International Standard Payload Rack to International Space Station, Software Interface Control Document Part 1

International Space Station Program

Revision M

September 2017

Type 4

National Aeronautics and Space Administration
International Space Station Program
Johnson Space Center
Houston, Texas
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REVISION AND HISTORY PAGE

REV.	DESCRIPTION	PUB. DATE
-	Initial Release per SSCD 000281, EFF. 07-20-96	05-23-97
A	Revision A (Reference per SSCD 001022, EFF. 08-25-98)	11-04-98
B	Revision B (Reference per SSCD 002495, EFF. 07-10-00) Revision B incorporates PIRN 52050-NA-0003B Revision A incorporated PIRN 52050-NA-0002D	12-08-00
C	Revision C (Reference per SSCD 004678, EFF. 12-07-00) Revision C incorporates the following PIRNs: 52050-NA-0004, 52050-NA-0005A, 52050-NA-0007, 52050-NA-0008	01-11-01
D	Revision D (Reference per SSCD 005611, EFF. 06-20-01) Revision D incorporates the following PIRNs: 52050-NA-0010, 52050-NA-0012A, 52050-NA-0013, 52050-NA-0015A	07-31-01
E	Revision E (Reference per SSCD 006891, EFF. 01-09-03) This is the first Release on the IPIC Contract Revision E incorporates the following PIRNs: 52050-NA-0014B, 52050-NA-0016E, 52050-NA-0018, 52050-NA-0019A, 52050-NA-0021A, 52050-NA-0022B, 52050-NA-0023A, 52050-NA-0024, and 52050-NA-0025	01-27-03
	IRN 0001 (PIRN 52050-NA-0015A) per SSCN 003928 was Administratively Canceled due to incorporation into Revision D.	
	IRN 0003 (PIRN 52050-NA-0026) per SSCN 007971, EFF. 08-14-03	08-25-03
	IRN 0004 (PIRN 52050-NA-0032) per SSCN 009254, EFF. 04-07-05	06-02-05
F	Revision F (Reference per SSCD 009656, EFF. 11-6-05) Revision F incorporates the following PIRNs: 52050-NA-0027A, 52050-NA-0028, 52050-NA-0029A, 52050-NA-0030, 52050-NA-0031, 52050-NA-0032, 52050-NA-0033A, and 52050-NA-0034 SSCN 003933 created the allocated/product baseline for PEP Release 2 which as a result was adding SSP-52050 to SSP-50257. SSP-50257 though is not applicable to the IPIC Contract, making this impact from SSCN 003933 OBE.	11-21-05

REVISION AND HISTORY PAGE (CONTINUED)

REV.	DESCRIPTION	PUB. DATE
G	Revision G (Reference SSCD 010420, EFF. 04/19/07) Revision G incorporates the following PIRNs: 52050-NA-0035, 52050-NA-0036	04-27-07
H	Revision H (Reference SSCD 011970, EFF. 10-28-09) Revision H incorporates the following PIRNs: 52050-NA-0037, 52050-NA-0038, 52050-NA-0039, and 52050-NA-0040	11-30-09
J	Revision J (Reference SSCD 013229, EFF. 04-23-12) Revision J incorporates the following PIRNs: 52050-NA-0041, 52050-NA-0042, 52050-NA-0043	05-30-12
K	Revision K (Reference SSCD 013985, EFF. 12-18-13) Revision K incorporates the following PIRNs: 52050-NA-0044, 52050-NA-0045, 52050-NA-0046	01-13-14
L	Revision L (Reference SSCD 015334, EFF. 02-02-16) Revision L incorporates the following PIRNs: 52050-NA-0047, 52050-NA-0048, 52050-NA-0049, 52050-NA-0050, 52050-NA-0051	02-15-16
M	Revision M (Reference SSCD 015755, Eff. 09-27-17) Revision M incorporates the following PIRNS: 52050-NA-0052 (Per SSCN 13876), 52050-NA-0053, 52050-NA-0054 (Per SSCN 15321), 52050-NA-0055 (Per SSCN 13736) * SSCN 12443 was incorporated via PIRN 52050-NA-0045 at Rev. K, but the SSCN was inadvertently omitted from the Revision & History Page.	11-07-17

ERU: /s/ Colleen Lippert 11-07-17

INTERNATIONAL SPACE STATION PROGRAM

INTERNATIONAL STANDARD PAYLOAD RACK TO INTERNATIONAL SPACE STATION, SOFTWARE INTERFACE CONTROL DOCUMENT PART 1

PREFACE

This document contains an introduction, a list of applicable documents, subsections on general and detailed interface and payload specific design requirements, along with appendices for MIL-STD-1553B, Interface Standard for Digital Time Division Command/Response Multiplex Data Bus, bus timing profiles, Acronyms and Abbreviations, Glossary of Terms, and Consultative Committee for Space Data Systems (CCSDS) header tailoring. The applicability of these requirements will depend upon the characteristics of the integrated rack or pallet payloads as specified in the individual Payload Integration Agreement (PIA). The interface requirements outlined in this document are mandatory and may not be violated unless specifically agreed upon in the individual Software Interface Control Document. This document is under the control of the Avionics and Software Control Board (ASCB), and any changes or revisions will be approved by the ASCB.

APPROVED BY: See Directive Approval

William R. Jones, II
Manager, Avionics & Software Office
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Date

INTERNATIONAL SPACE STATION PROGRAM

INTERNATIONAL STANDARD PAYLOAD RACK TO INTERNATIONAL SPACE STATION, SOFTWARE INTERFACE CONTROL DOCUMENT PART 1

SEPTEMBER 2017

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INTERNATIONAL SPACE STATION PROGRAM

INTERNATIONAL STANDARD PAYLOAD RACK TO INTERNATIONAL SPACE STATION, SOFTWARE INTERFACE CONTROL DOCUMENT PART 1

SEPTEMBER 2017

LIST OF CHANGES

All changes to paragraphs, tables, and figures in this document are shown below:

SSCBD	ENTRY DATE	CHANGE	PARAGRAPH(S)
000281	20-July-96	Initial Release	All
001022	25-Aug-98	Revision A	2.2.2, 3.0, 3.1.3.1.1
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1.0 INTRODUCTION

1.1 PURPOSE & SCOPE

The purpose of this document is to provide definition of the software interface requirements between the International Standard Payload Rack (ISPR) plus C&DH related non-rack end items and the International Space Station (ISS) flight elements. Related non-rack end items include portable payloads in any of the modules, payloads on the Japanese Experiment Module Exposed Facility (JEM EF), payloads on the Columbus Exposed Payload Facility (COL EPF), and attached payloads mounted on the ISS truss.

1.2 PRECEDENCE

In the event of conflict between SSP 41162, Segment Specification for the United States On-orbit Specification and the contents of this Interface Control Document (ICD), the requirements of the United States On-orbit Segment (USOS) Specification shall take precedence.

1.3 RESPONSIBILITY AND CHANGE AUTHORITY

This document is prepared and maintained in accordance with SSP 30459, International Space Station Interface Control Plan.

2.0 DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form a part of this document to the extent specified herein.

DOCUMENT NO.	TITLE
CCSDS 133.0-B-1 Technical Corrigendum 2	Space Packet Protocol
CCSDS 133.1-B-2 Issue 2 October 2009	Encapsulation Service
CCSDS 135.0-B-4 Issue 4 October 2009	Space Link Identifiers
CCSDS 301.0-B-2	Time Code Formats
CCSDS 701.0-B-3 Issue 3 June 2001	Advanced Orbiting Systems, Networks and Data Links: Architectural Specification
CCSDS 727.0-B-4 Issue 4 January 2007	CCSDS File Delivery Protocol (CFDP)
CCSDS 732.0-B-2 Technical Corrigendum 1	AOS Space Data Link Protocol
CCSDS 734.1-R-3	Licklider Transmission Protocol (LTP) for CCSDS
CCSDS 734.2-R-3	CCSDS Bundle Protocol Specification
IETF RFC 768	Internet Engineering Task Force Request for Comments 768 – User Datagram Protocol
IETF RFC 791	Internet Engineering Task Force Request for Comments 791 – Internet Protocol
IETF RFC 793	Internet Engineering Task Force Request for Comments 793 – Transmission Control Protocol
IETF RFC 2326	Internet Engineering Task Force Request for Comments 2326 – Real Time Streaming Protocol
IETF RFC 3550	Internet Engineering Task Force Request for Comments 3550 – RTP: A Transport Protocol for Real-Time Applications
IETF RFC 6143	Internet Engineering Task Force Request for Comments 6143 –The Remote Framebuffer Protocol

DOCUMENT NO.	TITLE
ISO/IEC 8802-3: 2014	Information Technology - Local and Metropolitan Area Networks -- Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications
MIL-STD-1553B Notice 2 September 1986	Interface Standard for Digital Time Division Command/Response Multiplex Data Bus
MS-SMB2 Revision 51.0 March 16, 2017	Server Message Block Protocol Version 2 and 3 (SMB2) (Microsoft Corporation)
SSP 30459 Revision H April 1999	International Space Station Interface Control Plan
SSP 41162 Revision BA December 2008	Segment Specification for the United States On-orbit
SSP 41175-02 Revision L September 2004	Software Interface Control Document Station Management and Control to International Space Station Book 2, General Software Interface Requirements
SSP 50304, Revision D	Payload Operations and Integration Center (POIC) Capabilities Document
SSP 50540 Revision F November 2007	Software Interface Definition Document Broadcast Ancillary Data
SSP 50892 Revision A	Ethernet Requirements for Interoperability with the Joint Station LAN (JSL)
SSP 50974	International Space Station Onboard IT Security Requirements for USOS Systems
SSP 50989	International Space Station IT Security Policy for Onboard Systems

2.2 REFERENCE DOCUMENTS

The following documents are referenced in this ICD. In the event of a conflict between the documents referenced, and this document, the contents of this document are considered the controlling information.

