Deep Space Network

TRK-2-34
DSN Tracking System Data Archival Format

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Document Change Log

Rev.	Check if Minor Rev.	Issue Date	Affected Sections or Pages	Change Summary
--		04/30/2000	All	This is a new document.
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)
C		09/15/2003	Section 3 and Appendix A	Updated with additional parameters, simplified Data Type 6, and corrected errors.
D		11/02/2004	Sections 1, 2 and 3, Appendix A	Updated Secondary CHDO 135, updated VLBI CHDO, add invalid/unknown to ul_assembly_num in CHDO 132, added enumerations to ramp_type in DT9 and corrected typos.
E		05/15/2005	Section 3	Updated Tone Range CHDO and corrected typos.
F		08/31/2005	Section 3, Appendix A	Updated Doppler Count CHDO and corrected typos. Added Note number 89.
G		03/15/2006	Appendix B	Updated file name format adding DSS ID.
H		07/31/2006	Section 1.2, Appendix A	Typo in the Signal Level equation (Note 58).
I		09/29/2006	Sections 1, 3 and Appendix A	Clarified the definition of data type in sections 1.6.1 and 3.1.3. Updated Uplink and Downlink PN Ranging Phase CHDOs and updated Note 34. Table 3-1
J		05/31/2007	Sections 1, 3 and Appendix A	Updated Downlink and Derived Secondary headers adding LNA correction value. Updated Downlink Sequential and Downlink PN Ranging Phase Data CHDOs, adding station calibration correction flag. Updated (reused) Note number 9.
J-1	X	02/29/2008	Section 1	Minor changes to update footer tags, change 'DSMS' to 'DSN', edit Section 1 sequence
K		07/15/2008	Table 3-18, Note 80	Angle Data CHDO replacing a reserved field with Acquisition Aid Mode (i.e., acq_aid_mode)
L		05/29/2009	Table 3-18, Note 80	Corrections to Angle Data CHDO descriptions.
M		01/10/2013	*Table 3-9, Table 3-12, Section 3.1.5.1.4 **Table 3-10 ***Table 3-11	*Added ramp_type 7 "extended" in Uplink Carrier Phase and Ramp CHDO. **Replace "reserve1" Identifier with "data_source" in Uplink Sequential Ranging Phase CHDO ***Added new Identifier "data_source" in Uplink PN Ranging Phase CHDO
N		11/07/2013	Sections 1.3 and 1.6 Tables 3-9 thru 3-12, 3-17, 3-20, 3-22, 3-23 Appendix A Appendix B, Table B-3	Cleaned up document lists and numbers to referenced documents throughout. Changes to accommodate generating fabricated records to support 3-way ranging. Changed note 90 in Appendix A. Updated file naming convention. Formatting/editing cleanup.

O		10/27/2015	Section 3. Data Types 2, 3, 4, 5, 7, and14.	Added CCSDS PN Ranging configuration items and Telemetry Based Ranging type. Changed naming of FOM to Probability of Acquisition. Corrected Ranging Cycle Time definitions to reflect existing implementation. Added software version to secondary CHDOs 132, 133, 134. Added range modulo (ambiguity) in range units to data types 4 and 5. Added more polarization values in CHDO 133, to reflect existing implementation.

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Section 1
Introduction

1.1 Purpose

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-2-18 product delivered to customers.

1.2 Applicability

This release adds CCSDS ranging patterns using weighted voting to the PN Ranging Data Types. It also adds telemetry based ranging, and other future types of ranging. This release replaces the ranging item name Figure of Merit with the more descriptive name Probability of Acquisition.

Certain parameters may not be available in 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 (DT13) and Smoothed Noise (DT12).

This document addresses the format of data from decommissioned 26-meter subnet and DSS-27 MTA to support the processing of archived data.

This document does not include DTT Ka2 tracking data. The DTT Ka2, or high-rate, receiver is for telemetry processing and does not output radio metric tracking data.

1.3 Revision Control

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

Documents controlling this version include

[1]	DSN 813-109, D-17818	*Preparation Guidelines and Procedures for Deep Space Network (DSN) Interface Specifications* (DSN internal document, for reference only.)
[2]	DSN 820-013, Module 0171-Telecomm-NJPL	*DSN External Interface Specification—JPL Created SFDU Structures*

1.4 Relationship to Other Documents

TRK-2-34 replaces TRK-2-25 as the archival format.

1.5 Terminology and Notation

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., Controlling Document [2] and Reference Document [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 Document [8]). This code has been incorporated into the ISO code of the same nature (Reference Document [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 Controlling Document [2] the specification in Reference Document [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 Controlling Document [2]. It does not strictly conform to the internationally recognized SFDU structure and construction rules recommended by CCSDS in Reference Document [6].

f) A *compressed header data object* (CHDO), as defined in Controlling Document [2] 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 Controlling Document [2], 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 Document [6], for example, provides several mechanisms that do not rely on an explicit length.

i) The term data type is used to distinguish between different types of SFDUs. A data type is uniquely identified by its record id, which is an aggregation of four fields: major data class, minor data class, mission id and format code.

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 Document [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 Document [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.

1.6 References

Documents:

[1]	DSN 820-013, D-16765	*DSN External Interface Specification*
[2]	DSN 820-013, Module OPS-6-21	*DSN External Interface Specification -Standard Code Assignments*
[3]	DSN 820-013, Module 0172-Telecomm-CHDO	*DSN External Interface Specification – DSN Created CHDO Structures*
[4]	DSN 820-013 Module TRK-2-18	*DSN External Interface Specification –Tracking System Interfaces Orbit Data File Interface*
[5]	CCSDS 620.0-B-2	*CCSDS Recommendation for Space Data System Standards—Standard Formatted Data Units—Structure and Construction Rules* (Issue 2, May 1992)
[6]	ANSI T-49-12	*ANSI/IEEE STD 754-1985—IEEE Standard for Binary Floating-Point Arithmetic*
[7]	ANSI X3.4-1986 (R1997)	*Information Systems - Coded Character Sets - 1 Bit American National Standard Code for Information Interchange (7-Bit ASCII)*
[8]	ISO/IEC 646-1991	*Information Technology - ISO 7-bit Coded Character Set for Information Interchange*
[9]	DSN 810-047	*DSN Antenna and Facility Identifiers* *(DSN internal document, for reference only.)*
[10]	DSN 810-005, Module 214	*DSMS Telecommunications Link Design Handbook, Module 214, Pseudo-Noise and Regenerative Ranging.*
[11]	CCSDS 414.1-B-1	*CCSDS Recommendation for Space Data System Standards – Pseudo-Noise (PN) Ranging Systems (Recommended Standard, March 2009)*

Web Sites:

[12]	DSN 820-013, D-16765	*DSN External Interface Specification* http://jaguar.jpl.nasa.gov

1.7 Abbreviations

Abbreviations used in this document are defined with the first textual use of the term. Abbreviations appearing in this module are:

ADID	Authority and Description Identifier
AMMOS	Advanced Multi-mission 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
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 (old term for range Probability of Acquisition)
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
TTC	Telemetry, Tracking, and Command System
UPL	Uplink Tracking and Command Subsystem
UTC	Universal Time Coordinated
VLBI	Very Long Baseline Interferometry
W	Watts

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 customers as files, stream-type queries, or broadcast streams. The file format is described in Appendix B.

