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

TRK-2-34

DSMS Tracking System Data Archival Format

Original Release: April 30, 2000

Revision B: December 15, 2002

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Change Log

Revision	Issue Date	Pages / Sections Affected	Change Summary
New issue	04/30/2000	All	
A	05/31/2002	All	Updated data blocks, added/corrected text descriptions
B	12/15/2002	Sections 1, 2 and 3, Appendix A and B	Corrected typos, added file header description (Appendix B)

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1 Introduction

Section 1
Introduction

1.1 Purpose and Scope

This module specifies the format and content of radio metric tracking data delivered to navigation and radio science customers from the Telecommunications Services. The method of delivery of the data is outside the scope of this document.

TRK-2-34 is essentially a consolidation of the data that are currently contained in the TRK-2-15A, TRK-2-18, TRK-2-20, TRK-2-25, and TRK-2-30 products delivered to customers.

1.1.1 Applicability of This Release

This module will supersede the TRK-2-15A module, as the MDAs are retired, and the TRK-2-25 module as the Radio Metric Data Conditioning (RMDC) process is retired.

This release corrects typos and adds description of the file header format.

Certain parameters may not be available in initial TRK-2-34 output. These parameters will be marked as invalid (using validity flags) in the data or not delivered (in the case of certain data types, such as Allan deviation and smoothed noise).

1.2 Revision and Control

Revisions or changes to the information herein presented may be initiated according to the procedure specified in the *Introduction* to Document 820-013.

1.3 Relationship to Other DSMS Documents

Currently, TRK-2-15A is generated by the Metric Data Assembly (MDA) of the DSCC Tracking Subsystem (DTK). In the Network Simplification Project (NSP) era, the MDAs will be replaced by the Uplink Tracking and Command Subsystem (UPL) and the Downlink Telemetry and Tracking Subsystem (DTT). As a result, TRK-2-15A will not be available. TRK-2-34 replaces TRK-2-25 as the archival format. TRK-2-20 and TRK-2-30 will continue to be available to the customers.

1.4 Applicable Documents

[1]	820-062	*DSMS Terms and Abbreviations* (DSMS internal document, for reference only.)
[2]	813-109, D-17818	*Preparation Guidelines and Procedures for Deep Space Mission System (DSMS) Interface Specifications* (DSMS internal document, for reference only.)
[3]	820-013, D-16765	*DSMS External Interface Specification* (http://jaguar.jpl.nasa.gov)
[3a]		OPS-6-21A *Standard Code Assignments*
[3b]		0171-Telecomm-NJPL *SFDU Global Definitions*
[3c]		0180-Data_Manage *DSMS DOM Electronic Access for External Users*
[3d]		0183-Telecomm-TDS *TDS Query Protocol Specification*
[4]	SFOC-5-SYS-*DU-NJPL	*NJPL SFDU Global Definitions* (DSMS internal document, for reference only; to be replaced by Reference [3b].)
[5]	820-013, Module 0172-Telecomm-CHDO	*DSMS External Interface Specification—DSMS Created CHDO Structures*
[6]	CCSDS 620.0-B-2	*CCSDS Recommendation for Space Data System Standards—Standard Formatted Data Units—Structure and Construction Rules* (Issue 2, May 1992)
[7]	ANSI T-49-12	*ANSI/IEEE STD 754-1985—IEEE Standard for Binary Floating-Point Arithmetic*
[8]	ANSI X3.4-1986 (R1997)	*Information Systems - Coded Character Sets - 1 Bit American National Standard Code for Information Interchange (7-Bit ASCII)*
[9]	ISO/IEC 646-1991	*Information Technology - ISO 7-bit Coded Character Set for Information Interchange*
[10]	810-047	*DSN Antenna and Facility Identifiers* (DSMS internal document, for reference only.)

1.5 Notation and Conventions

1.5.1 Terminology

Many of the terms used in this module are taken from the literature describing the Standard Formatted Data Unit (SFDU) concept (e.g., Reference [5] and Reference [6]). The SFDU concept was developed by the Consultative Committee for Space Data Systems (CCSDS) to provide a standardized and internationally recognized methodology for information interchange. Because the SFDU concept evolved over time, the meaning of some terms has evolved. The definitions provided herein are intended to clarify the use of certain terms as they apply to this module:

a) The term *ASCII* refers to the American Standard Code for Information Interchange, a seven-bit code for representing letters, digits, and symbols which has been standardized by the American National Standards Institute (Reference [8]). This code has been incorporated into the ISO code of the same nature (Reference [9]) which includes other symbols and alphabets. Since the ISO code is an eight-bit code, the ASCII code is embedded in an eight-bit field in which the most significant bit is set to zero. In this module, ASCII always refers to the seven-bit ASCII code embedded, as described, in an eight-bit field. When applied to a multi-byte field, it implies that each byte in the field contains an ASCII code.

b) The term *restricted ASCII (RA)* refers to the subset of ASCII consisting of the codes for the twenty-six upper-case letters ('A'-'Z') and the ten decimal digits ('0'-'9'). When applied to a multi-byte field, it implies that each byte in the field contains an RA code.

c) A *label-value-object* (LVO) is a data structure that is comprised of a *label field* and a *value field*. The label field provides for the data structure to be self-identifying and self-delimiting. The value field contains user-defined data in any format. The LVOs themselves are made up of a sequence of bytes. In this module, LVO is used in a generic sense to refer to any data structure with these attributes.

d) An LVO may be a *simple LVO* or a *compound LVO*. If the value field of the LVO contains purely user data, it is a simple LVO. If the value field of the LVO contains purely LVOs, it is a compound LVO. The value field of a compound LVO consists of a sequence of one or more LVOs, each of which can be a simple or compound LVO itself.

e) A *standard formatted data unit* (SFDU) is an LVO that conforms to a defined set of structure and construction rules, namely the specification in Reference [5] or the specification in Reference [6]. Unfortunately, the two specifications are slightly different, leading to two different definitions of what an SFDU is. The term *DSN tracking SFDU* (or, more simply, *tracking SFDU*) refers to the SFDU defined and controlled by this module. The DSN tracking SFDU conforms to the structure and construction rules specified in Reference [5]. It does not strictly conform to the internationally recognized SFDU structure and construction rules recommended by CCSDS in Reference [6].

f) A *compressed header data object* (CHDO), as defined in Reference [5], is an LVO. Its design is modeled on the SFDU concept, but a CHDO is not an SFDU. The CHDO derives its name from the fact that the label field of a CHDO is considerably shorter than the label field of an SFDU (four bytes instead of twenty). The CHDO provides a means of structuring user data with less overhead than would be required if an SFDU were used. However, with respect to SFDU structure and construction rules, a CHDO (or a sequence of CHDOs) is merely user data contained in the value field of an SFDU.

g) The term *type attribute* is used to refer to the subfield(s) of an LVO label field that affect the self-identifying property of the LVO. Within the applicable domain, the type attribute is a unique reference to a description of the format and meaning of the data contained in the value field of the LVO.

h) All of the LVOs described in this module contain a *length attribute* in their label field. The length attribute is a subfield of the LVO label field; it contains the length, in bytes, of the value field of the LVO. When interpreted in the context of the structure and construction rules specified in Reference [5], the length attribute affects the self-delimiting property of the LVO. The use of a length attribute is not the only means by which an LVO can be self-delimiting; Reference [6], for example, provides several mechanisms that do not rely on an explicit length.

i) The term data type refers to the SFDU format code. This term is used when distinguishing between different data blocks.

1.5.2 Conventions

The following conventions are used in this module:

a) LVOs are defined as being made up of a sequence of eight-bit bytes, so data structures in this module are illustrated as a sequence of bytes. All data structures defined in this module must be an even number of bytes in length. Given a data structure that is N bytes in length, the first byte in the structure is drawn in the most top justified position and is identified as "byte 0." The following byte is identified as "byte 1" and so on, to "byte N-1" which is drawn in the most bottom justified position. Within each byte, the most significant bit is drawn in the most left justified position and is identified as "bit 1." The next most significant bit is identified as "bit 2" and so on, to "bit 8" which is drawn in the most right justified position. Any bit in a data structure is uniquely identified by specifying the byte within which it occurs and its position within that byte (e.g., "byte 5, bit 8").

b) Data structures are divided into fields, where a field is a sequence of bits. Fields are identified by specifying the starting and ending bits of the field. For fields that cross byte boundaries, bit 8 of byte M is more significant than, and is immediately followed by, bit 1 of byte M+1. A field may be divided into subfields in a similar manner.

c) Several conventions for expressing the length of a data structure, or a part of a data structure, are used in this module. The length attribute of an LVO is always given in bytes and always refers to the length of the value field of the LVO (i.e., excluding the label field).

d) In the data structure descriptions in this module, many fields are defined to contain a numerical value. Several different formats for expressing numbers are used, as follows:

   1) *Unsigned integer*. An integer number is expressed in binary, using all bits of the field as necessary. Negative quantities cannot be expressed. For an n-bit field, the range of values that can be represented is from 0 to 2^n-1. The number of bytes in the unsigned integer (m) is represented by a "-m" after the format statement.

   2) *Integer*. An integer number is expressed in binary, using two's complement notation. For an n-bit field, the range of values that can be represented is from -2^{n-1} to 2^{n-1}-1. The number of bytes in the integer (m) is represented by a "-m" after the format statement.

   3) *Restricted ASCII*. Each decimal digit of an integer number is expressed by its corresponding RA code. The field must be an integral number of bytes in length. For multi-digit fields, the first byte of the field contains the most significant digit, the second byte contains the next most significant digit, and so on. If the number of digits is less than the number of bytes in the field, leading zeroes are used to fill the field. Negative quantities cannot be expressed. In an n-byte field, the range of

values that can be represented is from 0 to 10^n-1. The number of bytes in the Restricted ASCII string (m) is represented by a "-m" after the format statement.

4) *IEEE Single*. A 32-bit, single precision, IEEE floating point-format is used to express real numbers. Single precision floating-point numbers are expressed in the ANSI/IEEE standard (Reference [7]) single precision format with a sign bit, 8-bit exponent, and 23-bit mantissa.

5) *IEEE Double*. A 64-bit, double precision, IEEE floating-point format is used to express real numbers. Double precision floating-point numbers are expressed in the ANSI/IEEE (Reference [7]) standard double precision format with a sign bit, 11-bit exponent, and 52-bit mantissa.

e) For fields defined to contain a constant value, the constant value will be enclosed in single quotes (e.g., '2') if the information is expressed in RA, and not so enclosed (e.g., 2) if the information is expressed in binary.

f) Unless explicitly stated otherwise, fields defined as "reserved" are to be set to binary zero by the originator, and are to be ignored by the recipient.

g) Time tags are in UTC, as received from the Frequency and Timing Subsystem (FTS) of the DSN:
- 00:00:00 is second 0.0.
- 23:59:59 is second 86399.0.
- Leap second is 86400.0.

h) The term "UPL-DTT antenna" refers to antennas that have UPL and DTT equipment (currently 34m HEF, 34m BWG, and 70m antennas). The term "non-UPL-DTT antenna" refers to antennas that do not have this equipment (currently 26m antennas and DSS-27).

1.6 Abbreviations

Abbreviations used in this document are defined with the first textual use of the term. Abbreviations and acronyms approved for use are listed in Document 820-062. Abbreviations appearing in this module are:

ADID	Authority and Description Identifier
AMMOS	Advanced Multimission Operations System
ASCII	American Standard Code for Information Exchange
ANSI	American Nation Standards Institute
CHDO	Compressed Header Data Object
CCSDS	Consultative Committee for Space Data Systems
dB	decibel

dBm	decibels above the reference level of 1 milliWatt
deg	degrees
DOD	Differential One-way Doppler
DOR	Differential One-way Ranging
DRVID	Differenced Range Versus Integrated Doppler
DSCC	Deep Space Communications Complex
DSMS	Deep Space Mission System
DSN	Deep Space Network
DSS	Deep Space Station
DTK	DSCC Tracking Subsystem
DTT	Downlink Telemetry and Tracking Subsystem
EOF	End of File
FFT	Fast Fourier Transform
FOM	Figure of Merit
FSP	Full Spectrum Processing Subsystem
FTS	Frequency and Timing Subsystem
Hz	Hertz
ID	Identifier
IEEE	Institute of Electrical and Electronics Engineers
IF	Intermediate Frequency
JPL	Jet Propulsion Laboratory
K	Kelvin
LCP	Left Hand Circular Polarization
LNA	Low Noise Amplifier
LVO	Label Value Object
MDA	Metric Data Assembly
MFR	MultiFunction Receiver
MPA	Metric Pointing Assembly
MTA	Metric Tracking Assembly
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NOCC	Network Operations Control Center
NSP	Network Simplification Project
NVP	NOCC VLBI Processor Subsystem

PN	Pseudo-Noise
RA	Restricted ASCII
RCP	Right Hand Circular Polarization
RF	Radio Frequency
RMDC	Radio Metric Data Conditioning
RTLT	Round-Trip Light Time
RU	Range Unit
sec	seconds
SFDU	Standard Formatted Data Unit
SNT	System Noise Temperature
UPL	Uplink Tracking and Command Subsystem
UTC	Universal Time Coordinated
VLBI	Very Long Baseline Interferometry
W	Watts

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Section 2
Functional Overview

2.1 General Description

Radio metric data received from the DSCCs will be processed, validated, and corrected. The resulting data will be placed into the TRK-2-34 and TRK-2-18 products. Validated/corrected data are available to (a) remote customers as TRK-2-34 files, and (b) JPL AMMOS customers as files, stream-type queries, or broadcast streams. The file format is described in Appendix B. This interface does not describe the transfer mechanisms for the delivery of the data to the customers; they are described, respectively, in References [3c] and [3d].

This processing is done in the AMMOS system. It includes the software tools that are used to perform radio metric data processing, validation, correction, and visualization, and to generate the tracking data file products. The function of the processing is to process, generate, and deliver radio metric data to projects and end users to support spacecraft navigation and scientific study.

Listed below are the documents and 820-013 interface modules that define specific fields in the TRK-2-34 headers:

Reference [3a]: DSN spacecraft ID, AMMOS mission ID

Reference [10]: station ID

Reference [4]: originator ID, last modifier ID

2.2 Operational Concept

Users provide spacecraft configuration data (such as transponder number, spacecraft oscillator frequency values, etc.) and light time data. The user also specifies data delivery options (such as data decimation rate). This data, along with the DSN physical data maintained in internal tables, are combined with the raw measurements from the DSN to generate the radiometric data described by this document.

TRK-2-15A data will continue to be produced by DSSs until the Metric Data Assembly (MDA) has been completely retired. The existing Radio Metric Data Conditioning (RMDC) software will continue to be used until the TRK-2-15A data are no longer produced.

Parameters and data types that require predicted values, such as prefit residuals and Allan deviation, will not be available if the trajectory data for generating the predicted values is not available. If this happens, the parameter status will be marked as invalid (using validity flags) and the data types will not be generated.

2.3 Equipment

All equipment used in the measurement or generation of tracking data get their frequency and timing references from the Frequency and Timing Subsystem (FTS) of the DSN.

The non-UPL-DTT antennas have a mixture of tracking equipment. The 26m subnet uses the Metric Pointing Assembly (MPA). DSS-27, a 34m antenna, uses the Metric Tracking Assembly (MTA).

Arraying at a complex is done with the Full Spectrum Processing Subsytem (FSP).

3 Detailed Interface Description

Section 3
Detailed Interface Description

3.1 Data Definition

Viewed as a compound LVO, the value field of the tracking data SFDU contains two LVOs, an *aggregation CHDO* and a *tracking data CHDO*. The aggregation CHDO is a compound LVO; its value field contains two simple LVOs, a *primary CHDO* and a *secondary CHDO*. The aggregation CHDO exists solely for the purpose of allowing the primary and secondary CHDOs to be grouped together and treated as a single LVO. The value fields of the primary and secondary CHDOs contain annotation data (identification, configuration, status, and performance parameters) that pertain to the data in the tracking data SFDU. The tracking data CHDO is a simple LVO; its value field contains the actual tracking data.

```
 +---------------------------------------------+
L|  Tracking Data SFDU                          |
 +-+  +--------------------------------------+  |
   | L|  Aggregation CHDO                     | |
   |  +-+  +------------------------------+  | |
   |    | L| Primary CHDO                 |  | |
   |    |  +-+                            |  | |
   |    |   V|                            |  | |
   |   V|  +---------------------------   |  | |
   |    | L| Secondary CHDO               |  | |
   |    |  +-+                            |  | |
  V|    |   V|                            |  | |
   |  +----------------------------------    | |
   | L|  Tracking Data CHDO                  | |
   |  +-+                                    | |
   |    |                                    | |
   |    |                                    | |
   |   V|                                    | |
   |    |                                    | |
   |    |                                    | |
   +-----------------------------------------+
```

L = label field V = value field

Figure 3-1. LVO Structure of the Tracking Data SFDU

Figure 3-2 shows the physical layout of the tracking data SFDU. It is divided into the following sections: the tracking SFDU label, the aggregation CHDO label, the primary CHDO, the secondary CHDOs, and the tracking data CHDOs. There are five different types of secondary CHDOs, and 18 types of tracking data CHDOs.

The following sections present the detailed definition of the tracking data SFDU.

```
                                BIT
         +-----------------------------------------------+
         |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
         +-----------------------------------------------|
  BYTE 0 |                                               |
         +-                                             -|
        ...                  SFDU LABEL                 ...
        ...                                             ...
         +-                                             -|
      18 |                                               |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--|
      20 |                                               |
         +-           AGGREGATION CHDO LABEL            -|
      22 |                                               |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--|
      24 |                                               |
         +-                                             -|
        ...                 PRIMARY CHDO                ...
        ...                                             ...
         +-                                             -|
      30 |                                               |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--|
      32 |                                               |
         +-                                             -|
        ...                SECONDARY CHDO               ...
        ...                                             ...
         +-                                             -|
      xx |                                               |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--|
      xx |                                               |
         +-                                             -|
        ...              TRACKING DATA CHDO             ...
        ...                                             ...
         +-                                             -|
     N-2 |                                               |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--|
         |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
         +-----------------------------------------------+
                    N Depends on Data Type
```

Figure 3-2. Physical Layout of the Tracking Data SFDU

3.1.1 Tracking Data SFDU Label

Bytes 0 through 19 of the tracking SFDU contain the SFDU label field. The format and content of the SFDU label are defined in Table 3-1. The concatenation of Bytes 0 through 3, and 8 through 11, constitutes the type attribute of the SFDU; in CCSDS parlance, this concatenated field is known as the Authority and Description Identifier (ADID). Bytes 12 to 19 constitute the length attribute.

Table 3-1. Tracking SFDU Label Definitions

Identifier	**Byte Offset**	**Item Name and Description**	**Format**	**Units/ Precision**	**Range**	**Notes**
control_auth_id	0	*Control authority identifier.* 'NJPL' indicates that the data description information for this SFDU is maintained and disseminated by NASA/JPL.	Restricted ASCII –4	N/A	'NJPL'	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
sfdu_version_id	4	*SFDU label version ID.* '2' indicates that the length attribute field in bytes 12 to 19 is formatted as a binary unsigned integer.	Restricted ASCII –1	N/A	'2'	
sfdu_class_id	5	*SFDU class ID.* 'I' indicates that this SFDU contains data to be used by an application process.	Restricted ASCII –1	N/A	'I'	
reserve2	6	*Reserved.* Two bytes.	Restricted ASCII –2	N/A	'00'	
data_description_id	8	*Data description identifier.* Uniquely identifies the data description information held by the control authority identified in the '*Control authority identifier'* item for this type of SFDU. C123 => Uplink types C124 => Downlink types C125 => Derived types C126 => Interferometric types C127 => Filtered types	Restricted ASCII –4	N/A	'C123', 'C124', 'C125', 'C126', 'C127'	
sfdu_length	12	*Length attribute of the tracking data SFDU.* Indicates the length of the data following this element. DT0 => 162 DT1 => 358 DT2 => 194 DT3 => 304 DT4 => 218 DT5 => 332 DT6 => 320 DT7 => 330 DT8 => 178 DT9 => 124 DT10 => 204 DT11 => 182 DT12 => 164 DT13 => 160 DT14 => 304 DT15 => 194 DT16 => 182 + 18 * num_obs DT17 => 194 + 22 * num_obs	Unsigned Integer –8	Bytes	124, 160, 162, 164, 178, 182, 194, 204, 218, 304, 304, 320, 330, 332, 358, 182 + 18 * num_obs, 194 + 22 * num_obs (num_obs ≤ 100)	

3.1.2 Aggregation CHDO Label

Bytes 20 through 23 of the tracking data SFDU contain the aggregation CHDO label field, which is defined in Table 3-2. The value field of the aggregation CHDO is composed of the primary CHDO and a secondary CHDO. The primary CHDO is described in Section 3.1.3. The secondary CHDOs, of which there are five types, are described in Section 3.1.4.

Table 3-2. Aggregation CHDO Label Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the aggregation CHDO.* A value of 1 indicates that this CHDO is an aggregation of CHDOs	Unsigned Integer –2	N/A	1	
chdo_length	2	*Length attribute of the aggregation CHDO.* Indicates the length of the sum of the primary and secondary CHDOs. CHDO 132 => 78 CHDO 133 => 122 CHDO 134 => 136 CHDO 135 => 100 CHDO 136 => 110	Unsigned Integer –2	Bytes	78, 100, 110, 122, 136	

3.1.3 Primary CHDO

Bytes 24 through 31 of the tracking SFDU contain the primary CHDO, which is defined in Table 3-3. Bytes 0 through 3 are the label field. Bytes 4 through 7 are the value field. The primary specifies the mission and the data type of the tracking data contained in the SFDU.

Table 3-3. Primary CHDO Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the primary CHDO.* A value of 2 indicates that this CHDO is a primary CHDO.	Unsigned Integer –2	N/A	2	
chdo_length	2	*Length attribute of the primary CHDO.* Indicates the length, in bytes, of the value field (bytes after this item) of the primary CHDO.	Unsigned Integer –2	Bytes	4	
mjr_data_class	4	*Major data class.* A value of 6 indicates that the data in this SFDU is ground station monitor data.	Unsigned Integer –1	N/A	6	
mnr_data_class	5	*Minor data class.* Indicates data is processed tracking data.	Unsigned Integer –1	N/A	14	
mission_id	6	*Mission ID.* Per Reference [3a], Table 3-4.	Unsigned Integer –1	N/A	0 to 255	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
format_code	7	*Format code.* Also referred to as the data type. 0 => Uplink Carrier Phase 1 => Downlink Carrier Phase 2 => Uplink Sequential Ranging Phase 3 => Downlink Sequential Ranging Phase 4 => Uplink PN Ranging Phase 5 => Downlink PN Ranging Phase 6 => Doppler 7 => Sequential Ranging 8 => Angles 9 => Ramps 10 => VLBI 11 => DRVID 12 => Smoothed Noise 13 => Allan Deviation 14 => PN Ranging 15 => Tone Ranging 16 => Carrier Observable 17 => Total Phase Observable	Unsigned Integer –1	N/A	0 to 17	

3.1.4 Secondary CHDOs

There are five types of secondary CHDOs, all of which start at Byte 32 of the tracking data SFDU. The five types are organized as follows (data type is equivalent to format code):

- CHDO 134: Derived data types - Doppler Count (data type 6), Sequential Range (data type 7), Angles (data type 8), DRVID (data type 11), PN Range (data type 14), Tone Range (data type 15), Carrier Frequency Observable (data type 16), and Total Count Phase Observable (data type 17).
- CHDO 132: Uplink data types - Uplink Carrier Phase (data type 0), Uplink Sequential Ranging Phase (data type 2), Uplink PN Ranging Phase (data type 4), and Ramps (data type 9).
- CHDO 133: Downlink data types - Downlink Carrier Phase (data type 1), Downlink Sequential Ranging Phase (data type 3), and Downlink PN Ranging Phase (data type 5).
- CHDO 135: Interferometric data types - VLBI (data type 10).
- CHDO 136: Filtered data types - Smoothed Noise (data type 12) and Allan Deviation (data type 13).