DOCUMENT NO.	TITLE
ANSI IEEE Std 754-1985 May 1991	IEEE Standard for Binary Floating-Point Arithmetic
AWK-4131	MOXA AWK-4131 User's Manual

DOCUMENT NO.	TITLE
BDTM11201-A01	BelAir 100N User Guide
D684-13406-01	Internet Protocol (IP) Address Management Plan for the International Space Station (ISS)
D684-14957-01	External Wireless Communications User Guide
IETF RFC 951	Internet Engineering Task Force Request for Comments 951 – Bootstrap Protocol
IETF RFC 959	Internet Engineering Task Force Request for Comments 959 – File Transfer Protocol
IETF RFC 1813	Internet Engineering Task Force Request for Comments 1813 – Transmission Control Protocol
IETF RFC 2817	Internet Engineering Task Force Request for Comments 2817 – Upgrading to TLS Within HTTP/1.1
IETF RFC 2818	Internet Engineering Task Force Request for Comments 2818 – HTTP Over TLS
IETF RFC 3720	Internet Engineering Task Force Request for Comments 3720 – Internet Small Computer Systems Interface (iSCSI)
ISO/IEC 15802-3 1998 Edition	Information Technology-Local and Metropolitan Area Networks-Part 3: Media Access Control (MAC) Bridges Specification
SSP 41002 Revision P March 2011	International Standard Payload Rack to NASA/ESA/JAXA Modules Interface Control Document
SSP 41158 Revision N January 2012	Software Interface Control Document Part 1 United States On-Orbit Segment to International Ground System Segment Ku-Band Telemetry Formats
SSP 50184 Revision C July 2011	Physical Media, Physical Signaling & Link-Level Protocol Specifications for Ensuring Interoperability of High Rate Data Link Stations on the International Space Station
SSP 50193-01 Revision J September 2010	Software Interface Control Document, Payload Multiplexer/Demultiplexer to International Space Station Book 1, Hardware Architecture
SSP 57002 Revision G December 2013	Payload Software Interface Control Document Template
SSP 57003	Attached Payload Interface Requirements Document

3.0 ISPR AND NON-RACK END ITEM SOFTWARE INTERFACES TO U.S. PAYLOAD DATA HANDLING EQUIPMENT

The ISPR and non-rack end item to U.S. Payload Command and Data Handling (C&DH) interface are composed of a Low Rate Data Link (LRDL) consisting of a 1553B Local Bus connection to the Payload Multiplexer/Demultiplexer (PL MDM), a Medium Rate Data Link (MRDL) including connections to Ethernet switched hubs and gateways, and a High Rate Data Link (HRDL) consisting of a fiber optic network connected to a central automated switch and multiplexer. The MRDL and HRDL networks along with the Integrated Communications Unit (ICU) (alternatively labeled the Ku-band Communications Unit (KCU)) form a High Rate Communication System (HRCS). The ISPR and non-rack end item software interfaces to U.S. PL data handling equipment are shown in Figure 3.0-1.

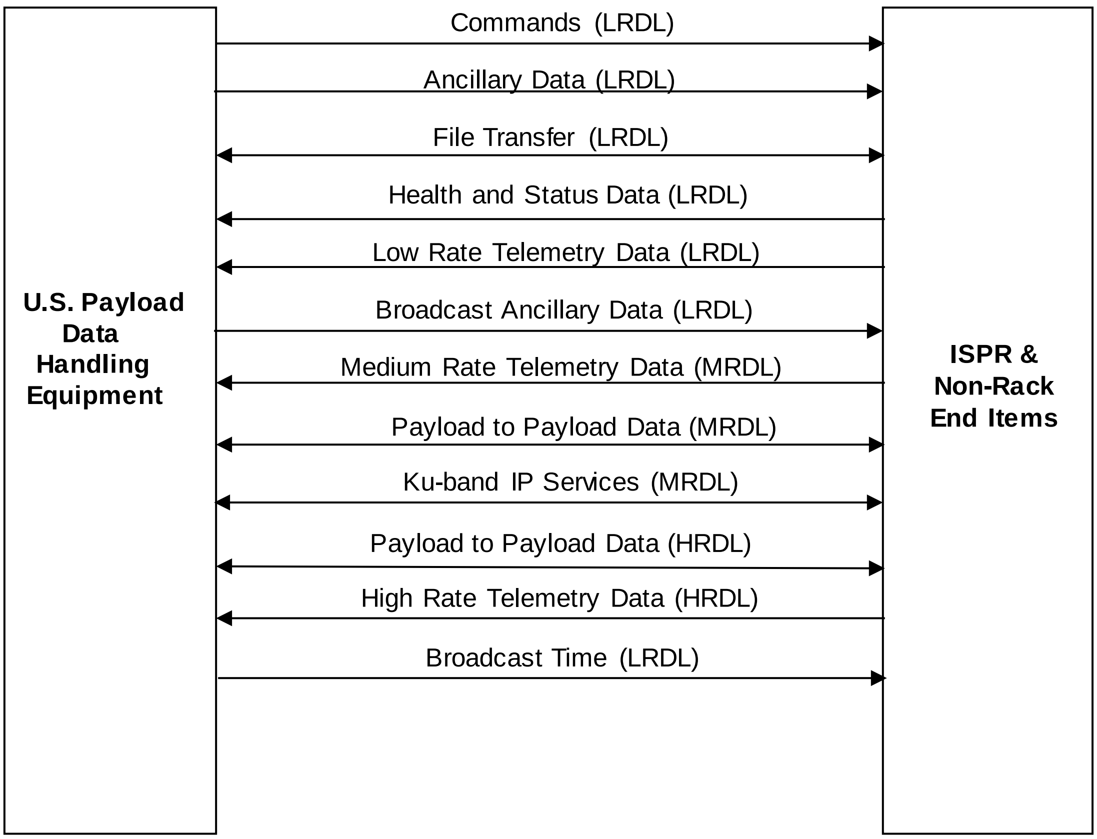


FIGURE 3.0-1 ISPR AND NON-RACK END ITEM SOFTWARE INTERFACES TO U.S. PAYLOAD DATA HANDLING EQUIPMENT

3.1 DATA FORMATS AND STANDARDS

3.1.1 NOTATIONS

The following notations are used in this document:

Binary Notation	‘<value>‘ b	e.g. ‘1010’ b
Octal Notation	‘<value>‘ O	e.g. ‘1674’ O
Hexadecimal Notation	0x-‘<value>‘	e.g. 0x- ‘AB1F’
Decimal Notation	<value>	e.g. 20.

The following nomenclature is used to describe contiguous groups of bits within a data packet:

1 byte	=	8 bits	=	1 octet		
1 bit	=	1b	=		=	
1 byte	=	1B	=		=	
1 word	=	2 bytes	=	2 octets	=	16 bits
1 double word	=	4 bytes	=	4 octets	=	32 bits
1 kilobit	=	1 Kb	=	1024 bits	=	
1 kilobyte	=	1 KB	=	1024 bytes	=	
1 megabit	=	1 Mb	=	1024 Kb	=	
1 megabyte	=	1 MB	=	1024 KB	=	

The following convention is used to identify each bit in an MIL-STD-1553B N-bit field and illustrated in Figure 3.1.1-1.

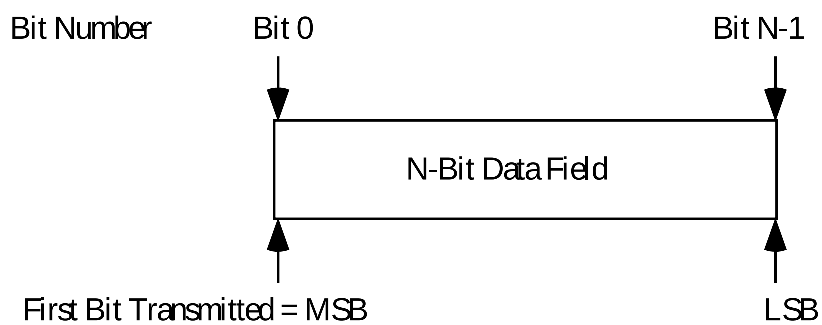


FIGURE 3.1.1-1 MIL-STD-1553B BIT NAMING CONVENTIONS

The first bit in a field, starting from the left is defined to be “Bit 0” and will be represented as the left most justified bit on a figure. The following bit is called “Bit 1”, and so on, up to “Bit N-1”, the bits being represented in this order from the left to right in the figure.

When the N-bit field is to be interpreted as a “Signed Integer”, Bit 0 will indicate the sign with Bit 0 = ‘0’ b corresponding to a positive number and Bit 0 = ‘1’ b corresponding to a negative number according to the “2’s complement” convention.

3.1.2 DATA TRANSMISSION

This section applies to PL data transmissions where the data will be processed by ISS systems (PL MDM, Payload Ethernet Hub Gateway, etc.). Two path service protocols as defined by the Consultative Committee for Space Data Systems (CCSDS) are available for transmitting data.

A. CCSDS Version 1 Space Packet format (LRDL, MRDL, HRDL)

B. CCSDS Version 8 Internet Protocol Encapsulation Packet format (MRDL only)

3.1.3 CONSULTATIVE COMMITTEE FOR SPACE DATA SYSTEMS (CCSDS) SPACE PACKET FORMATS

The ISS provides logical interfaces to each ISPR location and non-rack end item via the LRDL, MRDL or HRDL. On each interface, the ISS provides a CCSDS space packet protocol as the logical interface in accordance with Paragraph 3.3.3 of CCSDS 701.0-B-3, Advanced Orbiting Systems, Networks, and Data Links: Architectural Specification, CCSDS Path Protocol Data Unit (CP PDU) in entirety, except as noted in this ICD or as modified by an ISS document referenced from this ICD. Space packet protocol is characterized by a source-destination path identifier or Application Process Identifier (APID). In addition, the HRDL accommodates private bit-stream interfaces.

For each interface, the CCSDS path service is provided layered above the Physical Layer and the minimum required Protocol Layer as described in the following subsections.

3.1.3.1 CCSDS SPACE PACKET PRIMARY HEADER FORMAT

The ISS provides data to and receives data from ISPR locations and non-rack end items in the form of CCSDS space packets. The first six octets of each packet are the CCSDS Space Packet Primary Header as shown in Figure 3.1.3.1-1, CCSDS Space Packet Primary Header Format. Field definitions for the primary header are per Paragraph 3.3.2.1.1 of SSP 41175-02, Software Interface Control Document Station Management and Control to International Space Station Book 2, General Software Interface Requirements.

All CCSDS packets downlinked via the Ku-Band return link shall {3.1.3.1-A} contain an even number of octets. This includes LRDL, MRDL and HRDL.