This processing is done in the TTC (Telemetry, Tracking, and Command) 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 Document [2]: spacecraft ID, mission ID

Reference Document [9]: station ID

Reference Document [3]: 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.

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.

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

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 Off-set	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'	
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'	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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 => 276 DT5 => 388 DT6 => 200 DT7 => 330 DT8 => 178 DT9 => 124 DT10 => 204 DT11 => 182 DT12 => 164 DT13 => 160 DT14 => 348 DT15 => 194 DT16 => 182 + 18 * num_obs DT17 => 194 + 22 * num_obs	Unsigned Integer –8	Bytes	124, 160, 162, 164, 178, 182, 194, 200, 204, 276, 304, 348, 330, 388, 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 described in Reference Document [3] and defined in Table 3-2 for convenience. 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 Off-set	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 Reference Document [3] and is included in Table 3-3 for convenience. 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 Off set	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 Document [2], Table 4.	Unsigned Integer –1	N/A	0 to 255	

Identifier	Byte Off set	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 Off-set	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 Document [3].	Unsigned Integer –1	N/A	0 to 255	
last_modifier_id	5	*Last modifier ID.* Indicates where this SFDU was last modified. Per Reference Document [3].	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 Document [2].	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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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	
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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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 Document [9].	Unsigned Integer –1	N/A	0 to 255	
dl_software_version	51	*Downlink Software version number.* Shows the DCC software version Major op code.	Unsigned Integer –1	N/A	0 to 255	22, 45
dl_chan_num	52	*Downlink channel number.* Value of 0 implies unknown.	Unsigned Integer –1	N/A	0 to 24	
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 Document [9]. 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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
ul_band_dl	55	*Uplink frequency band assumed by downlink.* Uplink band value used by downlink for turnaround 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
lna_num	67	*LNA Number.* Value of 0 indicates unknown.	Unsigned Integer –1	N/A	0 to 4	9
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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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 Document [9]. 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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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
scft_transpd_delay	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
version_num	124	*Version number.* Version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	
sub_version_num	125	*Sub-version number.* Sub-version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
sub_sub_version_num	126	*Sub-sub-version number.* Sub-sub-version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	
lna_corr_value	127	*LNA Correction Value.* Indicates results of validation of LNA number. Value of 0 indicates no validation or correction was made, otherwise if non-zero, this value is to be used instead of lna_num .	Unsigned Integer –1	N/A	0 to 4	9

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 Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
chdo_type	0	*Type attribute of the secondary CHDO.*	Unsigned Integer –2	N/A	132	
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 Document [3].	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 Document [3].	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 Document [2].	Unsigned Integer –1	N/A	1 to 255	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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 216 - 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 Document [9].	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	
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. 0 => Invalid/unknown 1 => S-/X-band uplink 2 => Ka-band uplink	Unsigned Integer –1	N/A	0 to 2	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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	
ul_software_version	43	*Uplink Software version number.* Shows the UPL software version Major op code.	Unsigned Integer –1	N/A	0 to 255	22, 45
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 216 - 1	73

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
mod_msec	58	*Modification time milliseconds of day.* Last modification time.	Unsigned Integer –4	msec / 1 msec	0 to 86,400,999	73
version_num	62	*Version number.* Version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	
sub_version_num	63	*Sub-version number.* Sub-version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	
sub_sub_version_num	64	*Sub-sub-version number.* Sub-sub-version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	
reserve1b	65	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
reserve4	66	*Reserved.* Four bytes.	Unsigned Integer –4	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 Off-set	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 Document [3].	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 document [3].	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 Document [2].	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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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
dl_dss_id	34	*Downlink antenna number.* Per Reference Document [9].	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 Document [9]. 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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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	
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 2=> UNKNOWN 3=> N/A	Unsigned Integer –1	N/A	0 to 3	
diplxr_stat	52	*Diplexer status.* 0 => Low noise 1 => Diplexed	Unsigned Integer –1	N/A	0 or 1	
lna_num	53	*LNA Number.* Value of 0 indicates unknown.	Unsigned Integer –1	N/A	0 to 4	9
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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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 Document [9]. 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
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
dl_software_version	73	*Downlink Software version number.* Shows the DCC software version Major op code.	Unsigned Integer –1	N/A	0 to 255	22, 45

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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
version_num	106	*Version number.* Version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	
sub_version_num	107	*Sub-version number.* Sub-version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	
sub_sub_version_num	108	*Sub-sub-version number.* Sub-sub-version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
lna_corr_value	109	*LNA Correction Value.* Indicates results of validation of LNA number. Value of 0 indicates no validation or correction was made, otherwise if non-zero, this value is to be used instead of lna_num.	Unsigned Integer –1	N/A	0 to 4	9
reserve4	110	*Reserved.* Four bytes.	Unsigned Integer –4	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 Off-set	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 Document [3].	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 Document [3].	Unsigned Integer –1	N/A	0 to 255	
reserve1a	6	*Reserved.* For future expansion of scft_id.	Unsigned Integer –1	N/A	0	
scft_id	7	*Spacecraft number.* Per Reference Document [2]	Unsigned Integer –1	N/A	1 to 255	

