Deep Space Network

# 0159-Science
# Radio Science Experiment Access Interface

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# Document Change Log

| Rev. | Check if Minor Rev. | Issue Date | Affected Sections | Change Summary |
|---|---|---|---|---|
| -- | | 02/28/2001 | All | |
| A | | 06/02/2004 | 1.2, 1.4, 2,7, 3.5 | Description of newly added schan fgain mult |
| B | X | 02/29/2008 | Section 1 | Minor changes to update footer tags, change 'DSMS' to 'DSN', edit Section 1 sequence |
| C | X | 02/24/2010 | Section 2 | Deleted references to RNS. Clarified data paths. |
| D | X | 11/01/2012 | 1.5, 2.1, | Added nonstandard one second records description<br>Added references to predicts interfaces<br>Added reference to S/W operator's Manual |
| E | X | 08/20/2015 | 3.6 Table 3-1 | Corrected errors in columns 5 and 6 |
| F | X | 11/13/2017 | Sections 1.1, 1.5, 2.4, 3.5, 3.6, Figure 2.1 | Added OLR Subsystem information<br>Minor corrections to sections and diagram |
| G | | 09/16/2019 | All | Major update to remove unneeded references to RSR, WVSR. Removes sample tables. |

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# *Contents*

# *Figures*

# Section 1
# Introduction

## 1.1 Purpose

This Deep Space Network (DSN) interface module specifies the interfaces for both Radio Science experiment access and data access services. It identifies the DSN interfaces that are needed to operate the Open Loop Receiver (OLR) and effectively use the data. It specifies the format and contents of the legacy Radio Science Receiver (RSR) Standard Formated Data Unit (SFDU). Although the RSR has been replaced by the OLR, the RSR SFDU data format is still used by some existing missions. An RSR SFDU, as specified by this module, is a self-identifying, self-delimiting data structure that is used to encapsulate a portion of the radio science data acquired by the OLR. Each SFDU contains data and ancillary information required for post processing.

The Planetary Radar & Radio Sciences Group (PRRSG, instead of DSN Operations) typically remotely monitors and controls the OLR during radio science experiments. For non-radio science activities, such as spacecraft contingency support during critical period, the DSN, or project, typically coordinates with the Planetary Radar & Radio Sciences Group for use of the non-schedulable “blue” OLRs at a complex – olr7 and olr8.

The Planetary Radar & Radio Sciences Group uses frequency predicts available on the Service Preparation Subsystem (SPS) portal for OLR tracking. These predicts help remove the Doppler effect and keep the spacecraft signal within the recording bandwidth.

While the primary scope of this module is to document interfaces and the format and contents of the RSR SFDU, it also briefly describes OLR itself, how it records a native data format and translates it into RSR SFDUs for customers who require the legacy format. Document references for more details about the design, interfaces and operation of the OLR are provided in section 1.5.

## 1.2 Applicability

Revision G removes detailed information about RSR and WVSR, adds OLR document references.

Revision F documents OLR Subsystem information.

Revision E documents corrections in Table 3-1.

Revision D documents the one second data record and adds a brief description of input interfaces used by the (PRRSG).

Revision C documents supported data paths, clarifies the Radio Science user interface, and removes Advanced Multi Mission Operations System Interface.

Revision B provides editorial updates only and supersedes Revision A.

Revision A differs from the initial release in it’s description of the change in the content of an RSR SFDU. Namely, the 16 bytes of reserved space at the end of the secondary data Compressed Header

Data Object (CHDO) in the SFDU has been reduced to 12 bytes and the 4 bytes remaining are occupied by the single precision floating point channel fgain multiplier.

## 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:

DSN 813-109, D-17818 *Preparation Guidelines and Procedures for Deep Space Network (DSN) Interface Specifications, October 27, 2009* [DSN Internal]

## 1.4 Terminology and Notation

The following conventions are used in figures defining the format of a data record or piece of a data record:

- All byte offsets are assumed to be relative to the beginning of a structure or substructure. The first byte of a structure is called offset 0 (normally shown as the left byte of two); the second byte is at offset 1 (normally shown as the right byte of two), etc.
- If a field in the SFDU requires more than one byte, the most significant byte is at the lowest-number byte offset with each succeeding byte in the next higher byte offset so that the least significant byte is in the highest-number byte offset.
- Bits in a byte are labeled 1 through 8, where the 1st bit (left-most bit) is the most-significant or sign bit and the 8th bit is the least-significant bit (right-most bit). For fields using more than one byte, bits are labeled 1 - n correspondingly.

### 1.4.1 Data Item Formats

#### 1.4.1.1 Integer

An integer format is used to express integral quantities, using two's complement notation. The range for an integer field is $[-1 * (2^n/2)]$ to $[(2^n/2) - 1]$, where n is the number of bits in the field. For example, an 8 bit integer field would have the following range:

range = $[-1 * (2^8/2)]$ to $[(2^8/2) - 1] = -128$ to 127.

#### 1.4.1.2 Unsigned Integer

An unsigned integer format is used to express integral quantities using the base 2 number system, also known as binary. The range for an unsigned integer field is 0 to $(2^n - 1)$, where n is the number of bits in the field.

#### *1.4.1.3 Floating Point*

Floating point numbers are represented in the basic single format defined in document American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE) Std 754-1985. This representation is commonly referred to as the 32-bit IEEE floating point format.

#### *1.4.1.4 Double Floating Point*

Double floating point numbers are represented in the basic double format defined in document ANSI/IEEE Std 754-1985. This representation is commonly referred to as the 64-bit IEEE floating point format.

#### *1.4.1.5 Restricted ASCII*

Restricted American Standard Code for Information Interchange (ASCII) is a subset of the ASCII character set consisting of uppercase letters A to Z and digits 0 to 9.

## *1.5 References*

**Documents**

The following documents are referenced within this module or provide supplemental information. Some documents are internal to the DSN and are included for reference only and do not form a part of this interface.

| | | |
|---|---|---|
| | DSN 820-013 | *DSN External Interface Specification—Standard* |
| (1) | 0222-Science | *Native OLR data format* |
| (2) | OPS-6-21 | *Code Assignments* |
| (3) | 0168-ServiceMgmt | *DSN Web Portal Services* |
| (4) | DSN 820-016 | *DSN Software Interface Modules*<br>DSN internal document, for reference only |
| (5) | 0443-OLR-SPS | *OLR and SPS Interface*<br>DSN internal document, for reference only |
| (6) | 0323-SPS-ULC | *SPS and Uplink Controller*<br>DSN internal document, for reference only |
| (7) | 837-083 | *OLR Subsystem Operations Manual*<br>DSN internal document, for reference only |
| (8) | 810-047C | *DSN Facility and Antenna Identification*<br>DSN internal document, for reference only |

| | | |
|---|---|---|
| (9) | CCSDS 620.0-B-2 | Consultative Committee for Space Data Systems *(CCSDS) Recommendation for Space Data System Standards—Standard Formatted Data Units—Structure and Construction Rules* (Issue 2, May 1992) |
| (10) | ANSI T-49-12 | *ANSI/IEEE STD 754-1985—IEEE Standard for Binary Floating-Point Arithmetic* |

**Web-Sites**

| | | |
|---|---|---|
| (1) | http://spsweb.fltops.jpl.nasa.gov | *For SPS products* |
| (2) | http://dsnprocess.jpl.nasa.gov/dsirt/ | *For DSN Antenna and Facility Identifiers* |

# Section 2
# Functional Overview

## 2.1 General Information

The Planetary Radar & Radio Sciences Group uses the Open Loop Receiver (OLR) Subsystem, deployed in the DSN, to gather data for their experiments. They may access the recievers remotely, copy downlink frequency predicts from the SPS portal to the receivers, configure and control the receiver operation, and initiate data playback to their local computer(s). For some experiments they may need to obtain other (e.g., the exciter and antenna pointing) predicts to refine their understanding of the data. However, most tracks are scheduled and automatically executed without manual interventaion.