Primary Header							User Data Field
Packet Identification				Sequence Control		Packet Length	
Version	Type	Secondary Header Flag	APID	Sequence Flags	Packet Sequence Count		
3 bits	1 bit	1 bit	11 bits	2 bits	14 bits	16 bits	
6 Octets							Var

FIGURE 3.1.3.1-1 CCSDS SPACE PACKET PRIMARY HEADER FORMAT

3.1.3.1.1 USE OF PACKET SEQUENCE COUNT FIELD

The Packet Sequence Count contained in bits 19 through 32 of the Primary Header is an Application Process Identifier (APID)-specific counter as noted in SSP 41175-02, Table 3.3.2.1.1-1, CCSDS Primary Header Field Definitions.

For transfer of File Data packets, Ancillary Data packets or Request Response packets from the PL MDM to an ISPR or non-rack end item, the PL MDM will use a PL MDM-to-Destination

APID. Therefore, the Packet Sequence Count will be incremented for each transaction, regardless of the type of data packet sent.

For Health & Status (H&S) packets being sent from an ISPR or non-rack end item to the PL MDM, the value contained in the Packet Sequence Count field of the Primary Header is immaterial because the PL MDM does not monitor that parameter. The same is true for Low Rate Telemetry (LRT) packets. However, the Packet Sequence Count for LRT packets will be checked by ground processors that will record an error if a missing or out-of-sequence packet counter is detected.

Because the Packet Sequence Counts are APID-specific, and given that there is a different APID for each Command Source-to-Destination, the PL MDM will simply pass on the commands it receives regardless of the Packet Sequence Count contained in the packet.

For File Data packets being sent from an ISPR or non-rack end item to the PL MDM, the value contained in the Packet Sequence Count field of the Primary Header must change from one packet to the next. The PL MDM software will use the combination of APID and Packet Sequence Count to distinguish a new File Data packet. Therefore, consecutive File Data packets from the same source must have different Packet Sequence Count values to be recognized as new packets. Because the PL MDM software only checks for different values from one packet to the next, there is no requirement for the Packet Sequence Count to start at a particular value or to increment in a consistent manner.

If desired, an ISPR or non-rack end item can perform a check of the APID, Type and Packet Sequence Count fields each time it checks a subaddress. If the APID, Type and Packet Sequence Count values are all identical to the values it read the last cycle at that subaddress, then they are an indication that no new command or data has been received. If, however, any value is not the same, then that is an indication that the ISPR or non-rack end item has received a new command or data packet. Any other processing of the Packet Sequence Count for delivered packets is discouraged. (Under nominal conditions, the Packet Sequence Count (for any type of packet) can be expected to increment by one for each new packet sent to a particular APID. However, conditions do exist that can cause a Packet Sequence Count to increment by more than one for a valid new packet sent to a particular APID.)

3.1.3.1.2 USE OF SEQUENCE FLAGS FIELD

For commands, the Sequence Flags field contained in bits 17 and 18 of the Primary Header must be marked as unsegmented data (’11’b). All other PL packets may be per source/destination ICDs.

The CCSDS Space Packet secondary header is required for MIL-STD-1553B data transfers and for all telemetry packets on the Ku-Band including PL MRDL and HRDL telemetry transfers. The format of the CCSDS Secondary Header is illustrated in Figure 3.1.3.2-1, CCSDS Space Packet Secondary Header Format. Field definitions for the secondary header are defined in Paragraph 3.3.2.1.1 of SSP 41175-02, and are tailored as shown in Appendix E of this document. In cases where SSP-41175-02 Secondary Header format requirements can be interpreted to compete with Appendix E of this document, Appendix E will have precedence. CCSDS headers are optional for payload-to-payload transfers on the MRDL and HRDL.

CCSDS Primary Header	**User Data Field**					
	Secondary Header					
	Time	**User Data Control Field**				**Packet ID**
		Time ID	**Check word Indicator**	**Spare**	**Packet Type**	
	5 octets	**2 bits**	**1 bit**	**1 bit**	**4 bits**	**4 octets**
6 octets	**10 octets**					

Note: Reference Appendix E for specific header requirements

FIGURE 3.1.3.2-1 CCSDS SPACE PACKET SECONDARY HEADER FORMAT

3.1.4 CCSDS INTERNET PROTOCOL ENCAPSULATION PACKET

In addition to support for CCSDS Space Packets on each MRDL downlink interface, the ISS also provides encapsulation of Internet Protocol packets from an ISPR or non-rack end item using CCSDS Internet Protocol Encapsulation (IPEncap). IPEncap processing is provided by the ICU for any packets that are forwarded to it by the PEHG and that conform with an Internet Protocol Version 4 (IPv4) datagram structure as illustrated in Figure 3.1.4-1, Internet Protocol Version 4 Datagram Structure. A typical IPv4 data structure including field definitions compatible with the ICU is described in SSP 41158, Paragraph E.5.1.3, Internet Protocol Version 4 (IPv4) Datagram Structure and in RFC 791.

Datagram							
IP Header							
Version 4 bits	Header Length 4 bits	Type Of Service 8 bits	Total Length 16 bits	Identification 16 bits	Flags 3 bits	Fragment Offset 13 bits	• • •
8 Octets							

Datagram							
IP Header							User Data Variable
• • •	Time to Live 8 bits	Protocol 8 bits	Header Checksum 16 bits	Source IP Address 32 bits	Destination IP Address 32 bits	Options/ Padding Variable	
12 Octets							

FIGURE 3.1.4-1 INTERNET PROTOCOL VERSION 4 DATAGRAM STRUCTURE

IP Packets generated by payloads that have a destination address and subnet format that conforms with the ground infrastructure shall be automatically forwarded to the ICU for further processing. This additional processing includes appending a CCSDS Internet Protocol Encapsulation (IPEncap) packet header as illustrated in Figure 3.1.4-2, CCSDS Internet Protocol Encapsulation Header Format, below, in accordance with Paragraph 4.2 of CCSDS 133.1-B-2, Encapsulation Service, Encapsulation Packet. The resultant IPEncap packet is routed to the Ku-Band downlink function within the ICU and transmitted via the Ku-Band return link.

Additional Ku-Band communication functions are described in Paragraph 3.3.7, Ku-band IP (KuIP) Services.

IP Encapsulation Header							
Packet Version Number **3 bits**	**Protocol ID** **3 bits**	**Length of Length** **2 bits**	**User Defined Field (Not Used)** **4 bits**	**Protocol ID Extension (Not Used)** **4 bits**	**Packet Length** **16 bits**	**IPE Header Extension** **8 bits**	**User Data Field**
5 Octets							**Var**

Note: For reference only. The IP Encapsulation Header is generated and appended to the user IPv4 packet by the ICU.

FIGURE 3.1.4-2 CCSDS INTERNET PROTOCOL ENCAPSULATION HEADER FORMAT

3.2 MIL-STD-1553B INTERFACE

The MIL-STD-1553B data interface provides the transfer of commands, request responses, ancillary data, files and time from the ISS to PLs and the transfer of PL health and status data, safety data, files, low rate telemetry, and requests for services from PLs to the ISS. The data formats, protocols, and application services are described in the following subsections.

3.2.1 DATA FORMATS

This section defines the set of types that will be used for PL health and status data, safety data, and PL generated ancillary data. The valid data types are described below.

3.2.1.1 OCTET

An octet is eight bits numbered as described in Paragraph 3.1.1, Notations.

3.2.1.2 SIGNED INTEGERS

Signed integers will have their sign determined by Bit 0 as described in Paragraph 3.1.1, Notations. Signed integers may have two lengths: 16 and 32 bits.

3.2.1.3 UNSIGNED INTEGERS

Unsigned integers are N-bit fields numbered as described in Paragraph 3.1.1, Notations. Unsigned integers may have two lengths: 16 and 32 bits.

3.2.1.4 FLOATING POINT

Floating point parameters will adhere to ANSI IEEE Std 754-1985, IEEE Standard for Binary Floating-Point Arithmetic, format for single and double precision.

3.2.1.5 ENUMERATION TYPE

An enumeration type will be defined as an ordered set of distinct enumeration literals. Each enumeration literal is identified by its position in the declaration. Enumerated types will start at

0. Enumeration literals are stored as distinct integer codes which satisfy the predefined ordering of the type, as if the enumeration type were a signed integer of the same length, using the bit numbering described in Paragraph 3.1.1, Notations. Enumeration types may have three lengths: 8, 16 and 32 bits.

3.2.1.6 BOOLEAN TYPE

Variables of the Boolean type:

- ’true’ shall {3.2.1.6-A} have the value of ’1’
- ’false’ shall {3.2.1.6-B} have the value of ’0’

3.2.1.7 CHARACTER TYPE

Character type will be an eight bit field with a range of 0 to 255. There are two sub-character types: 1) The basic American Standard Code for Information Interchange (ASCII) type with the numeric range 0 to 127; 2) The user character type with a numeric range 128 to 255 for user defined coding scheme.

3.2.1.8 BITSET

The bitset type is 32 bits containing specific bit patterns. It is null derived from a 32 bit unsigned integer.

3.2.1.9 DURATION

Reserved

3.2.1.10 STRINGS

There will be two character types: 1) A string type character; and 2) A string type octet. The string type comprises a length delimiting field followed by a sequence of characters or octets. The length delimiter will be a 16 bit unsigned integer identifying the number of characters or octets that follow.

3.2.2 TIME CODES

This section describes the formats for CCSDS unsegmented and segmented time codes.

PLs sending Time Codes shall {3.2.2-A} be as defined in CCSDS 301.0-B-2, Time Code Format.

3.2.2.1 SEGMENTED TIME CODES

Segmented time codes will be Broadcast Time as defined in Paragraph 3.3.2.2.2 of SSP 41175-02.

3.2.2.2 UNSEGMENTED TIME CODES

Unsegmented time codes will be as defined in Table 3.3.2.1.1-2 of SSP 41175-02.

3.2.3 LAYER 2 PROTOCOL

This section identifies the MIL-STD-1553B protocol implementation used by PLs to communicate as a Remote Terminal (RT) with the MIL-STD-1553B Controller (PL MDM).

3.2.3.1 GENERAL

The protocol implementation for the PL MDM MIL-STD-1553B local buses conforms to applicable document MIL-STD-1553B. The MIL-STD-1553B Bus Controller (BC) always initiates the information transfers on the MIL-STD-1553B. There can only be one BC on a MIL-STD-1553B at any one time. All other terminals on the MIL-STD-1553B will operate as RTs. The BC is located in the PL MDM. The MIL-STD-1553B protocol is composed of the Command Words (CW), Status Words (SW), and Data Words (DW). From these three word types, 8 message formats are composed as stated in MIL-STD-1553B.