Identifier	Byte Off-set	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 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 86,400.9999	1
rct_day	24	*Record creation time days.* Days since 1/1/1958.	Unsigned Integer –2	Days / 1 day	0 to 216 - 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 Document [9].	Unsigned Integer –1	N/A	0 to 255	
dl_dss_id	31	*Primary downlink antenna number.* Per Reference Document [9].	Unsigned Integer –1	N/A	0 to 255	
dl_dss_id_2	32	*Secondary downlink antenna number.* Per Reference Document [9].	Unsigned Integer –1	N/A	0 to 255	
dl_band	33	*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	
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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
ul_band	35	*Uplink Frequency band.* 0 => Unknown 1 => S-band 2 => X-band 3 => Ka-band 4 => Ku-band 5 => L-band 6 => C-band Valid only if prdx_mode is 2 or 3. A value of 0 means that the number is unknown or not valid (e.g., no uplink).	Unsigned Integer –1	N/A	0 to 6	
rec_type	36	*Record type.* 71 => Spacecraft DOD 72 => Quasar DOD 73 => Spacecraft DOR 74 => Quasar DOR	Unsigned Integer –1	N/A	71 to 74	
source_type	37	*VLBI source.* 0 => Quasar 1 => Spacecraft	Unsigned Integer –1	N/A	0 or 1	
fts_vld_flag	38	*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	
reserve1b	39	*Reserved.*	Unsigned Integer-1	N/A	0	
array_flag	40	*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
array_flag_2	41	*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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
array_delay	42	*Array delay value at primary antenna.* Time delay added to signal 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
array_delay_2	50	*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
rcv_time_tag_delay	58	*Receive time tag delay at primary antenna.* Value offsets downlink time tag (e.g., for Goldstone Beam Wavefuide antennas). A value of –1.0 indicates invalid (or not provided).	IEEE Double	Seconds / 0.1 nsec	-1.0, 0.0 to 1.0	
rcv_time_tag_delay_2	66	*Receive time tag delay at secondary antenna.* Value offsets downlink time tag (e.g., for Goldstone Beam Wavefuide antennas). A value of –1.0 indicates invalid (or not provided).	IEEE Double	Seconds / 0.1 nsec	-1.0, 0.0 to 1.0	
mod_day	74	*Modification time days.* Days since 1/1/1958. Last modification time.	Unsigned Integer –2	Days / 1 day	0 to 216 - 1	73
mod_msec	76	*Modification time milliseconds of day.* Last modification time.	Unsigned Integer –4	msec / 1 msec	0 to 86,400,999	73
version_num	80	*Version number.* Version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	
sub_version_num	81	*Sub-version number.* Sub-version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
sub_sub_version_num	82	*Sub-sub-version number.* Sub-sub-version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	
reserve1c	83	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
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 Off-set	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 Document [3].	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 Document [3]	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 Document [2].	Unsigned Integer –1	N/A	1 to 255	

Identifier	Byte Off-set	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 Document [9].	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 Document [9]. 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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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	
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.* Value of 0 indicates unknown.	Unsigned Integer –1	N/A	0 to 4	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
vld_ul_stn	56	*Validated uplink station.* Per Reference Document [9]. 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
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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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
version_num	94	*Version number.* Version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	
sub_version_num	95	*Sub-version number.* Sub-version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	
sub_sub_version_num	96	*Sub-sub-version number.* Sub-sub-version number of the assembly that generated the data.	Unsigned Integer –1	N/A	0 to 63	
reserve1b	97	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
reserve4	98	*Reserved.* Four bytes.	Unsigned Integer –4	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)
    - SequentialRange (data type 7)
    - Angle (data type 8)
    - DRVID (data type 11)
    - PN Range (data type 14)
    - ToneRange (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 Off-sets	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	

Identifier	Byte Off-sets	Item Name and Description	Format	Units/ Precision	Range	Notes
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	
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 7	
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	

Identifier	Byte Off-sets	Item Name and Description	Format	Units/ Precision	Range	Notes
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	
fabricated_sfdu_flag	72	*Fabricated SFDU Flag* Indicates whether this SFDU was artificially fabricated in support of 3-way ranging. 0 => Originally generated by UPL and validated by TTC software 1 => Fabricated by TTC software	Unsigned Integer –1	N/A	0 or 1	
reserve1	73	*Reserved.* One byte.	Unsigned Integer-1	N/A	0	
reserve6	74	*Reserved.* Six bytes.	Unsigned Integer –6	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 Off-set	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	

Identifier	Byte Off-set	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
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 at which the calibration was done.	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 230	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.* Ranging configuration file ID, or the name of the PN pattern	ASCII –8	N/A	ASCII string	92
t1	56	*T1 setting.*	Unsigned Integer –2	Seconds / 1 sec	1 to 3600	12
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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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 212	
exc_scalar_num	84	*Exciter Scalar Numerator.* Numerator of ratio between ranging reference signal and uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
exc_scalar_den	88	*Exciter Scalar Denominator.* Denominator of ratio between ranging reference signal and 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 / 1 second	4.0 to 504,536.0	18

Identifier	Byte Off-set	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
rng_meas_type	104	*Range Measurement Type.* Type of sequential measurement. 0 => Ranging Round Trip 1 => Calibration 2 => Telemetry-Based Ranging 3 => 1-way to Spacecraft 4 => 1-way from Spacecraft 5 => Coupled Noncoherent	Unsigned Integer –1	N/A	0 to 5	93
fabricated_sfdu_flag	105	*Fabricated SFDU Flag* Indicates whether this SFDU was artificially fabricated in support of 3-way ranging. 0 => Originally generated by UPL and validated by TTC software 1 => Fabricated by TTC software	Unsigned Integer –1	N/A	0 or 1	
reserve6	106	*Reserved.* Six bytes.	Unsigned Integer –6	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 Off-set	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	190	
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 at which the calibration was done.	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_subcode1	42	*Subcode #1 code state.* Position in the subcode at the time tag.	Unsigned Integer –1	N/A	0 to 63	19
state_subcode2	43	*Subcode #2 code state.* Position in the subcode at the time tag.	Unsigned Integer –1	N/A	0 to 63	19
state_subcode3	44	*Subcode #3 code state.* Position in the subcode at the time tag.	Unsigned Integer –1	N/A	0 to 63	19