## 2.2 Open Loop Receiver (OLR) Subsystem

The OLR Subsystem is capable of generating RSR SFDU data format. The OLR is the replacement for the RSR and has a different native data format - Raw Data Exchange Format (RDEF). However, the OLR software suite provides a translator, which produces RSR data records. Details of the OLR native data format and interface are specified in 820-013 0222-Science and the OLR Subsystem Operations Manual (SOM 837-083). Since the OLR became operational in early 2019, the interface in this document is no longer an option for new missions.

The OLR Subsystem is a computer-controlled open loop receiver, which digitally records spacecraft signals. The OLR then downconverts, channelizes and records data samples onto a shared array of networked RAID disks. The digital samples from each OLR channel are stored to disk in one second records in real time. In near real time the one second records are translated from the native OLR RDEF format into a sequence of RSR SFDUs which are transmitted to JPL's Planetary Radar & Radio Sciences Group or any designated user computers, with approved access. Included in each RSR SFDU is the ancillary data necessary to reconstruct the signal represented by the recorded data samples in that SFDU. Analysis of variations in the amplitude, phase, and frequency of the recorded signals provides information on the ring structure, atmospheric density, magnetic field, and charged-particle environment of planets which occult the spacecraft. Variations in the recorded signal can also be used for gravity wave detection.

## 2.3 Interface Diagram

The main functional data flow is depicted in Figure 2-1. The data are temporarily stored, possibly processed, and forwarded to the science users, or can be retrieved by the science users via Secure File Transfer Protocol (SFTP). The users can be the Planetary Radar & Radio Sciences Group, other principal investigators, or mission-specific data analysis capability for critical event such as Entry Descent Landing Data Analysis (EDA)

The SPS is a DSN subsystem. The predicts needed to operate the OLR are the downlink frequency, which can be retrieved from the SPS Portal via interface 820-013 0168-ServiceMgmt, or are automatically pulled when the OLR is in a DSN antenna link. The format is documented in the OLR interface 820-016 0443-OLR-SPS. The predicts used by Planetary Radar & Radio Sciences Group for post-processing are retrieved for from the same portal and have the formats documented in 0443-OLR-

SPS and 0323-SPS-ULC of 820-016. All these predicts are automatically generated for any uplink and/or downlink antenna for any DSN scheduled spacecraft pass.

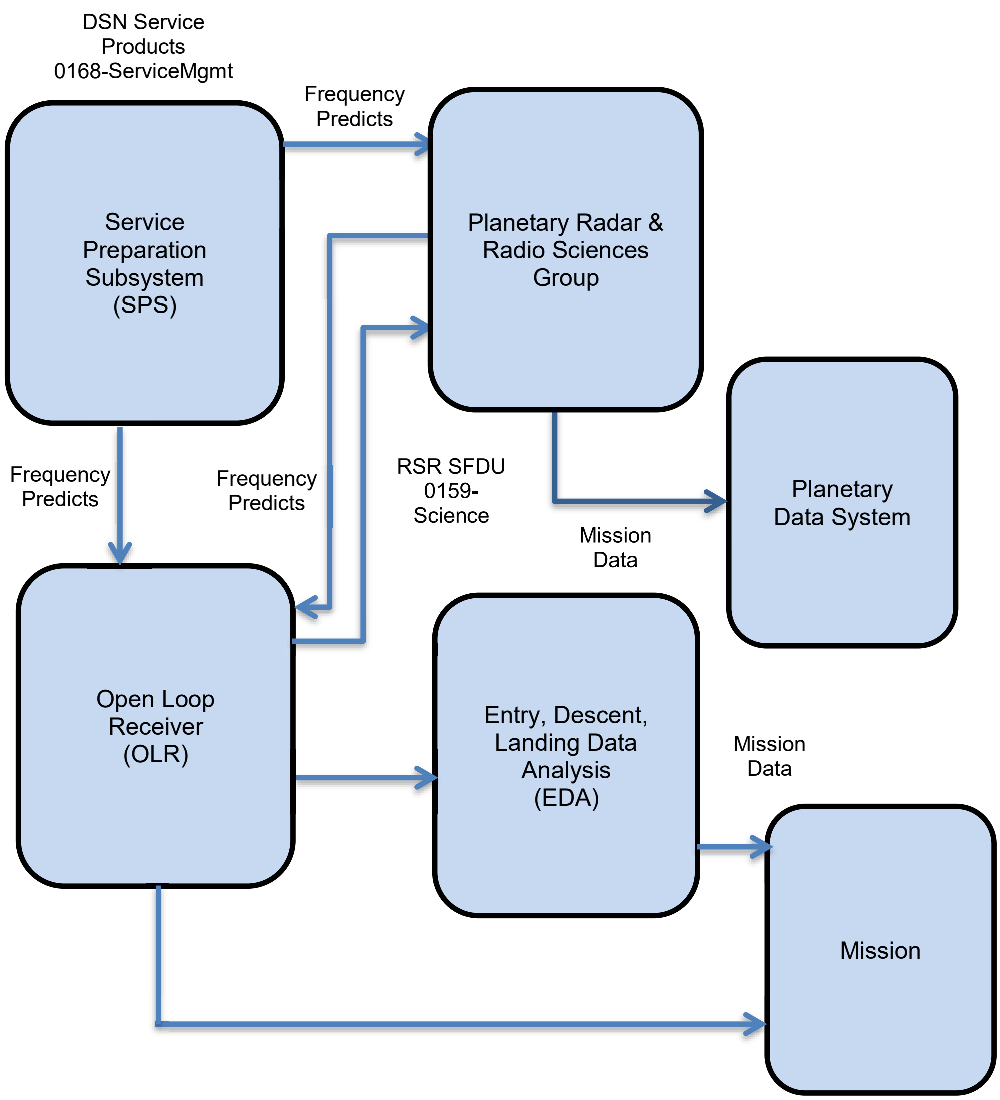


***Figure 2-1 OLR to user data flow***

## 2.4 Numerically Controlled Oscillator (NCO) Phase and Frequency

At the start of each pass the OLR is provided with a file containing a list of frequency predicts points. Using the predicts points the OLR computes the expected sky frequency of the spacecraft signal at the beginning, middle and end of each second. From the sky frequency points and the values of the RF to IF LO, the Digital Down-Converter (DDC) LO, and the current values of the Frequency Offset (FRO), Structural Channel Frequency Offset (SFRO) and Frequency Rate (FRR) parameters, the OLR computes the expected frequency of the spacecraft signal within the DDC channel. Using the three DDC channel frequency points, the OLR computes the coefficients of a frequency polynomial. The frequency polynomial spans a one second interval and is fitted to the predicted DDC channel frequency points. Next the OLR computes the coeffcients of a phase polynomial. The phase polynomial also spans a one second interval and is computed by integrating the frequency polynomial. The end value of one phase polynomial is used as the start phase of the next phase polynomial so that the modeled phase across second boundaries is continuous. The OLR computes the phase and frequency polynomials in real time. Over the course of each second, it computes the polynomials to be used for the next second. By setting a paramater on the OLR, the 3-point frequency model can be replaced by a millisecond based predict calculation.