The secondary CHDOs are defined in Tables 3-4 through 3-8. Bytes 0 through 3 are the label field. Bytes 4 through M-1 (M being the length of the secondary CHDO) comprise the value field. The secondary CHDO contains parameters that a user might want to sort or filter on.

3.1.4.1 Secondary CHDO 134 (Derived Data Types)

Secondary CHDO 134 is used for the following derived data types (format codes): Doppler Count (data type 6), Sequential Range (data type 7), Angle (data type 8), DRVID (data type 11), PN Range (data type 14), Tone Range (data type 15), Carrier Frequency Observable (data type 16), and Total Count Phase Observable (data type 17). Secondary CHDO 134 is defined in Table 3-4.

Table 3-4. Secondary CHDO 134 Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the secondary CHDO.*	Unsigned Integer –2	N/A	134	
chdo_length	2	*Length attribute of the secondary CHDO.* Indicates the length, in bytes, of the value field (bytes after this item) of the secondary CHDO.	Unsigned Integer –2	Bytes	124	
orig_id	4	*Originator ID.* Indicates where this SFDU was originated. Per Reference[4].	Unsigned Integer –1	N/A	0 to 255	
last_modifier_id	5	*Last modifier ID.* Indicates where this SFDU was last modified. Per Reference [4].	Unsigned Integer –1	N/A	0 to 255	
reserve1	6	*Reserved.* For future expansion of scft_id.	Unsigned Integer –1	N/A	0	
scft_id	7	*Spacecraft number.* Per Reference [3a].	Unsigned Integer –1	N/A	1 to 255	
rec_seq_num	8	*Record sequence number (RSN).* Begins with zero; increments by one for each successive tracking SFDU of the same type; wraps around from 2^{32}-1 to zero. Value is reset to zero when software is restarted.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
year	12	*Time tag year.*	Unsigned Integer –2	N/A	1958 to 3000	
doy	14	*Time tag day of year.*	Unsigned Integer –2	N/A	1 to 366	
sec	16	*Time tag seconds of day.*	IEEE Double	Seconds / 0.01 sec	0.00 to 86,400.99	1
rct_day	24	*Record creation time days.* Days since 1/1/1958.	Unsigned Integer –2	Days / 1 day	0 to 2^{16} - 1	74
rct_msec	26	*Record creation time milliseconds of day.*	Unsigned Integer –4	msec / 1 msec	0 to 86,400,999	74
stn_stream_src	30	*Station stream source.* 1 => UPL/DTT 2 => non-UPL-DTT: TRK-2-30 3 => non-UPL-DTT: TRK-2-20	Unsigned Integer –1	N/A	1 to 3	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
ul_band	31	*Uplink frequency band.* 0 => unknown or not applicable 1 => S-band 2 => X-band 3 => Ka-band 4 => Ku-band 5 => L-band	Unsigned Integer -1	N/A	0 to 5	79
ul_assembly_num	32	*Uplink Assembly Number.* Note that this is to allow for potential future cases where there might be more than one uplink of the same band at the same antenna. 0 => Unknown/Not applicable 1 => S-/X-band uplink 2 => Ka-band uplink	Unsigned Integer –1	N/A	0 to 2	79
transmit_num	33	*Transmitter number.* Value depends on transmitter used. A value of 0 means that the number is unknown or not applicable.	Unsigned Integer –1	N/A	0 to 3	79
transmit_stat	34	*Transmit Status.* 0 => not transmitting out the horn 1 => transmitting out the horn 2 => invalid or unknown	Unsigned Integer –1	N/A	0 to 2	79
transmit_mode	35	*Transmitter mode.* 0 => low power 1 => high power 2 => invalid or unknown	Unsigned Integer –1	N/A	0 to 2	79
cmd_modul_stat	36	*Command modulation status.* 0 => OFF 1 => ON 2 => invalid or unknown	Unsigned Integer –1	N/A	0 to 2	79
rng_modul_stat	37	*Ranging modulation status.* 0 => OFF 1 => ON 2 => invalid or unknown	Unsigned Integer –1	N/A	0 to 2	79
transmit_time_tag_delay	38	*Transmit time tag delay.* Value used to offset uplink time tag (e.g., for Goldstone Beam Waveguide antennas). A value of -1.0 indicates invalid (or not provided).	IEEE Double	Seconds / 0.1 nsec	-1.0, 0.0 to 1.0	2, 79
ul_zheight_corr	46	*Uplink Z-height correction.* Value of -99.0 indicates invalid.	IEEE Single	Seconds / 0.1 nsec	-99.0, -1.000 to 1.000	60, 72, 79
dl_dss_id	50	*Downlink antenna number.* Per Reference [10].	Unsigned Integer –1	N/A	0 to 255	
reserve1a	51	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
dl_chan_num	52	*Downlink channel number.* Value of 0 implies unknown.	Unsigned Integer –1	N/A	0 to 24	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
prdx_mode	53	*Predicts mode.* Predicts subset used by downlink channel. 0 => No Predicts 1 => One-way 2 => Two-way 3 => Three-way 4 => Unknown	Unsigned Integer –1	N/A	0 to 4	
ul_prdx_stn	54	*Uplink station used for predicts.* Valid only if prdx_mode is 2 or 3. Per Reference [10]. A value of 0 means that the number is unknown or not valid (e.g., no uplink).	Unsigned Integer –1	N/A	0 to 255	
ul_band_dl	55	*Uplink frequency band assumed by downlink.* Uplink band value used by downlink for turn around computations. 0 => Unknown or not applicable 1 => S-band 2 => X-band 3 => Ka-band 4 => Ku-band 5 => L-band	Unsigned Integer –1	N/A	0 to 5	
array_delay	56	*Array delay value.* Time delay added to path by arraying equipment. Obtained from arraying equipment. Any measurements include this delay. Valid only if Array Flag (array_flag) is non-zero.	IEEE Double	Seconds / 0.1 nsec	0.0 to 1.0	4
fts_vld_flag	64	*Frequency and Timing (FTS) validity.* 0 => Equipment is not synced with FTS 1 => Equipment is synced with FTS	Unsigned Integer –1	N/A	0 or 1	
carr_lock_stat	65	*Carrier lock status.* 0 => Off 1 => Open (using only predicts) 2 => Acquiring, FFT Search 3 => Acquiring, Waiting for Lock Decision 4 => In Lock 5 => Out of Lock	Unsigned Integer –1	N/A	0 to 5	83
array_flag	66	*Array flag.* 0 => Non-arrayed 1 => Arrayed with FSP #1 2 => Arrayed with FSP #2	Unsigned Integer –1	N/A	0 to 2	87

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
lna_num	67	*LNA Number.* Value of 0 indicates unknown.	Unsigned Integer –1	N/A	0 to 4	
rcv_time_tag_delay	68	*Receive time tag delay.* Value used to offset downlink time tag (e.g., for Goldstone Beam Waveguide antennas). A value of -1.0 indicates invalid (or not provided).	IEEE Double	Seconds / 0.1 nsec	-1.0, 0.0 to 1.0	3
dl_zheight_corr	76	*Downlink Z-height correction.* Value of -99.0 indicates invalid.	IEEE Single	Seconds / 0.1 nsec	-99.0, -1.000 to 1.000	60, 72
vld_ul_stn	80	*Validated uplink station.* Per Reference [10]. The uplink station per the validation process. A value of 0 means that the antenna is unknown or not valid.	Unsigned Integer –1	N/A	0 to 255	61, 79
vld_dop_mode	81	*Validated doppler mode.* 0 => Unknown or not applicable 1 => One-way 2 => Two-way 3 => Three-way	Unsigned Integer –1	N/A	0 to 3	61, 79
vld_scft_coh	82	*Validated spacecraft coherency.* 0 => Unknown or not applicable 1 => Coherent 2 => Non-coherent 3 => Transponded, non-coherent	Unsigned Integer –1	N/A	0 to 3	79
vld_dl_band	83	*Validated downlink frequency band.* 0 => unknown 1 => S-band 2 => X-band 3 => Ka-band 4 => Ku-band 5 => L-band 6 => S or X band (26m stations)	Unsigned Integer –1	N/A	0 to 6	82
scft_transpd_lock	84	*Spacecraft transponder lock.* 0 => Unknown 1 => Out-of-lock 2 => In Lock	Unsigned Integer –1	N/A	0 to 2	5
scft_transpd_num	85	*Spacecraft transponder number.* 0 if unknown, transponder number otherwise.	Unsigned Integer –1	N/A	0 to 5	5
Reserve2	86	*Reserved.* Two bytes.	Unsigned Integer –2	N/A	0	
scft_osc_freq	88	*Spacecraft oscillator frequency.* Spacecraft one-way frequency. 0.0 if unknown.	IEEE Double	Hz / 1.0 mHz	0.0, 2.0e9 to 32.3e9	6

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
scft_transpd_dela y	96	*Spacecraft transponder delay.* Coherent ranging delay. Value of -1.0 indicates invalid.	IEEE Double	Seconds / 0.1 nsec	-1.0, 0.0 to 1.0	7
scft_transpd_turn _num	104	*Spacecraft transponder turn around ratio numerator.* A value of 0 indicates unknown.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
scft_transpd_turn _den	108	*Spacecraft transponder turn around ratio denominator.* A value of 0 indicates unknown.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
scft_twnc_stat	112	*Spacecraft two-way non-coherent (TWNC) status.* 0 => Unknown 1 => OFF 2 => ON	Unsigned Integer-1	N/A	0 to 2	5
scft_osc_type	113	*Spacecraft oscillator type.* 0 => Unknown 1 => AUX OSC (auxiliary oscillator) 2 => USO (ultra-stable oscillator)	Unsigned Integer –1	N/A	0 to 2	5
mod_day	114	*Modification time days.* Days since 1/1/1958. Last modification time.	Unsigned Integer –2	Days / 1 day	0 to 2^{16} - 1	73
mod_msec	116	*Modification time milliseconds of day.* Last modification time.	Unsigned Integer –4	msec / 1 msec	0 to 86,400,999	73
cnt_time	120	*Count time.* Integration time of the counts. Value of 0 indicates Not Applicable	IEEE Single	Seconds / 0.1 sec	0.0 to 3600.0	88
Reserve4	124	*Reserved.* Four bytes.	Unsigned Integer –4	N/A	0	

3.1.4.2 Secondary CHDO 132 (Uplink Data Types)

Secondary CHDO 132 is used for the following Uplink data types (format codes): Uplink Carrier Phase (data type 0), Uplink Sequential Ranging Phase (data type 2), Uplink PN Ranging Phase (data type 4), and Ramps (data type 9). Secondary CHDO 132 is defined in Table 3-5.

Table 3-5. Secondary CHDO 132 Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the secondary CHDO.*	Unsigned Integer –2	N/A	132	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_length	2	*Length attribute of the secondary CHDO.* Indicates the length, in bytes, of the value field (bytes after this item) of the secondary CHDO.	Unsigned Integer –2	bytes	66	
orig_id	4	*Originator ID.* Indicates where this SFDU was originated. Per Reference [4].	Unsigned Integer –1	N/A	0 to 255	
last_modifier_id	5	*Last modifier ID.* Indicates where the contents of this SFDU were last modified. Per Reference [4].	Unsigned Integer –1	N/A	0 to 255	
reserve1	6	*Reserved.* For future expansion of scft_id.	Unsigned Integer –1	N/A	0	
scft_id	7	*Spacecraft number.* Per Reference [3a].	Unsigned Integer –1	N/A	1 to 255	
upl_rec_seq_num	8	*Uplink record sequence number (UPL RSN).* This is the record sequence number reported by the uplink subsystem (UPL) equipment.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
rec_seq_num	12	*Record sequence number (RSN).* Begins with zero; increments by one for each successive uplink tracking SFDU of the same data type; wraps around from 2^{32}-1 to zero. Value is reset to zero when the data processing system software is restarted.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
year	16	*Time tag year.*	Unsigned Integer –2	N/A	1958 to 3000	
doy	18	*Time tag day of year.*	Unsigned Integer –2	N/A	1 to 366	
sec	20	*Time tag seconds of day.*	IEEE Double	Seconds / 0.01 sec	0.00 to 86,400.99	1
rct_day	28	*Record creation time days.* Days since 1/1/1958.	Unsigned Integer –2	Days / 1 day	0 to 2^{16} - 1	74
rct_msec	30	*Record creation time milliseconds of day.*	Unsigned Integer –4	msec / 1 msec	0 to 86,400,999	74
ul_dss_id	34	*Uplink antenna number.* Per Reference [10].	Unsigned Integer –1	N/A	0 to 255	
ul_band	35	*Uplink frequency band.* 0 => unknown 1 => S-band 2 => X-band 3 => Ka-band 4 => Ku-band 5 => L-band	Unsigned Integer –1	N/A	0 to 5	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
ul_assembly_num	36	*Uplink Assembly Number.* Note that this is to allow for potential future cases where there might be more than one uplink of the same band at the same antenna. 1 => S-/X-band uplink 2 => Ka-band uplink	Unsigned Integer –1	N/A	1 or 2	
transmit_num	37	*Transmitter number.* Value depends on transmitter used. A value of 0 indicates unknown.	Unsigned Integer –1	N/A	0 to 3	
transmit_stat	38	*Transmit status.* 0 => not transmitting out the horn 1 => transmitting out the horn 2 => invalid/unknown	Unsigned Integer –1	N/A	0 to 2	
transmit_mode	39	*Transmitter mode.* 0 => low power 1 => high power 2 => invalid/unknown	Unsigned Integer –1	N/A	0 to 2	
cmd_modul_stat	40	*Command modulation status.* 0 => OFF 1 => ON 2 => invalid/unknown	Unsigned Integer –1	N/A	0 to 2	
rng_modul_stat	41	*Ranging modulation status.* 0 => OFF 1 => ON 2 => invalid/unknown	Unsigned Integer –1	N/A	0 to 2	
fts_vld_flag	42	*Frequency and Timing (FTS) validity.* 0 => Equipment is not synced with FTS 1 => Equipment is synced with FTS	Unsigned Integer –1	N/A	0 or 1	
reserve1a	43	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
transmit_time_tag_delay	44	*Transmit time tag delay.* Value used to offset uplink time tag (e.g., for Goldstone Beam Waveguide antennas). Value of -1.0 indicates invalid (or not provided).	IEEE Double	seconds / 0.1 nsec	-1.0, 0.0 to 1.0	2
ul_zheight_corr	52	*Uplink Z-height correction.* Value of -99.0 indicates invalid.	IEEE Single	seconds / 0.1 nsec	-99.0, -1.000 to 1.000	60
mod_day	56	*Modification time days.* Days since 1/1/1958. Last modification time.	Unsigned Integer –2	Days / 1 day	0 to 2^{16} - 1	73
mod_msec	58	*Modification time milliseconds of day.* Last modification time.	Unsigned Integer –4	msec / 1 msec	0 to 86,400,999	73

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
reserve8	62	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.4.3 Secondary CHDO 133 (Downlink Data Types)

Secondary CHDO 133 is used for the following Downlink data types (format codes): Downlink Carrier Phase (data type 1), Downlink Sequential Ranging Phase (data type 3), and Downlink PN Ranging Phase (data type 5). Secondary CHDO 133 is defined in Table 3-6.

Table 3-6. Secondary CHDO 133 Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the secondary CHDO.*	Unsigned Integer –2	N/A	133	
chdo_length	2	*Length attribute of the secondary CHDO.* Indicates the length, in bytes, of the value field (bytes after this item) of the secondary CHDO.	Unsigned Integer –2	bytes	110	
orig_id	4	*Originator ID.* Indicates where this SFDU was originated. Per Reference [4].	Unsigned Integer –1	N/A	0 to 255	
last_modifier_id	5	*Last modifier ID.* Indicates where the contents of this SFDU were last modified. Per Reference [4].	Unsigned Integer –1	N/A	0 to 255	
reserve1	6	*Reserved.* For future expansion of scft_id.	Unsigned Integer –1	N/A	0	
scft_id	7	*Spacecraft number.* Per Reference [3a].	Unsigned Integer –1	N/A	1 to 255	
dtt_rec_seq_num	8	*Downlink Record sequence number (DTT RSN).* This is the record sequence number reported by the downlink subsystem (DTT) equipment.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
rec_seq_num	12	*Record sequence number (RSN).* Begins with zero; increments by one for each successive downlink tracking SFDU of the same data type; wraps around from 2^{32}-1 to zero. Value is reset to zero when the data processing system software is restarted.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
year	16	*Time tag year.*	Unsigned Integer –2	N/A	1958 to 3000	
doy	18	*Time tag day of year.*	Unsigned Integer –2	N/A	1 to 366	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
sec	20	*Time tag seconds of day.*	IEEE Double	Seconds / 0.01 sec	0.00 to 86,400.99	1
rct_day	28	*Record creation time days.* Days since 1/1/1958.	Unsigned Integer –2	Days / 1 day	0 to 2^{16} - 1	74
rct_msec	30	*Record creation time milliseconds of day.*	Unsigned Integer –4	msec / 1 msec	0 to 86,400,999	74
dl_dss_id	34	*Downlink antenna number.* Per Reference [10].	Unsigned Integer –1	N/A	0 to 255	
dl_band	35	*Downlink frequency band.* 0 => Unknown 1 => S-band 2 => X-band 3 => Ka-band 4 => Ku-band 5 => L-band	Unsigned Integer –1	N/A	0 to 5	
dl_chan_num	36	*Downlink channel number.*	Unsigned Integer –1	N/A	1 to 24	
prdx_mode	37	*Predicts mode.* Predicts subset used by downlink channel. 0 => No Predicts 1 => One-way 2 => Two-way 3 => Three-way	Unsigned Integer –1	N/A	0 to 3	
ul_prdx_stn	38	*Uplink station used for predicts.* Valid only if prdx_mode is 2 or 3. Per Reference [10]. A value of 0 means that the number is unknown or not valid (e.g., no uplink).	Unsigned Integer –1	N/A	0 to 255	
ul_band_dl	39	*Uplink frequency band assumed by downlink.* 0 => Unknown 1 => S-band 2 => X-band 3 => Ka-band 4 => Ku-band 5 => L-band	Unsigned Integer –1	N/A	0 to 5	
array_delay	40	*Array delay value.* Time delay added to path by arraying equipment. Obtained from arraying equipment. Any measurements include this delay. Valid only if Array Flag (array_flag) is non-zero.	IEEE Double	seconds / 0.1 nsec	0.0 to 1.0	4
fts_vld_flag	48	*Frequency and Timing (FTS) validity.* 0 => Equipment is not synced with FTS 1 => Equipment is synced with FTS	Unsigned Integer –1	N/A	0 or 1	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
carr_lock_stat	49	*Carrier lock status.* 0 => Off 1 => Open (only using predicts) 2 => Acquiring, FFT Search 3 => Acquiring, Waiting for Lock Decision 4 => In Lock 5 => Out of Lock	Unsigned Integer –1	N/A	0 to 5	
array_flag	50	*Array flag.* 0 => Not arrayed 1 => Arrayed with FSP #1 2 => Arrayed with FSP #2	Unsigned Integer –1	N/A	0 to 2	87
polarization	51	*Polarization.* 0 => RCP 1 => LCP	Unsigned Integer –1	N/A	0 or 1	
diplxr_stat	52	*Diplexer status.* 0 => Low noise 1 => Diplexed	Unsigned Integer –1	N/A	0 or 1	
lna_num	53	*LNA Number.*	Unsigned Integer –1	N/A	1 to 4	
rf_if_chan_num	54	*RF-to-IF Downconverter Channel number.*	Unsigned Integer –1	N/A	1 or 2	
if_num	55	*IF input number.* Defines path into downlink channel.	Unsigned Integer –1	N/A	1 to 3	
rcv_time_tag_delay	56	*Receive time tag delay.* Value used to offset downlink time tag (e.g., for Goldstone Beam Waveguide antennas). A value of -1.0 indicates invalid (or not provided).	IEEE Double	seconds / 0.1 nsec	-1.0, 0.0 to 1.0	3
dl_zheight_corr	64	*Downlink Z-height correction.* Value of -99.0 indicates invalid.	IEEE Single	seconds / 0.1 nsec	-99.0, -1.000 to 1.000	60
vld_ul_stn	68	*Validated uplink station.* Per Reference [10]. The uplink station per the validation process. A value of 0 means that the antenna is unknown or not valid.	Unsigned Integer –1	N/A	0 to 255	61, 79
vld_dop_mode	69	*Validated doppler mode.* 0 => Unknown or not applicable 1 => One-way 2 => Two-way 3 => Three-way	Unsigned Integer –1	N/A	0 to 3	61, 79
vld_scft_coh	70	*Validated spacecraft coherency.* 0 => Unknown or not applicable 1 => Coherent 2 => Non-coherent 3 => Transponded, non-coherent	Unsigned Integer –1	N/A	0 to 3	79

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
scft_transpd_lock	71	*Spacecraft transponder lock.* 0 => Unknown 1 => Out-of-lock 2 => In Lock	Unsigned Integer –1	N/A	0 to 2	5
scft_transpd_num	72	*Spacecraft transponder number.* 0 if unknown, transponder number otherwise.	Unsigned Integer –1	N/A	0 to 5	5
reserve1a	73	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
scft_osc_freq	74	*Spacecraft oscillator frequency.* Spacecraft one-way frequency. 0.0 if unknown.	IEEE Double	Hz / 1 mHz	0.0, 2.0e9 to 32.3e9	6
scft_transpd_delay	82	*Spacecraft transponder delay.* Coherent ranging delay. Value of -1.0 indicates invalid.	IEEE Double	Seconds / 0.1 nsec	-1.0, 0.0 to 1.0	7
scft_transpd_turn_num	90	*Spacecraft transponder turn around ratio numerator.* A value of 0 indicates unknown.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
scft_transpd_turn_den	94	*Spacecraft transponder turn around ratio denominator.* A value of 0 indicates unknown.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
scft_twnc_stat	98	*Spacecraft two-way non-coherent (TWNC) status.* 0 => Unknown 1 => OFF 2 => ON	Unsigned Integer –1	N/A	0 to 2	5
scft_osc_type	99	*Spacecraft oscillator type.* 0 => Unknown 1 => AUX OSC (auxiliary oscillator) 2 => USO (ultra-stable oscillator)	Unsigned Integer –1	N/A	0 to 2	5
mod_day	100	*Modification time days.* Days since 1/1/1958. Last modification time.	Unsigned Integer –2	Days / 1 day	0 to 2^{16} - 1	73
mod_msec	102	*Modification time milliseconds of day.* Last modification time.	Unsigned Integer –4	msec / 1 msec	0 to 86,400,999	73
reserve8	106	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.4.4 Secondary CHDO 135 (Interferometric Data Types)

Secondary CHDO 135 is used for the following Interferometric data type (format code): VLBI (data type 10). Secondary CHDO 135 is defined in Table 3-7.