PL MDM local bus has unique 100 millisecond processing frame profiles which are shown for informational purposes in Appendix D of this document. Timing requirements related to those bus profiles are contained in Paragraphs 3.2.3.5, 3.2.3.9.1, and 3.2.3.10 of this document. Other information regarding processing frames and synchronization may be found in Paragraphs 3.3.2.1.2, 3.3.2.2.1, and 3.3.2.2.2 of SSP 41175-02.

PL MDM local bus address assignments for ISPR or non-rack end item RTs are in accordance with Table 3.3.4.3.4-1 of SSP 41002, International Standard PL Rack to NASA/ESA/NASDA Modules Interface Control Document. The complete PL bus address assignment list is in accordance with Paragraph 3.2, Bus Address Assignments of SSP 50193-01, Software Interface Control Document, Payload Multiplexer/Demultiplexer to International Space Station, Book 1, Hardware Architecture.

For CCSDS data transfers between the BC and RT, the CCSDS Packet Transfer Mechanism protocol is a layer above the standard MIL-STD-1553B protocol. RT to RT transfers are not supported on the 1553 PL MDM local buses.

3.2.3.2 WORD INTERFACE

The following sections define the content and format of the MIL-STD-1553B Command, Status, and Data Word Interfaces.

3.2.3.2.1 COMMAND WORD INTERFACE

The command word shall {3.2.3.2.1-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.

3.2.3.2.1.1 SYNC

The sync field in the command word shall {3.2.3.2.1.1-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.1.

3.2.3.2.1.2 REMOTE TERMINAL ADDRESS

The remote terminal address shall {3.2.3.2.1.2-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.2.

3.2.3.2.1.3 TRANSMIT/RECEIVE BIT

The Transmit/Receive (T/R) bit shall {3.2.3.2.1.3-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.3.

3.2.3.2.1.4 SUBADDRESS/MODE (SAM) FIELD

For a list of the Subaddress (SA) Numbers that are currently defined, see Table 3.2.3.2.1.4-1 Subaddress Assignments.

TABLE 3.2.3.2.1.4-1 SUBADDRESS ASSIGNMENTS

SA#	Transmit (T/R=1)	Receive (T/R=0)
0	Mode Code (SAM=00000) Command	Mode Code Command
1	Reserved	Reserved
2	Reserved	Reserved
3	Reserved	Reserved
4	Reserved	Reserved
5	Reserved	Reserved
6	Reserved	Reserved
7	Reserved	Ancillary Data
8	Low Rate Telemetry Data	Command, Request Response (1)
9	Health and Status Data	Command, Request Response (2)
10	Reserved	Reserved
11	Reserved	Reserved
12	Reserved	Reserved
13	Reserved	Broadcast Ancillary Data (1)
14	Reserved	Broadcast Ancillary Data (2)
15	Reserved	File Transfer
16	Reserved	File Transfer
17	File Transfer	File Transfer
18	File Transfer	File Transfer
19	File Transfer	File Transfer
20	File Transfer	File Transfer
21	File Transfer	File Transfer
22	File Transfer	File Transfer
23	File Transfer	File Transfer
24	File Transfer	Reserved
25	File Transfer	Reserved
26	Reserved	Reserved
27	Reserved	Reserved
28	Reserved	Reserved
29	Reserved	Broadcast Time
30	Reserved(Data Wrap Read)	Reserved(Data Wrap Write)
31	Mode Code (SAM=11111) Command	Mode Code Command

3.2.3.2.1.5 DATA WORD COUNT/MODE CODE

The contents of the data word count/mode code field shall {3.2.3.2.1.5-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.5.

The standard MIL-STD-1553B mode codes are shown in Table 3.2.3.2.1.5-1, Mode Codes. BC and RT hardware shall {3.2.3.2.1.5-B} implement the mode codes which contain a “Yes” in the required column, as specified in the corresponding paragraphs which follow.

TABLE 3.2.3.2.1.5-1 MODE CODES

T/R	Mode Code	Function	Data Words	Required
1	00000	Dynamic Bus Control	No	No
1	00001	Synchronize (without data word)	No	No
1	00010	Transmit Status Word	No	Yes
1	00011	Initiate Self Test	No	Yes
1	00100	Transmitter Shutdown (SD)	No	Yes
1	00101	Override Transmitter (SD)	No	Yes
1	00110	Inhibit Terminal Flag	No	No
1	00111	Override Inhibit Terminal Flag	No	No
1	01000	Reset Remote Terminal	No	Yes
1	01001	Reserved	No	N/A
	to			
1	01111	Reserved	No	N/A
1	10000	Transmit Vector Word	Yes	No
0	10001	Synchronize (with data word)	Yes	Yes
1	10010	Transmit Last Command	Yes	Yes
1	10011	Transmit BIT Word *	Yes	Yes
0	10100	Selected Transmitter SD	Yes	No
0	10101	Override Selected Transmitter SD	Yes	No
1/0	10110	Reserved	Yes	N/A
	to			
1/0	11111	Reserved	Yes	N/A

* BIT = Built In Test

3.2.3.2.1.5.1 DYNAMIC BUS CONTROL

This mode code causes the RT to become the BC as described in Paragraph 4.3.3.5.1.7.1 of MIL-STD-1553B. The Dynamic Bus Control is not implemented by the PL MDM and is shown only for completeness.

3.2.3.2.1.5.2 SYNCHRONIZE (WITHOUT DATA WORDS)

This mode code causes the RT to Synchronize as defined in Paragraph 4.3.3.5.1.7.2 of MIL-STD-1553B. The Synchronize Without Data Words mode code is not implemented by the PL MDM and is shown only for completeness.

3.2.3.2.1.5.3 TRANSMIT STATUS WORD

This mode code causes the transmitting of status word and shall {3.2.3.2.1.5.3-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.7.3.

3.2.3.2.1.5.4 INITIATE SELF TEST

This mode code causes the RT to initiate the self test and shall {3.2.3.2.1.5.4-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.7.4.

3.2.3.2.1.5.5 TRANSMITTER SHUTDOWN (SD)

This mode code causes the RT to disable the transmitter and shall {3.2.3.2.1.5.5-A) be as defined in MIL-STD-1553B, 4.3.3.5.1.7.5.

3.2.3.2.1.5.6 OVERRIDE TRANSMITTER SD

This mode code causes the RT to enable a transmitter which was previously disabled and shall {3.2.3.2.1.5.6-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.7.6.

3.2.3.2.1.5.7 INHIBIT TERMINAL FLAG

This mode code causes the RT to set the Terminal Flag bit in the status word as defined in MIL-STD-1553B, 4.3.3.5.1.7.7. The Inhibit Terminal Flag is not implemented by the PL MDM and is shown only for completeness.

3.2.3.2.1.5.8 OVERRIDE INHIBIT TERMINAL FLAG

This mode code causes the RT to override the Terminal Flag bit set in the Inhibit Terminal Flag command as defined in MIL-STD-1553B, 4.3.3.5.1.7.8. The Override Inhibit Terminal Flag is not implemented by the PL MDM and is shown only for completeness.

3.2.3.2.1.5.9 RESET REMOTE TERMINAL

This mode code causes the RT to reset and shall {3.2.3.2.1.5.9-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.7.9.

3.2.3.2.1.5.10 TRANSMIT VECTOR WORD

This mode code causes the RT to transmit a status word containing the service request information and shall {3.2.3.2.1.5.10-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.7.11.

3.2.3.2.1.5.11 SYNCHRONIZE (WITH DATA WORD)

This mode code causes the RT to synchronize. The synchronization shall {3.2.3.2.1.5.11-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.7.12. The PL MDM will provide the Synchronize with Data Word message in the form of Broadcast Sync with Data per Paragraph 3.3.2.2.1 of SSP 41175-02. The format of the data word contained in the Broadcast Sync with Data is given in Table 3.3.2.2.1-1 of SSP 41175-02.

Note that following a re-boot of the PL MDM, the Broadcast Sync with Data will not be available for a duration of up to 5 minutes. An ISPR or non-rack C&DH end item that uses the Broadcast Sync as a “heartbeat” for determining presence of the PL MDM needs to take into account this possible 5 minutes absence.

3.2.3.2.1.5.12 TRANSMIT LAST COMMAND

This mode code causes the RT to transmit its status word and bits 4-19 of the last command word before the Transmit last command and shall {3.2.3.2.1.5.12-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.7.13.

3.2.3.2.1.5.13 TRANSMIT BIT WORD

This mode code causes the RT to transmit its status word and shall {3.2.3.2.1.5.13-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.7.14.

3.2.3.2.1.5.14 SELECTED TRANSMITTER SHUTDOWN

This mode code causes the RT to disable the transmitter associated with a specified redundant data bus. The command is designed for use with systems employing more than two redundant buses. The Selected Transmitter Shutdown command is not implemented by the PL MDM and is shown only for completeness.

3.2.3.2.1.5.15 OVERRIDE SELECTED TRANSMITTER SD

This mode code causes the RT to enable a transmitter which was previously disabled. The command is designed for use with systems employing more than two redundant buses. The Override Selected Transmitter Shutdown command is not implemented by the PL MDM and is shown only for completeness.

3.2.3.2.1.5.16 PARITY

The Parity Bit shall {3.2.3.2.1.6-A} be as defined in MIL-STD-1553B, 4.3.3.5.1.6.

3.2.3.2.2 STATUS WORD INTERFACE

The status word is used to communicate the condition of the RT to the MIL-STD-1553B controller as defined in MIL-STD-1553B, 4.3.3.5.3.

3.2.3.2.2.1 SYNC

The Sync field in the status word shall {3.2.3.2.2.1-A} be as defined in MIL-STD-1553B, 4.3.3.5.3.1.

3.2.3.2.2.2 RT ADDRESS

The RT address shall {3.2.3.2.2.2-A} be as defined in MIL-STD-1553B, 4.3.3.5.3.2.

3.2.3.2.2.3 MESSAGE ERROR BIT

The message error bit of the status word shall {3.2.3.2.2.3-A} be as defined in MIL-STD-1553B, 4.3.3.5.3.3.

3.2.3.2.2.4 INSTRUMENTATION BIT

The Instrumentation Bit of the status word is defined in Paragraph 4.3.3.5.3.4 of MIL-STD-1553B. This function is not implemented by the PL MDM and is shown only for completeness.

3.2.3.2.2.5 SERVICE REQUEST BIT

The Service Request Bit of the status word is described in Paragraph 4.3.3.5.3.5 of MIL-STD-1553B. This function is not implemented by the PL MDM and is shown only for completeness.