As mentioned earlier the phase and frequency of the OLR channel NCOs are updated each msec using values computed from phase and frequency polynomials. Each msec the OLR receives an interrupt from its real-time processor (ORX). In response to this interrupt, the OLR reads a register in the ORX channel that indicates the current msec of the second. The OLR channel obtains this information from the msec time code that accompanies the data it is processing. Using the msec information and the phase and frequency polynomials, the OLR computes the phase and frequency that the channel should use at the start of the next msec. The OLR writes the new phase and frequency to holding registers in the channel NCO. At the start of the next msec the NCO moves the new phase and frequency from the holding registers into active registers and begins using them.

To obtain the desired NCO phase for each msec, the OLR evaluates the phase polynomial at the start of the msec as indicated in the following equation. It should be noted that the ***msec*** parameter has a range of from 0 to 999.

$$\begin{aligned} Phase(msec) = {} & Phase\_Coef\_1 + \\ & Phase\_Coef\_2 * ( msec / 1000 ) + \\ & Phase\_Coef\_3 * ( msec / 1000 )^2 + \\ & Phase\_Coef\_4 * ( msec / 1000 )^3 \end{aligned}$$

To obtain the desired NCO frequency for each msec the OLR evaluates the frequency polynomial at the middle of the msec as indicated in the following equation.

$$\begin{aligned} Freq(msec) = {} & Freq\_Coef\_1 + \\ & Freq\_Coef\_2 * ( ( msec + 0.5 ) / 1000 ) + \\ & Freq\_Coef\_3 * ( ( msec+ 0.5 ) / 1000 )^2 \end{aligned}$$

The coefficients of the phase and frequency polynomials used in these equations are stored in the ancillary data of each one second SFDU.

## 2.5 OLR Data Time Tags

Each SFDU generated by the OLR contains narrow band channel sample data and channel NCO phase and frequency polynomials which require time tags. The OLR hardware and software have been designed to compensate for pipeline delays in the signal processing path that would cause offsets between the data time tags and the polynomial timetags. The DDC compensates for the pipeline delay associated with its signal processing by adjusting the msec time code that it generates. The OLR channel partiallly compensates for the delay associated with its signal processing by delaying the start time of the FIR filter so that the total delay is in multiples of an output sample. The OLR completes the channel compensation by copying data read from the channel into the correct place in its one second data buffers.

The time tag of the first data sample in an SFDU is obtained from the “year”, “day of year”, and “second of day” fields of the SFDU time tag. It indicates the time at which the sample was created by the IFD. Time tags for subsequent samples in the SFDU should be obtained by incrementing the time tag with the sample period of the data. OLR time tags, added to the data stream at the DTT digitizer, are precise to the 10 nano-second level.

The NCO phase and frequency polynomials span one second intervals which begin and end on the second. The polynomial coefficients are copied into the ancillary information of each SFDU when the one second data buffers from the OLR are partitioned into multiple SFDUs. For a given SFDU the time tag of the one second interval over which the polynomials apply is specified by the “day counter” and “second counter” fields of the SFDU time tag.

## 2.6 Analyzing OLR Data

The previous sections of this document described how RSR SFDUs are created, this section will describe how to use the information they contain. The “RF frequency” or “Sky frequency” is a characteristic of the recorded signal that is of primary interest. An equation for obtaining the Sky frequency from the information contained in the SFDU is given below.

***Sky Freq = RF_to_IF_LO + DDC_LO – NCO_Freq + Resid_Freq***

***RF_to_IF_LO*** is the amount of down conversion applied to the signal in the RF to IF down converter. This information is stored in the secondary header of the RSR SFDU, its value depends on the RF band of the spacecraft signal, S-Band, X-Band, or Ka-band. It is constant for a data set.

***DDC_LO*** is the total amount of down conversion applied to the signal in the OLR. This information is stored in the secondary header of the RSR SFDU, its value depends on the position the of the spacecraft signal in the IF frequency band. It is usually constant for a data set, but its value can be changed during a pass with the DDCLO command

***NCO_Freq*** is the frequency of the signal generated by the OLR channel NCO. As described in section 2.2 the NCO signal is used in conjunction with a complex multiplier to down convert the spacecraft signal to zero Hz. The phase and frequency of the NCO signal are updated each msec based on polynomials derived from frequency predicts. The coefficients of these polynomials are stored in the secondary header of the RSR SFDU. Refer to section 0 for details regarding the use of these polynomials.

***Resid_Freq*** is the residual frequency of the recorded data. The OLR is driven by frequency predicts which are designed to track a spacecraft signal as it moves in frequency. The frequency predicts usually contain errors which cause the recorded signal to have a residual frequency. To obtain the residual frequency post processing software must perform spectral analysis of the recorded data.

## *2.7 OLR Data Storage and Delivery*

The digital samples from each OLR narrow band channel are stored to disk in one second records in real time. After a pass, the one second records are partitioned, formatted and translated into a sequence of RSR SFDUs which are transmitted to the Planetary Radar & Radio Sciences Group at JPL. The number of SFDUs per one second data record depends on the bandwidth and sample size of the recorded data

If desired, these one-second records can be retrieved by S/W, which bypasses the SFDU reformatting caused by the shortness of the length attribute word that was imposed by the SFDU rules. Both the Planetary Radar & Radio Sciences Group and the EDA use the non-SFDU records.

## *2.8 SFDU Structure*

The SFDU is an international structure standard for data products. This standard was developed to facilitate the transfer of spacecraft data between organizations that use different computer systems and to ensure that data can be preserved effectively for future use. The RSR SFDU structure and construction rules are based on guidelines for SFDU structure provided by the Consultative Committee for Space Data Systems (CCSDS). Within these guidelines, SFDUs output by the OLR are constructed.

Any SFDU is composed of Label-Value Objects (LVOs). An LVO is a data structure that is composed of a fixed length label field and a variable length value field. The label field provides for the data structure to be self-identifying and self-delimiting. The value field contains either more LVOs or user-defined data. An LVO with a value field containing purely user-defined data is referred to as a simple LVO. An LVO with a value field containing a sequence of one or more LVOs is referred to as a compound LVO.