Table 3-7. Secondary CHDO 135 Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the secondary CHDO.*	Unsigned Integer –2	N/A	135	
chdo_length	2	*Length attribute of the secondary CHDO.* Indicates the length, in bytes, of the value field (bytes after this item) of the secondary CHDO.	Unsigned Integer –2	bytes	88	
orig_id	4	*Originator ID.* Indicates where this SFDU was originated. Per Reference [4].	Unsigned Integer –1	N/A	0 to 255	
last_modifier_id	5	*Last modifier ID.* Indicates that the contents of this SFDU were last modified by the VLBI system. Per Reference [4].	Unsigned Integer –1	N/A	0 to 255	
reserve1	6	*Reserved.* For future expansion of scft_id.	Unsigned Integer –1	N/A	0	
scft_id	7	*Spacecraft number.* Per Reference [3a] (set to 0 if quasar sample).	Unsigned Integer –1	N/A	1 to 255	
rec_seq_num	8	*Record sequence number (RSN).* Begins with zero; increments by one for each successive VLBI tracking SFDU of the same data type; wraps around from 2^{32}-1 to zero.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
year	12	*Time tag year.*	Unsigned Integer –2	N/A	1958 to 3000	
doy	14	*Time tag day of year.*	Unsigned Integer –2	N/A	1 to 366	
sec	16	*Time tag seconds of day.*	IEEE Double	seconds / 0.1 msec	0.00 to 86,400.999 9	1
rct_day	24	*Record creation time days.* Days since 1/1/1958.	Unsigned Integer –2	Days / 1 day	0 to 2^{16} - 1	74
rct_msec	26	*Record creation time milliseconds of day.*	Unsigned Integer –4	msec / 1 msec	0 to 86,400,999	74
ul_dss_id	30	*Primary uplink antenna number.* Per Reference [10].	Unsigned Integer –1	N/A	0 to 255	

Identifier	**Byte Offset**	**Item Name and Description**	**Format**	**Units/ Precision**	**Range**	**Notes**
dl_dss_id	31	*Primary downlink antenna number.* Per Reference [10].	Unsigned Integer –1	N/A	0 to 255	
dl_band	32	*Downlink frequency band.* 0 => unknown 1 => S-band 2 => X-band 3 => Ka-band 4 => Ku-band 5 => L-band	Unsigned Integer –1	N/A	0 to 5	
dl_chan_num	33	*Downlink channel number.*	Unsigned Integer –1	N/A	1 to 24	
prdx_mode	34	*Predicts mode.* 0 => No Predicts 1 => One-way 2 => Two-way 3 => Three-way	Unsigned Integer –1	N/A	0 to 3	
ul_prdx_stn	35	*Uplink station used for predicts.* Valid only if prdx_mode is 2 or 3. Per Reference [10]. A value of 0 means that the number is unknown or not valid (e.g., no uplink).	Unsigned Integer –1	N/A	0 to 255	
ul_band_dl	36	*Uplink frequency band assumed by downlink.* 0 => Unknown 1 => S-band 2 => X-band 3 => Ka-band 4 => Ku-band 5 => L-band	Unsigned Integer –1	N/A	0 to 5	
rec_type	37	*Record type.* 71 => spacecraft DOD 72 => quasar DOD 73 => spacecraft DOR 74 => quasar DOR	Unsigned Integer –1	N/A	71 to 74	
rcv_time_tag_delay	38	*Receive time tag delay at primary antenna.* Value used to offset downlink time tag (e.g, for Goldstone Beam Waveguide antennas). A value of -1.0 indicates invalid (or not provided).	IEEE Double	seconds / 0.1 nsec	-1.0, 0.0 to 1.0	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
array_delay	46	*Array delay value at primary antenna.* Time delay added to path by arraying equipment. Obtained from arraying equipment. Any measurements include this delay. Valid only if Array Flag (array_flag) is non-zero.	IEEE Double	seconds / 0.1 nsec	0.0 to 1.0	4
dl_dss_id_2	54	*Secondary downlink antenna number.* Per Reference [10].	Unsigned Integer –1	N/A	0 to 255	
reserve1a	55	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
rcv_time_tag_ delay_2	56	*Receive time tag delay at secondary antenna.* Value used to offset downlink time tag (e.g., for Goldstone Beam Waveguide antennas). A value of -1.0 indicates invalid (or not provided).	IEEE Double	seconds / 0.1 nsec	-1.0, 0.0 to 1.0	
array_delay_2	64	*Array delay value at secondary antenna.* Time delay added to path by arraying equipment. Obtained from arraying equipment. Any measurements include this delay. Valid only if Secondary Antenna Array Flag (array_flag_2) is non-zero.	IEEE Double	seconds / 0.1 nsec	0.0 to 1.0	4
fts_vld_flag	72	*Frequency and Timing (FTS) validity.* 0 => Equipment is not synced with FTS 1 => Equipment is synced with FTS	Unsigned Integer –1	N/A	0 or 1	
carr_lock_stat	73	*Carrier lock status.* 0 => Off 1 => Open 2 => Acquiring, FFT Search 3 => Acquiring, Waiting for Lock Decision 4 => In Lock 5 => Out-of-Lock	Unsigned Integer –1	N/A	0 to 5	
array_flag	74	*Array flag for primary antenna.* 0 => Not arrayed 1 => Arrayed with FSP #1 2 => Arrayed with FSP #2	Unsigned Integer –1	N/A	0 to 2	87
source_type	75	*VLBI source.* 0 => quasar 1 => spacecraft	Unsigned Integer –1	N/A	0 or 1	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
lna_num	76	*LNA Number.*	Unsigned Integer –1	N/A	1 to 4	
array_flag_2	77	*Array flag for secondary antenna.* 0 => Not arrayed 1 => Arrayed with FSP #1 2 => Arrayed with FSP #2	Unsigned Integer –1	N/A	0 to 2	87
mod_day	78	*Modification time days.* Days since 1/1/1958. Last modification time.	Unsigned Integer –2	Days / 1 day	0 to 2^{16} - 1	73
mod_msec	80	*Modification time milliseconds of day.* Last modification time.	Unsigned Integer –4	msec / 1 msec	0 to 86,400,999	73
reserve8	84	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.4.5 Secondary CHDO 136 (Filtered Data Types)

Secondary CHDO 136 is used for the following Filtered data types (format codes): Smoothed Noise (data type 12) and Allan Deviation (data type 13). These data types are only generated for DTT-type antennas. Secondary CHDO 136 is defined in Table 3-8.

Table 3-8. Secondary CHDO 136 Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the secondary CHDO.*	Unsigned Integer –2	N/A	136	
chdo_length	2	*Length attribute of the secondary CHDO.* Indicates the length, in bytes, of the value field (bytes following this item) of the secondary CHDO.	Unsigned Integer –2	Bytes	98	
orig_id	4	*Originator ID.* Indicates where this SFDU was originated. Per Reference [4].	Unsigned Integer –1	N/A	0 to 255	
last_modifier_id	5	*Last modifier ID.* Indicates where the contents of this SFDU were last modified. Per Reference [4].	Unsigned Integer –1	N/A	0 to 255	
reserve1	6	*Reserved.* For future expansion of scft_id.	Unsigned Integer –1	N/A	0	
scft_id	7	*Spacecraft number.* Per Reference [3a].	Unsigned Integer –1	N/A	1 to 255	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
rec_seq_num	8	*Record sequence number (RSN).* Begins with zero; increments by one for each successive filtered SFDU of the same data type; wraps around from 2^{32}-1 to zero. Value is reset to zero when the data processing system software is restarted.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
year	12	*Time tag year.*	Unsigned Integer –2	N/A	1958 to 3000	
doy	14	*Time tag day of year.*	Unsigned Integer –2	N/A	1 to 366	
sec	16	*Time tag seconds of day.*	IEEE Double	seconds / 0.01 sec	0.00 to 86,400.99	1
rct_day	24	*Record creation time days.* Days since 1/1/1958.	Unsigned Integer –2	Days / 1 day	0 to 2^{16} - 1	74
rct_msec	26	*Record creation time milliseconds of day.*	Unsigned Integer –4	msec / 1 msec	0 to 86,400,999	74
dl_dss_id	30	*Downlink antenna number.* Per Reference [10].	Unsigned Integer –1	N/A	0 to 255	
dl_band	31	*Downlink frequency band.* 0 => unknown 1 => S-band 2 => X-band 3 => Ka-band 4 => Ku-band 5 => L-band	Unsigned Integer –1	N/A	0 to 5	
dl_chan_num	32	*Downlink channel number.*	Unsigned Integer –1	N/A	1 to 24	
prdx_mode	33	*Predicts mode.* 0 => No Predicts 1 => One-way 2 => Two-way 3 => Three-way	Unsigned Integer –1	N/A	0 to 3	
ul_prdx_stn	34	*Uplink station used for predicts.* Valid only if prdx_mode is 2 or 3. Per Reference [10]. A value of 0 means that the number is unknown or not valid (e.g., no uplink).	Unsigned Integer –1	N/A	0 to 255	
ul_band_dl	35	*Uplink band assumed by downlink.* 0 => Unknown or not applicable 1 => S-band 2 => X-band 3 => Ka-band 4 => Ku-band 5 => L-band	Unsigned Integer –1	N/A	0 to 5	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
rcv_time_tag_ delay	36	*Receive time tag delay.* Value used to offset downlink time tag (e.g., for Goldstone Beam Waveguide antennas). A value of -1.0 indicates invalid (or not provided).	IEEE Double	seconds / 0.1 nsec	-1.0, 0.0 to 1.0	3
array_delay	44	*Array delay value.* Time delay added to path by arraying equipment. Obtained from arraying equipment. Any measurements include this delay. Valid only if Array Flag (array_flag) is non-zero.	IEEE Double	seconds / 0.1 nsec	0.0 to 1.0	4
fts_vld_flag	52	*Frequency and Timing (FTS) validity.* 0 => Equipment is not synced with FTS 1 => Equipment is synced with FTS	Unsigned Integer –1	N/A	0 or 1	
carr_lock_stat	53	*Carrier lock status.* 0 => Off 1 => Open (only using predicts) 2 => Acquiring, FFT Search 3 => Acquiring, Waiting for Lock Decision 4 => In Lock 5 => Out of Lock	Unsigned Integer –1	N/A	0 to 5	
array_flag	54	*Array flag.* 0 => Not arrayed 1 => Arrayed with FSP #1 2 => Arrayed with FSP #2	Unsigned Integer –1	N/A	0 to 2	87
lna_num	55	*LNA Number.*	Unsigned Integer –1	N/A	1 to 4	
vld_ul_stn	56	*Validated uplink station.* Per Reference [10]. The uplink station per the validation process. A value of 0 means that the antenna is unknown or not valid.	Unsigned Integer –1	N/A	0 to 255	61, 79
vld_dop_mode	57	*Validated doppler mode.* 0 => Unknown or not applicable 1 => One-way 2 => Two-way 3 => Three-way	Unsigned Integer –1	N/A	0 to 3	61, 79
vld_scft_coh	58	*Validated spacecraft coherency.* 0 => Unknown or not applicable 1 => Coherent 2 => Non-coherent 3 => Transponded, non-coherent	Unsigned Integer –1	N/A	0 to 3	79

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
scft_transpd_lock	59	*Spacecraft transponder lock.* 0 => Unknown 1 => Out-of-lock 2 => Locked	Unsigned Integer –1	N/A	0 to 2	5
scft_transpd_num	60	*Spacecraft transponder number.* 0 if unknown, transponder number otherwise.	Unsigned Integer –1	N/A	0 to 5	5
reserve1a	61	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
scft_osc_freq	62	*Spacecraft oscillator frequency.* Spacecraft one-way frequency. 0.0 if unknown.	IEEE Double	Hz / 1 mHz	0.0, 2.0e9 to 32.3e9	6
scft_transpd_delay	70	*Spacecraft transponder delay.* Coherent ranging delay. Value of -1.0 indicates invalid.	IEEE Double	Seconds / 0.1 nsec	-1.0, 0.0 to 1.0	7
scft_transpd_turn_num	78	*Spacecraft transponder turn around ratio numerator.* A value of 0 indicates unknown.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
scft_transpd_turn_den	82	*Spacecraft transponder turn around ratio denominator.* A value of 0 indicates unknown.	Unsigned Integer –4	N/A	0 to 2^{32}-1	
scft_twnc_stat	86	*Spacecraft two-way non-coherent (TWNC) status.* 0 => Unknown 1 => OFF 2 => ON	Unsigned Integer –1	N/A	0 to 2	5
scft_osc_type	87	*Spacecraft oscillator type.* 0 => Unknown 1 => AUX OSC (auxiliary oscillator) 2 => USO (ultra-stable oscillator)	Unsigned Integer –1	N/A	0 to 2	5
mod_day	88	*Modification time days.* Days since 1/1/1958. Last modification time.	Unsigned Integer –2	Days / 1 day	0 to 2^{16} - 1	73
mod_msec	90	*Modification time milliseconds of day.* Last modification time.	Unsigned Integer –4	msec / 1 msec	0 to 86,400,999	73
reserve8	94	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5 Tracking Data CHDOs

There are 18 types of Tracking Data CHDOs, split into five categories: uplink data, downlink data, derived data, interferometric data, and filtered data. Uplink data are the validated uplink phases from the UPL-DTT antennas and the uplink ramps. Downlink data are the validated downlink phases from the UPL-DTT antennas. Derived data are the data from the non-UPL-DTT antennas, and the processed doppler, range and DRVID data from the UPL-DTT antennas. Interferometric data are the VLBI data. Filtered data are the measurements derived from the accumulated downlink carrier phase data (smoothed noise and Allan Deviation) and are only available for UPL-DTT antennas. The data types are as follows:

- Uplink Data
  - Uplink Carrier Phase (data type 0)
  - Uplink Sequential Ranging Phase (data type 2)
  - Uplink PN Ranging Phase (data type 4)
  - Ramp (data type 9)
- Downlink Data
  - Downlink Carrier Phase (data type 1)
  - Downlink Sequential Ranging Phase (data type 3)
  - Downlink PN Ranging Phase (data type 5)
- Derived Data
  - Doppler Count (data type 6)
  - Sequential Range (data type 7)
  - Angle (data type 8)
  - DRVID (data type 11)
  - PN Range (data type 14)
  - Tone Range (data type 15)
  - Carrier Frequency Observable (data type 16)
  - Total Count Phase Observable (data type 17)
- Interferometric Data
  - VLBI (data type 10)
- Filtered Data
  - Smoothed Noise (data type 12)
  - Allan Deviation (data type 13)

3.1.5.1 Uplink Data CHDOs

There are four Uplink Data CHDOs: Uplink Carrier Phase (data type 0), Uplink Sequential Ranging Phase (data type 2), Uplink PN Ranging Phase (data type 4), and Ramp (data type 9). Their formats and contents are specified in sections 3.1.5.1.1 to 3.1.5.1.4.

3.1.5.1.1 Uplink Carrier Phase CHDO (Data Type 0)

The Uplink Carrier Phase CHDO is defined in Table 3-9.

Table 3-9. Uplink Carrier Phase CHDO (Data Type 0) Definitions

Identifier	Byte Offsets	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the uplink carrier phase data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the uplink carrier phase data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	76	
ul_hi_phs_cycles	4	*High part phase data whole cycles.*	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
ul_lo_phs_cycles	8	*Low part phase data whole cycles.*	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8
ul_frac_phs_cycles	12	*Fractional part phase data cycles.*	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
ramp_freq	16	*Ramp frequency.* Precision varies with band (phase data gives higher precision). A value of 0.0 indicates an invalid or unknown value S-band => 0.5 μHz X-band => 1.6 μHz Ka-band => 7.7 μHz	IEEE Double	Sky level Hz, at least 7.7 μHz precision (band dependent)	0.0, 2.0e9 to 34.7e9	
ramp_rate	24	*Ramp rate.*	IEEE Double	Sky level Hz/sec, μHz/sec precision	-3.2e5 to 3.2e5	
transmit_switch_stat	32	*Transmitter switch status.* 0 => antenna 1 => water load 2 => invalid/unknown	Unsigned Integer –1	N/A	0 to 2	

Identifier	Byte Offsets	Item Name and Description	Format	Units/ Precision	Range	Notes
ramp_type	33	*Ramp type.* 0 => snap 1 => start of new ramp 2 => medial report 3 => periodic report 4 => end of ramps 5 => ramping terminated by operator 6 => invalid/unknown	Unsigned Integer –1	N/A	0 to 6	
transmit_op_pwr	34	*Transmitter output power.*	IEEE Single	W / 0.1 W	0.0 to 500,000.0	
sup_data_id	38	*Support data ID.* Name of the frequency predicts set used.	ASCII –8	N/A	ASCII string	
sup_data_rev	46	*Support data revision.* Revision of the frequency predicts set used.	ASCII –8	N/A	ASCII string	
prdx_time_offset	54	*Predicts time offset.* Seconds added to current time.	IEEE Double	Seconds / 0.1 sec	-31,536,000.0 to 31,536,000.0	54
prdx_freq_offset	62	*Predicts frequency offset.* Hz added to predicted value.	IEEE Double	Hz / 1 mHz	-4.8e6 to 4.8e6	55
time_tag_corr_flag	70	*Time tag correction flag.* Indicates results of validation of the block time tag. 0 => no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
type_time_corr_flag	71	*Type of time tag correction flag.* Indicates what type of time tag correction was made. 0 => no correction 1 => Year correction 2 => DOY correction 3 => Both Year and DOY correction	Unsigned Integer –1	N/A	0 to 3	
reserve8	72	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.1.2 Uplink Sequential Ranging Phase CHDO (Data Type 2)

The Uplink Sequential Ranging Phase CHDO is defined in Table 3-10.

Table 3-10. Uplink Sequential Ranging Phase CHDO (Data Type 2) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the uplink sequential ranging phase data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the uplink sequential ranging phase data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	108	
stn_cal	4	*Station calibration value.* (Two-way). Value includes the equipment in the path, but not the Z-height correction. (0.0 if not measured.)	IEEE Double	Range Units / 0.01 RU	0.0 to 1.8e5	24
ul_stn_cal	12	*Uplink station calibration value.* Value includes the uplink equipment in the path, but not the Z-height correction. (0.0 if not measured.)	IEEE Double	Range Units / 0.01 RU	0.0 to 1.8e5	10,24
ul_cal_freq	20	*Uplink calibration frequency.* Frequency the calibration was done at.	IEEE Double	Sky level Hz / 1 mHz	2.0e9 to 34.4e9	
cal_std_dev	28	*Standard deviation of station calibration value.* For stn_cal and ul_stn_cal.	IEEE Single	Range Units / 0.01 RU	0.0 to 1.8e5	24
cal_pts	32	*Calibration points.* Number of measurements made in computing station calibration values (stn_cal, ul_stn_cal, cal_std_dev).	Unsigned Integer –2	N/A	0 to 65,535	
ul_rng_phs	34	*Measured range phase.* Range phase.	IEEE Double	Range Units / 0.01 RU	0.0 to 2^{30}	11,24
transmit_switch_stat	42	*Transmitter switch status.* 0 => antenna 1 => water load 2 => invalid/unknown	Unsigned Integer –1	N/A	0 to 2	
invert	43	*Invert.* Polarity of modulation. 0 => not inverted 1 => inverted	Unsigned Integer –1	N/A	0 or 1	52
transmit_op_pwr	44	*Transmitter output power.*	IEEE Single	W / 0.1 W	0.0 to 500,000.0	
template_id	48	*Template ID.* Value is the file name of the ranging parameter file.	ASCII –8	N/A	ASCII string	
t1	56	*T1 setting.*	Unsigned Integer –2	Seconds / 1 sec	1 to 3600	12

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
t2	58	*T2 setting.*	Unsigned Integer –2	Seconds / 1 sec	1 to 1800	13
t3	60	*T3 setting.*	Unsigned Integer –2	Seconds / 1 sec	0 to 1800	14
first_comp_num	62	*First component number.*	Unsigned Integer –1	N/A	1 to 24	15
last_comp_num	63	*Last component number.*	Unsigned Integer –1	N/A	1 to 24	15
chop_comp_num	64	*Chop component number.* This is the component used to chop the other components.	Unsigned Integer –1	N/A	0 to 10	15,16
num_drvid	65	*Number of DRVID measurements.*	Unsigned Integer –1	N/A	0 to 255	
transmit_inphs_time_year	66	*Transmit In-phase time – year.* Year of the time of zero phase on uplink range generation.	Unsigned Integer –2	N/A	1958 to 3000	75
transmit_inphs_time_doy	68	*Transmit In-phase time – day of year.* Day of year of the time of zero phase on uplink range generation.	Unsigned Integer –2	N/A	1 to 366	75
transmit_inphs_time_sec	70	*Transmit In-phase time – seconds of day.* Seconds of day of the time of zero phase on uplink range generation.	IEEE Double	Seconds / 1 μsec	0.000000 to 86,400.999999	75
carr_sup_rng_modul	78	*Carrier Suppression by ranging modulation.* Reduction in carrier power due to ranging modulation.	IEEE Single	dB / 0.1 dB	0.0 to -15.0	
rng_modul_amp	82	*Ranging modulation amplitude.* Actual digital modulation amplitude used by the ranging hardware.	Unsigned Integer –2	N/A	0 to 2^{12}	
exc_scalar_num	84	*Exciter Scalar Numerator.* Numerator of multiplier that is used to generate ranging reference signal from uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
exc_scalar_den	88	*Exciter Scalar Denominator.* Denominator of multiplier that is used to generate ranging reference signal from uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
rng_cycle_time	92	*Ranging cycle time.* Time to complete one cycle of the ranging code.	IEEE Double	Seconds / 0.1 sec	4.0 to 504,536.0	18

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
time_tag_corr_flag	100	*Time tag correction flag.* Indicates results of validation of the block time tag. 0 => no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
type_time_corr_flag	101	*Type of time tag correction flag.* Indicates what type of time tag correction was made. 0 => no correction 1 => Year correction 2 => DOY correction 3 => Both Year and DOY correction	Unsigned Integer –1	N/A	0 to 3	
clock_waveform	102	*Clock waveform type.* 0 => squarewave 1 => sinewave	Unsigned Integer -1	N/A	0 or 1	
chop_start_num	103	*Chop Start.* The first component chopped.	Unsigned Integer –1	N/A	0 to 25	16
reserve8	104	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.1.3 Uplink PN Ranging Phase CHDO (Data Type 4)

The Uplink PN Ranging Phase CHDO is defined in Table 3-11.