3.2.3.2.2.6 RESERVED

The reserved field shall {3.2.3.2.2.6-A} be as defined in MIL-STD-1553B, 4.3.3.5.3.6.

3.2.3.2.2.7 BROADCAST COMMAND RECEIVED BIT

The broadcast command received bit shall {3.2.3.2.2.7-A} be as defined in MIL-STD-1553B, 4.3.3.5.3.7.

3.2.3.2.2.8 SUBSYSTEM FLAG BIT

The Subsystem Flag Bit is defined in Paragraph 4.3.3.5.3.9 of MIL-STD-1553B. This function is not implemented by the PL MDM and is shown only for completeness.

3.2.3.2.2.9 MIL-STD-1553B BUSY BIT

The Busy Bit is defined in Paragraph 4.3.3.5.3.8 of MIL-STD-1553B. The PL MDM takes no system level action based on the busy bit.

3.2.3.2.2.10 DYNAMIC MIL-STD-1553B CONTROL ACCEPTANCE BIT

The Dynamic MIL-STD-1553B Control Acceptance Bit of the status word is described in Paragraph 4.3.3.5.3.10 of MIL-STD-1553B. This function is not implemented by the PL MDM and is shown only for completeness.

3.2.3.2.2.11 TERMINAL FLAG BIT

The terminal flag bit shall {3.2.3.2.2.11-A} be as defined in MIL-STD-1553B, 4.3.3.5.3.11.

3.2.3.2.2.12 PARITY

The parity bit of the status word shall {3.2.3.2.2.12-A} be as defined in MIL-STD-1553B, 4.3.3.5.3.12.

3.2.3.2.3 DATA WORD INTERFACE

Data words and data word format shall {3.2.3.2.3-A} be as defined in MIL-STD-1553B, 4.3.3.5.2.

3.2.3.2.3.1 SYNC

The sync field in the data word shall {3.2.3.2.3.1-A} be as defined in MIL-STD-1553B, 4.3.3.5.2.1.

3.2.3.2.3.2 DATA

The data field of the data word shall {3.2.3.2.3.2-A} be as defined in MIL-STD-1553B, 4.3.3.5.2.2.

3.2.3.2.3.3 PARITY

The parity bit of the data word shall {3.2.3.2.3.3-A} be as defined in MIL-STD-1553B, 4.3.3.5.2.3.

3.2.3.3 STANDARD MESSAGES

The legal message categories for the MIL-STD-1553B are defined in the sections below.

3.2.3.3.1 RECEIVE DATA MESSAGE (BC TO RT)

The Receive Data message is defined below, and Figure 3.2.3.3.1-1, Receive Data Message, illustrates the basic mechanisms involved.

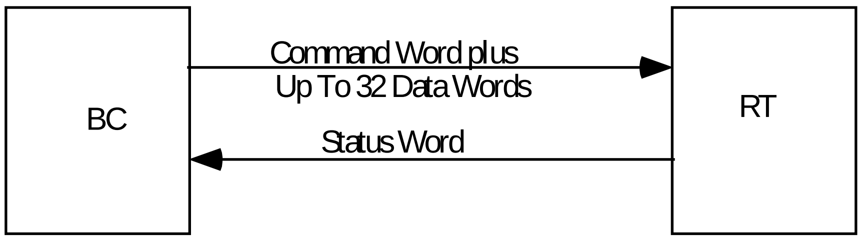


FIGURE 3.2.3.3.1-1 RECEIVE DATA MESSAGE

Table 3.2.3.3.1-1, Receive Data Message, describes the receive data message format. A Receive Data message shall {3.2.3.3.1-A} be as defined in MIL-STD-1553B, 4.3.3.6.1.

TABLE 3.2.3.3.1-1 RECEIVE DATA MESSAGE

Source:	BC	Transfer Type:	BC->RT
Destination:	RT	Data Word Count:	1-32
Subaddress:	Receive Data	Transmit/Receive	R-SA# 1-30

Word #	Description	Function	Range	Position
CW	MIL-STD-1553B Command Word			
1	Data Word 1	Data from the BC	0-65535	0-15
2	Data Word 2	Data from the BC	0-65535	0-15
through	through			
32	Data Word 32	Data from the BC	0-65535	0-15
SW	MIL-STD-1553B Status Word			

3.2.3.3.2 TRANSMIT DATA MESSAGE (RT TO BC)

The Transmit Data message is defined below, and Figure 3.2.3.3.2-1, Transmit Data Message, illustrates the basic mechanisms involved.

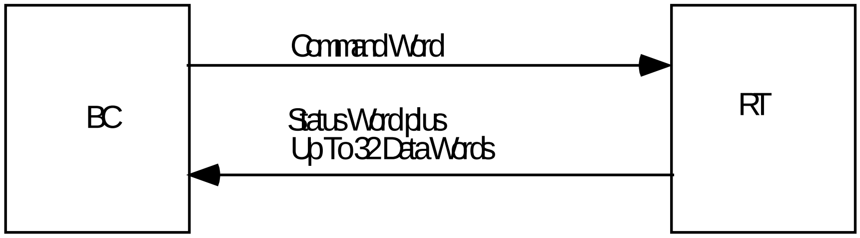


FIGURE 3.2.3.3.2-1 TRANSMIT DATA MESSAGE

Table 3.2.3.3.2-1, Transmit Data Message Format, describes the transmit data message format. A Transmit Data message shall {3.2.3.3.2-A} be as defined in MIL-STD-1553B, 4.3.3.6.2.

TABLE 3.2.3.3.2-1 TRANSMIT DATA MESSAGE FORMAT

Source:	RT	Transfer Type:	RT->BC
Destination:	BC	Data Word Count:	1-32
Subaddress:	Transmit Data	Transmit/Receive	T-SA# 1-30

Word #	Description	Function	Range	Position
CW	MIL-STD-1553B Command Word			
SW	MIL-STD-1553B Status Word			
1	Data Word 1	Data from the RT	0-65535	0-15
2	Data Word 2	Data from the RT	0-65535	0-15
through	through			
32	Data Word 32	Data from the RT	0-65535	0-15

3.2.3.4 COMMANDING

The USL provides commands to PLs from Ground, Timeliner, and the on-board Portable Computer System (PCS).

On each PL MDM local bus, commands are transferred from the PL MDM through two 32-word messages (i.e., a 64 word command packet) in each 100 millisecond processing frame through the two consecutive subaddresses shown in Table 3.2.3.2.1.4-1. This implies that an ISPR or non-rack end item RT can receive up to ten commands in one second. For most commands, the data contained in the command message originates from or is routed through the PL MDM and contains information meaningful only to the destination ISPR, non-rack end item or subrack PL.

Each command packet will contain a CCSDS header as defined in Paragraph 3.3.2.1.1 of SSP 41175-02, and tailored per Appendix E of this document.

Command packets are transmitted from the PL MDM in the format shown in Table 3.2.3.4-1, Command Packet Format. Command packets are always transmitted on the PL MDM local buses as a 64 word Command Packet. The 64 word command packet has 11 words of overhead as described below:

A. eight words of CCSDS header,

B. one reserved word,

C. one word of Legal Station Mode, and

D. one word checksum.

The deductions from the CCSDS command packets noted above implies that only 53 words of the command packet may contain the actual command data.

Commands that are uplinked via S-Band have a minimum size of 24 words.

The results of the processing of the PL command by Payload Executive Processor (PEP) will be recorded in the PEP History Log data. The data will include a unique identifier for the command packet, the space station current time, and any error status.

TABLE 3.2.3.4-1 COMMAND PACKET FORMAT

Source:	BC	Transfer Type:	BC->RT
Destination:	RT	Data Word Count:	11-64
Subaddress:	Receive Data	Transmit/Receive	R-SA# 8,9

Message #1		
Word #	**Description**	**Function**
CW	MIL-STD-1553B Command Word	
1	Data Word 1	CCSDS Primary Header
through		
3	Data Word 3	CCSDS Primary Header
4	Data Word 4	CCSDS Secondary Header
through		
8	Data Word 8	CCSDS Secondary Header
9	Reserved	Spare
10	Reserved	Legal Station Mode
11	Data Word 11	Command Data
through		
32	Data Word 32	Command Data
Message #2		
CW	MIL-STD-1553B Command Word	
1	Data Word 1	Command Data
through		
32	Data Word 32	Command Data

Note: The last word of the Command Packet is the checksum per the CCSDS packet. Since the PL MDM always transmits commands as a 64-word packet, if the actual command length is less than 64 words then the data beyond the checksum should be considered “don’t care”.

3.2.3.4.1 PL COMMANDING SERVICE CONSTRAINTS

Any command for routing by the PEP must have an APID identified by PEP in its configuration data.

3.2.3.4.2 PL COMMANDING SERVICE ASSUMPTIONS

Assumptions upon which the PL Commanding Service is based are as follows:

A. It is assumed that any rack or integrated payload which has multiple PLs, such as an Expedite the Process of Experiments to Space Station (EXPRESS) rack, will have some form of central rack controller. The PEP only routes commands to the ISPR- or non-rack end item level. Routing of the commands beyond the RT level is the responsibility of the rack controller per rack specified protocols.

3.2.3.5 HEALTH AND STATUS (H&S) DATA

H&S data is defined as: information originating at the payload/subrack payload and passed to the PL MDM that provides the crew and ground confirmation of PL performance, operational state, resource consumption, and assurance that the PL is operating within safety guidelines as defined by the PL Safety Review Panel (PSRP) and the ISS Flight Rules. Some examples of PL H&S data are subsystem status (power, voltages, currents, temperatures, pressures, fluid flow velocities, warning indicators, error messages/codes, etc.), digital communications systems statistics (1553, ethernet, and high rate system status, etc.), and video system status (camera and video recorder on/off indications, synchronization indicators, etc.).

A Subset Identifier (ID) is assigned to each PL, subrack PL, PL support system, or other entity which is required to provide H&S data to the PEP via the 1553 PL MDM local buses, or which expects to request PEP services via the PL MDM local bus. This Subset ID will be unique to the entity to which it is assigned. It will be used by the PL MDM for various reasons and will be used for decommutating the H&S data on the ground.

The format for the H&S data provided by an RT with a single Subset ID shall {3.2.3.5-A} be as given in Figure 3.2.3.5-1, Single Subset ID Health and Status Format. Once the H&S data has been provided to the PL MDM by the Subset ID via the RTs H&S data, the data is then available for access by the Limit Checking Service, Timeliner, PCS Interface, Ancillary Data Services, etc.