The label field of an LVO is divided into type attribute and length attribute subfields. The type attribute subfield(s) of the LVO label provides the self-identifying property of the LVO. Within the application domain, the type attribute is a unique reference to a description of the format and interpretation of the data contained in the value field of the LVO. For JPL SFDUs, type attributes are assigned by the NASA JPL Control Authority, which is also responsible for maintaining the associated data descriptions. The CCSDS maintains a registry of control authorities.

The length attribute subfield(s) of the LVO label provides the self-delimiting property of the LVO. The length attribute subfield contains the length, in bytes, of the value field of the LVO. While all of the LVOs described in this module make use of length attribute subfields it should be noted that other means are available to enable an LVO to be self-delimiting.

Label-Value Objects used to construct CCSDS SFDUs must follow specific CCSDS structuring and labeling recommendations. In particular they must contain a standard 20-byte LVO label that conforms to strict format requirements. In some situations the standard 20-byte CCSDS LVO label incurs too much overhead to be used practically. To deal with this problem JPL has defined a short, 4-byte label that can be used in the same manner as the longer CCSDS label. An LVO constructed with this type of label is termed a Compressed Header Data Object (CHDO), usually pronounced "chay-doe." The CHDO label contains a two-byte type field and a two-byte length field. CHDOs are used when concerns for efficiency rule out the use of full CCSDS labels. Although the CHDO structure itself is used for exchange within JPL subsystems, CHDOs must be enclosed within legal CCSDS SFDU labels in order to be readable by other systems that use the SFDU standard.

## *2.9 LVO Structure of the RSR SFDU*

An RSR SFDU is a compound LVO that conforms to the SFDU structure and construction rules specified in reference [8]. At the top level it is composed of an SFDU label field and a value field. The value field of the RSR SFDU contains two LVOs, a header aggregation CHDO and a data CHDO. The header aggregation CHDO is a compound LVO; its value field contains two simple LVOs, a primary header CHDO and a secondary header CHDO. The header aggregation CHDO exists solely for the purpose of allowing the primary and secondary header CHDOs to be grouped together and treated as a single object. The value fields of the primary and secondary header CHDOs contain ancillary data (identification, configuration, predicts models, etc.) that pertain to the information in the data CHDO. The data CHDO is a simple LVO; its value field contains the data samples recorded by the OLR. Figure 2-7 depicts the LVO structure of the RSR SFDU.

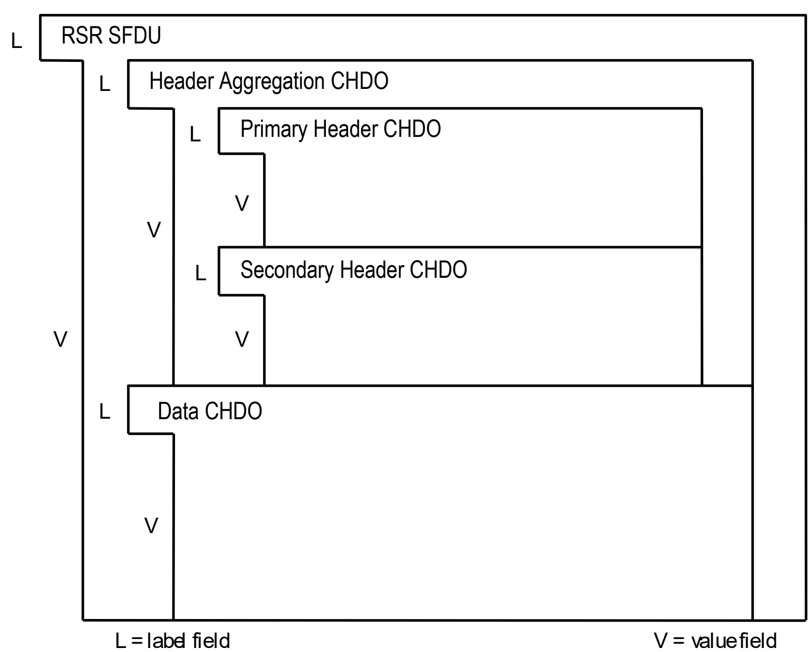


***Figure 2-2 LVO Structure of the RSR SFDU***

# *Section 3*
# *Detailed Interface Description*

## *3.1 RSR SFDU Physical Layout*

The physical layout of the RSR SFDU is shown in figure 3-1. The structure is divided into five sections: the SFDU label, the header aggregation CHDO label, the primary header CHDO, the secondary header CHDO, and the data CHDO. The primary header CHDO and the secondary header CHDO together constitute the value field of the header aggregation CHDO; the header aggregation CHDO and the data CHDO together constitute the value field of the RSR SFDU.

```
           BIT
          +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
          |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
          +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
    BYTE 0|                                               |
          |                                               |
         ...                 SFDU LABEL                  ...
         ...                 [20 Bytes]                  ...
          |                                               |
        18|                                               |
          +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
        20|                                               |
          +          HEADER AGGREGATION CHDO LABEL        +
        22|                  [4 Bytes]                    |
          +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
        24|                                               |
          |                                               |
         ...             PRIMARY HEADER CHDO             ...
         ...                 [8 Bytes]                   ...
          |                                               |
        30|                                               |
          +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
        32|                                               |
          |                                               |
         ...            SECONDARY HEADER CHDO            ...
         ...                [224 Bytes]                  ...
          |                                               |
       254|                                               |
          +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
       256|                                               |
          |                                               |
         ...                  DATA CHDO                  ...
         ...                 [ M Bytes]                 ...
          |                                               |
       N-2|                                               |
          +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
          |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
          +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
```

***Figure 3-1. Physical Layout of the RSR SFDU***

As shown in figure 3-1, the length of the RSR SFDU (in 8-bit bytes) is designated as *N* in this module. In general, the length of all items in the RSR SFDU are fixed, except for the data CHDO. The length of the data CHDO is variable and is determined by the sample rate and sample size of the recorded data. The length of the data CHDO is designated as *M* in this module, where M is the [length attribute in the label, bytes 12 to 19] – 236. In any case, the total length of the RSR SFDU is easily ascertained from the length attribute in the SFDU label (total SFDU length *N* = SFDU length attribute + 20). Each section of the RSR SFDU is described in more detail in the following paragraphs.

## *3.2 RSR SFDU Label*

Bytes 0 through 19 of the RSR SFDU in figure 3-1 contain the SFDU label field, which is illustrated in figure 3-2 and defined in the following paragraphs. The concatenation of bytes 0 to 3 and 8 to 11 constitutes the type attribute of the SFDU. In CCSDS parlance, that concatenated field is known as the Authority and Description Identifier (ADID). Bytes 12 through 19 constitute the length attribute of the SFDU.

```
             BIT
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
            |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      BYTE 0| CONTROL AUTHORITY ID = 'NJPL'                 |
            +                                               +
           2|                                               |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
           4| VERSION ID = '2'      | CLASS ID = 'I'        |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
           6| RESERVED                                      |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
           8| DATA DESCRIPTION ID = 'C997'                  |
            +                                               +
          10|                                               |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
          12| LENGTH ATTRIBUTE                              |
            +                                               +
          14|                                               |
            +                                               +
          16|                                               |
            +                                               +
          18|                                               |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
            |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
```

***Figure 3-2. RSR SFDU Label***

<u>BYTES 0 TO 3</u>

BITS

1 thru 8 Control authority identifier, value = 'NJPL', restricted ASCII. Indicates that the data description information for this type of SFDU is maintained and disseminated by the NASA/JPL control authority. Control authority identifiers are assigned by the CCSDS.