Table 3-11. Uplink PN Ranging Phase CHDO (Data Type 4) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the uplink PN ranging phase data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the uplink PN ranging phase data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	132	
stn_cal	4	*Station calibration value.* (two-way). Value includes the equipment in the path, but not the Z-height correction. (0.0 if not measured.)	IEEE Double	Range Units / 0.01 RU	0.0 to 1.8e5	24

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
ul_stn_cal	12	*Uplink station calibration value.* Value includes the uplink equipment in the path, but not the Z-height correction. (0.0 if not measured.)	IEEE Double	Range Units / 0.01 RU	0.0 to 1.8e5	10,24
ul_cal_freq	20	*Uplink calibration frequency.* Frequency the calibration was done at.	IEEE Double	Sky level Hz / 1 mHz	2.0e9 to 34.4e9	
cal_std_dev	28	*Standard deviation of station calibration value.* For stn_cal and ul_stn_cal.	IEEE Single	Range Units / 0.01 RU	0.0 to 1.8e5	24
cal_pts	32	*Calibration points.* Number of measurements made in computing station calibration values (stn_cal, ul_stn_cal, and cal_std_dev).	Unsigned Integer –2	N/A	0 to 65,535	
ul_rng_phs	34	*Measured range phase.* Range phase.	IEEE Double	Range Units / 0.01 RU	0.0 to 2^{30}	11,24
state_seq1	42	*Sequence #1 code state.* Position in the sequence at the time tag.	Unsigned Integer –1	N/A	0 to 7	19
state_seq2	43	*Sequence #2 code state.* Position in the sequence at the time tag.	Unsigned Integer –1	N/A	0 to 15	19
state_seq3	44	*Sequence #3 code state.* Position in the sequence at the time tag.	Unsigned Integer –1	N/A	0 to 15	19
state_seq4	45	*Sequence #4 code state.* Position in the sequence at the time tag.	Unsigned Integer –1	N/A	0 to 31	19
state_seq5	46	*Sequence #5 code state.* Position in the sequence at the time tag.	Unsigned Integer –1	N/A	0 to 31	19
state_seq6	47	*Sequence #6 code state.* Position in the sequence at the time tag.	Unsigned Integer –1	N/A	0 to 31	19
pn_clk_phs	48	*PN chip clock phase.* Position in the chip at the time tag.	IEEE Double	Cycles / 1 μcycle	0.0 to 1.0	19
transmit_switch_stat	56	*Transmitter switch status.* 0 => antenna 1 => water load 2 => invalid/unknown	Unsigned Integer –1	N/A	0 to 2	
invert	57	*Invert.* Polarity of modulation signal. 0 => not inverted 1 => inverted	Unsigned Integer –1	N/A	0 or 1	52

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
transmit_op_pwr	58	*Transmitter output power.*	IEEE Single	W / 0.1 W	0.0 to 500,000.0	
template_id	62	*Template ID.* Value is the file name of the ranging parameter file.	ASCII –8	N/A	ASCII string	
clk_divider	70	*Clock divider.* Value that exciter ranging reference frequency is divided by to get PN chip rate.	Unsigned Integer –1	N/A	1 to 64	20
len_seq1	71	*Sequence #1 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 8	21
len_seq2	72	*Sequence #2 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 16	21
len_seq3	73	*Sequence #3 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 16	21
len_seq4	74	*Sequence #4 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 32	21
len_seq5	75	*Sequence #5 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 32	21
len_seq6	76	*Sequence #6 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 32	21
def_seq1	77	*Sequence #1 component value.* Definition of the sequence.	Unsigned Integer –1	N/A	0 to 2^8-1	21
def_seq2	78	*Sequence #2 component value.* Definition of the sequence.	Unsigned Integer –2	N/A	0 to 2^{16}-1	21
def_seq3	80	*Sequence #3 component value.* Definition of the sequence.	Unsigned Integer –2	N/A	0 to 2^{16}-1	21
def_seq4	82	*Sequence #4 component value.* Definition of the sequence.	Unsigned Integer –4	N/A	0 to 2^{32}-1	21
def_seq5	86	*Sequence #5 component value.* Definition of the sequence.	Unsigned Integer –4	N/A	0 to 2^{32}-1	21
def_seq6	90	*Sequence #6 component value.* Definition of the sequence.	Unsigned Integer –4	N/A	0 to 2^{32}-1	21
pn_code_length	94	*Code Length.*	Unsigned Integer –4	PN chips / 1 chip	2 to 11000000	22
transmit_inphs_time_year	98	*Transmit In-phase time – year.* Year of the time of zero phase on uplink range generation.	Unsigned Integer –2	N/A	1958 to 3000	75

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
transmit_inphs_time_doy	100	*Transmit In-phase time – day of year.* Day of year of the time of zero phase on uplink range generation.	Unsigned Integer –2	N/A	1 to 366	75
transmit_inphs_time_sec	102	*Transmit In-phase time – seconds of day.* Seconds of day of the time of zero phase on uplink range generation.	IEEE Double	Seconds / 1 μsec	0.000000 to 86,400.999 999	75
carr_sup_rng_modul	110	*Carrier Suppression by ranging modulation.* Reduction in carrier power due to ranging modulation.	IEEE Single	dB / 0.1 dB	-15.0 to 0.0	
rng_modul_amp	114	*Ranging modulation amplitude.* Actual digital modulation amplitude used by the ranging hardware.	Unsigned Integer –2	N/A	0 to 2^{12}	
exc_scalar_num	116	*Exciter Scalar Numerator.* Numerator of multiplier that is used to generate ranging reference signal from uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
exc_scalar_den	120	*Exciter Scalar Denominator.* Denominator of multiplier that is used to generate ranging reference signal from uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
rng_cycle_time	124	*Ranging cycle time.* Time to complete one cycle of ranging code.	IEEE Double	Range Units / 0.01 RU	0.0 to 1.0e9	23,24
time_tag_corr_flag	132	*Time tag correction flag.* Indicates results of validation of the block time tag. 0 => no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
type_time_corr_flag	133	*Type of time tag correction flag.* Indicates what type of time tag correction was made. 0 => no correction 1 => Year correction 2 => DOY correction 3 => Both Year and DOY correction	Unsigned Integer –1	N/A	0 to 3	
clock_waveform	134	*Clock waveform type.* 0 => squarewave 1 => sinewave	Unsigned Integer -1	N/A	0 or 1	
reserve1	135	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	

3.1.5.1.4 Ramp CHDO (Data Type 9)

The Ramp CHDO is generated only when **ramp_type** equals 0, 1, 4, or 5, and is defined in Table 3-12.

Table 3-12. Ramp CHDO (Data Type 9) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the ramp data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the ramp data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	38	
ul_hi_phs_cycles	4	*High part uplink phase data whole cycles.* Phase at time tag.	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
ul_lo_phs_cycles	8	*Low part uplink phase data whole cycles.* Phase at time tag.	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8
ul_frac_phs_cycles	12	*Fractional part uplink phase data cycles.* Phase at time tag.	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
ramp_freq	16	*Ramp frequency.* Precision varies with band (phase data gives higher precision). A value of 0.0 indicates an invalid or unknown value. S-band => 0.5 μHz X-band => 1.6 μHz Ka-band => 7.7 μHz	IEEE Double	Sky level Hz, at least 7.7 μHz precision (band dependent)	0.0, 2.0e9 to 34.7e9	
ramp_rate	24	*Ramp rate.*	IEEE Double	Sky level Hz/sec, μHz/sec precision	-3.2e5 to 3.2e5	
ramp_type	32	*Ramp type.* 0 => snap 1 => start of new ramp 4=> end of ramps 5 => ramping terminated by operator	Unsigned Integer –1	N/A	0 to 5	
reserve1	33	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
reserve8	34	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.2 Downlink Data CHDOs

There are three Downlink Data CHDOs: Downlink Carrier Phase (data type 1), Downlink Sequential Ranging Phase (data type 3), and Downlink PN Ranging Phase (data type 5). Their formats and contents are specified in sections 3.1.5.2.1 to 3.1.5.2.3.

3.1.5.2.1 Downlink Carrier Phase CHDO (Data Type 1)

The Downlink Carrier Phase CHDO is defined in Table 3-13.

Table 3-13. Downlink Carrier Phase CHDO (Data Type 1) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the downlink carrier phase data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the downlink carrier phase data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	228	
carr_loop_bw	4	*Carrier tracking loop bandwidth.*	IEEE Single	Hz / 1 mHz	0.1 to 50.0	
pcn0	8	*Pc/N0.* Carrier power to noise spectral density ratio. Has a value of –300.0 if no signal.	IEEE Single	dB-Hz / 0.1 dB-Hz	0.0 to 90.0, -300.0	
pcn0_resid	12	*Pc/N0 residual.* Actual value minus predicted value.	IEEE Single	dB-Hz / 0.1 dB-Hz	-90.0 to 90.0	
pdn0	16	*Pd/N0.* Data power to noise spectral density ratio. Has a value of –300.0 if no signal.	IEEE Single	dB-Hz / 0.1 dB-Hz	0.0 to 90.0, -300.0	25
pdn0_resid	20	*Pd/N0 residual.* Actual value minus predicted value.	IEEE Single	dB-Hz / 0.1 dB-Hz	-90.0 to 90.0	
system_noise_temp	24	*System Noise Temperature.*	IEEE Single	k (degrees kelvin) / 0.1 k	0.1 to 2000.0	
phs_hi_0	28	*Raw phase sample 0 – High part phase data whole cycles.* (time tag + 0.0 sec)	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
phs_lo_0	32	*Raw phase sample 0 – Low part phase data whole cycles.* (time tag + 0.0 sec)	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
phs_frac_0	36	*Raw phase sample 0 – Fractional part phase data cycles.* (time tag + 0.0 sec)	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
phs_hi_1	40	*Raw phase sample 1 – High part phase data whole cycles.* (time tag + 0.1 sec)	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
phs_lo_1	44	*Raw phase sample 1 – Low part phase data whole cycles.* (time tag + 0.1 sec)	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8
phs_frac_1	48	*Raw phase sample 1 – Fractional part phase data cycles.* (time tag + 0.1 sec)	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
phs_hi_2	52	*Raw phase sample 2 – High part phase data whole cycles.* (time tag + 0.2 sec)	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
phs_lo_2	56	*Raw phase sample 2 – Low part phase data whole cycles.* (time tag + 0.2 sec)	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8
phs_frac_2	60	*Raw phase sample 2 – Fractional part phase data cycles.* (time tag + 0.2 sec)	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
phs_hi_3	64	*Raw phase sample 3 – High part phase data whole cycles.* (time tag + 0.3 sec)	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
phs_lo_3	68	*Raw phase sample 3 – Low part phase data whole cycles.* (time tag + 0.3 sec)	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
phs_frac_3	72	*Raw phase sample 3 – Fractional part phase data cycles.* (time tag + 0.3 sec)	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
phs_hi_4	76	*Raw phase sample 4 – High part phase data whole cycles.* (time tag + 0.4 sec)	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
phs_lo_4	80	*Raw phase sample 4 – Low part phase data whole cycles.* (time tag + 0.4 sec)	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8
phs_frac_4	84	*Raw phase sample 4 – Fractional part phase data cycles.* (time tag + 0.4 sec)	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
phs_hi_5	88	*Raw phase sample 5 – High part phase data whole cycles.* (time tag + 0.5 sec)	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
phs_lo_5	92	*Raw phase sample 5 – Low part phase data whole cycles.* (time tag + 0.5 sec)	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8
phs_frac_5	96	*Raw phase sample 5 – Fractional part phase data cycles.* (time tag + 0.5 sec)	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
phs_hi_6	100	*Raw phase sample 6 – High part phase data whole cycles.* (time tag + 0.6 sec)	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
phs_lo_6	104	*Raw phase sample 6 – Low part phase data whole cycles.* (time tag + 0.6 sec)	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
phs_frac_6	108	*Raw phase sample 6 – Fractional part phase data cycles.* (time tag + 0.6 sec)	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
phs_hi_7	112	*Raw phase sample 7 – High part phase data whole cycles.* (time tag + 0.7 sec)	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
phs_lo_7	116	*Raw phase sample 7 – Low part phase data whole cycles.* (time tag + 0.7 sec)	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8
phs_frac_7	120	*Raw phase sample 7 – Fractional part phase data cycles* (time tag + 0.7 sec)	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
phs_hi_8	124	*Raw phase sample 8 – High part phase data whole cycles.* (time tag + 0.8 sec)	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
phs_lo_8	128	*Raw phase sample 8 – Low part phase data whole cycles.* (time tag + 0.8 sec)	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8
phs_frac_8	132	*Raw phase sample 8 – Fractional part phase data cycles.* (time tag + 0.8 sec)	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
phs_hi_9	136	*Raw phase sample 9 – High part phase data whole cycles.* (time tag + 0.9 sec)	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
phs_lo_9	140	*Raw phase sample 9 – Low part phase data whole cycles.* (time tag + 0.9 sec)	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
phs_frac_9	144	*Raw phase sample 9 – Fractional part phase data cycles.* (time tag + 0.9 sec)	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
phs_hi_avg	148	*Averaged phase sample – High part phase data whole cycles.* One-second average, centered around time tag.	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8
phs_lo_avg	152	*Averaged phase sample – Low part phase data whole cycles.* One-second average, centered around time tag.	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8
phs_frac_avg	156	*Averaged phase sample – Fractional part phase data cycles.* One-second average, centered around time tag.	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8
dl_freq	160	*Downlink frequency.* Frequency at the time tag.	IEEE Double	Sky level Hz / 1 mHz	2.2e9 to 32.3e9	
dop_resid	168	*Doppler residual.* Negative of frequency residual.	IEEE Single	Sky level Hz / 1 mHz	-1.0e6 to 1.0e6	
dop_noise	172	*Doppler noise.* Averaged over 10 points in record.	IEEE Single	Hz / 1 mHz	0.0 to 1000.0	26
slipped_cycles	176	*Slipped cycles.*	Integer –4	N/A	-10 to 10	31
carr_loop_type	180	*Carrier loop type.*	Unsigned Integer –1	N/A	1 to 3	53
snt_flag	181	*SNT measurement flag.* 0 => SNT value is the predicted value 1 => SNT value is the measured value	Unsigned Integer –1	N/A	0 or 1	
carr_resid_wt	182	*Carrier residual weight.* (Weight value applied to residual phase error in carrier tracking; suppressed carrier weight is 1.0 minus this value.)	IEEE Single	N/A	0.0 to 1.0	27
sup_data_id	186	*Support data ID.* Name of the frequency predicts set used.	ASCII –8	N/A	ASCII String	
sup_data_rev	194	*Support data revision.* Revision of the frequency predicts set used.	ASCII –8	N/A	ASCII String	
prdx_time_offset	202	*Predicts time offset.* Seconds added to current time.	IEEE Double	Seconds / 1 msec	-8.64e4 to 8.64e4	54

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
prdx_freq_offset	210	*Predicts frequency offset.* Hz added to predicted value.	IEEE Double	Hz / 1 mHz	-1.0e6 to 1.0e6	55
carr_resid_tol_flag	218	*Carrier residual tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer –1	N/A	0 or 1	62
time_tag_corr_flag	219	*Time tag correction flag.* Indicates results of validation of the block time tag. 0 => no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
type_time_corr_flag	220	*Type of time tag correction flag.* Indicates what type of time tag correction was made. 0 => no correction 1 => Year correction 2 => DOY correction 3 => Both Year and DOY correction	Unsigned Integer –1	N/A	0 to 3	
dop_mode_corr_flag	221	*Doppler mode correction flag.* Indicates the results of the validation of the doppler mode. 0 => not applicable or no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
ul_stn_corr_flag	222	*Uplink station correction flag.* Indicates the results of the validation of the uplink station. 0 => not applicable or no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
reserve1	223	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
reserve8	224	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.2.2 Downlink Sequential Ranging Phase CHDO (Data Type 3)

The Downlink Sequential Ranging Phase CHDO is defined in Table 3-14.

Table 3-14. Downlink Sequential Ranging Phase CHDO (Data Type 3) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the downlink sequential ranging phase data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10 (CHDO contains binary data)	
chdo_length	2	*Length attribute of the downlink sequential ranging phase data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	174	
stn_cal	4	*Station calibration value.* (Two-way). Value includes the equipment in the path, but not the Z-height correction. (0.0 if not measured.)	IEEE Double	Range Units / 0.01 RU	0.0 to 1.8e5	24
dl_stn_cal	12	*Downlink station calibration value.* Value includes the downlink equipment in the path, but not the Z-height correction. (0.0 if not measured.)	IEEE Double	Range Units / 0.01 RU	0.0 to 1.8e5	10,24
dl_cal_freq	20	*Downlink calibration frequency.* Frequency the calibration was done at.	IEEE Double	Sky level Hz / 1 mHz	2.2e9 to 32.3e9	
cal_std_dev	28	*Standard deviation of station calibration value.* For stn_cal and dl_stn_cal.	IEEE Single	Range Units / 0.01 RU	0.0 to 1.8e5	24
cal_pts	32	*Calibration points.* Number of measurements made in computing station calibration values (stn_cal, dl_stn_cal, and cal_std_dev).	Unsigned Integer –2	N/A	0 to 65,535	
dl_rng_phs	34	*Measured range phase.* Range phase.	IEEE Double	Range Units / 0.01 RU	0.0 to 2^{30}	11,24
figure_merit	42	*Figure of Merit.* Rating of the measured range value.	IEEE Single	Percentage / 0.1 percent	0.0 to 100.0	28
rng_resid	46	*Range residual.* Measured range minus predicted range.	IEEE Double	Range Units / 0.01 RU	-2^{30} to 2^{30}	29
drvid	54	*DRVID.* DRVID measured using phase data from carrier.	IEEE Double	Range Units / 0.01 RU	-2^{30} to 2^{30}	30, 81
rtlt	62	*Round trip light time.* Predicted value.	IEEE Single	Seconds / 0.1 sec	0.0 to 86,400.0	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
pcn0	66	*Pc/N0.* Carrier power to noise spectral density ratio. Has a value of –300.0 if no signal.	IEEE Single	dB-Hz / 0.1 dB-Hz	0.0 to 90.0, -300.0	
pcn0_resid	70	*Pc/N0 residual.* Actual value minus predicted value.	IEEE Single	dB-Hz / 0.1 dB-Hz	-90.0 to 90.0	
pdn0	74	*Pd/N0.* Data power to noise spectral density ratio. Has a value of –300.0 if no signal.	IEEE Single	dB-Hz / 0.1 dB-Hz	0.0 to 90.0, -300.0	25
pdn0_resid	78	*Pd/N0 residual.* Actual value minus predicted value.	IEEE Single	dB-Hz / 0.1 dB-Hz	-90.0 to 90.0	
prn0	82	*Pr/N0.* Ranging power to noise spectral density ratio. Has a value of –300.0 if no signal.	IEEE Single	dB-Hz / 0.1 dB-Hz	-10.0 to 90.0, -300.0	
prn0_resid	86	*Pr/N0 residual.* Actual value minus predicted value.	IEEE Single	dB-Hz / 0.1 dB-Hz	-90.0 to 90.0	
system_noise_temp	90	*System Noise Temperature.*	IEEE Single	K (degrees Kelvin) / 0.1 K	0.1 to 2000.0	
carr_loop_type	94	*Carrier loop type.*	Unsigned Integer –1	N/A	1 to 3	53
snt_flag	95	*SNT measurement flag.* 0 => SNT value is the predicted value 1 => SNT value is the measured value	Unsigned Integer –1	N/A	0 or 1	
carr_resid_wt	96	*Carrier residual weight.* (Weight value applied to residual phase error in carrier tracking; suppressed carrier weight is 1.0 minus this value.)	IEEE Single	N/A	0.0 to 1.0	27
template_id	100	*Template ID.* Value is the file name of the ranging parameter file.	ASCII –8	N/A	ASCII string	
invert	108	*Invert.* Inverted implies that the polarity of the correlation reference is the invert of what was transmitted. 0 => not inverted 1 => inverted	Unsigned Integer –1	N/A	0 or 1	52
correl_type	109	*Correlation type.* 0 => squarewave 1 => sinewave	Unsigned Integer –1	N/A	0 or 1	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
t1	110	*T1 setting.*	Unsigned Integer –2	Seconds / 1 sec	1 to 3600	12
t2	112	*T2 setting.*	Unsigned Integer –2	Seconds / 1 sec	1 to 1800	13
t3	114	*T3 setting.*	Unsigned Integer –2	Seconds / 1 sec	0 to 1800	14
first_comp_num	116	*First component number.*	Unsigned Integer –1	N/A	1 to 24	15
last_comp_num	117	*Last component number.*	Unsigned Integer –1	N/A	1 to 24	15
chop_comp_num	118	*Chop component number.* This is the component used to chop the other components.	Unsigned Integer –1	N/A	0 to 10	15, 16
num_drvid	119	*Number of DRVID measurements.*	Unsigned Integer –1	N/A	0 to 255	
rcv_inphs_time_year	120	*Receive In-phase time – year.* Year of the time of zero phase on downlink range signal correlation.	Unsigned Integer –2	N/A	1958 to 3000	75
rcv_inphs_time_doy	122	*Receive In-phase time – day of year.* Day of year of the time of zero phase on downlink range signal correlation.	Unsigned Integer –2	N/A	1 to 366	75
rcv_inphs_time_sec	124	*Receive In-phase time – seconds of day.* Seconds of day of the time of zero phase on downlink range signal correlation.	IEEE Double	Seconds / 1 μsec	0.000000 to 86,400.999999	75
exc_scalar_num	132	*Exciter Scalar Numerator.* Numerator of multiplier that is used to generate ranging reference signal from uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
exc_scalar_den	136	*Exciter Scalar Denominator.* Denominator of multiplier that is used to generate ranging reference signal from uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
rng_cycle_time	140	*Ranging cycle time.* Time to complete one cycle of the ranging code.	IEEE Double	Seconds / 0.1 sec	4.0 to 504,536.0	18
inphs_correl	148	*In phase correlation value.* The in phase value of the clock component correlation.	IEEE Single	N/A	-1.0 to 1.0	
quad_phs_correl	152	*Quadrature phase correlation value.* The quadrature phase value of the clock component correlation.	IEEE Single	N/A	-1.0 to 1.0	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
metrics_vld_flag	156	*Metrics validity flag.* Validity of the Range Residual (rng_resid) and DRVID (drvid) measurements. 0 => Invalid (No uplink data available) 1 => Invalid (Other reasons) 2 => Valid	Unsigned Integer –1	N/A	0 to 2	70
correl_vld_flag	157	*Correlation validity flag.* 0 => Invalid 1 => Valid	Unsigned Integer –1	N/A	0 or 1	56
rng_resid_tol_flag	158	*Range residual tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer –1	N/A	0 or 1	63
drvid_tol_flag	159	*DRVID tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer –1	N/A	0 or 1	64
prn0_resid_tol_flag	160	*Pr/N0 residual tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer –1	N/A	0 or 1	65
rng_sigma_tol_flag	161	*Range sigma tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer –1	N/A	0 or 1	66
rng_vld_flag	162	*Range validity flag.* 0 => Invalid 1 => Valid	Unsigned Integer –1	N/A	0 or 1	67
rng_config_flag	163	*Range configuration change flag.* 0 => Changed 1 => Unchanged	Unsigned Integer –1	N/A	0 or 1	68
rng_hw_flag	164	*Ranging hardware status flag.* 0 => Bad 1 => Good	Unsigned Integer –1	N/A	0 or 1	
time_tag_corr_flag	165	*Time tag correction flag.* Indicates results of validation of the block time tag. 0 => no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
type_time_corr_flag	166	*Type of time tag correction flag.* Indicates what type of time tag correction was made. 0 => no correction 1 => Year correction 2 => DOY correction 3 => Both Year and DOY correction	Unsigned Integer –1	N/A	0 to 3	
dop_mode_corr_flag	167	*Doppler mode correction flag.* Indicates the results of the validation of the doppler mode. 0 => not applicable or no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
ul_stn_corr_flag	168	*Uplink station correction flag.* Indicates the results of the validation of the uplink station. 0 => not applicable or no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
chop_start_num	169	*Chop Start.* The first component chopped.	Unsigned Integer –1	N/A	0 to 25	16
reserve8	170	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.2.3 Downlink PN Ranging Phase CHDO (Data Type 5)

The Downlink PN Ranging Phase CHDO is defined in Table 3-15.