The format for the H&S data provided by an ISPR or non-rack end item containing multiple Subset IDs shall {3.2.3.5-B} be as given in Figure 3.2.3.5-2, Integrated ISPR or non-rack end item Health and Status Format.

For any H&S packet provided to the PL MDM, APID number 0 (PLs to PL MDM) can be used in the CCSDS Primary Header.

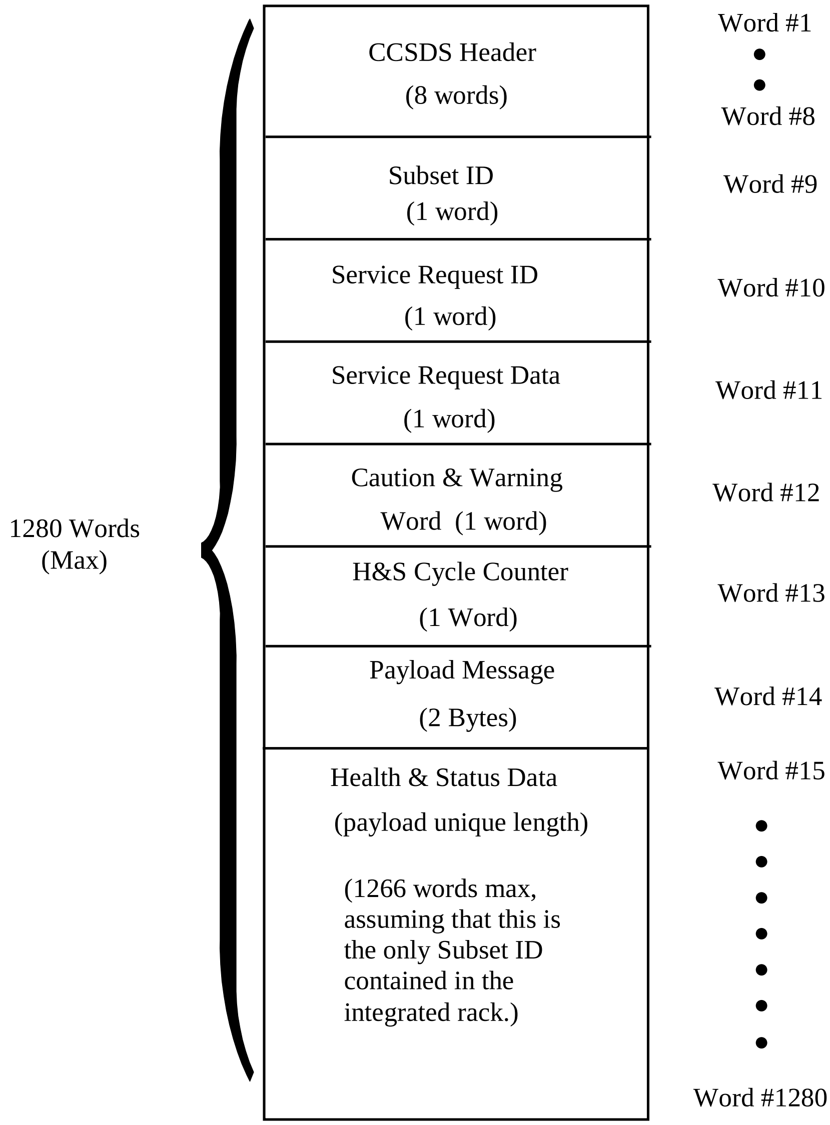


FIGURE 3.2.3.5-1 SINGLE SUBSET ID HEALTH AND STATUS FORMAT

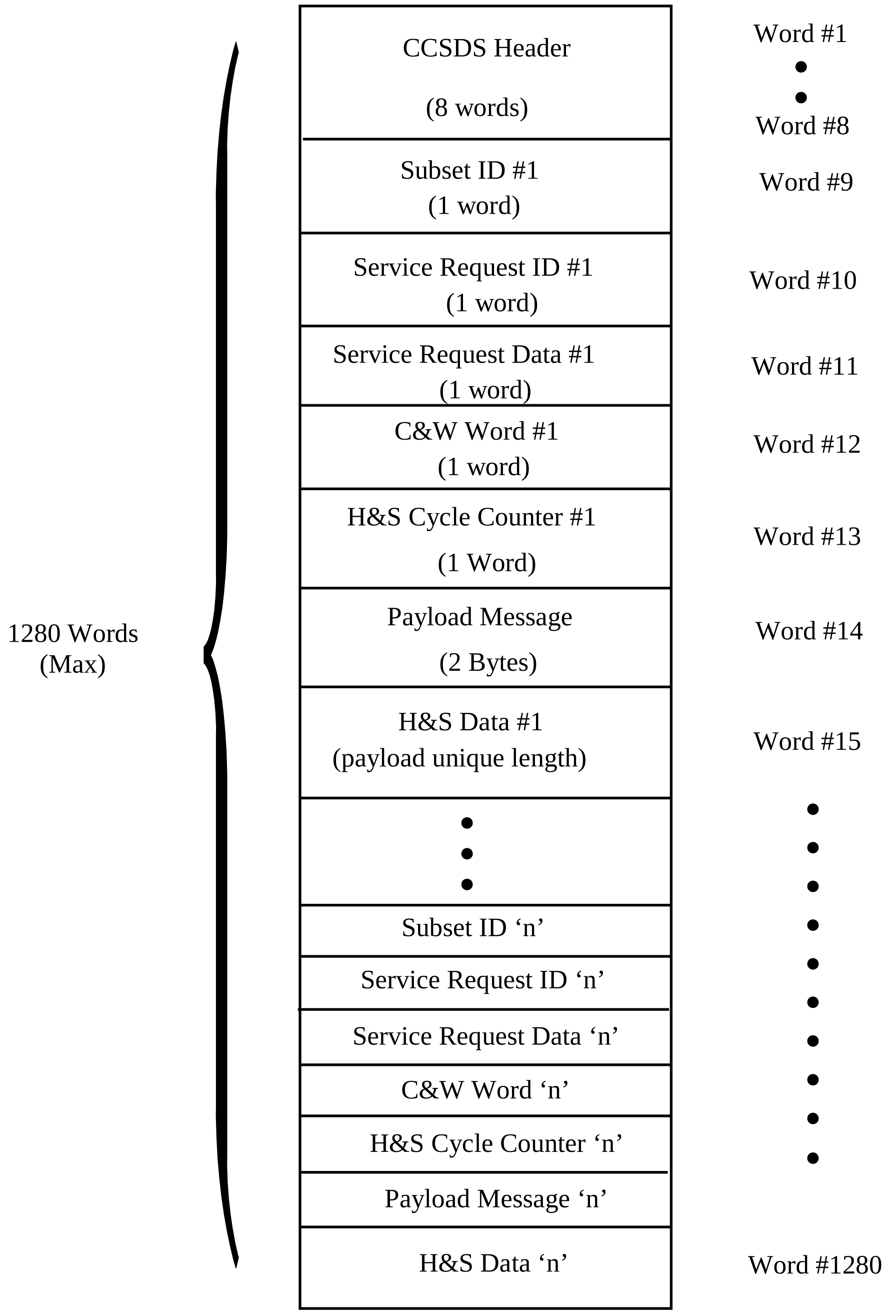


FIGURE 3.2.3.5-2 INTEGRATED ISPR OR NON-RACK END ITEM HEALTH AND STATUS FORMAT

Each H&S data package provided to the PL MDM by an ISPR or non-rack end item RT contains a CCSDS Header as specified in Paragraph 3.3.2.1.1 of SSP 41175-02. The CCSDS header is placed in the first eight words of the H&S data provided by an RT as shown in Figure 3.2.3.5-1, Figure 3.2.3.5-2, and Table 3.2.3.5-1, Health and Status Packet Format.

TABLE 3.2.3.5-1 HEALTH AND STATUS PACKET FORMAT

Source:	RT	Transfer Type:	RT->BC
Destination:	BC	Data Word Count:	11-1280
Subaddress:	Transmit Data	Transmit/Receive	T-SA# 9

Message #1		
Word#	**Description**	**Function**
CW	MIL-STD-1553B Command Word	
1	Data Word 1	CCSDS Primary Header
through		
3	Data Word 3	CCSDS Primary Header
4	Data Word 4	CCSDS Secondary Header
through		
8	Data Word 8	CCSDS Secondary Header
The following words and Messages contain the Health and Status Data of one or more Subset IDs contained within an ISPR or non-rack end item. Note: As a minimum, the H&S packet format will contain a single Subset ID with Request Data words and a C&W Summary Word as shown in Figure 3.2.3.5-1. The format for an RT to report H&S data for multiple Subset IDs is given in Figure 3.2.3.5-2.		
9	Data Word 9	Health and Status Data
through		
32	Data Word 32	Health and Status Data

Message #2		
CW	MIL-STD-1553B Command Word	
1	Data Word 1	Health and Status Data
through		
32	Data Word 32	Health and Status Data

Messages #3 through 40		
CW	MIL-STD-1553B Command Word	
1	Data Word 1	Health and Status Data
through		
32	Data Word 32	Health and Status Data

The PL MDM shall {3.2.3.5-C} collect the H&S CCSDS packages from the RTs at a predefined rate of 1.0 Hz or 0.1 Hz. The data rate at which the H&S data is collected will be determined by the Payload Developer (PD)/Payload Integrator (PI) in conjunction with the PSRP, and their own analysis and associated safety reviews.

The PL MDM shall {3.2.3.5-D} collect up to 1280 words of H&S data from each ISPR and non-rack end item RT location. The 1280 words will include the CCSDS header.

The PL MDM shall {3.2.3.5-E} collect H&S Data from ISPR or non-rack end item RTs as four 32-word messages in the first 100 millisecond processing frame of the 1 second minor frame collection cycle. During subsequent 100 millisecond processing frames of the 1 second minor frame, the PL MDM shall {3.2.3.5-F} collect up to four 32 word messages, but only enough 32 word messages to complete the collection of the H&S data. The exact number of transactions beyond the first 100 milliseconds will depend on the length of the packet as defined in Word #3 of the CCSDS primary header. Therefore, a maximum transfer of H&S data coming from an ISPR or non-rack end item RT consists of 10 transactions within one second, each being four 32 word messages.

The H&S data is collected from the RTs at a single subaddress as shown in Table 3.2.3.2.1.4-1, Subaddress Assignments.