<u>BYTE 4</u>

BITS

1 thru 8 SFDU label version identifier, value = '2', restricted ASCII. Indicates that the length attribute field in bytes 12 to 19 of the SFDU label is formatted as a binary unsigned integer.

<u>BYTE 5</u>

BITS

1 thru 8 SFDU class identifier, value = 'I', restricted ASCII. Indicates that this is a CHDO structured SFDU.

<u>BYTES 6 AND 7</u>

BITS

1 thru 8 Reserved.

<u>BYTES 8 TO 11</u>

BITS

1 thru 8 Data description identifier, value = 'C997', restricted ASCII. Uniquely identifies the data description information maintained for this type of SFDU within the domain of the control authority identified in bytes 0 to 3. The value shown here is registered with the identified control authority (i.e., NJPL).

<u>BYTES 12 TO 19</u>

BITS

1 thru 8 Length attribute of the RSR SFDU, value varies, binary unsigned integer. Indicates the length, in bytes, of the value field of the RSR SFDU, bytes 20 through *N-1* in figure 3-1. The length of the value field of the RSR SFDU is the sum of the total lengths of the header aggregation CHDO and the data CHDO.

## *3.3 Header Aggregation CHDO Label*

Bytes 20 to 23 of the RSR SFDU in figure 3-1 contain the header aggregation CHDO label field, which is illustrated in figure 3-3 and defined in the following paragraphs. The value field of the header aggregation CHDO is composed of the primary header CHDO and the secondary header CHDO, which are defined in sections 3.4 and 3.5.

```
             BIT
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
            |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
     BYTE 0| TYPE ATTRIBUTE = 1                              |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
          2| LENGTH ATTRIBUTE = 232                          |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
            |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
            +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
```

***Figure 3-3. Header Aggregation CHDO Label***

BYTES 0 AND 1

BITS

1 thru 8 — Type attribute of the header aggregation CHDO, value = 1, binary unsigned integer. Indicates that this CHDO is an aggregation of header CHDOs. The NJPL control authority maintains a registry of CHDO type attributes.

BYTES 2 AND 3

BITS

1 thru 8 — Length attribute of the header aggregation CHDO, value = 232, binary unsigned integer. Indicates the length, in bytes, of the value field of the header aggregation CHDO, bytes 24 through 255 in figure 3-1.

## 3.4 Primary Header CHDO

Bytes 24 through 31 of the RSR SFDU in figure 3-1 contain the primary header CHDO, which is illustrated in figure 3-4 and defined in the following paragraphs. Bytes 0 through 3 of the primary header CHDO are the label field; bytes 4 to 7 are the value field.

```
          BIT
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
         |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
  BYTE 0| TYPE ATTRIBUTE = 2                              |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
        2| LENGTH ATTRIBUTE = 4                            |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
        4| MAJOR DATA CLASS = 21 | MINOR DATA CLASS = 5   |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
        6| MISSION ID = 255      | FORMAT CODE = 0        |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
         |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
```

***Figure 3-4. Primary Header CHDO***

<u>BYTES 0 AND 1</u>

BITS

1 thru 8 — Type attribute of the primary header CHDO, value = 2, binary unsigned integer. Indicates that this CHDO is a primary header CHDO. The NJPL control authority maintains a registry of CHDO type attributes.

<u>BYTES 2 AND 3</u>

BITS

1 thru 8 — Length attribute of the primary header CHDO; value = 4, binary unsigned integer. Indicates the length, in bytes, of the value field of the primary header CHDO.

<u>BYTE 4</u>

BITS

1 thru 8 — Major data class, value = 21, binary unsigned integer. Indicates that this SFDU contains radio science data.

<u>BYTE 5</u>

BITS

1 thru 8 — Minor data class, value = 5, binary unsigned integer. Indicates that this SFDU was created by the OLR.

<u>BYTE 6</u>

BITS

1 thru 8 — Mission identifier, value = 255, binary unsigned integer. The OLR does not use this field.

<u>BYTE 7</u>

BITS

1 thru 8 — Format code, value = 0, binary unsigned integer. The OLR only supports one data format which is discussed in section 3.6