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
state_subcode4	45	*Subcode #4 code state.* Position in the subcode at the time tag.	Unsigned Integer –1	N/A	0 to 63	19
state_subcode5	46	*Subcode #5 code state.* Position in the subcode at the time tag.	Unsigned Integer –1	N/A	0 to 63	19
state_subcode6	47	*Subcode #6 code state.* Position in the subcode at the time tag.	Unsigned Integer –1	N/A	0 to 63	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
transmit_op_pwr	58	*Transmitter output power.*	IEEE Single	W / 0.1 W	0.0 to 500,000.0	
template_id	62	*Template ID.* Ranging configuration file ID, or the name of the PN pattern.	ASCII – 22	N/A	ASCII string	92
clk_divider	84	*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_subcode1	85	*Subcode #1 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode2	86	*Subcode #2 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode3	87	*Subcode #3 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode4	88	*Subcode #4 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode5	89	*Subcode #5 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode6	90	*Subcode #6 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
op_subcode1	91	*Operation #1.* Logical operation between the accumulated pattern and the next subcode. 0 => AND 1 => OR 2 => XOR 3 => Weighted Vote, weight = 1 4 => Weighted Vote, weight = 2 5 => Weighted Vote, weight = 3 6 => Weighted Vote, weight = 4 7 => Weighted Vote, weight = 5 8 => Weighted Vote, weight = 6	Unsigned Integer –1	N/A	0 to 8	91
op_subcode2	92	*Operation #2.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
op_subcode3	93	*Operation #3.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
op_subcode4	94	*Operation #4.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
op_subcode5	95	*Operation #5.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
def_subcode1	96	*Subcode #1 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode2	104	*Subcode #2 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode3	112	*Subcode #3 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode4	120	*Subcode #4 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode5	128	*Subcode #5 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode6	136	*Subcode #6 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
pn_code_length	144	*PN Code Length.* The length of the complete PN pattern, in chips.	Unsigned Integer –4	PN chips/1 chip	2 to 2^{32}-1	22
transmit_inphs_time_year	148	*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	150	*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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
transmit_inphs_time_sec	152	*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	160	*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	164	*Ranging modulation amplitude.* Actual digital modulation amplitude used by the ranging hardware.	Unsigned Integer –2	N/A	0 to 2^{12}	
exc_scalar_num	166	*Exciter Scalar Numerator.* Numerator of ratio between ranging reference signal and uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
exc_scalar_den	170	*Exciter Scalar Denominator.* Denominator of ratio between ranging reference signal and uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
rng_cycle_time	174	*Ranging cycle time.* Integration time for each PN range point.	IEEE Double	Seconds / 1 second	1.0 to 5.0e5	23
clock_waveform	182	*Clock waveform type.* 0 => Squarewave 1 => Sinewave	Unsigned Integer -1	N/A	0 or 1	
rng_meas_type	183	*Range Measurement Type.* Type of PN measurement. 0 => Ranging Round Trip 1 => Calibration 2 => Telemetry-Based Ranging 3 => 1-way to Spacecraft 4 => 1-way from Spacecraft 5 => Coupled Noncoherent	Unsigned Integer –1	N/A	0 to 5	93
time_tag_corr_flag	184	*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 Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
type_time_corr_flag	185	*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	
fabricated_sfdu_flag	186	*Fabricated SFDU Flag* Indicates whether this SFDU was artificially fabricated in support of 3-way ranging. 0 => Originally generated by UPL and validated by TTC software 1 => Fabricated by TTC software	Unsigned Integer –1	N/A	0 or 1	
op_subcode6	187	*Operation #6.* (See Item op_subcode1)	Unsigned Integer-1	N/A	0 to 8	91
ccsds_k	188	*CCSDS PN Parameter K.* Parameter K setting PN ranging chip rate.	Unsigned Integer-1	N/A	6 to 10	20
ccsds_l	189	*CCSDS PN Parameter L.* Parameter L setting PN ranging chip rate.	Unsigned Integer-1	N/A	1 to 100	20
ul_rng_modulo	190	*Uplink Range Modulo value.* Range measurement modulo (ambiguity).	Unsigned Integer-4	Range Units/1 RU	2 to 2^{32}-1	45

3.1.5.1.4 Ramp CHDO (Data Type 9)

For UPL-DTT antennas the Ramp CHDO is generated only when **ramp_type** equals 0, 1, 4, or 5, OR when **transmit_stat** changes. For non-UPL-DTT antennas the Ramp CHDO is generated at the beginning of a pass or when either **prdx_mode** or **ul_band_dl** changes for a given spacecraft. The Ramp CHDO is defined in Table 3-12.

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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes

Identifier	Byte Off-set	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 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 7	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
fabricated_sfdu_flag	33	*Fabricated SFDU Flag* Indicates whether this SFDU was artificially fabricated in support of 3-way ranging. 0 => Originally generated by UPL and validated by TTC software 1 => Fabricated by TTC software	Unsigned Integer –1	N/A	0 or 1	
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 Off-set	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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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
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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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
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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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
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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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
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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
prdx_time_offset	202	*Predicts time offset.* Seconds added to current time.	IEEE Double	Seconds / 1 msec	-8.64e4 to 8.64e4	54
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 Off-set	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_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 at which the calibration was done.	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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
figure_merit	42	*Probability of Acquisition.* Formerly called 'Figure of Merit', this is the probability of acquiring the correct range.	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	
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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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.* Ranging configuration file ID, or the name of the PN pattern.	ASCII –8	N/A	ASCII string	92
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	
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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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 ratio between ranging reference signal and uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
exc_scalar_den	136	*Exciter Scalar Denominator.* Denominator of ratio between ranging reference signal and 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 / 1 second	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	-1.000e8 to 1.000e8	
quad_phs_correl	152	*Quadrature phase correlation value.* The quadrature phase value of the clock component correlation.	IEEE Single	N/A	-1.000e8 to 1.000e8	
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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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	
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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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
rng_meas_type	170	*Range Measurement Type.* Type of sequential measurement. 0 => Ranging Round Trip 1 => Calibration 2 => Telemetry-Based Ranging 3 => 1-way to Spacecraft 4 => 1-way from Spacecraft 5 => Coupled Noncoherent	Unsigned Integer –1	N/A	0 to 5	93
stn_cal_corr_flag	171	*Station calibration correction flag.* Indicates result of validation of station calibration values. 0 => Unable to correct 1 => Validated, no change 2 => Validated, changed ul_stn_cal 3 => Validated, changed dl_stn_cal 4 => Validated, changed both ul_stn_cal and dl_stn_cal 5 => Validated, changed round-trip stn_cal	Unsigned Integer –1	N/A	0 to 5	
reserve6	172	*Reserved.* Six bytes.	Unsigned Integer –6	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	258	
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 at which the calibration was done.	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	*Probability of Acquisition.* Formerly called 'Figure of Merit', this is the probability of acquiring the correct range.	IEEE Single	Percentage / 0.1 percent	0.0 to 100.0	28

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
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	
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_subcode1	94	*Subcode #1 code state.* Position in the subcode at the time tag.	Unsigned Integer –1	N/A	0 to 63	19
state_subcode2	95	*Subcode #2 code state.* Position in the subcode at the time tag.	Unsigned Integer –1	N/A	0 to 63	19
state_subcode3	96	*Subcode #3 code state.* Position in the subcode at the time tag.	Unsigned Integer –1	N/A	0 to 63	19
state_subcode4	97	*Subcode #4 code state.* Position in the subcode at the time tag.	Unsigned Integer –1	N/A	0 to 63	19