Table 3-15. Downlink PN Ranging Phase CHDO (Data Type 5) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the downlink PN ranging phase data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the downlink PN ranging phase data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	202	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
stn_cal	4	*Station calibration value.* (Two-way) Value includes the equipment in the path, but not the Z-height correction. (0.0 if not measured.)	IEEE Double	Range Units / 0.01 RU	0.0 to 1.8e5	24
dl_stn_cal	12	*Downlink station calibration value.* Value includes the downlink equipment in the path, but not the Z-height correction. (0.0 if not measured.)	IEEE Double	Range Units / 0.01 RU	0.0 to 1.8e5	10, 24
dl_cal_freq	20	*Downlink calibration frequency.* Frequency the calibration was done at.	IEEE Double	Sky level Hz / 1 mHz	2.2e9 to 32.3e9	
cal_std_dev	28	*Standard deviation of station calibration value.* For stn_cal and dl_stn_cal.	IEEE Single	Range Units / 0.01 RU	0.0 to 1.8e5	24
cal_pts	32	*Calibration points.* Number of measurements made in computing station calibration values (stn_cal, dl_stn_cal, and cal_std_dev).	Unsigned Integer –2	N/A	0 to 65,535	
dl_rng_phs	34	*Measured range phase.* Range phase.	IEEE Double	Range Units / 0.01 RU	0.0 to 2^{30}	11, 24
figure_merit	42	*Figure of Merit.* Rating of the measured range value.	IEEE Single	Percentage / 0.1 percent	0.0 to 100.0	28
rng_resid	46	*Range residual.* Measured range minus predicted range.	IEEE Double	Range Units / 0.01 RU	-2^{30} to 2^{30}	29
drvid	54	*DRVID.* DRVID measured using doppler data from carrier.	IEEE Double	Range Units / 0.01 RU	-2^{30} to 2^{30}	30
rtlt	62	*Round trip light time.* Predicted value.	IEEE Single	Seconds / 0.1 sec	0.0 to 86,400.0	
pcn0	66	*Pc/N0.* Carrier power to noise spectral density ratio. Has a value of -300.0 if no signal.	IEEE Single	dB-Hz / 0.1 dB-Hz	0.0 to 90.0, -300.0	
pcn0_resid	70	*Pc/N0 residual.* Actual value minus predicted value.	IEEE Single	dB-Hz / 0.1 dB-Hz	-90.0 to 90.0	
pdn0	74	*Pd/N0.* Data power to noise spectral density ratio. Has a value of -300.0 if no signal.	IEEE Single	dB-Hz / 0.1 dB-Hz	0.0 to 90.0, -300.0	25
pdn0_resid	78	*Pd/N0 residual.* Actual value minus predicted value.	IEEE Single	dB-Hz / 0.1 dB-Hz	-90.0 to 90.0	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
prn0	82	*Pr/N0.* Ranging power to noise spectral density ratio. Has a value of –300.0 if no signal.	IEEE Single	dB-Hz / 0.1 dB-Hz	-10.0 to 90.0, -300.0	
prn0_resid	86	*Pr/N0 residual.* Actual value minus predicted value.	IEEE Single	dB-Hz / 0.1 dB-Hz	-90.0 to 90.0	
system_noise_temp	90	*System Noise Temperature.*	IEEE Single	K (degrees Kelvin) / 0.1 K	0.1 to 2000.0	
state_seq1	94	*Sequence #1 code state.* Position in the sequence at the time tag.	Unsigned Integer –1	N/A	0 to 7	19
state_seq2	95	*Sequence #2 code state.* Position in the sequence at the time tag.	Unsigned Integer –1	N/A	0 to 15	19
state_seq3	96	*Sequence #3 code state.* Position in the sequence at the time tag.	Unsigned Integer –1	N/A	0 to 15	19
state_seq4	97	*Sequence #4 code state.* Position in the sequence at the time tag.	Unsigned Integer –1	N/A	0 to 31	19
state_seq5	98	*Sequence #5 code state.* Position in the sequence at the time tag.	Unsigned Integer –1	N/A	0 to 31	19
state_seq6	99	*Sequence #6 code state.* Position in the sequence at the time tag.	Unsigned Integer –1	N/A	0 to 31	19
pn_clk_phs	100	*PN chip clock phase.* Position in the chip at the time tag.	IEEE Double	Cycles / 1 μcycle	0.0 to 1.0	19
carr_loop_type	108	*Carrier loop type.*	Unsigned Integer –1	N/A	1 to 3	53
snt_flag	109	*SNT measurement flag.* 0 => SNT value is the predicted value 1 => SNT value is the measured value	Unsigned Integer –1	N/A	0 or 1	
carr_resid_wt	110	*Carrier residual weight.* (Weight value applied to residual phase error in carrier tracking; suppressed carrier weight is 1.0 minus this value.)	IEEE Single	N/A	0.0 to 1.0	27
template_id	114	*Template ID.* Value is the file name of the ranging parameter file.	ASCII –8	N/A	ASCII string	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
invert	122	*Invert.* Inverted implies that the polarity of the correlation reference is the invert of what was transmitted. 0 => not inverted 1 => inverted	Unsigned Integer –1	N/A	0 or 1	52
correl_type	123	*Correlation type.* 0 => squarewave 1 => sinewave	Unsigned Integer –1	N/A	0 or 1	
int_time	124	*Integration time.* Time, in PN cycle periods, that the signal was integrated over.	Unsigned Integer –4	Number of PN cycle periods / 1 period	1 to 2^{32} –1	
clk_divider	128	*Clock divider.* Value that ranging reference frequency is divided by to get chip rate.	Unsigned Integer –1	N/A	1 to 64	20
len_seq1	129	*Sequence #1 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 8	21
len_seq2	130	*Sequence #2 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 16	21
len_seq3	131	*Sequence #3 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 16	21
len_seq4	132	*Sequence #4 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 32	21
len_seq5	133	*Sequence #5 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 32	21
len_seq6	134	*Sequence #6 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 32	21
def_seq1	135	*Sequence #1 component value.* Definition of the sequence.	Unsigned Integer –1	N/A	0 to 2^8-1	21
def_seq2	136	*Sequence #2 component value.* Definition of the sequence.	Unsigned Integer –2	N/A	0 to 2^{16}-1	21
def_seq3	138	*Sequence #3 component value.* Definition of the sequence.	Unsigned Integer –2	N/A	0 to 2^{16}-1	21
def_seq4	140	*Sequence #4 component value.* Definition of the sequence.	Unsigned Integer –4	N/A	0 to 2^{32}-1	21
def_seq5	144	*Sequence #5 component value.* Definition of the sequence.	Unsigned Integer –4	N/A	0 to 2^{32}-1	21
def_seq6	148	*Sequence #6 component value.* Definition of the sequence.	Unsigned Integer –4	N/A	0 to 2^{32}-1	21

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
pn_code_length	152	*PN Code Length.*	Unsigned Integer –4	PN chips / 1 chip	2 to 11,000,000	22
rcv_inphs_time_year	156	*Receive In-phase time – year.* Year of the time of zero phase on downlink range signal correlation.	Unsigned Integer –2	N/A	1958 to 3000	75
rcv_inphs_time_doy	158	*Receive In-phase time – day of year.* Day of year of the time of zero phase on downlink range signal correlation.	Unsigned Integer –2	N/A	1 to 366	75
rcv_inphs_time_sec	160	*Receive In-phase time – seconds of day.* Seconds of day of the time of zero phase on downlink range generation.	IEEE Double	Seconds / 1 μsec	0.000000 to 86,400.999 999	75
exc_scalar_num	168	*Exciter Scalar Numerator.* Numerator of multiplier that is used to generate ranging reference signal from uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
exc_scalar_den	172	*Exciter Scalar Denominator.* Denominator of multiplier that is used to generate ranging reference signal from uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
rng_cycle_time	176	*Ranging cycle time.* Time to complete one cycle of ranging code.	IEEE Double	Range Units / 0.01 RU	0.0 to 1.0e9	23, 24
inphs_correl	184	*In phase correlation value.* The in phase value of the clock component correlation.	IEEE Single	N/A	-1.0 to 1.0	
quad_phs_correl	188	*Quadrature phase correlation value.* The quadrature phase value of the clock component correlation.	IEEE Single	N/A	-1.0 to 1.0	
metrics_vld_flag	192	*Metrics validity flag.* Validity of the Range Residual (rng_resid) and DRVID (drvid) measurements. 0 => Invalid (No uplink data available) 1 => Invalid (Other reasons) 2 => Valid	Unsigned Integer –1	N/A	0 to 2	70
correl_vld_flag	193	*Correlation validity flag.* 0 => Invalid 1 => Valid	Unsigned Integer –1	N/A	0 or 1	56
rng_resid_tol_flag	194	*Range residual tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer –1	N/A	0 or 1	63

Identifier	**Byte Offset**	**Item Name and Description**	**Format**	**Units/ Precision**	**Range**	**Notes**
drvid_tol_flag	195	*DRVID tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer –1	N/A	0 or 1	64
prn0_resid_tol_flag	196	*Pr/N0 residual tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer –1	N/A	0 or 1	65
rng_sigma_tol_flag	197	*Range sigma tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer –1	N/A	0 or 1	66
rng_vld_flag	198	*Range validity flag.* 0 => Invalid 1 => Valid	Unsigned Integer –1	N/A	0 or 1	67
rng_config_flag	199	*Range configuration change flag.* 0 => Changed 1 => Unchanged	Unsigned Integer –1	N/A	0 or 1	68
rng_hw_flag	200	*Ranging hardware status flag.* 0 => Bad 1 => Good	Unsigned Integer –1	N/A	0 or 1	
time_tag_corr_flag	201	*Time tag correction flag.* Indicates results of validation of the block time tag. 0 => no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
type_time_corr_flag	202	*Type of time tag correction flag.* Indicates what type of time tag correction was made. 0 => no correction 1 => Year correction 2 => DOY correction 3 => Both Year and DOY correction	Unsigned Integer –1	N/A	0 to 3	
dop_mode_corr_flag	203	*Doppler mode correction flag.* Indicates the results of the validation of the doppler mode. 0 => not applicable or no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
ul_stn_corr_flag	204	*Uplink station correction flag.* Indicates the results of the validation of the uplink station. 0 => not applicable or no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
reserve1a	205	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	

3.1.5.3 Derived Data CHDOs

There are seven derived data CHDOs: Doppler Count (data type 6), Sequential Range (data type 7), Angle (data type 8), DRVID (data type 11), PN Range (data type 14), Tone Range (data type 15), Carrier Frequency Observable (data type 16), and Total Count Phase Observable (data type 17). Their formats and contents are specified in sections 3.1.5.3.1 to 3.1.5.3.7.

3.1.5.3.1 Doppler Count CHDO (Data Type 6)

The Doppler Count CHDO is defined in Table 3-16.

Table 3-16. Doppler Count CHDO (Data Type 6) Definitions

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the Doppler Count data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the Doppler Count data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	176	
ref_rcv_type	4	*Reference receiver type.* 0 => Unknown 1 => DTT 2 => MFR	Unsigned Integer –1	N/A	0 to 2	
sampl_interval	5	*Sample interval.* 1 => 0.1 second 2 => 1 second (non-UPL-DTT) 3 => 10 seconds (non-UPL-DTT) 4 => 60 seconds (non-UPL-DTT)	Unsigned Integer –1	N/A	1 to 4	84
reserve1a	6	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
carr_vld_flag	7	*Received carrier validity indicator.* 0 => Invalid Doppler 1 => Valid Doppler	Unsigned Integer-1	N/A	0 or 1	69
dop_noise	8	*Doppler noise.* Invalid for non-DTT antennas; indicated by value of -1.0.	IEEE Single	Hz / 1 mHz	-1.0, 0.0 to 1000.0	26

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
slipped_cycles _vld_flag	12	*Slipped cycles validity flag.* 0 => Invalid 1 => Valid	Unsigned Integer –1	N/A	0 or 1	
delta_ff_vld_fl ag	13	*Delta-f/f validity flag.* 0 => Invalid 1 => Valid	Unsigned Integer –1	N/A	0 or 1	
delta_ff	14	*Delta-f/f.* Valid only for UPL-DTT antennas.	IEEE Double	N/A	-1.0 to 1.0	32
slipped_cycles	22	*Slipped cycles.* Number of detected slipped cycles at time tag. Valid only for UPL-DTT antennas.	Integer –4	Number of cycles / 1 cycle	-10,000 to 10,000	31
rcv_sig_lvl	26	*Received signal level.* Carrier power or data power (if suppressed carrier tracking). (-300.0 if not valid.)	IEEE Single	dBm / 0.1 dBm	-300.0, -190.0 to –45.0	58
ul_freq	30	*Uplink frequency.* Uplink frequency value used in the Doppler computation at time tag. For UPL-DTT antennas, it is determined by the downlink frequency. Otherwise, depends on antenna configuration.	IEEE Double	Hz / 1 mHz	2.0e9 to 34.7e9	34
dop_cnt_bias _freq	38	*Doppler count bias frequency.*	IEEE Double	Hz / 1 mHz	-240.0e3 to 10.0e6	34
dop_cnt_hi_0	46	*Doppler Count 0 – High part phase data whole cycles.*	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt_lo_0	50	*Doppler Count 0 – Low part phase data whole cycles.*	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt_frac_0	54	*Doppler Count 0 – Fractional part phase data cycles.*	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _hi_1	58	*Doppler Count 1 – High part phase data whole cycles.* (time tag + 0.1 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _lo_1	62	*Doppler Count 1 – Low part phase data whole cycles.* (time tag + 0.1 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8, 34, 85

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
dop_cnt _frac_1	66	*Doppler Count 1 – Fractional part phase data cycles.* (time tag + 0.1 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _hi_2	70	*Doppler Count 2 – High part phase data whole cycles.* (time tag + 0.2 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _lo_2	74	*Doppler Count 2 – Low part phase data whole cycles.* (time tag + 0.2 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _frac_2	78	*Doppler Count 2 – Fractional part phase data cycles.* (time tag + 0.2 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _hi_3	82	*Doppler Count 3 – High part phase data whole cycles.* (time tag + 0.3 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _lo_3	86	*Doppler Count 3 – Low part phase data whole cycles.* (time tag + 0.3 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _frac_3	90	*Doppler Count 3 – Fractional part phase data cycles.* (time tag + 0.3 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _hi_4	94	*Doppler Count 4 – High part phase data whole cycles.* (time tag + 0.4 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _lo_4	98	*Doppler Count 4 – Low part phase data whole cycles.* (time tag + 0.4 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8, 34, 85

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
dop_cnt _frac_4	102	*Doppler Count 4 – Fractional part phase data cycles.* (time tag + 0.4 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _hi_5	106	*Doppler Count 5 – High part phase data whole cycles.* (time tag + 0.5 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _lo_5	110	*Doppler Count 5 – Low part phase data whole cycles.* (time tag + 0.5 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _frac_5	114	*Doppler Count 5 – Fractional part phase data cycles.* (time tag + 0.5 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _hi_6	118	*Doppler Count 6 – High part phase data whole cycles.* (time tag + 0.6 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _lo_6	122	*Doppler Count 6 – Low part phase data whole cycles.* (time tag + 0.6 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _frac_6	126	*Doppler Count 6 – Fractional part phase data cycles.* (time tag + 0.6 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _hi_7	130	*Doppler Count 7 – High part phase data whole cycles.* (time tag + 0.7 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _lo_7	134	*Doppler Count 7 – Low part phase data whole cycles.* (time tag + 0.7 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8, 34, 85

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
dop_cnt _frac_7	138	*Doppler Count 7 – Fractional part phase data cycles* (time tag + 0.7 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _hi_8	142	*Doppler Count 8 – High part phase data whole cycles.* (time tag + 0.8 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _lo_8	146	*Doppler Count 8 – Low part phase data whole cycles.* (time tag + 0.8 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _frac_8	150	*Doppler Count 8 – Fractional part phase data cycles.* (time tag + 0.8 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _hi_9	154	*Doppler Count 9 – High part phase data whole cycles.* (time tag + 0.9 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _lo_9	158	*Doppler Count 9 – Low part phase data whole cycles.* (time tag + 0.9 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8, 34, 85
dop_cnt _frac_9	162	*Doppler Count 9 – Fractional part phase data cycles.* (time tag + 0.9 sec) Zero if non-UPL-DTT antenna.	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8, 34, 85
time_tag_corr_ flag	166	*Time tag correction flag.* Indicates the results of validation of the block time tag. 0 => no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
type_time_corr_flag	167	*Type of time tag correction flag.* Indicates what type of time tag correction was made. 0 => no correction 1 => Year correction 2 => DOY correction 3 => Both Year and DOY correction	Unsigned Integer –1	N/A	0 to 3	
dop_mode_corr_flag	168	*Doppler mode correction flag.* Indicates the results of validation of the doppler mode. 0 => not applicable or no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
ul_stn_corr_flag	169	*Uplink station correction flag.* Indicates the results of validation of the uplink station. 0 => not applicable or no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
dl_band_corr_flag	170	*Downlink frequency band correction flag.* Indicates the results of validation of downlink band for the 26m stations only. 0 => not applicable or no validation attempted 1 => validated, no change 2 => validated, changed	Unsigned Integer –1	N/A	0 to 2	
reserve1	171	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
reserve8	172	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.3.2Sequential Range CHDO (Data Type 7)

The Sequential Range CHDO is defined in Table 3-17.

Table 3-17. Sequential Range CHDO (Data Type 7) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the range data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the range data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	186	
ul_stn_cal	4	*Uplink station calibration value.* Invalid indicated by value of –1.0.	IEEE Double	Range Units / 0.01 RU	-1.0, 0.0 to 1.8e5	24, 40
dl_stn_cal	12	*Downlink station calibration value.* Invalid indicated by value of –1.0.	IEEE Double	Range Units / 0.01 RU	-1.0, 0.0 to 1.8e5	24, 41
meas_rng	20	*Measured range value.* Does not include compensation for station calibration and other adjustments. Invalid is indicated by value of -1.0.	IEEE Double	Range Units, modulo rng_modulo / 0.01 RU	-1.0, 0.0 to 2^{30}	24, 38
rng_obs	28	*Range observable.* Includes all measurement adjustments (station calibration, spacecraft delay, and Z-height). Invalid is indicated by value of -1.0.	IEEE Double	Range Units, modulo rng_modulo / 0.01 RU	-1.0, 0.0 to 2^{30}	24, 39
rng_obs_dl	36	*Downlink range observable.* Includes all measurement adjustments (station calibration, spacecraft delay, and Z-height). A value of -1.0 indicates invalid.	IEEE Double	Range Units, modulo rng_modulo / 0.01 RU	-1.0, 0.0 to 2^{30}	24, 76
clock_waveform	44	*Uplink clock waveform type.* 0 => squarewave 1 => sinewave	Unsigned Integer -1	N/A	0 or 1	
chop_start_num	45	*Chop Start.* The first component chopped.	Unsigned Integer –1	N/A	0 to 25	16
figure_merit	46	*Figure of Merit.* Rating of the measured range value.	IEEE Single	Percentage / 0.1 percent	0.0 to 100.0	28
drvid	50	*DRVID.* DRVID measured using phase data from carrier.	IEEE Double	Range Units / 0.01 RU	-2^{30} to 2^{30}	24, 30, 80
rtlt	58	*Round trip light time.* Predicted value.	IEEE Single	Seconds / 0.1 sec	0.0 to 86,400.0	
prn0	62	*Pr/N0.* Ranging power to noise spectral density ratio.	IEEE Single	dB-Hz / 0.1 dB-Hz	-10.0 to 90.0	
transmit_pwr	66	*Transmitter power.*	IEEE Single	W / 0.1 W	0.0 to 500,000.0	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
invert	70	*Invert.* Inverted implies that the polarity of the correlation reference is the invert of what was transmitted. 0 => not inverted 1 => inverted	Unsigned Integer –1	N/A	0 or 1	
correl_type	71	*Correlation type.* 0 => squarewave 1 => sinewave	Unsigned Integer –1	N/A	0 or 1	
t1	72	*T1 setting.*	Unsigned Integer –2	Seconds / 1 sec	1 to 3600	12
t2	74	*T2 setting.*	Unsigned Integer –2	Seconds / 1 sec	1 to 1800	13
t3	76	*T3 setting.*	Unsigned Integer –2	Seconds / 1 sec	0 to 1800	14
first_comp_num	78	*First component number.*	Unsigned Integer –1	N/A	1 to 24	15
last_comp_num	79	*Last component number.*	Unsigned Integer –1	N/A	1 to 24	15
chop_comp_num	80	*Chop component number.* This is the component used to chop the other components.	Unsigned Integer –1	N/A	0 to 10	15, 16
num_drvid	81	*Number of DRVID measurements.*	Unsigned Integer –1	N/A	0 to 255	
transmit_inphs _time	82	*Transmit In-phase time.* Offset from time tag of time of zero phase on uplink range signal generation.	IEEE Single	Seconds / 1 μsec	-86,400.0 00000 to 86,400.00 0000	59
rcv_inphs_time	86	*Receive In-phase time.* Offset from time tag of time of zero phase on downlink range signal correlation.	IEEE Single	Seconds / 1 μsec	-86,400.0 00000 to 86,400.00 0000	59
carr_sup_rng _modul	90	*Carrier suppression by ranging modulation.* Amount carrier power is reduced by ranging modulation.	IEEE Single	dB / 0.1 dB	-15.0 to 0.0	
exc_scalar_num	94	*Exciter Scalar Numerator.* Numerator of multiplier that is used to generate ranging reference signal from uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
exc_scalar_den	98	*Exciter Scalar Denominator.* Denominator of multiplier that is used to generate ranging reference signal from uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
rng_cycle_time	102	*Range cycle time.* Time, in seconds, of one complete cycle of the ranging signal.	IEEE Double	Seconds / 0.1 sec	4.0 to 504,536.0	18
rng_modulo	110	*Range modulo value.* Range measurement modulo (ambiguity).	Unsigned Integer –4	Range Units / 1 RU	1 to 2^{30}	37

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
inphs_correl	114	*In phase correlation value.* The in phase value of the clock component correlation.	IEEE Single	N/A	-1.0 to 1.0	
quad_phs_correl	118	*Quadrature phase correlation value.* The quadrature phase value of the clock component correlation.	IEEE Single	N/A	-1.0 to 1.0	
ul_freq	122	*Uplink frequency.* Uplink frequency at time tag.. Set to 0.0 if unavailable.	IEEE Double	Hz / 1 mHz	0.0, 2.0e9 to 34.4e9	42
rng_type	130	*Range measurement type.* Type of sequential measurement. 0 => Ranging measurement 1 => Calibration	Unsigned Integer –1	N/A	0 or 1	
reserve1a	131	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
rng_noise	132	*Range noise.* Invalid indicated by value of -1.0.	IEEE Single	Range Units / 0.01 RU	-1.0, 0.0 to 2^{30}	43
rng_prefit_resid	136	*Range pre-fit residual.* Observed range minus predicted range.	IEEE Double	Range Units / 0.01 RU	-2^{30} to 2^{30}	24, 29, 86
rng_dl_prefit_resid	144	*Downlink range pre-fit residual.* Observed range minus predicted range.	IEEE Double	Range Units / 0.01 RU	-2^{30} to 2^{30}	24, 29, 86
rng_prefit_resid_vld_flag	152	*Range pre-fit residual validity indicator.* 0 => Invalid pre-fit residual data 1 => Valid pre-fit residual data	Unsigned Integer-1	N/A	0 or 1	86
rng_dl_prefit_resid_vld_flag	153	*Downlink range pre-fit residual validity indicator.* 0 => Invalid pre-fit residual data 1 => Valid pre-fit residual data	Unsigned Integer-1	N/A	0 or 1	86
rng_resid_tol_value	154	*Range residual tolerance value.* Value used for setting Range residual tolerance flag. Provided by customer. Applies to both rng_prefit_resid and rng_dl_prefit_resid; not applicable if rng_prefit_resid_vld_flag and rng_dl_prefit_resid_vld_flag are 0.	IEEE Single	Range Units / 0.01 RU	-2^{30} to 2^{30}	24, 63
drvid_tol_value	158	*DRVID tolerance value.* Value used for setting DRVID tolerance flag. Provided by customer.	IEEE Single	Range Units / 0.01 RU	-2^{30} to 2^{30}	24, 64

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
prn0_resid_tol_value	162	*Pr/N0 residual tolerance value.* Value used for setting Pr/N0 residual tolerance flag. Provided by customer.	IEEE Single	dB-Hz / 0.1 dB-Hz	-10.0 to 90.0	65
rng_sigma_tol_value	166	*Range sigma tolerance value.* Value used for setting Range sigma tolerance flag. Provided by customer. Not applicable if rng_noise is -1.0.	IEEE Single	Range Units / 0.01 RU	0.0 to 2^{30}	43, 66
fom_tol_value	170	*Figure of Merit tolerance value.* Value used in setting of Range Validity flag. Provided by customer.	IEEE Single	Percentage / 0.1 percent	0.0 to 100.0	28
rng_resid_tol_flag	174	*Range residual tolerance flag.* Not applicable if rng_prefit_resid_vld_flag and rng_dl_prefit_resid_vld_flag are 0. 0 => Out of tolerance 1 => In tolerance	Unsigned Integer-1	N/A	0 or 1	63
drvid_tol_flag	175	*DRVID tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer-1	N/A	0 or 1	64
prn0_resid_tol_flag	176	*Pr/N0 residual tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer-1	N/A	0 or 1	65
rng_sigma_tol_flag	177	*Range sigma tolerance flag.* Not applicable if rng_noise is set to -1.0. 0 => Out of tolerance 1 => In tolerance	Unsigned Integer-1	N/A	0 or 1	66
rng_vld_flag	178	*Range validity flag.* 0 => Invalid 1 => Valid	Unsigned Integer-1	N/A	0 or 1	67
rng_config_flag	179	*Range configuration change flag.* 0 => Changed 1 => Unchanged	Unsigned Integer-1	N/A	0 or 1	68

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
stn_cal_corr_flag	180	*Station calibration correction flag.* Indicates results of validation of the station calibration value. 0 => unable to correct 1 => validated, no change 2 => validated, changed uplink 3 => validated, changed downlink 4 => validated, changed both uplink and downlink	Unsigned Integer –1	N/A	0 to 4	
rng_chan_num	181	*Ranging channel number.* Only provided by 26m antennas.	Unsigned Integer –1	N/A	1 or 2	
reserve8	182	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.3.3 Angle CHDO (Data Type 8)

The Angle CHDO is defined in Table 3-18. The Angle CHDO applies only to the 26m antennas.