## *3.5 Secondary Header CHDO*

Bytes 32 through 255 of the RSR SFDU in figure 3-1 contain the secondary header CHDO, which is illustrated in figure 3-5 and defined in the following paragraphs. Bytes 0 to 3 of the secondary header CHDO are the label field; bytes 4 through 207 are the value field. Some fields are documented as “deprecated, always zero” which indicates that these fields are not pupulated by the OLR.

```
         BIT
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
        |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
  BYTE 0| TYPE ATTRIBUTE = 104                          |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
       2| LENGTH ATTRIBUTE = 220                        |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
       4| ORIGINATOR ID = 48    | LAST MODIFIER ID = 48 |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
       6| RSR SOFTWARE ID                               |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
       8| RECORD SEQUENCE NUMBER                        |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      10| SPC ID                | DSS ID                |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      12| OLR ID                | SCHAN ID              |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      14| RESERVED              | SPACECRAFT            |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      16| PRDX PASS NUMBER                              |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      18| U/L BAND (S,X,K)     | D/L BAND (S,X,K)     |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      20| TRK MODE (1,2,3)   | U/L DSS ID            |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      22| *FGAIN PX/NO          | *FGAIN IF BANDWIDTH   |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      24| *FROV FLAG             | *ATTENUATION          |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      26| *ADC RMS              | *ADC PEAK             |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      28| *ADC INFO TIME TAG, YEAR                      |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      30| *ADC INFO TIME TAG, DAY OF YEAR               |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      32| *ADC INFO TIME TAG, SECONDS OF DAY            |
        +                                               +
      34|                                               |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      36| BITS PER SAMPLE       | DATA ERROR            |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      38| SAMPLE RATE                                   |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      40| DDC LO                                        |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      42| RF->IF LO                                     |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      44| SFDU TIME TAG, YEAR                           |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      46| SFDU TIME TAG, DAY OF YEAR                    |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      48| SFDU TIME TAG, SECONDS OF DAY                 |
        +                                               +
      50|                                               |
        +                                               +
      52|                                               |
        +                                               +
      54|                                               |
        +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
      56| *PREDICTS TIME SHIFT                          |
```

```
    +                                               +
 58|                                               |
    +                                               +
 60|                                               |
    +                                               +
 62|                                               |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
 64| PREDICTS FREQ OVERRIDE (FROV)                 |
    +                                               +
 66|                                               |
    +                                               +
 68|                                               |
    +                                               +
 70|                                               |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
 72| *PREDICTS FREQ RATE (FRR)                     |
    +                                               +
 74|                                               |
    +                                               +
 76|                                               |
    +                                               +
 78|                                               |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
 80| *PREDICTS FREQ OFFSET (FRR + FRO)             |
    +                                               +
 82|                                               |
    +                                               +
 84|                                               |
    +                                               +
 86|                                               |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
 88| STRUCTURAL CHANNEL FREQ OFFSET (SFRO + FRO)   |
    +                                               +
 90|                                               |
    +                                               +
 92|                                               |
    +                                               +
 94|                                               |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
 96| RF FREQ POINT 1                               |
    +                                               +
 98|                                               |
    +                                               +
100|                                               |
    +                                               +
102|                                               |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
104| RF FREQ POINT 2                               |
    +                                               +
106|                                               |
    +                                               +
108|                                               |
    +                                               +
110|                                               |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
112| RF FREQ POINT 3                               |
    +                                               +
114|                                               |
    +                                               +
116|                                               |
    +                                               +
118|                                               |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
120| SCHAN FREQ POINT 1                            |
    +                                               +
122|                                               |
    +                                               +
124|                                               |
    +                                               +
126|                                               |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
128| SCHAN FREQ POINT 2                            |
```

```
   +                                               +
130|                                               |
   +                                               +
132|                                               |
   +                                               +
134|                                               |
   +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
136| SCHAN FREQ POINT 3                            |
   +                                               +
138|                                               |
   +                                               +
140|                                               |
   +                                               +
142|                                               |
   +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
144| SCHAN FREQ POLY COEF 1                        |
   +                                               +
146|                                               |
   +                                               +
148|                                               |
   +                                               +
150|                                               |
   +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
152| SCHAN FREQ POLY COEF 2                        |
   +                                               +
154|                                               |
   +                                               +
156|                                               |
   +                                               +
158|                                               |
   +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
160| SCHAN FREQ POLY COEF 3                        |
   +                                               +
162|                                               |
   +                                               +
164|                                               |
   +                                               +
166|                                               |
   +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
168| SCHAN ACCUM PHASE                             |
   +                                               +
170|                                               |
   +                                               +
172|                                               |
   +                                               +
174|                                               |
   +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
176| SCHAN PHASE POLY COEF 1                       |
   +                                               +
178|                                               |
   +                                               +
180|                                               |
   +                                               +
182|                                               |
   +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
184| SCHAN PHASE POLY COEF 2                       |
   +                                               +
186|                                               |
   +                                               +
188|                                               |
   +                                               +
190|                                               |
   +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
192| SCHAN PHASE POLY COEF 3                       |
   +                                               +
194|                                               |
   +                                               +
196|                                               |
   +                                               +
198|                                               |
   +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
200| SCHAN PHASE POLY COEF 4                       |
```

```
    +                                               +
 202|                                               |
    +                                               +
 204|                                               |
    +                                               +
 206|                                               |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
 208| *SCHAN MULT                                   |
    +                                               +
 210|                                               |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
 212| RESERVED                                      |
    +                                               +
 214|                                               |
    +                                               +
 216|                                               |
    +                                               +
 218|                                               |
    +                                               +
 220|                                               |
    +                                               +
 222|                                               |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
    |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
    +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
```

* Values no longer in records, filled with zeros

***Figure 3-5. Secondary Header CHDO***

<u>BYTES 0 AND 1</u>

BITS

1 thru 8 — Type attribute of the secondary header CHDO; value = 104; unsigned binary integer. Indicates that this is an RSR secondary header CHDO. The NJPL control authority maintains a registry of CHDO type attributes.

<u>BYTES 2 AND 3</u>

BITS

1 thru 8 — Length attribute of the secondary header CHDO; value = 220; unsigned binary integer. Indicates the length, in bytes, of the value field of the secondary header CHDO.

<u>BYTE 4</u>

BITS

1 thru 8 — Originator identifier; value = 48; unsigned binary integer. Indicates that this SFDU originated within the DSN.

<u>BYTE 5</u>

BITS

1 thru 8 — Last modifier identifier; value = 48; unsigned binary integer. Indicates that the contents of this SFDU were last modified by the DSN.

<u>BYTE 6 AND 7</u>

BITS

1 thru 8 (deprecated, dummy value) RSR software identifier, value range 0 to $2^{16}$-1; unsigned binary integer. Identifies the RSR software version used to create this SFDU.

<u>BYTES 8 AND 9</u>

BITS

1 thru 8 Record sequence number (RSN); value range 0 to $2^{16}$-1; unsigned binary integer. The RSN is a sequence counter for the RSR SFDUs. It starts at zero and increments by one for each successive RSR SFDU in a stream. It wraps around from $2^{16}$-1 to zero. The RSN may reset to zero at any time (e.g., whenever the OLR is started or restarted); however, such resets should be infrequent. The RSN is provided by the originator of the RSR SFDU and shall not be changed subsequently; e.g., a RSR SFDU replayed from a recording shall retain the RSN that was assigned when the SFDU was created.

<u>BYTE 10</u>

BITS

1 thru 8 Signal Processing Center (SPC) identifier; valid values are 10, 40, 60, and 21; unsigned binary integer. Indicates the SPC at which the SFDU was created,
10 => Goldstone, 40 => Canberra, 60 => Madrid, 21 => DTF21.

<u>BYTE 11</u>

BITS

1 thru 8 Deep Space Station (DSS) identifier; value range 0 to $2^{8}$-1; unsigned binary integer. Specifies the DSS identifier listed in the frequency predicts file used to collect the radio science data in this SFDU. For example a value of 15 indicates DSS-15. DSS identifiers are defined in DSN 810-047.

<u>BYTE 12</u>

BITS

1 thru 8 OLR identifier; value range 31 to 38; unsigned binary integer. Specifies the receiver used to acquire the radio science data in this SFDU,
31=>OLR1, 32=>OLR2, …, 38=>OLR8

<u>BYTE 13</u>

BITS

1 thru 8 Complex-wide channel identifier; encoded value range 0 to 255 for all channels on all 8 OLRs; unsigned binary integer. Specifies the channel used to acquire the radio science data in this SFDU. To convert from HW numbers use the formula:
*channel number = (rsp-1)*32 + (dsp-1)*16 + (chan-1)
Where: 1 <= rsp <= 4, 1 <= dsp <= 2, 1 <= chan <= 16

<u>BYTE 14</u>

BITS

1 thru 8 Reserved.

BYTE 15

BITS

1 thru 8 DSN-assigned spacecraft identifier; value range 0 to $2^8$-1; unsigned binary integer. Specifies the spacecraft identifier listed in the frequency predicts file used to collect the radio science data in this SFDU. See 820-013, OPS-6-21.

BYTES 16 AND 17

BITS

1 thru 8 Predicts Pass Number; value range 0 to $2^{16}$-1; unsigned binary integer. Specifies the DSN pass number listed in the predicts file used to collect the radio science data in this SFDU.

BYTE 18

BITS

1 thru 8 Uplink frequency band; valid values are S, X, and K; restricted ASCII. Specifies the uplink frequency band listed in the predicts file used to collect the radio science data in this SFDU, S => S-band, X => X-band, K => Ka-band.