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
state_subcode5	98	*Subcode #5 code state.* Position in the subcode at the time tag.	Unsigned Integer –1	N/A	0 to 63	19
state_subcode6	99	*Subcode #6 code state.* Position in the subcode at the time tag.	Unsigned Integer –1	N/A	0 to 63	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.* Ranging configuration file ID, or the name of the PN pattern.	ASCII –20	N/A	ASCII string	92
invert	134	*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	135	*Correlation type.* 0 => Squarewave 1 => Sinewave	Unsigned Integer –1	N/A	0 or 1	
int_time	136	*Integration time.* Time that the signal was integrated over.	Unsigned Integer –4	Seconds/1 second	1 to 2^{32} – 1	
clk_divider	140	*Clock divider.* Value that ranging reference frequency is divided by to get chip rate.	Unsigned Integer –1	N/A	1 to 64	20
len_subcode1	141	*Subcode #1 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
len_subcode2	142	*Subcode #2 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode3	143	*Subcode #3 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode4	144	*Subcode #4 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode5	145	*Subcode #5 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode6	146	*Subcode #6 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
op_subcode1	147	*Operation #1.* Logical operation between the accumulated pattern and the next subcode. 0 => AND 1 => OR 2 => XOR 3 => Weighted Vote, weight = 1 4 => Weighted Vote, weight = 2 5 => Weighted Vote, weight = 3 6 => Weighted Vote, weight = 4 7 => Weighted Vote, weight = 5 8 => Weighted Vote, weight = 6	Unsigned Integer –1	N/A	0 to 8	91
op_subcode2	148	*Operation #2.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
op_subcode3	149	*Operation #3.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
op_subcode4	150	*Operation #4.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
op_subcode5	151	*Operation #5.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
def_subcode1	152	*Subcode #1 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
def_subcode2	160	*Subcode #2 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode3	168	*Subcode #3 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode4	176	*Subcode #4 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode5	184	*Subcode #5 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode6	192	*Subcode #6 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
pn_code_length	200	*PN Code Length.* The length of the complete PN pattern, in chips.	Unsigned Integer –4	PN chips/1 chip	2 to 2^{32}-1	22
rcv_inphs_time_year	204	*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	206	*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	208	*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 86,400.9 99999	75
exc_scalar_num	216	*Exciter Scalar Numerator.* Numerator of ratio between ranging reference signal and uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
exc_scalar_den	220	*Exciter Scalar Denominator.* Denominator of ratio between ranging reference signal and uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
rng_cycle_time	224	*Ranging cycle time.* Integration time for each PN range point.	IEEE Double	Seconds / 1 second	1.0 to 1.0e5	23

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
inphs_correl	232	*In phase correlation value.* The in phase value of the clock component correlation.	IEEE Single	N/A	-1.000e8 to 1.000e8	
quad_phs_correl	236	*Quadrature phase correlation value.* The quadrature phase value of the clock component correlation.	IEEE Single	N/A	-1.000e8 to 1.000e8	
metrics_vld_flag	240	*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	241	*Correlation validity flag.* 0 => Invalid 1 => Valid	Unsigned Integer –1	N/A	0 or 1	56
rng_resid_tol_flag	242	*Range residual tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer –1	N/A	0 or 1	63
drvid_tol_flag	243	*DRVID tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer –1	N/A	0 or 1	64
prn0_resid_tol_flag	244	*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	245	*Range sigma tolerance flag.* 0 => Out of tolerance 1 => In tolerance	Unsigned Integer –1	N/A	0 or 1	66
rng_vld_flag	246	*Range validity flag.* 0 => Invalid 1 => Valid	Unsigned Integer –1	N/A	0 or 1	67
rng_config_flag	247	*Range configuration change flag.* 0 => Changed 1 => Unchanged	Unsigned Integer –1	N/A	0 or 1	68
rng_hw_flag	248	*Ranging hardware status flag.* 0 => Bad 1 => Good	Unsigned Integer –1	N/A	0 or 1	

Identifier	Byte Offset	Item Name and Description	Format	Units/ Precision	Range	Notes
rng_meas_type	249	*Range Measurement Type.* Type of PN measurement. 0 => Ranging Round Trip 1 => Calibration 2 => Telemetry-Based Ranging 3 => 1-way to Spacecraft 4 => 1-way from Spacecraft 5 => Coupled Noncoherent	Unsigned Integer –1	N/A	0 to 5	93
time_tag_corr_flag	250	*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	251	*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	252	*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	253	*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
stn_cal_corr_flag	254	*Station calibration correction flag.* Indicates result of validation of station calibration values. 0 => Unable to correct 1 => Validated, no change 2 => Validated, changed ul_stn_cal 3 => Validated, changed dl_stn_cal 4 => Validated, changed both ul_stn_cal and dl_stn_cal 5 => Validated, changed round-trip stn_cal	Unsigned Integer-1	N/A	0 to 5	
op_subcode6	255	*Operation #6.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
ccsds_k	256	*CCSDS PN Parameter K.* Parameter K setting PN ranging chip rate.	Unsigned Integer-1	N/A	6 to 10	20
ccsds_l	257	*CCSDS PN Parameter L.* Parameter L setting PN ranging chip rate.	Unsigned Integer-1	N/A	1 to 100	20
dl_rng_modulo	258	*Downlink Range Modulo value*. Range measurement modulo (ambiguity).	Unsigned Integer-4	Range Units/1 RU	2 to 2^{32}-1	45

3.1.5.3 Derived Data CHDOs

There are seven derived data CHDOs: Doppler Count (data type 6), SequentialRange (data type 7), Angle (data type 8), DRVID (data type 11), PN Range (data type 14), ToneRange (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. It is generated only for non-UPL-DTT antennas.

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	56	
ref_rcv_type	4	*Reference receiver type.* 0 => Unknown 2 => MFR	Unsigned Integer –1	N/A	0 or 2	
reserve1a	5	*Reserved.* One byte.	Unsigned Integer –1	N/A	0	
sampl_interval	6	*Sample interval.* Interval between points. Value of –1.0 indicates interval is unknown.	IEEE Single	Seconds / 0.1 second	-1.0, 1.0 to 60.0	84
rcv_sig_lvl	10	*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	14	*Uplink frequency.* Uplink frequency value used in the Doppler computation at time tag. Also called the Doppler Reference Frequency.	IEEE Double	Hz / 1 mHz	2.0e9 to 34.7e9	34
dop_cnt_bias _freq	22	*Doppler count bias frequency.* Bias value used in Doppler Count measurement.	IEEE Double	Hz / 1 mHz	-10.0e6 to 10.0e6	34
dop_cnt	30	*Doppler Count.*	IEEE Double	Cycles / 1 mcycle	0.000 to 242 / 1000	34
dop_pseudo_re sid	38	*Doppler Pseudo Residual.* Actual minus predicted value.	IEEE Double	Hz / 1 mHz	-228 / 1000 to 228 / 1000	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
time_tag_corr_flag	46	*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	
type_time_corr_flag	47	*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	48	*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	49	*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	50	*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	
dop_vld_flag	51	*Doppler Validity Flag.* 0 => Valid 1 => Invalid.	Unsigned Integer –1	N/A	0 or 1	89
reserve8	52	*Reserved.* Eight bytes.	Unsigned Integer –8	N/A	0	