Table 3-18. Angle CHDO (Data Type 8) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the angle data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the angle data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	34	
source_type	4	*Source type.* 0 => unknown 2 => MPA (26m), or MTA	Unsigned Integer –1	N/A	0 or 2	
ang_type	5	*Angles Type.* 0 => Unknown 1 => Azimuth / Elevation 2 => Hour angle / Declination 3 => X/Y (where +X is East) 4 => X/Y (where +X is South)	Unsigned Integer –1	N/A	0 to 4	
ang_vld_flag	6	*Angles validity flag.* 0 => Invalid 1 => Valid	Unsigned Integer –1	N/A	0 or 1	57
ang_mode	7	*Angle Mode.* 0 => Auto Track 1 => Manual Aided 2 => Computer 3 => Sidereal 4 => Brake	Unsigned Integer –1	N/A	0 to 4	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
conscan_mode	8	*Conscan Mode.* 0 => Conscan off 1 => Closed loop 2 => Open loop	Unsigned Integer –1	N/A	0 to 2	
reserve1	9	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
ang1	10	*Angle 1.* Azimuth, hour angle, or X.	IEEE Single	Deg / 0.1 deg	-90.0 to 90.0	
ang2	14	*Angle 2.* Elevation, declination, or Y.	IEEE Single	Deg / 0.1 deg	-90.0 to 90.0	
ang1_pseudo _resid	18	*Angle 1 pseudo-residual.* Actual minus predicted.	IEEE Single	Deg / 0.1 deg	-90.0 to 90.0	
ang2_pseudo _resid	22	*Angle 2 pseudo-residual.* Actual minus predicted.	IEEE Single	Deg / 0.1 deg	-90.0 to 90.0	
reserve4	26	*Reserved.* Four bytes.	Unsigned Integer –4	N/A	0	
reserve8	30	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.3.4 DRVID CHDO (Data Type 11)

The DRVID CHDO is generated for sequential and PN ranging (not tone ranging) from UPL-DTT antennas and is defined in Table 3-19.

Table 3-19. DRVID CHDO (Data Type 11) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the DRVID data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the DRVID data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	38	
drvid_type	4	*DRVID type.* 0 => Unknown 1 => Sequential 2 => PN	Unsigned Integer –1	N/A	0 to 2	
drvid_pts	5	*DRVID points.*	Unsigned Integer –1	N/A	0 to 255	
drvid	6	*DRVID measurement.*	IEEE Double	Range Units / 0.01 RU	-2^{30} to 2^{30}	24, 30, 79
prn0	14	*Pr/N0.*	IEEE Single	dB-Hz / 0.1 dB-Hz	-10.0 to 90.0	
drvid_noise	18	*DRVID noise.* Invalid indicated by value of -1.0.	IEEE Single	Range Units / 0.01 RU	-1.0, 0.0 to 2^{30}	24, 44
drvid_tol_value	22	*DRVID tolerance value.* Value used for setting DRVID tolerance flag. Provided by customer.	IEEE Single	Range Units / 0.01 RU	-2^{30} to 2^{30}	24, 64
prn0_resid_tol_value	26	*Pr/N0 residual tolerance value.* Value used for setting Pr/N0 residual tolerance flag. Provided by customer.	IEEE Single	dB-Hz / 0.1 dB-Hz	-10.0 to 90.0	65
reserve1	30	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
drvid_tol_flag	31	*DRVID tolerance flag.* 0 => Out of Tolerance 1 => In tolerance	Unsigned Integer-1	N/A	0 or 1	64
prn0_resid_tol_flag	32	*Pr/N0 residual tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer-1	N/A	0 or 1	65
drvid_noise_pts	33	*DRVID noise points.* Number of points used in DRVID noise computation.	Unsigned Integer –1	N/A	0 to 200	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
reserve8	34	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.3.5 PN Range CHDO (Data Type 14)

The PN Range CHDO is defined in Table 3-20.

Table 3-20. PN Range CHDO (Data Type 14) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the PN range data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the PN range data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	160	
ul_stn_cal	4	*Uplink station calibration value.* Invalid indicated by value of –1.0.	IEEE Double	Range Units / 0.01 RU	-1.0, 0.0 to 1.8e5	24, 40
dl_stn_cal	12	*Downlink station calibration value.* Invalid indicated by value of –1.0.	IEEE Double	Range Units / 0.01 RU	-1.0, 0.0 to 1.8e5	24, 41
meas_rng	20	*Measured range value.* Does not include compensation for station calibration and other adjustments. Invalid is indicated by value of -1.0.	IEEE Double	Range Units, modulo rng_modulo / 0.01 RU	-1.0, 0.0 to 2^{30}	24, 45, 46
rng_obs_dl	28	*Downlink range observable.* Includes measurement adjustments (station calibration, spacecraft delay, and Z-height). Invalid is indicated by value of -1.0.	IEEE Double	Range Units, modulo rng_modulo / 0.01 RU	-1.0, 0.0 to 2^{30}	24, 76
figure_merit	36	*Figure of Merit.* Rating of the measured range value.	IEEE Single	Percentage / 0.1 percent	0.0 to 100.0	28
drvid	40	*DRVID.* DRVID measured using doppler data from carrier	IEEE Double	Range Units / 0.01 RU	-2^{30} to 2^{30}	30, 24, 79
rtlt	48	*Round trip light time.* Predicted value.	IEEE Single	Seconds / 0.1 sec	0.0 to 86,400.0	
prn0	52	*Pr/N0.* Ranging power to noise spectral density ratio.	IEEE Single	dB-Hz / 0.1 dB-Hz	-10.0 to 90.0	
transmit_pwr	56	*Transmitter power.*	IEEE Single	W / 0.1 W	0.0 to 500,000.0	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
invert	60	*Invert.* Inverted implies that the polarity of the correlation reference is the invert of what was transmitted. 0 => not inverted 1 => inverted	Unsigned Integer –1	N/A	0 or 1	52
correl_type	61	*Correlation type.* 0 => squarewave 1 => sinewave	Unsigned Integer –1	N/A	0 or 1	
clk_divider	62	*Clock divider.* Value that ranging reference frequency is divided by to get chip rate.	Unsigned Integer –1	N/A	1 to 64	20
len_seq1	63	*Sequence #1 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 8	21
len_seq2	64	*Sequence #2 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 16	21
len_seq3	65	*Sequence #3 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 16	21
len_seq4	66	*Sequence #4 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 32	21
len_seq5	67	*Sequence #5 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 32	21
len_seq6	68	*Sequence #6 length.* A value of 0 implies no sequence.	Unsigned Integer –1	Chips / 1 chip	0 to 32	21
def_seq1	69	*Sequence #1 component value.* Definition of the sequence.	Unsigned Integer –1	N/A	0 to 2^8-1	21
def_seq2	70	*Sequence #2 component value.* Definition of the sequence.	Unsigned Integer –2	N/A	0 to 2^{16}-1	21
def_seq3	72	*Sequence #3 component value.* Definition of the sequence.	Unsigned Integer –2	N/A	0 to 2^{16}-1	21
def_seq4	74	*Sequence #4 component value.* Definition of the sequence.	Unsigned Integer –4	N/A	0 to 2^{32}-1	21
def_seq5	78	*Sequence #5 component value.* Definition of the sequence.	Unsigned Integer –4	N/A	0 to 2^{32}-1	21
def_seq6	82	*Sequence #6 component value.* Definition of the sequence.	Unsigned Integer –4	N/A	0 to 2^{32}-1	21
pn_code_length	86	*PN Code Length.*	Unsigned Integer –4	PN chips	2 to 11,000,000	22
transmit_inphs_time	90	*Transmit In-phase time.* Offset from time tag of time of zero phase on uplink range signal generation.	IEEE Single	Seconds / 1 μsec	-86,400.000000 to 86,400.000000	59

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
rcv_inphs_time	94	*Receive In-phase time.* Offset from time tag of time of zero phase on downlink range signal correlation.	IEEE Single	Seconds / 1 μsec	-86,400.000000 to 86,400.000000	59
carr_sup_rng_modul	98	*Carrier suppression by ranging modulation.* Reduction in carrier power due to ranging modulation.	IEEE Single	dB / 0.1 dB	-15.0 to 0.0	
exc_scalar_num	102	*Exciter Scalar Numerator.* Numerator of multiplier that is used to generate ranging reference signal from uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
exc_scalar_den	106	*Exciter Scalar Denominator.* Denominator of multiplier that is used to generate ranging reference signal from uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
rng_cycle_time	110	*Range cycle time.* Time, in Range Units, of one complete cycle of the ranging signal.	IEEE Double	Range Units / 0.01 RU	0.0 to 1.0e9	23, 24
rng_modulo	118	*Range modulo value.* Range measurement modulo (ambiguity).	Unsigned Integer –4	Range Units / 1 RU	0 to 2^{30}	45
rng_noise	122	*Range noise.* Invalid indicated by value of -1.0.	IEEE Single	Range Units / 0.01 RU	-1.0, 0.0 to 2^{30}	43
rng_dl_prefit_resid	126	*Downlink range pre-fit residual.* Observed range minus predicted range.	IEEE Double	Range Units / 0.01 RU	-2^{30} to 2^{30}	24, 29, 86
rng_dl_prefit_resid_vld_flag	134	*Downlink range pre-fit residual validity indicator.* 0 => Invalid pre-fit residual data 1 => Valid pre-fit residual data	Unsigned Integer-1	N/A	0 or 1	86
clock_waveform	135	*Uplink clock waveform type.* 0 => squarewave 1 => sinewave	Unsigned Integer -1	N/A	0 or 1	
rng_resid_tol_value	136	*Range residual tolerance value.* Value used for setting Range residual tolerance flag. Provided by customer. Applies to rng_dl_prefit_resid; not applicable if rng_dl_prefit_resid_vld_flag is 0.	IEEE Single	Range Units / 0.01 RU	-2^{30} to 2^{30}	24, 63
drvid_tol_value	140	*DRVID tolerance value.* Value used for setting DRVID tolerance flag. Provided by customer.	IEEE Single	Range Units / 0.01 RU	-2^{30} to 2^{30}	24, 64

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
prn0_resid_tol_value	144	*Pr/N0 residual tolerance value.* Value used for setting Pr/N0 residual tolerance flag. Provided by customer.	IEEE Single	dB-Hz / 0.1 dB-Hz	-10.0 to 90.0	65
rng_sigma_tol_value	148	*Range sigma tolerance value.* Value used for setting Range sigma tolerance flag. Provided by customer. Not applicable if rng_noise is set to -1.0.	IEEE Single	Range Units / 0.01 RU	0.0 to 2^{30}	43, 66
fom_tol_value	152	*Figure of Merit tolerance value.* Value used in setting of Range Validity flag. Provided by customer.	IEEE Single	Percentage / 0.1 percent	0.0 to 100.0	28
rng_resid_tol_flag	156	*Range residual tolerance flag.* Not applicable if rng_dl_prefit_resid_vld_flag is 0. 0 => Out of tolerance 1 => In tolerance	Unsigned Integer-1	N/A	0 or 1	63
drvid_tol_flag	157	*DRVID tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer-1	N/A	0 or 1	64
prn0_resid_tol_flag	158	*Pr/N0 residual tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer-1	N/A	0 or 1	65
rng_sigma_tol_flag	159	*Range sigma tolerance flag.* Not applicable if rng_noise is set to -1.0. 0 => Out of tolerance 1 => In tolerance	Unsigned Integer-1	N/A	0 or 1	66
rng_vld_flag	160	*Range validity flag.* 0 => Invalid 1 => Valid	Unsigned Integer-1	N/A	0 or 1	67
rng_config_flag	161	*Range configuration change flag.* 0 => Changed 1 => Unchanged	Unsigned Integer-1	N/A	0 or 1	68

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
stn_cal_corr_flag	162	*Station calibration correction flag.* Indicates results of validation of the station calibration value. 0 => unable to correct 1 => validated, no change 2 => validated, changed uplink 3 => validated, changed downlink 4 => validated, changed both uplink and downlink	Unsigned Integer –1	N/A	0 to 4	
reserve1b	163	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	

3.1.5.3.6 Tone Range CHDO (Data Type 15)

The Tone Range CHDO is defined in Table 3-21. The Tone Range CHDO applies only to the non-UPL-DTT antennas.

Table 3-21. Tone Range CHDO (Data Type 15) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the tone range data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the tone range data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	50	
source_type	4	*Source type.* 0 => Unknown 2 => MPA (26m), MTA	Unsigned Integer –1	N/A	0 or 2	
mjr_tone_freq	5	*Major tone frequency.* 0 => Not used 1 => 20 kHz 2 => 100 kHz 3 => 500 kHz	Unsigned Integer –1	N/A	0 to 3	
mnr_tone_freq	6	*Minor tone frequency.* 0 => not used 1 => 10 Hz	Unsigned Integer –1	N/A	0 or 1	
reserve1	7	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
meas_rng	8	*Measured range value.* Range as reported by the station; includes corrections for Z-height and station calibration	IEEE Double	nsec, modulo 2^{32} / 0.1 nsec	0 to 2^{32} - 1	72

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
rng_obs	16	*Range observable.* Includes measurement adjustments (station calibration, spacecraft delay, and Z-height).	IEEE Double	nsec, modulo 2^{32} / 0.1 nsec	0 to 2^{32} - 1	72
stn_cal	24	*Station calibration.* Not currently reported by station; value set to 0.0.	IEEE Double	nsec / 0.1 nsec	0.0 to 1.8e5	72
carr_pwr	32	*Carrier power.*	IEEE Single	dBm / 0.1 dBm	-185.0 to –85.0	
rng_prefit _resid	36	*Tone Range pre-fit residual.* Observed range minus predicted range.	IEEE Double	nsec / 0.1 nsec	-2^{27} to 2^{27}	86
rng_prefit_resid_v ld_flag	44	*Tone range pre-fit residual validity indicator.* 0 => Invalid pre-fit residual data 1 => Valid pre-fit residual data	Unsigned Integer-1	N/A	0 or 1	86
reserve1a	45	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
reserve8	46	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.3.7 Carrier Frequency Observable CHDO (Data Type 16)

The Carrier Frequency Observable CHDO is defined in Table 3-22.

Table 3-22. Carrier Frequency Observables CHDO (Data Type 16) Definitions

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the Carrier Frequency Observables data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the Carrier Frequency Observables data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	Bytes	38 + 18 * num_obs	
ref_rcv_type	4	*Reference receiver type.* 0 => Unknown 1 => DTT 2 => MFR	Unsigned Integer –1	N/A	0 to 2	
reserve1	5	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
carr_prefit_resid_tol_value	6	*Received carrier pre-fit residual tolerance value.* Value used for setting received carrier pre-fit residual tolerance flag. Provided by customer.	IEEE Single	Hz / 1 mHz	-1.0e6 to 1.0e6	62
reserve2	10	*Reserved.* Two bytes.	Unsigned Integer –2	N/A	0	
dop_noise	12	*Doppler noise.* Invalid indicated by value of -1.0.	IEEE Single	Hz / 1 mHz	-1.0, 0.0 to 1000.0	26
delta_ff	16	*Delta-f/f.*	IEEE Double	N/A	-1.0 to 1.0	32
rcv_sig_lvl	24	*Received signal level.* Carrier power or data power (if suppressed carrier tracking). (-300.0 if not valid.)	IEEE Single	dBm / 0.1 dBm	-300.0, -190.0 to –45.0	58
num_obs	28	*Number of Observable measurements.*	Unsigned Integer –2	N/A	1 to 100	33
obs_cnt_time	30	*Observable count time.* Integration time of the observables.	IEEE single	seconds / 0.1 sec	0.1 to 3600.0	33
rcv_carr_obs	34, 52, …, 34 + 18 * (num_obs – 1)	*Received Carrier observable.* This measurement is part of a set of measurements that are repeated num_obs times.	IEEE Double	Sky level Hz / 1 mHz	-32.3e9 to -2.0e9	35
carr_prefit_resid	42, 60, …, 42 + 18 * (num_obs – 1)	*Received carrier pre-fit residual.* Observed minus predicted.	IEEE Single	Hz / 1 mHz	-1.0e6 to 1.0e6	86
carr_prefit_resid_vld_flag	46, 64, …, 46 + 18 * (num_obs – 1)	*Received carrier pre-fit residual validity indicator.* 0 => Invalid pre-fit residual data 1 => Valid pre-fit residual data	Unsigned Integer –1	N/A	0 or 1	86
carr_prefit_resid_tol_flag	47, 65, …, 47 + 18 * (num_obs – 1)	*Received carrier pre-fit residual tolerance flag.* 0 => Out of tolerance 1 => In tolerance 2 => Not applicable	Unsigned Integer –1	N/A	0 to 2	62, 86
reserve4	48, 66, …, 48 + 18 * (num_obs – 1)	*Reserved.* Four bytes.	Unsigned Integer –4	N/A	0	
reserve8	34 + 18 * num_obs	*Reserved.* Eight bytes.	Unsigned Integer -8	N/A	0	

3.1.5.3.8 Total Count Phase Observable CHDO (Data Type 17)

The Total Count Phase Observable CHDO is defined in Table 3-23.

Table 3-23. Total Count Phase Observable CHDO (Data Type 17) Definitions

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the Total Count Phase Observables data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the Total Count Phase Observables data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	50 + 22 * num_obs	
ref_rcv_type	4	*Reference receiver type.* 0 => Unknown 1 => DTT 2 => MFR	Unsigned Integer –1	N/A	0 to 2	
reserve1	5	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
total_cnt_phs_prefit_resid_tol_value	6	*Total Count Phase pre-fit residual tolerance value.* Value used for setting total count phase pre-fit residual tolerance flag. Provided by customer.	IEEE Single	Hz / 1 mHz	-1.0e6 to 1.0e6	62
reserve2	10	*Reserved.* Two bytes.	Unsigned Integer –2	N/A	0	
dop_noise	12	*Doppler noise.* Invalid indicated by value of -1.0.	IEEE Single	Hz / 1 mHz	-1.0, 0.0 to 1000.0	26
delta_ff	16	*Delta-f/f.*	IEEE Double	N/A	-1.0 to 1.0	32
rcv_sig_lvl	24	*Received signal level.* Carrier power or data power (if suppressed carrier tracking). (-300.0 if not valid.)	IEEE Single	dBm / 0.1 dBm	-300.0, -190.0 to –45.0	58
num_obs	28	*Number of Observable measurements.*	Unsigned Integer –2	N/A	1 to 100	33
obs_cnt_time	30	*Observable count time.* Integration time of the observables.	IEEE Single	seconds / 0.1 sec	0.1 to 3600.0	33
total_cnt_phs_st_year	34	*Total Count Phase observable start time year.*	Unsigned Integer –2	N/A	1900 to 3000	36
total_cnt_phs_st_doy	36	*Total Count Phase observable start time day of year.*	Unsigned Integer –2	N/A	1 to 366	36

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
total_cnt_phs_st_sec	38	*Total Count Phase observable start time seconds.*	IEEE Double	Seconds / 0.01 sec	0.00 to 86,400.99	1, 36
total_cnt_phs_obs_hi	46, 68, …, 46 + 22 * (num_obs – 1)	*Negative of Total Count Phase observable - High part phase data whole cycles.* This measurement is part of a set of measurements that are repeated num_obs times.	Unsigned Integer –4	Total integer phase cycles divided by 2^{32}	0 to 2^{32}-1	8, 36
total_cnt_phs_obs_lo	50, 72, …, 50 + 22 * (num_obs – 1)	*Negative of Total Count Phase observable - Low part phase data whole cycles.* This measurement is part of a set of measurements that are repeated num_obs times.	Unsigned Integer –4	Total integer phase cycles modulo 2^{32}	0 to 2^{32}-1	8, 36
total_cnt_phs_obs_frac	54, 76, …, 54 + 22 * (num_obs – 1)	*Negative of Total Count Phase observable – Fractional part phase data cycles.* This measurement is part of a set of measurements that are repeated num_obs times.	Unsigned Integer –4	Fractional phase cycles multiplied by 2^{32}	0 to 2^{32}-1	8, 36
total_cnt_phs_prefit_resid	58, 80, …, 58 + 22 * (num_obs – 1)	*Total Count Phase pre-fit residual.* Observed minus predicted.	IEEE Single	Hz / 1 mHz	-1.0e6 to 1.0e6	86
total_cnt_phs_prefit_resid_vld_flag	62, 84, …, 62 + 22 * (num_obs – 1)	*Total Count Phase pre-fit residual validity indicator.* 0 => Invalid pre-fit residual data 1 => Valid pre-fit residual data	Unsigned Integer –1	N/A	0 or 1	86
total_cnt_phs_prefit_resid_tol_flag	63, 85, …, 63 + 22 * (num_obs – 1)	*Total Count Phase pre-fit residual tolerance flag.* 0 => Out of tolerance 1 => In tolerance 2 => Not applicable	Unsigned Integer –1	N/A	0 to 2	62, 86
reserve4	64, 86, …, 64 + 22 * (num_obs – 1)	*Reserved.* Four bytes.	Unsigned Integer –4	N/A	0	
reserve8	46 + 22 * num_obs	*Reserved.* Eight bytes.	Unsigned Integer -8	N/A	0	

3.1.5.4 Interferometric Data CHDOs

There is one interferometric data CHDO: VLBI (data type 10). Its format and contents are specified in section 3.1.5.4.1.

3.1.5.4.1 VLBI CHDO (Data Type 10)

The VLBI CHDO is defined in Table 3-24.

Table 3-24. VLBI CHDO (Data Type 10) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the VLBI data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the VLBI data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	96	
clk_off_epoch _year	4	*Clock offset epoch year.*	Unsigned Integer –2	Years	1958 to 3000	78
clk_off_epoch _doy	6	*Clock offset epoch DOY.*	Unsigned Integer –2	Days	1 to 366	78
clk_off_epoch_sec	8	*Clock offset epoch seconds.*	IEEE Double	seconds / 0.1 msec	0.0000 to 86,400.9999	1, 78
clk_off_1	16	*Clock offset at first receiving antenna for scan.* (UTC-station time)	Signed Integer –4	nsec / 1 nsec	-2^{31} to 2^{31} - 1	
clk_off_2	20	*Clock offset at second receiving antenna for scan.* (UTC-station time)	Signed Integer –4	nsec / 1 nsec	-2^{31} to 2^{31} - 1	
phs_cal_flag	24	*Phase calibration flag.* 0 => unknown 1 => no calibration 2 => default calibration 3 => quasar calibration only 4 => spacecraft calibration only 5 => spacecraft and quasar calibration	Unsigned Integer –1	N/A	0 to 5	
chan_sampl_flag	25	*Channel sampling flag.* 1 => multiplexed 2 => dual-frequency combined 3 => 4 parallel channels	Unsigned Integer –1	N/A	1 to 3	
quasar_id	26	*Quasar ID.* Name of quasar used.	ASCII – 12	N/A	ASCII string	
quasar_id_num	38	*Quasar ID numeric.* Number assigned to the quasar used.	Unsigned Integer –2	N/A	0 to 1024	
data_qual_flag	40	*Data quality flag.* 0 => good 1 => poor	Unsigned Integer –1	N/A	0 or 1	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chan_num	41	*Channel number.* Valid only if rec_type is 71 or 72.	Unsigned Integer –1	N/A	0 to 255	
mode_id	42	*Mode identifier.* Valid only if rec_type is 73; equals 0 otherwise. 0 => one-way 1 => two-way	Unsigned Integer –1	N/A	0 or 1	
modulo_flag	43	*Modulo flag.* Valid only if rec_type is 73 or 74. 0 => modded 1 => unmodded	Unsigned Integer –1	N/A	0 or 1	
ref_freq	44	*Reference frequency.*	IEEE Double	Hz / 1 mHz	2.0e9 to 34.7e9	
modulus	52	*Modulus.* Valid only if rec_type is 73 or 74.	IEEE Double	nsec / 0.1 nsec	0.0 to 100,000.0	
cnt_time_nar _band_phs	60	*Count time for narrow-band phase mode observable.*	IEEE Single	Seconds / 1 sec	1 to 100,000	
nar_band_phs	64	*Narrow-band phase mode observable.*	IEEE Double	Cycles / 1 mcycle	-4.0e12 to 4.0e12	
cnt_time_nar _band_dop	72	*Count time for narrow-band Doppler mode observable.*	IEEE Single	Seconds / 1 sec	1 to 100,000	
nar_band_dop	76	*Narrow-band Doppler mode observable.*	IEEE Double	Hz / 1 mHz	-1.0e6 to 1.0e6	
wide_band_obs	84	*Wide-band observable.*	IEEE Double	nsec / 0.1 nsec	-4.0e12 to 4.0e12	
reserve8	92	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.5 Filtered Data CHDOs

There are two filtered data CHDOs: Smoothed Noise (data type 12) and Allan Deviation (data type 13). Their formats and contents are specified in sections 3.1.5.5.1 to 3.1.5.5.2.