BYTE 19

BITS

1 thru 8 Downlink frequency band; valid values are S, X, and K; restricted ASCII. Specifies the downlink frequency band listed in the predicts file used to collect the radio science data in this SFDU, S => S-band, X => X-band, K => Ka-band.

BYTE 20

BITS

1 thru 8 Tracking mode; value range 1 to 3; unsigned binary integer. Specifies the tracking mode in use by the OLR at the time the radio science data in this SFDU was acquired, 1 => one-way, 2 => two-way, 3 => three-way. Refer to the WAY command in the SOM for more information.

BYTE 21

BITS

1 thru 8 Uplink DSS identifier for tracking mode = three-way; value range 0-255; unsigned binary integer, as specified in DSN 810-047. Specifies the uplink DSS identifier portion of the tracking mode when the OLR is configured for three way tracking.

BYTE 22

BITS

1 thru 8 (Deprecated, always zero) FGAIN Px/No in dB-Hz; value range –128 to +127; signed binary integer. Specifies the value of the expected Px/No in use by the OLR at the time the radio science data in this SFDU was acquired. This

parameter is used to compute the settings of the channel filter gain. Refer to the FGAIN command in the SOM for more information.

<u>BYTE 23</u>

BITS

1 thru 8 (Deprecated, always zero) FGAIN IF Bandwidth in Mega-Hz; value range 1 to 127; unsigned binary integer. Specifies the value of the expected IF bandwidth in use by the OLR at the time the radio science data in this SFDU was acquired. This parameter is used to compute the settings of the channel filter gain. Refer to the FGAIN command in the SOM for more information.

<u>BYTE 24</u>

BITS

1 thru 8 (Deprecated, always zero) Frequency predicts override flag; range 255; unsigned binary integer. A value of 0 indicates that the frequency predicts file is in use, any other value indicates that the frequency specified by the FROV command is in use. The value of the override frequency is specified in bytes 64-71

<u>BYTE 25</u>

BITS

1 thru 8 (Deprecated, always zero) IFD attenuation; value range 0-63; unsigned binary integer. Specifies the current setting of the IFD attenuator in 0.5 dB increments. Refer to the ATT command in the SOM for more information.

<u>BYTE 26</u>

BITS

1 thru 8 (Deprecated, always zero) IFD ADC RMS amplitude; value range 0-128; unsigned binary integer. Indicates the RMS amplitude of the 8-bit sample stream produced by the IFD ADC. A time-tag for the measurement is provided in bytes 28-35

<u>BYTE 27</u>

BITS

1 thru 8 (Deprecated, always zero) IFD ADC peak amplitude; value range 0-128; unsigned binary integer. Indicates the peak amplitude of the 8-bit sample stream produced by the IFD ADC. A time-tag for the measurement is provided in bytes 28-35

<u>BYTES 28 AND 29</u>

BITS

1 thru 8 (Deprecated, always zero) ADC info time tag - year; value range 1900 to 3000; unsigned binary integer. Specifies the UTC year of the ADC info.

<u>BYTES 30 AND 31</u>

BITS

1 thru 8 — (Deprecated, always zero) ADC info time tag – day of year; value range 1 to 366; unsigned binary integer Specifies the UTC day of year of the ADC info.

<u>BYTES 32 TO 35</u>

BITS

1 thru 8 — (Deprecated, always zero) ADC info time tag – seconds of day; value range 0 to 86400; unsigned binary integer Specifies the UTC second of day of the ADC info.

<u>BYTE 36</u>

BITS

1 thru 8 — Sample resolution in bits per data sample; valid values are 1, 2, 4, 8, and 16; unsigned binary integer. Specifies the size of the data samples contained in this SFDU. Refer to the OLR SOM for more information.

<u>BYTE 37</u>

BITS

1 thru 8 — Data error flag; value range 0 to 1; unsigned binary integer. A value of 0 indicated no error. Any other value indicates data may be corrupted due to hardware errors. See Validity Flag Definitions in Appendix A.

<u>BYTES 38 AND 39</u>

BITS

1 thru 8 — Sample rate in Kilo-samples per second. Specifies the sample rate of the data contained in this SFDU. Refer to the OLR SOM for more information.

<u>BYTE 40 AND 41</u>

BITS

1 thru 8 — Digital Down Converter LO (DDC LO) in Mega-Hz; value range 50 to 650MHz, value closest to multiples of 25MHz; unsigned binary integer. Specifies the total down conversion applied to the signal in the OLR. This frequency is needed in order to compute the sky frequency of the data contained in this SFDU. Refer to the DDCLO command in the OLR SOM for more information.

<u>BYTE 42 AND 43</u>

BITS

1 thru 8 — RF to IF down converter LO in Mega-Hz; value range 0 to $2^{16}$-1; unsigned binary integer. Specifies the total down conversion applied to the signal before it entered the IFD. This value is subtracted from the RF predicts points in order to obtain the frequency of the desired signal at IF. This frequency is needed in order to compute the sky frequency of the data contained in this SFDU. The OLR selects a default value based on the downlink frequency band, S-band => 2000, X-band => 8100, Ka-band =>31700.

BYTES 44 AND 45

BITS

1 thru 8 SFDU time tag - year; value range 1900 to 3000; unsigned binary integer. Specifies the UTC year of the SFDU data and models. More information on time tags is provided is section 2.5

BYTES 46 AND 47

BITS

1 thru 8 SFDU time tag – day of year; value range 1 to 366; unsigned binary integer Specifies the UTC day of year of the SFDU data and models.

BYTES 48 TO 55

BITS

1 thru 8 SFDU time tag – seconds of day; value range 0.0 to 86400.0; double precision floating point. Specifies the UTC second of day of the SFDU data and models.

BYTES 56 TO 63

BITS

1 thru 8 (Deprecated, always zero) Predicts time shift in seconds; double precision floating point. Indicates the number a seconds added to the time tags of the frequency predicts points in order to shift them in time. This is a feature of the OLR that is provided to allow testing the system with old predicts files. Should have a value of 0.0 in all SFDUs recorded during a standard pass.

BYTES 64 TO 71

BITS

1 thru 8 (Deprecated, always zero) Predicts frequency override in Hz; double precision floating point. Indicates the value of the predicts frequency override as specified by the FROV command. Byte 24 contains a flag which indicates if the frequency override is active.

BYTES 72 TO 79

BITS

1 thru 8 (Deprecated, always zero) Predicts frequency rate in Hz per second; value range –8 to +8 Kilo-Hz per second; double precision floating point. Indicates the frequency rate added to the RF frequency predicts as specified by the FRR command.

BYTES 80 TO 87

BITS

1 thru 8 (Deprecated, always zero) Predicts frequency offset in Hz; value range –8 to +8 Mega-Hz; double precision floating point. Indicates the total frequency added to the RF frequency predicts as specified by the FRO command and the accumulation of the frequency rate as specified by the FRR command .