3.1.5.3.2 Sequential 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 Off-set	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, time tag adjustments, 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, time tag adjustments, 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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
figure_merit	46	*Probability of Acquisition.* Formerly called 'Figure of Merit', this is the probability of acquiring the correct range.	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
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	
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	-86,400.000000 to 86,400.000000	59

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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	-86,400.000000 to 86,400.000000	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	0.0 to 15.0	
exc_scalar_num	94	*Exciter Scalar Numerator.* Numerator of ratio between ranging reference signal and uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
exc_scalar_den	98	*Exciter Scalar Denominator.* Denominator of ratio between ranging reference signal and 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 / 1 second	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
inphs_correl	114	*In phase correlation value.* The in phase value of the clock component correlation.	IEEE Single	N/A	-1.000e8 to 1.000e8	
quad_phs_correl	118	*Quadrature phase correlation value.* The quadrature phase value of the clock component correlation.	IEEE Single	N/A	-1.000e8 to 1.000e8	
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 Round Trip 1 => Calibration 2 => Telemetry-Based Ranging 3 => 1-way to Spacecraft 4 => 1-way from Spacecraft 5 => Coupled Noncoherent	Unsigned Integer –1	N/A	0 to 5	93

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
fabricated_ul_flag	131	*Fabricated uplink flag.* Indicates whether this SFDU was created based on uplink records fabricated in support of 3-way ranging. 0 => SFDU created using uplink records originally generated by UPL and validated by TTC software 1 => SFDU created using uplink records fabricated by TTC software	Unsigned Integer –1	N/A	0 or 1	90
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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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
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	*Probability of Acquisition tolerance value.* Formerly called '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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
rng_config_flag	179	*Range configuration change flag.* 0 => Changed 1 => Unchanged	Unsigned Integer-1	N/A	0 or 1	68
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	
time_tag_corr_flag	182	*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	
type_time_corr_flag	183	*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	
reserve6	184	*Reserved.* Six bytes.	Unsigned Integer –6	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 to both 26m antennas and those 34m antennas which have acquisition aid antennas mounted to them.

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

Identifier	Byte Off-set	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 1 => APC, (34m BWG) 2 => MPA (26m), or MTA	Unsigned Integer –1	N/A	0 to 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	
conscan_mode	8	*Conscan Mode.* 0 => Conscan off 1 => Closed loop 2 => Open loop	Unsigned Integer –1	N/A	0 to 2	
acq_aid_mode	9	*Acquisition Aid Mode* 0 => 34m-mounted Acquisition Aid is off 1 => 34m-mounted Acquisition Aid driving antenna pointing 2 => 34m-mounted Acquisition Aid not driving antenna pointing	Unsigned Integer –1	N/A	0 to 2	80

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
ang1	10	*Angle 1.* Azimuth, hour angle, or X.	IEEE Single	Deg / 0.1 deg	-90.0 to 360.	
ang2	14	*Angle 2.* Elevation, declination, or Y.	IEEE Single	Deg / 0.1 deg	-90.0 to 90.0	
ang1_pseudo_resid	18	(if source type = 2) *Angle 1 pseudo-residual.* Actual minus predicted. (if source type = 1) *Angle 1 Acquisition Aid Processor Correction*	IEEE Single	Deg / 0.1 deg millideg / 0.0001 degree	-90.0 to 90.0 -90000.0 to +360000.0	
ang2_pseudo_resid	22	(if source type = 2) *Angle 2 pseudo-residual.* Actual minus predicted. (if source type = 1) *Angle 2 Acquisition Aid Processor Correction*	IEEE Single	Deg / 0.1 deg millideg / 0.0001 degree	-90.0 to 90.0 -90000.0 to +360000.0	
time_tag_corr_flag	26	*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	
type_time_corr_flag	27	*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	
reserve2	28	*Reserved.* Two bytes.	Unsigned Integer –2	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 Off-set	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	-230 to 230	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 230	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	-230 to 230	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 Off-set	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 Off-set	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	204	
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, time tag offsets, 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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
figure_merit	36	*Probability of Acquisition.* Formerly called 'Figure of Merit', this is the probability of acquiring the correct range.	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	
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_subcode1	63	*Subcode #1 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode2	64	*Subcode #2 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode3	65	*Subcode #3 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode4	66	*Subcode #4 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
len_subcode5	67	*Subcode #5 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
len_subcode6	68	*Subcode #6 length.* A value of 0 implies no subcode.	Unsigned Integer –1	Chips / 1 chip	0 to 64	21
op_subcode1	69	*Operation #1.* Logical operation between the accumulated pattern and the next subcode. 0 => AND 1 => OR 2 => XOR 3 => Weighted Vote, weight = 1 4 => Weighted Vote, weight = 2 5 => Weighted Vote, weight = 3 6 => Weighted Vote, weight = 4 7 => Weighted Vote, weight = 5 8 => Weighted Vote, weight = 6	Unsigned Integer –1	N/A	0 to 8	91
op_subcode2	70	*Operation #2.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
op_subcode3	71	*Operation #3.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
op_subcode4	72	*Operation #4.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
op_subcode5	73	*Operation #5.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
def_subcode1	74	*Subcode #1 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode2	82	*Subcode #2 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode3	90	*Subcode #3 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode4	98	*Subcode #4 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
def_subcode5	106	*Subcode #5 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21

Identifier	**Byte Off-set**	**Item Name and Description**	**Format**	**Units/ Precision**	**Range**	**Notes**
def_subcode6	114	*Subcode #6 component value.* Definition of the subcode.	Unsigned Integer –8	N/A	0 to 2^{64}-1	21
pn_code_length	122	*PN Code Length.* The length of the complete PN pattern, in chips.	Unsigned Integer –4	PN chips/1 chip	2 to 2^{32}-1	22
transmit_inphs_time	126	*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
rcv_inphs_time	130	*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	134	*Carrier suppression by ranging modulation.* Reduction in carrier power due to ranging modulation.	IEEE Single	dB / 0.1 dB	0.0 to 15.0	
exc_scalar_num	138	*Exciter Scalar Numerator.* Numerator of ratio between ranging reference signal and uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
exc_scalar_den	142	*Exciter Scalar Denominator.* Denominator of ratio between ranging reference signal and uplink sky frequency.	Unsigned Integer –4	N/A	1 to 2^{32}-1	17
rng_cycle_time	146	*Range cycle time.* Integration time for each PN range point.	IEEE Double	Seconds / 1 second	1.0 to 5.0e5	23
rng_modulo	154	*Range modulo value.* Range measurement modulo (ambiguity).	Unsigned Integer –4	Range Units / 1 RU	0 to 2^{30}	45
rng_type	158	*Range measurement type.* Type of PN measurement. 0 => Ranging Round Trip 1 => Calibration 2 => Telemetry-Based Ranging 3 => 1-way to Spacecraft 4 => 1-way from Spacecraft 5 => Coupled Noncoherent	Unsigned-1	N/A	0 to 5	93