3.1.5.5.1Smoothed Noise CHDO (Data Type 12)

The Smoothed Noise CHDO is generated for UPL-DTT antennas only and is defined in Table 3-25. Not generated if predicted frequencies are not available.

Table 3-25. Smoothed Noise CHDO (Data Type 12) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the smoothed noise data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_length	2	*Length attribute of the smoothed noise data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	46	
01sec_sm_noise	4	*0.1-second smoothed noise measurement.*	IEEE Single	Hz / 0.1 Hz	0.0 to 1000.0	47
1sec_sm_noise	8	*1-second smoothed noise measurement.*	IEEE Single	Hz / 0.1 Hz	0.0 to 1000.0	47
10sec_sm_noise	12	*10-second smoothed noise measurement.*	IEEE Single	Hz / 0.1 Hz	0.0 to 1000.0	47
100sec_sm_noise	16	*100-second smoothed noise measurement.*	IEEE Single	Hz / 0.1 Hz	0.0 to 1000.0	47
200sec_sm_noise	20	*200-second smoothed noise measurement.*	IEEE Single	Hz / 0.1 Hz	0.0 to 1000.0	47
600sec_sm_noise	24	*600-second smoothed noise measurement.*	IEEE Single	Hz / 0.1 Hz	0.0 to 1000.0	47
int_time	28	*Integration time.* Total integration time of measurements.	Unsigned Integer –4	Seconds / 1 sec	1 to 10,800	
percent_data_used	32	*Percent of data used.*	IEEE Single	Percentage / 0.1 percent	0.0 to 100.0	50
new_01sec	36	*0.1-second measurement is new.* 0 => Old data 1 => New data	Unsigned Integer-1	N/A	0 or 1	48
new_1sec	37	*1-second measurement is new.* 0 => Old data 1 => New data	Unsigned Integer-1	N/A	0 or 1	48
new_10sec	38	*10-second measurement is new.* 0 => Old data 1 => New data	Unsigned Integer-1	N/A	0 or 1	48
new_100sec	39	*100-second measurement is new.* 0 => Old data 1 => New data	Unsigned Integer-1	N/A	0 or 1	48
new_200sec	40	*200-second measurement is new.* 0 => Old data 1 => New data	Unsigned Integer-1	N/A	0 or 1	48
new_600sec	41	*600-second measurement is new.* 0 => Old data 1 => New data	Unsigned Integer-1	N/A	0 or 1	48

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
reserve8	42	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.5.2 Allan Deviation CHDO (Data Type 13)

The Allan Deviation CHDO is generated for UPL-DTT antennas only and is defined in Table 3-26. Not generated if predicted frequencies are not available.

Table 3-26. Allan Deviation CHDO (Data Type 13) Definitions

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the Allan Deviation data CHDO.* CHDO contains binary data.	Unsigned Integer –2	N/A	10	
chdo_length	2	*Length attribute of the Allan Deviation data CHDO value field.* Number of bytes after this item.	Unsigned Integer –2	bytes	42	
01sec_allan_dev	4	*0.1-second Allan Deviation measurement.*	IEEE Single	Unitless	0.0 to 1.0	49
1sec_allan_dev	8	*1-second Allan Deviation measurement.*	IEEE Single	Unitless	0.0 to 1.0	49
10sec_allan_dev	12	*10-second Allan Deviation measurement.*	IEEE Single	Unitless	0.0 to 1.0	49
100sec_allan_dev	16	*100-second Allan Deviation measurement.*	IEEE Single	Unitless	0.0 to 1.0	49
1000sec_allan _dev	20	*1000-second Allan Deviation measurement.*	IEEE Single	Unitless	0.0 to 1.0	49
int_time	24	*Integration time.*	Unsigned Integer –4	Seconds / 1 sec	1 to 10^6	
percent_data_used	28	*Percent of data used.*	IEEE Single	Percentage / 0.1 percent	0.0 to 100.0	50
rpt_cause	32	*Cause of report generation.* 0 => 1000 second report 1 => Doppler mode change 2 => Idle mode	Unsigned Integer –1	N/A	0 to 2	
new_01sec	33	*0.1-second measurement is new.* 0 => Old data 1 => New data	Unsigned Integer-1	N/A	0 or 1	51
new_1sec	34	*1-second measurement is new.* 0 => Old data 1 => New data	Unsigned Integer-1	N/A	0 or 1	51

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
new_10sec	35	*10-second measurement is new.* 0 => Old data 1 => New data	Unsigned Integer-1	N/A	0 or 1	51
new_100sec	36	*100-second measurement is new.* 0 => Old data 1 => New data	Unsigned Integer-1	N/A	0 or 1	51
new_1000sec	37	*1000-second measurement is new.* 0 => Old data 1 => New data	Unsigned Integer-1	N/A	0 or 1	51
reserve8	38	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.2 Dependencies

None identified.

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Appendix A Notes

1. Seconds to HH:MM:SS (UTC) format:

0.0	=>	00:00:00
86399.0	=>	23:59:59
86400.0	=>	Leap second

2. This offset (**transmit_time_tag_delay**) should be added to the time tag. It is used to compensate for differences in the time tag point and the antenna radiation point.

3. This offset (**rcv_time_tag_delay**) should be subtracted from the time tag. It is used to compensate for differences in the time tag point and the antenna radiation point.

4. Array delay (**array_delay**) is included in the station calibration value (**stn_cal**) measurement and should be subtracted from the time tag.

5. Spacecraft transponder lock (**scft_transpd_lock**), spacecraft transponder number (**scft_transpd_num**), spacecraft two-way non-coherent (TWNC) status (**scft_twnc_stat**), and spacecraft oscillator type (**scft_osc_type**) are obtained from spacecraft engineering data, which may not be available.

6. Spacecraft oscillator frequency (**scft_osc_freq**) is obtained from spacecraft project supplied data.

7. Spacecraft transponder delay (**scft_transpd_delay**) is based on spacecraft and configuration data supplied from spacecraft project. In the future, it may be based on engineering data from the spacecraft. This is the delay the ranging signal experiences through the spacecraft.

8. $PHASE = HI * 2^{32} + LO + FRAC * 2^{-32}$,

   where,

   HI = **ul_hi_phs_cycles**, or **phs_hi_x** (with x = 0 through 9), **phs_hi_avg**, or **dop_cnt_hi**, or **total_cnt_phs_ob_hi**
   LO = **ul_lo_phs_cycles**, or **phs_lo_x** (with x = 0 through 9), or **phs_lo_avg**, or **dop_cnt_lo**, or **total_cnt_phs_obs_lo**
   FRAC = **ul_frac_phs_cycles**, or **phs_frac_x** (with x = 0 through 9), or **phs_frac_avg**, or **dop_cnt_frac**, or **total_cnt_phs_obs_frac**

9. Not applicable.

10. If hardware at station allows splitting the uplink and downlink ranging delays, the value will be included here. Otherwise, it is set to 0.0.

11. Measured code value (**ul_rng_phs**) and measured range value (**dl_rng_phs**) are the phase of the ranging signal at the time tag.

12. T1 setting (**t1**) is the length of time that the first component (the clock) is transmitted.

13. T2 setting (**t2**) is the length of time that each subsequent component is transmitted.

14. T3 setting (**t3**) is the length of time that the clock is transmitted for each DRVID measurement.

15. Component frequency is F_EXC * $2^{-(n+2)}$, where n is the component number and F_EXC is the exciter reference signal (see note 17).

16. Chopping modulates the ranging signal with a subcarrier at the chop component frequency (**chop_comp_num**), for all components after and including the chop start component (**chop_start_num**). For example, if the chop start component value is 6 and the chop component is 5, all components from 6 on will be modulated with component 5. If the chop value is zero, all components starting with 15 and larger are chopped with the clock component.

17. The exciter reference frequency (F_EXC) is defined as follows:

    F_EXC = FRQ_UP * (**exc_scalar_num**/**exc_scalar_den**)

    Where FRQ_UP is the uplink carrier frequency.

18. Sequential ranging cycle time is defined as follows:

    rng_cycle_time = (t1 + 2) + (**last_comp_num** – **first_comp_num**) * (t2 + 1) + **num_drvid** * (t3 + 2) + 1

19. The PN ranging code is a combination of multiple sequences logically combined. The code state is the particular bit (or chip) in the sequence, plus the phase of that chip at the time tag. For a component length L, and a subsequence state S, the code state C is related to L and S by:

    S = C mod L

20. PN chip rate = F_EXC / **clk_divider**

21. The first "n" bits (where n is the length specified in **len_seqj**) define the PN subsequence, e.g., a value of 46 for **def_seq4** gives the following sequence: 0101110, which will have a value of 7 in **len_seq4**.

22. Code length (**pn_code_length**) equals the result of multiplying the lengths of all of the subsequences together.

23. PN cycle time is 16 * **clk_divider** * **pn_code_length**.

24. One Range Unit (RU) is defined as:

    1 RU = (**exc_scalar_den** / **exc_scalar_num**) / (16 * FRQ_UP)

    Where FRQ_UP is the uplink carrier frequency. Range is measured in RU to give a stable reference measurement when the uplink is being ramped.

25. If carrier is suppressed (**carr_resid_wt** = 0.0), then the data power is used for the carrier tracking.

26. Doppler noise (**dop_noise**) is the standard deviation of the detrended downlink frequency residuals. The detrending is the removal of the least squares linear fit of the frequency residuals over the sample period. For the Downlink Carrier Phase data type (data type 1) and Doppler data type (data type 6), the sample period is 1 second. For the Carrier observable data type (data type 16), the sample period is sample integration time (**obs_cnt_time**) times the number of samples (**num_obs**). The equation for the Doppler noise is (F is the frequency residual, F_L is the linear least squares fit of F, and t is the spacing between points):

$$dop\_noise = \sqrt{\frac{1}{N}\sum_{I=1}^{N}\left\{F(I*t) - F_L(I*t)\right\}^2 - \left\{\frac{1}{N}\sum_{I=1}^{N}\left\{F(I*t) - F_L(I*t)\right\}\right\}^2}$$

27. **carr_resid_wt** is the weight value applied to residual phase error in carrier tracking; suppressed carrier weight is 1.0 minus this value, e.g.,

ϕ_{err} = **carr_resid_wt** * ϕ_{err_resid} + (1 – **carr_resid_wt**) * $\phi_{err\_suppressed}$

28. Figure of Merit (FOM) (**figure_merit**) is the estimate of the probability of successfully acquiring all of the lower components (other than the clock component). It is expressed as a percentage (0.0 to 100.0). For sequential ranging, it is defined as:

$$FOM = \frac{\left[1 + Erf\left(-\sqrt{PRN0 * T2}\right)\right]^{RNG\_COMP2 - RNG\_COMP1}}{2^{RNG\_COMP2 - RNG\_COMP1}}$$

Where Erf(*) is the error function.

For PN ranging, it is defined as:

$$FOM = \prod_{i=1}^{6}\left(\frac{1}{\sqrt{\pi}}\int_{-\infty}^{\infty}\exp(-x^2)\left(\frac{1 + Erf\left(x + (C_{\max} - C_{\min})\sqrt{INT\_TIME * PRN0}\right)}{2}\right)^{LEN(i)-1} dx\right)$$

Where, C_{min} and C_{max} are the minimum and maximum correlation value for each subsequence and LEN(I) is the length of the ith subsequence (2, 7, 11, 15, 19, and 23).

29. Range residual accuracy depends on the accuracy of the predicts and is rarely better than 1 μsec (1000 RU).

30. DRVID (**drvid**) stands for Differenced Range Versus Integrated Doppler. It is a measurement of the difference between the group and phase delay of the media. The measurement (at time tag TT) is the difference between two consecutive measured range points (i.e., points separated by the cycle time) minus the scaled difference in the uplink and downlink carrier phases over the same time period. The measurement is defined below:

D_RNG = (**meas_rng**(TT) – **meas_rng**(TT- **rng_cycle_tim**e)), mod **rng_modulo**

I_DOP = {(ϕ_T(TT) - ϕ_T(TT – **rng_cycle_time**)) –
(**scft_transpd_turn_den** / **scft_transpd_turn_num**) *
(ϕ_R(TT) - ϕ_R(TT – **rng_cycle_time**))}

drvid = D_RNG – [16 * (**exc_scalar_num** / **exc_scalar_den**) * I_DOP mod **rng_modulo**]

This has previously been called pseudo-DRVID, since the measurement does not require increasing the cycle time by adding additional clock transmissions during the measurement. The method of using additional clock cycles does not measure the carrier phase over the same period of time as the range measurement; this is why the pseudo-DRVID implementation was selected.

31. Slipped cycles (**slipped_cycles**) are estimated by processing the frequency residuals in a software-simulated, digital phase-locked loop and comparing the phase error with slip conditions. This estimate is subject to degradation during high noise conditions. The slipped cycles value is the number of cycle slips (both positive and negative) detected in this manner, for the sample interval.

32. Delta Frequency/Frequency (**delta_ff**) is the change in downlink frequency since the last sample, divided by the downlink frequency at this time tag.

33. A set of measurements is provided in the Received Carrier and Total Count Phase Observables data types (data types 16 and 17). For each set, a number of measurements (**num_obs**) and a time interval (**obs_cnt_time**) are provided. The first measurement is at the time tag reported in the header; the ith measurement (i = 1 to number of measurements) is at the time tag (TT) plus (i-1) * **obs_cnt_time**. The interval of time covered by the measurements is TT – **obs_cnt_time** to TT + (number of measurements – 1)* **obs_cnt_time**.

34. The Doppler Count is defined as difference in the uplink carrier phase (generated by integrating **ul_freq**), scaled by the spacecraft transponder turn around ratio, minus the downlink carrier phase plus a bias term (generated by integrating **dop_cnt_bias_freq**). The bias term is used to keep the Doppler Count a positive value. For UPL-DTT antennas, the **ul_freq** value is determined by the downlink frequency; for other antennas, it depends on the equipment configuration. The time tag of the ith measurement (i equals 1 to 10) is TT + (i - 1) * 0.1. The time tag is the end of the Doppler Count interval.

Doppler Count = - ($\phi_{R,i}$) + ((**scft_transpd_turn_num**/**scft_transpd_turn_den**) * **ul_freq** + **dop_cnt_bias_freq**)* ($Time_I$ – $Time_{start}$)

35. The Received Carrier Frequency Observable is defined as the negative of the difference in the downlink phase at the end of the interval and the downlink phase at the start of the interval, divided by the interval time. The time tag point of the difference is the middle point of the count time interval (note that this means that the time tag may be on the half second). The time tag of the ith measurement (i equals 1 to **num_obs**) is TT + (i – 1.0) * **obs_cnt_time**.

Observable = - (ϕ_i - ϕ_{i-1}) / **obs_cnt_time**

36. The Total Count Phase Observable is the difference between the downlink carrier phase at the measurement time tag and the downlink carrier phase at a starting point (a running integration). The time of the starting point is given by **total_cnt_phs_st_year**, **total_cnt_phs_st_doy**, and **total_cnt_phs_st_sec**. The starting point changes whenever something causes the carrier lock to be broken, such as spacecraft mode changes or downlink loss of lock. The time tag of the ith measurement (i equals 1 to **num_obs**) is TT + (i - 1) * **obs_cnt_time**.

Observable = - (ϕ_i - ϕ_{start})

The value reported is the negative of the observable, e.g.:

Reported Observable = (ϕ_i - ϕ_{start})

37. Sequential ranging ambiguity (**rng_modulo**) in Range Units is defined as $2^{6+last\_comp\_num}$.

38. Sequential measured range (**meas_rng**) is the difference between the uplink ranging phase (**ul_rng_phs**) and the downlink ranging phase (**dl_rng_phs**) (for UPL-DTT antennas). For non-UPL-DTT antennas, the Sequential Ranging Assembly range value is used. The difference is the positive modulo of **rng_modulo** value. This measurement is not corrected for any calibration issues.

39. Range Observable is defined as the measured range (**meas_rng**) minus the calibration correction. This observable is valid for both UPL-DTT and non-UPL-DTT antennas and is supplied to maintain compatibility between the two. The calibration correction is defined as:

Correction = (**ul_stn_cal – transmit_time_tag_delay**) **+ ul_zheight_corr** + **scft_transpd_delay** + (**dl_stn_cal** – **rcv_time_tag_delay** – **array_delay**) + **dl_zheight_corr**

40. If the measured uplink calibration value (**ul_stn_cal)** as reported in the uplink range SFDUs is non-zero, then the uplink calibration value (**ul_stn_cal**) in the derived SFDUs for sequential and PN range is this value. Otherwise, it is one-half of the station calibration value (**stn_cal**). If the value is invalid, the parameter is set to –1.0.

41. If the measured downlink calibration value (**dl_stn_cal**) as reported in the downlink ranging SFDUs is non-zero, then the downlink calibration value (**dl_stn_cal**) in the derived SFDUs for sequential and PN range is this value. Otherwise, it is one-half of the station calibration value (**stn_cal**).). If the value is invalid, the parameter is set to –1.0.

42. The uplink frequency (**ul_freq**) is provided for computing the Range Unit definition for those antennas that do not support ramped uplinks (i.e., no Data Type 9).

43. Range noise (**rng_noise**) is the standard deviation of up to the last 100 (i.e., if more than 100 data points exist, only the last 100 are used) range residuals, detrended by removing the least squares linear fit of the data. The equation for the Range noise is (R is the range residual, R_L is the linear least squares fit of R, N is the number of points (up to 100), and t is the spacing between points):

$$rng\_noise = \sqrt{\frac{1}{N}\sum_{I=1}^{N}\left\{R(I*t) - R_L(I*t)\right\}^2 - \left\{\frac{1}{N}\sum_{I=1}^{N}\left\{R(I*t) - R_L(I*t)\right\}\right\}^2}$$

44. DRVID noise (**drvid_noise**) is the standard deviation of up to the last 200 (i.e., if more than 200 data points exist, only the last 200 are used) DRVID values. The equation for the DRVID noise is (D is the DRVID residual, N is the number of points (up to 200), and t is the spacing between points):

$$drvid\_noise = \sqrt{\frac{1}{N}\sum_{I=1}^{N}\left\{D(I*t)\right\}^2 - \left\{\frac{1}{N}\sum_{I=1}^{N}\left\{D(I*t)\right\}\right\}^2}$$

45. PN ranging ambiguity (modulo value) is defined as:

rng_modulo = 16 * **clk_divider** * **pn_code_length**

46. PN measured range value (**meas_rng**) is the difference between the uplink ranging phase (**ul_rng_phs**) and the downlink ranging phase (**dl_rng_phs**). It is only available from the UPL-DTT antennas. The difference is the positive modulo of the **rng_modulo** value. This measurement is not corrected for any calibration issues.

47. Smoothed noise is the standard deviation of the detrended downlink frequency residuals. The detrending is the removal of the least squares linear fit of the frequency residuals over the sample period. Estimates are computed for 0.1, 1, 10, 100, 200, and 600-second intervals. The minimum

sample period is 180 seconds, the maximum is 10,800. The standard deviation is computed over 18 points; if the number of points in the reporting period is more than 18 (e.g., 0.1-second and 1.0-second), the 18-sample standard deviations are averaged. The equation for the Smoothed noise is (F is the frequency residual, F_L is the linear least squares fit of F, and t is the time spacing between points):

$$NOISE = \sqrt{\frac{1}{18}\sum_{I=1}^{18}\left\{F(I*t) - F_L(I*t)\right\}^2 - \left\{\frac{1}{18}\sum_{I=1}^{18}\left\{F(I*t) - F_L(I*t)\right\}\right\}^2}$$

48. Since the record is generated every 180 seconds and each integration needs 18 points, the longer integrations will not be updated every time. The **new_xxx** flags are used to indicate which integrations have been updated.

49. Allan deviation is computed for interval (τ) values of 0.1, 1, 10, 100, and 1000 seconds. The record is nominally output once every 1000 seconds. The frequency residuals are used for the computation (to remove the known motion effects, such as earth rotation). The result is normalized to DSN channel 14 (2295 MHz for S-band, 8415 MHz for X-band, and 31.977 GHz for Ka-band); this value is referred to as F0. The number of points, N, is equal to the integration time, INT_TIME, divided by τ.

$$\frac{\Delta F_\tau}{F} = \frac{\sqrt{\frac{1}{2N}\sum_{I=1}^{N}\left\{F(\tau I) - F(\tau(I-1)\right\}^2}}{F0}$$

50. **percent_data_used** indicates if some data in the integration period was not used (e.g., carrier was out of lock).

51. If a record is generated due to a change in system status (e.g., receiver mode change), the report time will be short of the normal 1000 seconds, so the longer integrations may not have a new point computed. The new_xxx flags are used to indicate which integrations have been updated.

52. Some hardware (ground or spacecraft) may invert the ranging modulation. **invert** allows these inversions to be corrected on the uplink or downlink processing.

53. Loop Type (**carr_loop_type**) is the number of poles in the carrier phase locked loop transfer function. The number poles (or order) of the loop filter is the Loop Type minus one. For each increment in the Loop Type, one higher order derivative of Doppler is tracked out to zero (Type 1 tracks out phase offsets, Type 2 tracks out frequency errors, Type 3 tracks out frequency rate errors).

54. The time offset (**prdx_time_offset**) is a value added to the current time when generating the predicted frequency from the frequency predicts (F(t)). Thus, the predicted frequency (F_PRED), at time t, used by the tracking loop is:

    F_PRED = F(t + **prdx_time_offset**)

55. The frequency offset (**prdx_freq_offset**) is a value added to the frequency value generated from the frequency predicts (F(t)). Thus, the predicted frequency (F_PRED), at time t, used by the tracking loop is:

    F_PRED = F(t) + **prdx_freq_offset**

56. Correlation validity (**correl_vld_flag**) is reported by the downlink ranging equipment. It is an estimate of whether or not the clock component is properly aligned with the received ranging signal (it measures the power in the inphase and quadrature signals when correlating the lower components – if the clock is properly aligned, the power in the inphase signal is much greater than the quadrature signal).

57. The Angles Validity Flag (**ang_vld_flag**) is set by the tracking equipment to indicate whether or not the angle data is valid.

58. The signal level (**rcv_sig_lvl**) is either provided by the tracking station (non-UPL-DTT antennas), or derived from other parameters (UPL-DTT antennas). For the 34m and 70m antennas, the derivation is as follows:

 Signal Level = P_N0 – (K_DB + 10 * log10(**system_noise_temp**))

 Where K_DB is Boltzmann's constant (-198.6 dBm/Hz/k), **system_noise_temp** is the system noise temperature, and P_N0 is either **pcn0** (**car_resid_wt** > 0.0) or **pdn0** (**car_resid_wt** = 0.0).