<u>BYTES 88 TO 95</u>

BITS

1 thru 8 — Channel frequency offset in Hz; value range –8 to +8 Mega-Hz; double precision floating point. Indicates the value of the frequency offset added to the frequency predicts for this channel as specified by the SFRO + FRO commands.

<u>BYTES 96 TO 119</u>

BITS

1 thru 8 — RF frequency points; double precision floating point, The values of the RF frequency points as calculated from the frequency predicts for the beginning, middle, and end of the second.

<u>BYTES 120 TO 143</u>

BITS

1 thru 8 — Channel frequency points; double precision floating point. The values of the channel frequency points for the beginning, middle, and end of the second. These are the frequency points used to create the channel phase and frequency polynomials.

<u>BYTES 144 TO 167</u>

BITS

1 thru 8 — Channel frequency polynomial coefficients; double precision floating point. The values of the channel frequency polynomial coefficients as calculated from the channel frequency points. Refer the section 0 for more information.

<u>BYTES 168 TO 175</u>

BITS

1 thru 8 — Channel accumulated phase; double precision floating point. The value of the accumulated whole turns of the channel phase polynomial. Refer the section 0 for more information.

<u>BYTES 176 TO 207</u>

BITS

1 thru 8 — Channel phase polynomial coefficients; double precision floating point. The values of the channel phase polynomial coefficients as calculated from the channel frequency polynomial coefficients. Refer the section 0 for more information.

<u>BYTES 208 TO 211</u>

BITS

1 thru 8 — (Deprecated, always zero) Channel fgain multiplier; single precision floating point. The value of the filter gain adjustment entered by the operator or calculated during an automatic fgain adjustment.

BYTES 212 TO 223

BITS

1 thru 8 Reserved.

## 3.6 Data CHDO

Bytes 256 through *N-1* of the RSR SFDU in figure 3-1 contain the data CHDO, which is illustrated in figure 3-6 and is defined in the following paragraphs. Bytes 0 to 3 of the data CHDO are the label field; Bytes 4 through *M-1* are the value field.

```
          BIT
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
         |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
   BYTE 0| TYPE ATTRIBUTE = 10                           |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
        2| LENGTH ATTRIBUTE                              |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
        4| SAMPLE WORD 1 - Q DATA                        |
         +                                               +
        6| SAMPLE WORD 1 - I DATA                        |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
        8| SAMPLE WORD 2 - Q DATA                        |
         +                                               +
       10| SAMPLE WORD 2 - I DATA                        |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
         |                                               |
        ...                                             ...
        ...                                             ...
         |                                               |
         +                                               +
      M-2|                                               |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
         |1 |2 |3 |4 |5 |6 |7 |8 |1 |2 |3 |4 |5 |6 |7 |8 |
         +--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
```

***Figure 3-6. RSR Data CHDO***

BYTES 0 AND 1

BITS

1 thru 8 Type attribute of the data CHDO; value = 10; unsigned binary integer. Indicates that this CHDO contains binary data.

BYTES 2 AND 3

BITS

1 thru 8 Length attribute of the data CHDO in bytes; value range 0 to $2^{16}$-1; unsigned binary integer. Indicates the length of the value field of the data CHDO. The length is determined by the sample rate and sample size of the recorded data as specified in Table 3-1, unless it is the one-second SFDU that is translated by the

OLR. In that case, this number is 0 but can be calculated from the length attribute in the SFDU label – 240 bytes.

# *Appendix A Validity Flag Definitions*

## Validity Flag definitions

If this field is set to 0xFFFF (i.e. all 16 bits are set), it indicates that the channel has not been marked valid. A channel will be marked valid after a successful DDCLO call followed by a successful FGAIN call. Additionally, if another DDCLO call is executed, either explicitly or implicitly via an IFS, FROV, PRED, or SFRO call, the channel reverts to the not valid state. If this DDCLO call is successful, only a successful FGAIN call is required to return to the valid state. Otherwise, if this DDCLO is unsuccessful, a successful DDCLO call followed by a successful FGAIN call is required.

Otherwise, if the field is not set to 0xFFFF (i.e. at least one bit is not set), see below.

The lower 13 bits of this 16 bit field are set to a value of 0-8190, representing the count of 1000 byte data blocks that were not received by the OLR server. If more than 8190 data blocks were not received, the reported value will be 8190. For data rates up to 64 Mbps (e.g. 16MHz x 2 bits), this provides a precise indication of the amount of valid data present, for higher rates, the actual value may be higher may. Note that the value of 0x1FFF (i.e. all 13 bits set) is not valid, which ensures that at least one of these bits will not be set.

Bit 13 represents MDLS_ERROR, i.e. a phase/phasedot model was not available for one or more milliseconds.

Bit 14 represents MSEC_ERROR, i.e. the channel millisecond register either glitched, returned an out of range value, jumped, or did not advance at the correct rate.

Bit 15 represents TGE_ERROR, i.e. the Ten Gigabit Ethernet input for the channel had one or more “fifo not ready”, “overflow”, or “underflow” events.

# *Appendix B Abbreviations*

Abbreviations and acronyms used in this document are defined where they first occur in the text. A complete list is provided here for the convenience of the reader.

| | |
|---|---|
| ACA | Antenna Control Assembly |
| ADC | Analog to Digital Conversion |
| ANSI | American National Standards Institute |
| ASCII | American Standard Code for Information Interchange |
| CCSDS | Consultative Committee for Space Data Systems |
| CDE | Cognizant Development Engineer |
| CHDO | Compressed Header Data Object |
| DIS | Digital IF Switch (DTT Subsystem assembly) |
| DSCC | Deep Space Communications Complex |
| DSN | Deep Space Network |
| DSP | Digital Signal Processor |
| DSS | Deep Space Station |
| DTT | DSN Telemetry and Tracking (Subsystem) |
| EDA | Entry, Descent, and Landing Data Analysis |
| FGAIN | Filter gain |
| FIR | Finite Impulse Response filter |
| FLTOPS | JPL Flight Operations Network |
| FRO | Frequency Offset |
| FROV | Frequency Override |
| FRR | Frequency Rate |
| I, Q | In-phase and Quad-phase samples |
| ID | Identifier |
| IEEE | Institute of Electrical and Electronic Engineers |
| IF | Intermediate Frequency |
| IFD | IF Digitizer (DTT Subsystem assembly) |
| JPL | Jet Propulsion Laboratory |
| LO | Local Oscilator |
| LVO | Label Value Object |
| NASA | National Aeronautics and Space Administration |
| NCO | Numerically Controlled Oscillator |
| NJPL | NASA/Jet Propulsion Laboratory (control authority identifier) |
| OLR | Open Loop Receiver (Subsystem) |
| PRRSG | Planetary Radar and Radio Sciences Group |
| RDEF | Raw Data Exchange Format |
| RF | Radio frequency |
| RSN | Record Sequence Number |
| RSR | Radio Science Receiver |
| SFDU | Standard Formatted Data Unit |
| SFTP | Secure File Transfer Protocol |
| SPS | Service Preparation Subsystem |

| | |
|---|---|
| ULC | Uplink Controller Subsystem |
| UTC | Coordinated Universal Time |