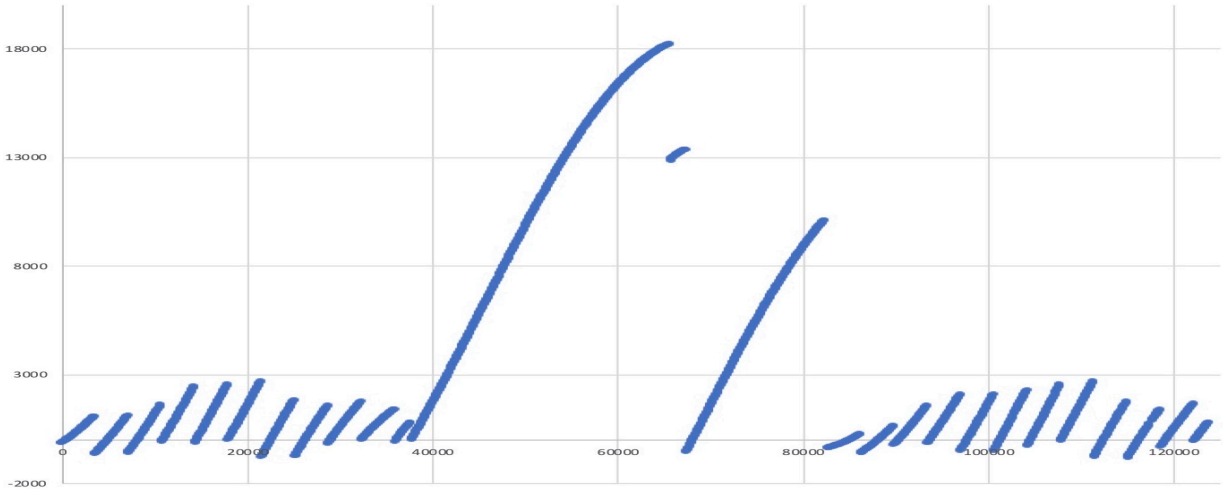

Figure 3. MESSENGER two-way Doppler (Hz) versus time (s) starting at 2009-155T10:23:17. The initial time and Doppler values have been treated as biases and have been subtracted to facilitate display.

Table 3. Unpacking Record 6				
Record	**Bytes or Bits**	**Hex or Binary**	**Description**	**Unpacked Value**
6	1-32	6c 02 80 48	Record Time Tag, seconds past reference date/time (integer part)	1812103240
6	33-42	0000000000	Record Time Tag, seconds past reference date/time (fractional part)	0
6	43-64	0 00 00	Primary Receiving Station Downlink Delay	0
6	65-96	ff fa 28 ee	Observable, integer part	-382738
6	97-128	d8 6f 2b 24	Observable, fractional part (x 10^{-9})	-663803100
6	129-131	010	Format ID	2
6	132-138	0111111	Primary Receiving Station ID Number	63
6	139-145	0000000	Transmitting Station ID Number	0
6	146-147	00	Transmitting Station Network ID	0 (DSN)
6	148-153	001011	Data Type ID	11 (one-way Doppler)
6	154-155	10	Downlink Band ID	2 (X-band)
6	156-157	00	Uplink Band ID	0 (N/A)
6	158-159	10	Reference Frequency Band ID	2 (X-band)
6	160	0	Data Validity Indicator	0 (valid)
6	161-167	0000001	Receiver Channel N umber	1
6	168-177	0011101100	Spacecraft ID	236 (MESSENGER)
6	178	1	Receiver/Exciter Independent Flag	1 (Rx/Tx independent)
6	179-200	02 17 77	Reference Frequency (high part) (x 2^{24} mHz)	137079
6	201-224	80 8d e8	Reference Frequency (low part) (mHz)	8424936
6	225-244	00 00 00	Reserved	N/A
6	245-266	00 17 70	Compression Time (0.01 s)	6000
6	267-288	00 00 00	Transmitting Station Uplink Delay	0