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
fabricated_ul_flag	159	*Fabricated uplink flag.* Indicates whether this SFDU was created based on uplink records fabricated in support of 3-way ranging. 0 => SFDU created using uplink records originally generated by UPL and validated by TTC software 1 => SFDU created using uplink records fabricated by TTC software	Unsigned-1	N/A	0 or 1	90
rng_noise	160	*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	164	*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	172	*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	173	*Uplink clock waveform type.* 0 => Squarewave 1 => Sinewave	Unsigned Integer -1	N/A	0 or 1	
rng_resid_tol_value	174	*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	178	*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	182	*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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
rng_sigma_tol_value	186	*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	190	*Probability of Acquisition tolerance value.* Formerly called '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	194	*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	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.* 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	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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
stn_cal_corr_flag	200	*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	
op_subcode6	201	*Operation #6.* (See Item op_subcode1)	Unsigned Integer –1	N/A	0 to 8	91
ccsds_k	202	*CCSDS PN Parameter K.* Parameter K setting PN ranging chip rate.	Unsigned Integer-1	N/A	6 to 10	20
ccsds_l	203	*CCSDS PN Parameter L.* Parameter L setting PN ranging chip rate.	Unsigned Integer-1	N/A	1 to 100	20
reserve4	204	*Reserved.* Four bytes.	Unsigned Integer-4	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. ToneRange CHDO (Data Type 15) Definitions

Identifier	Byte Off-set	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	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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	
rng_prefit_resid_vld_flag	7	*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
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
rng_obs	16	*Range observable.* Includes measurement adjustments (station calibration, spacecraft delay, and Z-height). Invalid is indicated by value of -1.0.	IEEE Double	nsec, modulo 2^{32} / 0.1 nsec	-1.0, 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	*ToneRange pre-fit residual.* Observed range minus predicted range.	IEEE Double	nsec / 0.1 nsec	-227 to 227	86
ul_freq	44	*Uplink frequency.* Uplink frequency value also called Doppler Reference Frequency.	IEEE Double	Hz / 1 mHz	2.0e9 to 34.7e9	34

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
time_tag_corr_flag	52	*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	
type_time_corr_flag	53	*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	

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	

Identifier	Byte Off set	Item Name and Description	Format	Units/ Precision	Range	Notes
fabricated_ul_flag	5	*Fabricated uplink flag.* Indicates whether this SFDU was created based on uplink records fabricated in support of 3-way ranging. 0 => SFDU created using uplink records originally generated by UPL and validated by TTC software 1 => SFDU created using uplink records fabricated by TTC software	Unsigned Integer –1	N/A	0 or 1	90
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.* Valid only for UPL-DTT antennas.	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

Identifier	Byte Off set	Item Name and Description	Format	Units/ Precision	Range	Notes
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	
fabricated_ul_flag	5	*Fabricated uplink flag.* Indicates whether this SFDU was created based on uplink records fabricated in support of 3-way ranging. 0 => SFDU created using uplink records originally generated by UPL and validated by TTC software 1 => SFDU created using uplink records fabricated by TTC software	Unsigned Integer –1	N/A	0 or 1	90
total_cnt_phs_pre fit_resid_tol_valu e	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.* Valid only for UPL-DTT antennas.	IEEE Double	N/A	-1.0 to 1.0	32

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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
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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
total_cnt_phs_pre fit_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_pre fit_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_pre fit_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 Off-set	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)	IEEE Single	Sec / 0.1 nsec	10.0e10 to 10.0e10	
clk_off_2	20	*Clock offset at second receiving antenna for scan.* (UTC-station time)	IEEE Single	Sec / 0.1 nsec	– -10.0e10 to 10.0e10	
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 216-1	

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
data_qual_flag	40	*Data quality flag.* 0 => Good 1 => Poor	Unsigned Integer –1	N/A	0 or 1	
freq_chan_num	41	*Frequency 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	1.0e9 to 4.0e9	
modulus	52	*Modulus.* Valid only if rec_type is 73 or 74.	IEEE Double	nsec / 0.1 psec	0.0 to 100,000.0	
dod_cnt_time	60	*Count time for VLBI delay rate observable.*	IEEE Single	Seconds / 0.1 sec	0.0 to 100,000.0	
dod_obs	64	*VLBI delay rate observable.*	IEEE Double	Hz / 10-6 Hz	-1.0e6 to 1.0e6	
dor_obs	72	*VLBI delay observable.*	IEEE Double	nsec / 0.1 psec	-1.0e9 to 1.0e9	
reserve20	80	*Reserved.* Twenty bytes.	Unsigned Integer –20	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.

3.1.5.5.1 Smoothed 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 Off-set	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	
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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
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
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 Off-set	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

Identifier	Byte Off-set	Item Name and Description	Format	Units/ Precision	Range	Notes
int_time	24	*Integration time.*	Unsigned Integer –4	Seconds / 1 sec	1 to 106	
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
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.

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. If LNA number (**lna_num**) as reported at the station is unknown or invalid (e.g., 0), then the default LNA number may be used (i.e., **lna_corr_value)**.LNA number, or when necessary the LNA correction value, is used to determine **dl_zheight_corr** (see note 60), which is subsequently used to formulate the range observable (i.e., **rng_obs**, see note 39). If **lna_corr_value** is reported as zero, then this value is not used.

10. If hardware at station allows splitting the uplink and downlink ranging delays, thevalue 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 ranging 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. PN Code length (**pn_code_length**) in chips equals the result of multiplying the lengths of all of the subsequences together.

23. PN cycle time is the integration time for each PN range point, in seconds.

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. Probability of Acquisition, formerly called 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 downlink carrier phase plus a bias term (generated by integrating **dop_cnt_bias_freq**) minus the uplink carrier phase (generated by integrating **ul_freq**)scaled by the spacecraft transponder turn around ratio.. The bias term is used to keep the Doppler Count a positive value. 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 = $-(\phi_i - \phi_{i-1})$ / **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 = $-(\phi_i - \phi_{start})$

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

Reported Observable = $(\phi_i - \phi_{start})$

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):

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

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):

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

45. All PN ranging measurements are expressed modulo the ranging ambiguity in range units. The Data Type 4 item **ul_rng_phs** is reported modulo item **ul_rng_modulo**. The Data Type 5 items **dl_rng_phs**, **rng_resid**, and **drvid** are reported modulo item **dl_rng_modulo**. The derived Data Type 14 items **meas_rng**, **rng_obs_dl**, and **drvid** are reported modulo item **rng_modulo**

The modulus is the length of the complete PN pattern, in range units. The modulus depends on the formula for the number of range units in a PN chip, given by the equation:

$$chip\_length = \frac{64 \times 2^K}{L} \quad \text{(range units)}$$

Where K = **ccsds_k** and L = **ccsds_l** (see note 20). For interface versions where the secondary header item '**dl_software_version**' is less than '12', the PN range modulo is:

rng_modulo (range units) = **16 * clk_divider * pn_code_length** (chips)

For interface versions where the secondary header item '**dl_software_version**' is '12' or greater, the PN range modulo is:

rng_modulo (range units) = **dl_rng_modulo** (range units)

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):

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

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.