59. The In Phase Time (**transmit_inphs_time** or **rcv_inphs_time**) is the time point that the ranging modulation reference was initialized to zero phase. It is used for three-way ranging cases. It is seconds of day offset from the block time tag.

60. Distance (in time) to the phase center of the antenna that is not included in the station calibration. Included in this value is the delay to and from the test translator, the delay inside the test translator, the delay from the range calibration coupler to the phase center of the antenna, and the delay between the main antenna dish and the subreflector. Z-height is expressed in seconds, so it must be converted to Range Units before it is included in the Range Observables. The uplink part of this compensation (which is the delay from the point that the test translator taps off of the uplink path to the phase center) is provided in **ul_zheight_corr** and the downlink part (which is the delay from the phase center to the point where the test translator joins the downlink path, minus the delay of the test translator path) is in **dl_zheight_corr**.

61. When downlink carrier data is received, it reports the configuration that was used at the tracking station for the source of the downlink (e.g., three-way with DSS 65). However, that may not be the actual spacecraft mode (for example, the spacecraft may have been locked to an uplink from DSS 54, but the receiving station did not have any three-way predicts for DSS 54, so the predicts for DSS 65 were used instead). A validation is done to determine the actual spacecraft mode and is reported in the validated uplink station (**vld_ul_stn**) and validated doppler mode (**vld_dop_mode**) fields of the downlink data secondary CHDO.

62. The Carrier and Total Phase Count Pre-fit Residual Tolerance flags (**carr_prefit_resid_tol_flag** and **total_phs_cnt_prefit_resid_tol_flag**) indicate whether or not the pre-fit residuals are within the tolerance (**carr_prefit_resid_tol_value** and **total_phs_cnt_prefit_resid_tol_value**) set by the spacecraft project. The prefit residual flags (**carr_prefit_resid_tol_flag** and **total_phs_cnt_prefit_resid_tol_flag**) are set to Not Applicable if the prefit residual validity flags (**carr_prefit_resid_vld_flag** and **total_phs_cnt_prefit_resid_vld_flag**) indicate invalid.

63. The Range Residual Tolerance flag (**rng_resid_tol_flag**) indicates whether or not the range residual is within the tolerance (**rng_resid_tol_value**) set by the spacecraft project.

64. The DRVID Tolerance flag (**drvid_tol_flag**) indicates whether or not the DRVID value is within the tolerance (**drvid_tol_value**) set by the spacecraft project.

65. The Pr/N0 Residual Tolerance flag (**prn0_resid_tol_flag**) indicates whether or not the Pr/N0 residual is within the tolerance (**prn0_resid_tol_value**) set by the spacecraft project.

66. The Range Sigma Tolerance flag (**rng_sigma_tol_flag**) indicates whether or not the range sigma (noise) is within the tolerance (**rng_sigma_tol_value**) set by the spacecraft project.

67. The Range Validity flag (**rng_vld_flag**) indicates that the range data is valid if the receiver is in-lock, if the Correlation Validity flag (**correl_vld_flag**) indicates valid data, and the FOM (**figure_merit**) is above its tolerance value (**fom_tol_value**).

68. The Range Configuration Change flag (**rng_config_flag**) is set whenever the system determines the microwave configuration has changed since the ranging calibration was done.

69. Note 69 has been deleted.

70. The Metrics Validity flag (**metrics_vld_flag**) indicates whether or not the downlink ranging equipment was able to process the ranging data to get a measurement of range and DRVID (for example, the pass may have been three-way and the uplink data was not available).

71. Note 71 has been deleted.

72. Currently, the equipment that performs the tone range measurement includes the corrections for the calibration and the Z-height correction in the reported range; however, these values are not reported by the station. Thus, **stn_cal**, **ul_zheight_corr**, **dl_zheight_corr** are set to 0.0. The range observable (**rng_obs**) is equal to **meas_rng** minus the spacecraft transponder delay **scft_transpd_delay**. If the equipment at the station is corrected, the values will be non-zero.

73. The Modification Time items (day and msec) are set to 0 when the block is first created. If any data in the block is changed, the items are set to the time of the modification. The time is expressed as the time (UTC) since the epoch of January 1, 1958. The time is represented as days since the epoch and milliseconds of the day.

74. The record creation time is the time when the data processing task first creates the record. It is expressed as the time (UTC) since the epoch of January 1, 1958. The time is represented as days since the epoch and milli-seconds of the day.

75. The In Phase Time (**transmit_inphs_time_xxx** or **rcv_inphs_time_xxx**, where **xxx** is **year**, **doy**, or **sec**) is the time point (UTC) that the ranging modulation reference was initialized to zero phase. It is used for three-way ranging cases. When reported from the DSN stations, it is reported as an absolute time (see note 59 regarding its other format).

76. The Downlink Range Observable (**rng_obs_dl**) is defined as the calibration correction minus the downlink ranging phase. It is only valid for UPL-DTT antennas. The calibration correction is defined as:

Correction = (**ul_stn_cal** – **transmit_time_tag_delay**) + **ul_zheight_corr** + **scft_transpd_delay** + (**dl_stn_cal** – **rcv_time_tag_delay** – **array_delay**) + **dl_zheight_corr**

77. Downlink range observable validity flag (**rng_obs_dl_vld_flag**) indicates whether or not the Downlink range observable item (**rng_obs_dl**) is valid. It will be invalid if the data is for a non-UPL-DTT antenna.

78. The Clock Offset Epoch Time (**clk_off_epoch_year**, **clk_off_epoch_doy**, and **clk_off_epoch_sec**) is the time (UTC) that the two clock offsets (**clk_off_1** and **clk_off_2**) where measured .

79. The uplink data is only valid if the validated spacecraft coherency (**vld_scft_coh**) indicates an uplink (value of 1 or 3).

80. The DRVID computation is done by the data processing task in AMMOS.

81. This computation is done at the station. The metrics validity flag (**metrics_vld_flag**) indicates its validity.

82. For DTT data, the downlink band is assumed to be correct. For non-DTT data, a validation is done. In the case of 26m stations, which use the two acquisition aid antennas (for both S- and X-band), if the downlink band cannot be definitively determined, the value gets set to "S or X".

83. The carrier lock status (**carr_lock_stat**) for non-DTT antennas is inferred from other values.

84. The count time (interval), T_c, that is used to form an observable is constrained by the sample interval.

85. A set of measurements is provided in the Doppler Count data type (data type 6). For each set, a number of measurements (10 or 1) and a time interval (**sampl_time**) are provided. The first measurement is at the time tag reported in the header; if there are 10 measurements, the ith measurement (i = 1 to number of measurements) is at the time tag (TT) plus (i-1) * 0.1. The interval of time covered by the measurements is TT to TT + (number of measurements – 1)* 0.1.

86. Until prefit residual values (**rng_dl_prefit_resid**, **rng_prefit_resid**, and **carr_prefit_resid**) are delivered, they will be indicated as invalid by setting their residual flags (**rng_dl_prefit_resid_vld_flag**, **rng_prefit_resid_vld_flag**, and **carr_prefit_resid_vld_flag**, respectively) to a value of 0.

87. Arraying is done using the Full Spectrum Processor (FSP). There are two FSPs per complex.

88. This field only pertains to the Doppler (Data Type 6), the Received Carrier Frequency Observables (Data Type 16) and the Total-Count Phase Observables (Data Type 17) data CHDOs. Otherwise, when not applicable, the field is set to 0. In the case of Data Types 16 and 17, this field describes the compression interval, which ranges from 0.1 through 3600.0 seconds. In the case of Data Type 6, this field describes the sample interval. 26m stations are capable of producing tracking data at sample intervals of 0.1, 1, 10, or 60 seconds. UPL/DTT stations produce tracking data at a 0.1 second interval.

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Appendix B *File Format*

B.1 LVO Structure of Files

When the data defined by this document are stored in a file, the file is wrapped with an attached header. The file consists of nested LVOs, including a catalog LVO (known as the K-object LVO) and a data LVO (known as the I-object LVO). The catalog LVO contains the meta-data needed to catalog the actual tracking data. The data LVO consists of CHDO SFDUs defined in Section 3. The LVO structure of a file is depicted in Figure B-1. Further details on the contents of the label and value fields of each LVO are provided in the following subsections.

```
 +----------------------------------------------+
L|   Primary SFDU Label                         |
 +-+   +--------------------------------------+|
   | L|   K-Object Label                      ||
   |   +-+                                     ||
   |    V|   Catalog Information               ||
   |     |   End Marker                        ||
  V|   +-------------------------------------- ||
   | L|   I-Object Label                      ||
   |   +-+                                     ||
   |    V|   CHDO SFDUs                        ||
   |     |                                     ||
   .     .                                     ..
   .     .                                     ..
   .     .                                     ..
   |     |   EOF                               ||
   +-------------------------------------------+
              L = label field      V = value field
```

Figure B-1. LVO Structure of Files

B.2 Physical Layout of Files

The physical layout of the TRK-2-34 file is shown in Figure B-2. The length in bytes is 88+M+L, where M is the length of the catalog field and L is the length of the CHDO SFDUs. The structure is divided into three main parts:

- primary label of the entire SFDU (Table B-1 describes the primary label.)
- K-header. The K-header (or K-object) consists of the K-header SFDU label (or K-object SFDU label), catalog information, and an end marker. The catalog information consists of meta-data for cataloging the SFDU file. The meta-data are in the form of keyword-value pairs (hence, the "K" for keyword). (Tables B-2 and B-3 describe the K-header.)
- I-object. The I-object (where "I" stands for information) contains the CHDO SFDUs defined by Section 3, preceded by an I-object SFDU label. (Table B-4 describes the I-object SFDU label.)

```
                                   BIT
            +-----------------------------------------------+
            |1  |2  |3  |4  |5  |6  |7  |8  |1  |2  |3  |4  |5  |6  |7  |8  |
            +-----------------------------------------------|
      BYTE 0|                                               |
            +-                                             -|
           ...              PRIMARY SFDU LABEL             ...
           ...                 (20 BYTES)                  ...
            +-                                             -|
          18|                                               |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--|
          20|                                               |
            +-                                             -|
           ...             K-OBJECT SFDU LABEL             ...
           ...                 (20 BYTES)                  ...
            +-                                             -|
          38|                                               |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--|
          40|                                               |
            +-                                             -|
           ...            CATALOG INFORMATION              ...
           ...                                             ...
            +-                                             -|
        38+M|                                               |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--|
        40+M|                                               |
            +-                                             -|
           ...             K-OBJECT END MARKER             ...
           ...                 (20 BYTES)                  ...
            +-                                             -|
        58+M|                                               |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--|
        60+M|                                               |
            +-                                             -|
           ...            I-OBJECT SFDU LABEL              ...
           ...                 (20 BYTES)                  ...
            +-                                             -|
        78+M|                                               |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--|
        80+M|                                               |
            +-                                             -|
           ...              BINARY DATA OBJECT             ...
           ...                                             ...
            +-                                             -|
      78+M+L|                                               |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--|
      80+M+L|                                               |
            +-                                             -|
           ...             END OF FILE MARKER              ...
           ...                  (8 BYTES)                  ...
            +-                                             -|
      86+M+L|                                               |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--|
            |1  |2  |3  |4  |5  |6  |7  |8  |1  |2  |3  |4  |5  |6  |7  |8  |
            +-----------------------------------------------+
                    M is length of Catalog Information
               L is length of Tracking SFDUs
```

Figure B-2. File Layout

See Figure B-3 for a sample header of a TRK-2-34 file.

```
CCSD3ZF0000100000001NJPL3KS0PDSX$T-2-34$
PDS_VERSION_ID = PDS3
RECORD_TYPE = UNDEFINED
MISSION_NAME = CASSINI
SPACECRAFT_NAME = CASSINI
SPACECRAFT_ID = 82
MISSION_ID = 7
DATA_SET_ID = TRK234
FILE_NAME = 20013610115SC82.234
PRODUCER_ID = TDDS
PRODUCT_CREATION_TIME = 2001-361T23:59:59
START_TIME = 2001-361T01:15:10
STOP_TIME = 2001-361T12:30:30
INTERCHANGE_FORMAT = BINARY
NOTE = "Carrier lock status in DT1 changed by Jane Doe."
CCSD$$MARKER$T-2-34$NJPL3IF0T23400000001
```

Figure B-3. Sample Header of File

B.2.1 Primary SFDU Label

Bytes 0 through 19 of the tracking SFDU file contain the primary SFDU label field for the files. The format and content of the label are defined in Table B-1.

Table B-1. Primary SFDU Label

Byte	**Data Item. Description and Units.**	**Format**	**Range**
0 to 3	Control authority identifier (CAID). This CAID field indicates that the data description information (referred to in bytes 8 to 11) for this SFDU is maintained and disseminated by the CCSDS control authority. Control authority identifiers are assigned by the CCSDS.	Restricted ASCII-4	'CCSD'
4	SFDU version identifier. This version field indicates how this primary SFDU label is delimited. The value of '3' indicates that this LVO can be delimited by marker, EOF (end of file), or length.	Restricted ASCII-1	'3'
5	SFDU class identifier. This class identifier field gives a high-level classification of the content of the value field of this LVO (i.e., this TRK-2-34 LVO that contains the K-header LVO and the I-object LVO). The value of 'Z' indicates that the value (V) field of this LVO contains a JPL LVO with a CCSD CAID.	Restricted ASCII-1	'Z'

Byte	Data Item. Description and Units.	Format	Range
6	Delimiter identifier. This delimitation identifier indicates the type of delimiter this primary SFDU label uses for its last eight bytes. A value of 'F' indicates this label ends with '00000001', as specified in bytes 12 to 19, which implies that the entire SFDU is closed with an EOF marker.	Restricted ASCII-1	'F'
7	Reserved. This byte is a spare field.	Restricted ASCII-1	'0'
8 to 11	Data description package identifier. This field uniquely identifies (for the specified Control Authority, i.e., CCSDS, per bytes 0 to 3) the package that contains the definition of the data object [or value (V) field of this LVO]. The value shown here is registered with the specified control authority.	Restricted ASCII-4	'0001'
12 to 19	Length attribute of the SFDU. This field is designated the "length" field because data are delimited by length for stream data. However, since this SFDU is considered to be a file SFDU, rather than a stream SFDU, the end of the TRK-2-34 LVO (SFDU) is designated by an EOF marker. The EOF marker is specified in this primary SFDU label as '00000001.'	Standard ASCII-8	'00000001'

B.2.2 K-Header (or K-Object)

Bytes 20 to 59+M are the K-header (or K-Object) for the file (M is the length of the catalog information, which is variable length). The three components of the K-header are described below.

B.2.2.1 K-Header SFDU Label

Bytes 20 to 39 are the label field for the K-Header SFDU (or Catalog LVO) for the files. The 20 bytes of the label field are defined below in Table B-2.

Table B-2. K-Header (or K-Object) SFDU Label

Byte	Data Item. Description and Units.	Format	Range
0 to 3	Control authority identifier (CAID). This CAID field indicates that the data description information (referred to at bytes 8 to 11) for this SFDU is maintained and disseminated by the NASA/JPL control authority.	Restricted ASCII-4	'NJPL'
4	SFDU version identifier. This version field indicates how this K-header SFDU label is delimited. The value of '3' indicates that this LVO can be delimited by marker, EOF (end of file), or length. In this case, the actual delimiter is by marker, as indicated by byte 6.	Restricted ASCII-1	'3'

Byte	Data Item. Description and Units.	Format	Range
5	SFDU class identifier. This class identifier field gives a high-level classification of the content of the value field of this LVO (i.e., the K-header LVO). The value of 'K' indicates that the value (V) field of this LVO contains a K-header. [The K-header contains metadata that describes the I-object LVO (information or data object) that follows it.]	Restricted ASCII-1	'K'
6	Delimiter identifier. This delimitation identifier indicates the type of delimiter this K-header SFDU label uses for its last eight bytes. A value of 'S' indicates that this label ends with a marker, i.e., a start marker (signifying the start of the value field). [The value (V) field of the K-header LVO is the Catalog information. It is delimited by a start marker at the end of this K-header SFDU label, and then by a matching end marker at the end of the value (V) field.] The marker is specified in the 'Length attribute' field of this label at bytes 12 to 19.	Restricted ASCII-1	'S'
7	Reserved. This byte is a spare field.	Restricted ASCII-1	'0'
8 to 11	Data description package identifier. This field uniquely identifies (for the specified Control Authority, i.e., NJPL, per bytes 0 to 3) the data object [or value (V) field of this LVO]. The value shown here is registered with the specified control authority.	Restricted ASCII-4	'PDSX'
12 to 19	Length attribute of the SFDU. The Catalog information is delimited with a start and end marker.	Standard ASCII-8	'$T-2-34$'

B.2.2.2 Catalog Information

The catalog information for the files starts at byte 40 and is defined below in Table B-3. This value field of the LVO contains the set of parameters and values, in <keyword/parameter>=<value> format, of attributes that are pertinent to the file data. Each line is terminated with a carriage return (ASCII decimal code 13, written as <CR> or Ctrl-M), and a line feed (ASCII decimal code 10, written as <LF> or Ctrl-J). The values must conform to the standard ASCII character set (32 through 127 decimal). In addition, the values should be in upper case, except for the NOTE field.

Table B-3. Catalog Information (Value Field of the K-Object)

Ref #	Keyword-Value Pairs. Description and Units.	Range for Value
1	**PDS_VERSION_ID = <value><CR><LF>** Represents the version number of the standards document that is valid when the label is created.	'PDS3'
2	**RECORD_TYPE = <value><CR><LF>** The record format of this file.	'UNDEFINED'
3	**MISSION_NAME = <value><CR><LF>** The name of the mission or project that is associated with the data contained in the I-object. Must be upper case.	Varies

Ref #	Keyword-Value Pairs. Description and Units.	Range for Value
4	**SPACECRAFT_NAME = <value><CR><LF>** The full, unabbreviated name of the spacecraft that is associated with the data contained in the I-object. Must be upper case.	Varies
5	**SPACECRAFT_ID = <value><CR><LF>** The decimal representation of the applicable DSN spacecraft number as defined in Reference [3a].	'0' thru '255'
6	**MISSION_ID = <value><CR><LF>** The decimal representation of the applicable DSN mission number per Reference [3a].	'0' thru '255'
7	**DATA_SET_ID = <value><CR><LF>** The unique identifier for this data type.	'TRK234 '
8	**FILE_NAME = <value><CR><LF>** The unique file name, without a directory path specified, for this SFDU file. The file name shall be of the form: **yyyydddhhmmSCsssss.234**, where, **yyyy** is the four-digit year **ddd** is the three-digit day-of-year (001 thru 366) **hh** is the two-digit hour into the day (00 thru 23) **mm** is minutes into the hour (00 thru 59) **SC** is fixed, and denotes that the spacecraft ID is to follow: **sssss** is the spacecraft ID (per Reference [3a], with leading zeros omitted) **. 234** is a fixed suffix, and identifies the file as being a TRK-2-34 file. The time reflects the time of the earliest tracking sample contained in the file.	Varies
9	**PRODUCER_ID = <value><CR><LF>** A short name or acronym for the producer or producing team/group (e.g., TDDS) of this file. An ASCII character string, limited to 20 characters (must be upper case).	Varies
10	**PRODUCT_CREATION_TIME = <value><CR><LF>** This attribute indicates the UTC time at which this file was created. The value is specified in the following time format: **yyyy-dddThh:mm:ss** where, **yyyy** four-digit year **ddd** day-of-year (001 thru 366) **T** ASCII literal field (i.e., "T") **hh** hours of the day (00 thru 23) **mm** minutes of the hour (00 thru 59) **ss** seconds of the minute (00 thru 60), allows for leap second	any valid UTC
11	**START_TIME = <value><CR><LF>** This attribute identifies the earliest time tag (in UTC) reported across all SFDU secondary CHDOs included in the data object. The value is specified in the following time format: **yyyy-dddThh:mm:ss** where, **yyyy** four-digit year **ddd** day-of-year (001 thru 366) **T** ASCII literal field (i.e., "T") **hh** hours of the day (00 thru 23) **mm** minutes of the hour (00 thru 59) **ss** seconds of the minute (00 thru 60), allows for leap second	any valid UTC

Ref #	Keyword-Value Pairs. Description and Units.	Range for Value
12	**STOP_TIME = <value><CR><LF>** This attribute identifies the latest time tag (in UTC) reported across all SFDU secondary CHDOs included in the data object. The value is specified in the following time format: **yyyy-dddThh:mm:ss** where, **yyyy** four-digit year **ddd** day-of-year (001 thru 366) **T** ASCII literal field (i.e., "T") **hh** hours of the day (00 thru 23) **mm** minutes of the hour (00 thru 59) **ss** seconds of the minute (00 thru 60), allows for leap second	any valid UTC
13	**INTERCHANGE_FORMAT = <value><CR><LF>** Identifies the way the data object is stored.	'BINARY"
14	**NOTE = "<value>"<CR><LF>** Description of changes made to the data in this TRK-2-34 file as a result of manual editing (may be upper or lower case).	Varies

B. 2.2.3 K-Object End Marker

After the catalog information, starting at byte 40+M (M being the length of the catalog field), is the marker field. The marker field delimits the end of the catalog LVO. The 20 byte field is the following ASCII string:

"CCSD$$MARKER$T-2-34$".

B.2.3 I-Object SFDU Label

Bytes 60+M to 79+M are the label field for the I-Object SFDU. The 20 bytes are defined below in Table B-4.

Table B-4. I-Object SFDU Label

Byte	Data Item. Description and Units.	Format	Range
0 to 3	Control authority identifier (CAID). This CAID field indicates that the data description information (referred to at bytes 8 to 11) for this SFDU is maintained and disseminated by the NASA/JPL control authority.	Restricted ASCII-4	'NJPL'
4	SFDU version identifier. This version field indicates how this I-object SFDU label is delimited. The value of '3' indicates that this LVO can be delimited by marker, EOF (end of file), or length. In this case, the actual delimiter is by EOF, as indicated by byte 6.	Restricted ASCII-1	'3'

Byte	Data Item. Description and Units.	Format	Range
5	SFDU class identifier. This class identifier field gives a high-level classification of the content of the value field of this LVO (i.e., the I-object LVO). The value of 'I' indicates that the value (V) field of this LVO contains an I-object (or information object.)	Restricted ASCII-1	'I'
6	Delimiter identifier. This delimitation identifier indicates the type of delimiter this I-object SFDU label uses for its last eight bytes. A value of 'F' indicates that this label ends with the value specified in bytes 12 to 19, which implies that the I-object ends with an EOF marker.	Restricted ASCII-1	'F'
7	Reserved. This byte is a spare field.	Restricted ASCII-1	'0'
8 to 11	Data description package identifier. This field uniquely identifies (for the specified Control Authority, i.e., NJPL, per bytes 0 to 3) the data object [or value (V) field of this LVO].	Restricted ASCII-4	'T234'
12 to 19	Length attribute of the SFDU. The end of this LVO is designated by marker — in this case, an EOF marker. The EOF marker is specified in this I-object SFDU label as '00000001.' Note that the EOF marker terminating the I-object serves a dual purpose in that it also terminates the entire file, per bytes 12 to 19 of the primary SFDU label.	Standard ASCII-8	'00000001 '

B.2.4 Binary Data Object

Starting at byte 80+M (M being the length of the catalog field) is the binary data object. The binary data object of the file contains a series of CHDO SFDUs in time-sorted order. That is, given a file containing different data types, all the data types are interleaved based on time. The CHDOs are defined in Section 3. The total length of the binary data object is L bytes.

B.2.5 End of File (EOF)

Starting at byte 80+M+L (M being the length of the catalog field and L being the length of the binary data object) is the end of the file (EOF) marker. This 8 byte marker is defined in the Primary Label field, bytes 12 to 19. The value of the EOF marker is '00000001'.