The PL MDM shall {3.2.3.5-G} collect H&S data during the first half of the 100 millisecond processing frames as shown in Appendix D. ISPR or non-rack end item RTs shall {3.2.3.5-H} update H&S data such that the data is ready to be read at the appropriate time within the 100 millisecond processing frame as the 32 word messages are requested. This requirement allows freedom of design such that the ISPR or non-rack end item RT may update the H&S data whenever it chooses, as long as the data is ready when requested from the PL MDM. The RT can accomplish this by updating the H&S data during the last half of a 100 millisecond processing frame (see example of Health & Status update shown in Figure 3.2.3.5-3), by updating upon buffer read interrupts (if this can be accomplished fast enough between 32 word transfers), or by chaining the data buffers together using an auto-indexing technique.

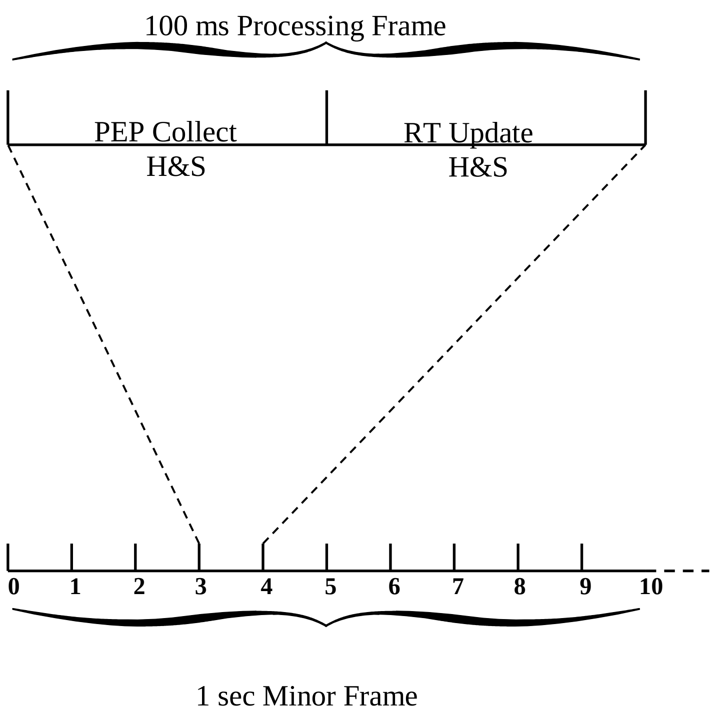


FIGURE 3.2.3.5-3 HEALTH AND STATUS UPDATE

Request Data embedded in the H&S data provided by a Subset ID shall {3.2.3.5-I} only be set for a single collection cycle for each request. The format for the Request Data shall {3.2.3.5-J} be as given in Table 3.2.3.7-1, Service Requests.

The Caution & Warning (C&W) word embedded in each Subset ID’s H&S data is provided so that the rack controller or the PEP can monitor for out-of-bounds safety related conditions. Availability of the C&W word to the PEP and the ISS C&W system will facilitate the isolation of problems or malfunctions to the subrack level for racks which have multiple PLs.

PLs or subrack PLs which the PSRP have determined cannot cause such a condition shall {3.2.3.5-K} zero fill the C&W word. PLs or subrack PLs which are required to report such a condition shall {3.2.3.5-L} set their summary C&W word to the following values:

0	—	No Problem
1	—	Advisory
2	—	Caution
3	—	Warning
4	—	Emergency(Toxic) - (Scar)

Subset IDs which have multiple C&W events occurring simultaneously shall {3.2.3.5-M} set their C&W word to the value representing the most severe event occurring at that time.

Note: PL advisory events are not currently supported by the ISS C&W system. PLs may set the C&W word to a value of 1, but that will not in and of itself cause an advisory to be displayed.

The C&W word shall {3.2.3.5-N} be placed as word #4 of H&S data for each Subset ID as shown in Figure 3.2.3.5-1 and Figure 3.2.3.5-2. The C&W word shall {3.2.3.5-O} be set to the appropriate value for each H&S reporting cycle (i.e., the out-of-bounds condition will be reported as long as it continues to be out-of-bounds).

For each Subset ID that is reporting H&S Data, a H&S Cycle Counter shall {3.2.3.5-P} be provided as shown in Figures 3.2.3.5-1 and 3.2.3.5-2. The H&S Cycle Counter shall {3.2.3.5-Q} be an unsigned 16 bit integer in the range 0..65,535. The H&S Cycle Counter value shall {3.2.3.5-R} be set to ‘0’ for the first H&S packet that the Subset ID transmits. The H&S Cycle Counter shall be incremented by a value of ‘1’ for each H&S packet transmitted. Once a value of ‘65,535’ is reached, the H&S Cycle Counter for the following packet shall {3.2.3.5-S} be reset to a value of ‘0’ and then the Subset ID will continue incrementing the H&S Cycle Counter as noted above. This H&S Cycle Counter will be used by PL Operations personnel to determine whether H&S data being received is stale.

PLs which require messages to be displayed on a PCS onboard the ISS or displayed by PL Operations personnel on the ground shall {3.2.3.5-T} include those messages in their H&S Data as shown in Figure 3.2.3.5-1 and Figure 3.2.3.5-2. PLs which do not require messages to be displayed on a PCS onboard the ISS or by PL Operations personnel on the ground are not required to reserve the PL Message area within the H&S Data.

PL messages shall {3.2.3.5-U} be formatted as shown in Figure 3.2.3.5-4. The Message Counter shall {3.2.3.5-V} be an 8-bit unsigned integer in the range 0..255. The Message Counter shall {3.2.3.5-W} initially contain a value of ‘0’. The Message Counter shall {3.2.3.5-X} be incremented by a value of ‘1’ with each message issued by the PL. Once a value of 255 is reached, the Message Counter for the next message shall {3.2.3.5-Y} be reset to a value of ‘0’ and then the PL will continue incrementing the Message Counter as noted above.

Message Counter	Message Identifier
Most Significant Bit	Lease Significant Bit

FIGURE 3.2.3.5-4 PAYLOAD MESSAGE FORMAT

The Message Identifier shall {3.2.3.5-Z} be an 8-bit unsigned integer in the range 0..255. The Message Counter and Message Identifier must both be defined as part of the PL's H&S packet in the Payload Data Library (PDL) during the development of the PL-unique ICD per SSP 57002, Payload Software Interface Control Document Template. Both of these parameters must also be marked as being "PCS Displayed" on the H&S service requirements screen in PDL in order to be visible to a PCS display.

To have a text message displayed on a PL PCS display, in addition to defining the Message Identifier and Message Counter H&S parameters within PDL, a display must exist to host the message. If there is no preexisting PCS display that can be used, then a PL Developer must negotiate with ISS Payload Software Engineering and Integration (PSE&I) for PCS display development and/or integration - no PCS display will be available to host the PL's messages otherwise. PLs may elect to develop their own displays (subject to ISS display requirements), in which case PSE&I will be responsible for integrating the displays into a PCS software load. The actual text to be displayed on a PCS display will be defined by the PD during the development of a Software Requirements Specification (SRS) for the PCS display. The Message Identifier will be associated with its unique message text in the SRS.

To have a text message displayed on a PL Operations ground display, in addition to defining the Message Identifier and Message Counter H&S parameters within PDL, a PL must negotiate with the Payload Operations Integration Function (POIF) in Huntsville, Alabama for ground display development. PL messages can be included on a PL Rack Officer's display, but are not automatically supported. A PL Developer should contact the POIF for implementation details.

As the PEP collects H&S for each active Subset ID, a record is maintained of the Subset IDs for which H&S data was collected. After the data for all Subset IDs has been processed, a check is performed to determine if any Subset IDs requiring H&S data collection did not provide data. If a Subset ID fails to provide H&S data, then the event is recorded in the PEP History Log.

3.2.3.5.1 LIMIT EXCEPTION SERVICE

The Limit Exception Service, in conjunction with the H&S Service, is for monitoring PL and PL support system data to detect out-of-limit conditions. PL/Subset ID data to be monitored by the Limit Exception Service is provided to the PEP as part of a Subset ID's H&S data. This service is activated every second to monitor data values stored in the PEP memory for possible limit exceptions.

The types of data which the PEP can monitor are specified below in Paragraph 3.2.3.5.1.1. PLs/subrack PLs which require the use of the PEP Limit Exception Service shall {3.2.3.5.1-A} provide the parameter(s) to be monitored on 16 bit word boundaries in one of the formats listed in Paragraph 3.2.3.5.1.1.

The checks that can be performed against these data types shall {3.2.3.5.1-B} be:

A. Upper Limit Exceeded,

B. Lower Limit Exceeded,

C. Equal To, and

D. Not Equal To.

A Limit Exception Service response consists of initiating exception processing. Exception processing is predefined and may consist of either providing a command to execute an automated sequence, providing a command to a PL or PL support system, and/or notifying the Command and Control Software (CCS) MDM of a C&W event. Determining the Limit Exception Service response(s) that is (are) required is the responsibility of the PD/PI in conjunction with the PSRP and associated safety reviews.

PD/PIs who require the Limit Exception Service will enter those requirements as a part of the C&DH data packet via the SSP 57002 series ICDs. PD/PIs will also enter as a part of their requirements, a 'fault count value' for each data item to be monitored which specifies the number of consecutive faults that must occur before any action is taken. The fault count value shall {3.2.3.5.1-C} be in the range 1..60.

3.2.3.5.1.1 LIMIT CHECK SERVICE DATA TYPES

The PEP Limit Check Service shall {3.2.3.5.1.1-A} accommodate the following data types:

A. Signed Integer (16 bits),
Range: -32768..32767

B. Signed Long Integer (32 bits),
Range: -2,147,483,648..2,147,483,647

C. Single Precision Floating Point (32 bits),
Range: (digits 6) -(2.0-2.0**(-23))*2.0**127 .. (2.0-2.0**(-23))*2.0**127

D. Double Precision Floating Point (64 bits),
Range: (digits 15) -(2.0-2.0**(-51))*2.0**1023 .. (2.0-2.0**(-51))*2.0**1023

E. Boolean (16 bits)
Range: '0000000000000000'b..'0000000000000001'b

WARNING

The Unsigned Integer data type is not supported. The PEP Limit Check Service will interpret any 16 bit integer value greater than 32767 as a negative value.