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

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 Probability of Acquisition (still called item **figure_merit**) is above its tolerance value (**fom_tol_value**). Additionally, for the derived data types (Data Types 7 and 14), the condition of the data not being calibration data (**rng_meas_type**) is also included.

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. Acquisition Aid Mode (acq_aid_mode) is set to zero ('0') when angle data originates from a 26m antenna. For angle information from the APC, there are two modes for reporting the acquisition aid information. These modes are shown in the item ‘Acquisition Aid Mode’. When the acquisition aid correction information is driving the antenna in closed loop control, the ‘Acquisition Aid Mode’ is ‘1’. Then the values in Angle 1 and Angle 2 are the Beam RF (Radio Frequency) angles of the antenna, while the antenna is actively tracking the target signal. When the acquisition aid is on, but the antenna is driven by predicts (or predicts and manual offsets), the ‘Acquisition Aid Mode’ is ‘2’. Then the values in Angle 1 and Angle 2 are the antenna pointing angles obtained from tracking using the predicts, plus any manual offsets. That is, the values in Angle 1 and Angle 2 represent ‘blind pointing’ values from the predicted angle data, and do not contain any measurement of the actual target position. To obtain an estimate of the target’s Beam RF angles, add Angle 1 to the Angle 1 Acquisition Aid Processor Correction, and add Angle

2 to the Angle 2 Acquisition Aid Processor Correction. For the 34m antennas, the Acquisition Aid Processor Correction angles are provided in place of the angle pseudo-residuals.

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. Note 85 has been deleted.

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.

89. The Doppler Validity Flag (**dop_vld_flag**) is set by the tracking equipment to indicate whether or not the doppler data is valid.

90. The Fabricated Uplink Flag (**fabricated_ul_flag**) pertains to 3-way range cases where TTC software fabricated Uplink Carrier Phase (UCP, DT0) records and uplink ranging phase records (DT2 for sequential range, DT4 for PN range) to artificially extend a pass, in order to formulate a range observable based on an uplink and downlink range record occurring at the same timetag. This flag is set by TTC software to indicate that this derived tracking data type was created based on fabricated uplink record(s).

    When this flag is set in DT7 (Sequential Range) and DT14 (PN Range), it indicates:

(a) The **meas_rng** and **rng_obs** values were computed using the **ul_rng_phs** value from a fabricated DT2 (Uplink Sequential Ranging Phase) or DT4 (Uplink PN Ranging Phase) record.
(b) The following fields were populated based on a fabricated DT2 or DT4: **ul_band**, **ul_assembly_num**, **transmit_num**, **transmit_stat**, **transmit_mode**, **cmd_modul_stat**, **rng_modul_stat**, **transmit_time_tag_delay**, **and ul_zheight_corr**.
(c) The **ramp_freq** from a fabricated DT0 (Uplink Carrier Phase) was used in performing the seconds to range units conversion on corrections incorporated into the range observables.

In the event that fabricated uplink records were to be used in the reprocessing of DT16 (Carrier Frequency Observable) and DT17 (Total Count Phase Observable), then this flag would indicate that the following fields were populated based on a fabricated DT0 (Uplink Carrier Phase): **ul_dss_id**, **ul_band**, **ul_assembly_num**, **transmit_num**, **transmit_stat**, **transmit_mode**, **cmd_modul_stat**, **and rng_modul_stat**.

91. The logical operation codes are used to create the accumulated PN pattern from the defined PN subcodes. These are described in the referenced documents [10] and [11].

92. For PN ranging, the Template ID may show the spacecraft number of the ranging configuration file, e.g. "99", or the type of PN ranging. For example, the standard DSN PN ranging pattern may have the Template ID "DSN". The CCSDS ranging patterns will have Template ID "T2B" or "T4B". Other configurations may appear with their own Template IDs.

93. Range Measurement Type: Ranging Round Trip (0) is the normal station to spacecraft to station ranging, with ranging measured at the tracking station. Calibration (1) is the ground loop station delay measurement through the test translator. Telemetry-Based Ranging (2) uses ranging tones sent from the station, measured at the spacecraft relative to a telemetry frame, and that telemetry frame Earth receive time is measured at the station. 1-way to Spacecraft (3) uses ranging tones sent from the station, measured at the spacecraft relative to the spacecraft clock. 1-way from Spacecraft (4) uses ranging tones created at the spacecraft, measured at the station relative to the station clock. Coupled Noncoherent (5) is a combined measurement of types (3) and (4).

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 = 013610115SC82DSS65.234
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'

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., 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’
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	‘0000000 1’

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'
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
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 Document [2].	'0' thru '255'
6	**MISSION_ID = <value><CR><LF>** The decimal representation of the applicable DSN mission number per Reference Document [2].	'0' thru '255'
7	**DATA_SET_ID = <value><CR><LF>** The unique identifier for this data type.	'TRK234 '

Ref #	Keyword-Value Pairs. Description and Units.	Range for Value
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: **yydddhhmmSCsssssDSSnnnnn.234**, where, **yy** is the two-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 Document [2], with leading zeros omitted) **DSS** is fixed, and denotes that the DSS ID is to follow: **nnnnn** is the DSS ID (per Reference Document [9], with leading zeros omitted) . **234** is a fixed suffix, and identifies the file as being a TRK-2-34 file. **yydddhhmm** corresponds to BOA as reported in the DSN 7-day schedule for the given pass. The naming convention for software-generated files containing data from more than one station [e.g., "fabricated" 3-way range products containing not only downlink station data, but also one or more associated uplink station(s)] utilize "ALL_3w" in lieu of **nnnnn**. In addition, **yydddhhmm** in the filename for the 3-way range product is the same as that for the standard product generated for the same pass, except the minute (**mm**) value for the 3-way range product is one minute less than that for the standard product. (The deviation in the **mm** value is driven by the underlying implementation with respect to directory structures.)	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

Ref #	Keyword-Value Pairs. Description and Units.	Range for Value
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
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’
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	‘0000000 1’

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'.