3.2.3.5.1.2 LIMIT EXCEPTION SERVICE CONSTRAINTS

A. The PEP Limit Exception Service can monitor up to 250 data items for out-of-limit conditions for a PL complement without reconfiguration of the PL MDM.

B. The C&W annunciation associated with the data item will be set for each sampling cycle (i.e., once per second) that the limit is exceeded, regardless if the exception has been handled previously or the consecutive fault count exceeded (i.e., the CCS will be notified each sampling cycle that the data value is out of limits).

C. The data items to be monitored by the Limit Exception Service are enabled either by default when the PEP configuration data is loaded, or via a commanded data load.

D. The data items to be monitored by the Limit Exception Service are disabled either by default when the PEP configuration data is loaded, via a commanded data load, or by PEP itself for any data items associated with a Subset ID for which the H&S collection service has been terminated.

E. The Fault Count associated with each data item is reset to zero each time the item being monitored goes back within bounds.

3.2.3.5.2 H&S SERVICE CONSTRAINTS

Specific constraints imposed upon the H&S Service are as follows:

A. For multiple PL racks, the combined total of all H&S data for the Subset IDs present in that rack cannot exceed 1280 data words, inclusive of the CCSDS header.

B. There is only one H&S data packet per Subset ID (i.e., the length of the H&S data cannot change per subset ID without reconfiguration of the PL MDM; the format of the H&S data may not change per Subset ID without reconfiguring the Huntsville Operations Support Center (HOSC) if processing of the data on the ground by the HOSC is required; the format of the H&S data cannot change per Subset ID without reconfiguring the PL MDM if processing of the data by the PL MDM is required).

3.2.3.5.3 H&S SERVICE ASSUMPTIONS

Assumptions upon which the H&S Service is based are as follows:

A. For multiple Subset IDs within a rack, there is a central rack controller which is responsible for collecting all active Subset ID H&S data, and for transmitting it upon command to the PEP (i.e., the PEP interface is to ISPR-level).

3.2.3.6 SAFETY DATA

Safety data is the set of PL generated C&W related parameters that are required to be monitored for C&W events. Determination of the safety-related parameters that are required is the responsibility of the PD/PI in conjunction with the PSRP and associated safety reviews. Examples of safety-related data includes: 1) A parameter (including the Health & Status C&W word itself) that is limit checked onboard by the PL MDM based on PSRP requirements or ISS requirements/flight rules; 2) A parameter that is monitored on the ground based on PSRP requirements or payload analyses; 3) A parameter that is monitored internally by the payload to determine if the Health & Status Caution or Warning bit needs to be set. Safety data shall {3.2.3.6-A} be included in the H&S data CCSDS packets provided by ISPR or non-rack end item RTs. (Note: Safety parameters such as current or temperature measurements that are being monitored onboard for a situation that could lead to a fire or overheating are not downlinked via S-Band; however, resultant rack-level ECW bits that are set based on the PL MDM limit check function are automatically included in the S-Band downlink.)

3.2.3.7 SERVICE REQUESTS

Service Requests placed in a H&S data packet by a Subset ID shall {3.2.3.7-A} be located in the two words following the Subset ID for each reporting entity in the H&S data packet.

Valid Service Requests IDs shall {3.2.3.7-B} be as defined in Table 3.2.3.7-1, Service Requests.

TABLE 3.2.3.7-1 SERVICE REQUESTS (2 PAGES)

Service Request Type	Structure	Binary Definition
Low Rate Telemetry Start	1 Word (Request ID) 1 Word Number of Packets	‘00000000 00000011’ b (or ’3’ or ’ 0x0003’) Range {1-100}
Low Rate Telemetry Stop	1 Word (Request ID)	‘00000000 00000100’ b (or ’4’ or ’ 0x0004’)
Procedure Execution Start	1 Word (Request ID) 1 Word (Sequence ID)	‘00000000 00010010’ b (or ’18’ or ’ 0x0012’) Payload Dependent
Procedure Execution Stop	1 Word (Request ID) 1 Word (Sequence ID)	‘00000000 00010011’ b (or ’19’ or ’ 0x0013’) Payload Dependent
Procedure Execution Resume	1 Word (Request ID) 1 Word (Sequence ID)	‘00000000 00010100’ b (or ’20’ or ’ 0x0014’H) Payload Dependent
Start File Read	1 Word (Request ID) 1 Word (File ID)	‘00000000 00010000’ b (or ’16’ or ’ 0x0010’H) Payload Dependent
Start File Write	1 Word (Request ID) 1 Word (File ID)	‘00000000 00010001’ b (or ’17’ or ’ 0x0011’) Payload Dependent
Stop File Read	1 Word (Request ID) 1 Word (File ID)	‘00000000 00011000’ b (or ’24’ or ’ 0x0018’) Payload Dependent
Stop File Write	1 Word (Request ID) 1 Word (File ID)	‘00000000 00011001’ b (or ’25’ or ’ 0x0019’) Payload Dependent
Restart File Read	1 Word (Request ID) 1 Word (Block #)	‘00000000 00011010’ b (or ’26’ or ’ 0x001A’) Payload Dependent
Ancillary Data Start	1 Word (Request ID) 1 byte (Data Set ID) 1 byte (Cyclic/Aperiodic)	‘00000000 00000001’ b (or ’1’ or ’ 0x0001’) Data Set Dependent; Range {1-100} ’1’ (Cyclic) (See Note 1 below) ’0’ (Aperiodic)
Ancillary Data Stop	1 Word (Request ID) 1 byte (Data Set ID)	‘00000000 00000010’ b (or ’2’ or ’ 0x0002’) Data Set Dependent (See Note 2 below)

TABLE 3.2.3.7-1 SERVICE REQUESTS (2 PAGES)

Service Request Type	Structure	Binary Definition
Install Bundle	1 Word (Request ID) 1 Word (Bundle ID Parameter)	‘00000000 00010101’ b (or ’21’ or ’ 0x0015’) Payload Dependent
Halt Bundle	1 Word (Request ID) 1 Word (Bundle ID Parameter)	‘00000000 00010110’ b (or ’22’ or ’ 0x0016’) Payload Dependent
Remove Bundle	1 Word (Request ID) 1 Word (Bundle ID Parameter)	‘00000000 00010111’ b (or ’23’ or ’ 0x0017’) Payload Dependent
’null’	1 Word (No Request)	‘00000000 00000000’ b (or ’0’ or ’ 0x0000’)

Note 1: For ‘Ancillary Data Start’ request:
Most Significant Byte (Bits 0-7) contains the Rate (i.e., Cyclic vs. Aperiodic)
Least Significant Byte (Bits 8-15) contains the Data Set ID

Note 2: For ‘Ancillary Data Stop’ request:
Most Significant Byte (Bits 0-7) is not used
Least Significant Byte (Bits 8-15) contains the Data Set ID

The PL MDM responds to PEP Service Requests with a Request Response packet. Request Response packets are normally only sent when a Service Request is denied. However, a positive response of “No Error” is provided for Timeliner-related Service Requests (Procedure Execution Start, Procedure Execution Stop, Procedure Execution Resume, Install Bundle, Halt Bundle and Remove Bundle) that are error-free. The Request Response packet will be returned to the PL within 1-20 seconds depending upon how many other commands/Request Responses are already on the queue. The Request Response packets are 13 words in length and shall {3.2.3.7-C} be as shown in Table 3.2.3.7-2.

TABLE 3.2.3.7-2 REQUEST RESPONSE PACKET FORMAT

Source:	BC	Transfer Type:	BC->RT
Destination:	RT	Data Word Count:	13 Note: 64 words will be xmitted
Subaddress:	Receive Data	Transmit/Receive	R-SA# 8, 9

Word #	Description	Function
CW	MIL-STD-1553B Command Word	
1	Data Word 1	CCSDS Primary Header
through		
3	Data Word 3	CCSDS Primary Header
4	Data Word 4	CCSDS Secondary Header
through		
8	Data Word 8	CCSDS Secondary Header (PL Subset ID)
9	Data Word 9	PL Request ID
10	Data Word 10	Request Data
11	Data Word 11	Fault Code
12	Data Word 12	Request Response Data
13	Data Word 13	Checksum

Data Word 9, Request ID, of the Request Response packet will contain the Service Request ID that was provided in the Health & Status data of the requesting Subset ID. Data Word 10, Request Data, will contain the Service Request Data that was provided as a parameter for the Service Request ID in the Health & Status data of the requesting Subset ID.

Data Word 11, Fault Code, of the Request Response Packet contains Fault Codes values as defined in Table 3.2.3.7-3, Payload Request Response Fault Code Values, that represent the response to PEP Service Requests. There are two possible Request Responses for any PEP Service Request.

PEP_Command_Buffer_Full is sent when the PL MDM’s internal command buffer is already full and thus cannot accommodate the request.

Queue_Full is sent when the PL MDM’s internal command buffer can accept the request but the command queue for a particular service application (Low Rate Telemetry, Ancillary Data, File Transfer or Procedure Execution service) is full, preventing that application from servicing the request.

Fault codes specific to particular Service Requests are described in the sections that follow and are summarized in Table 3.2.3.7-3.

Data Word 12, Request Response Data, is only used for Request Response packets related to the File Transfer Service as outlined in Paragraphs 3.2.3.9.1 and 3.2.3.9.2.

TABLE 3.2.3.7-3 PAYLOAD REQUEST RESPONSE FAULT CODE VALUES (2 PAGES)

Fault Code Name	Value	Meaning	Paragraph
No_Error	0	Possible response to Procedure Execution Start, Procedure Execution Stop, Procedure Execution Resume, Install Bundle, Halt Bundle, or Remove Bundle	3.2.3.7, 3.2.3.11
Invalid_Anc_Data_Set_Requested	1	Possible response to Ancillary Data Start request.	3.2.3.8.2
Undefined_Anc_Data_Set_Requested	2	Possible response to Ancillary Data Start request	3.2.3.8.2
Req_Anc_Data_Already_Being_Provided	3	Possible response to Ancillary Data Start request	3.2.3.8.2
Req_Anc_Data_Is_Not_Being_Provided	4	Possible response to Ancillary Data Stop request	3.2.3.8.2
Invalid_Cyclic_Flag	5	Possible response to Ancillary Data Start request	3.2.3.8.2
Invalid_File_ID	15	Possible response to Start File Read or Start File Write request	3.2.3.9, 3.2.3.9.1, 3.2.3.9.2
PEP_Command_Buffer_Full	20	Possible response to any payload request	3.2.3.7
Queue_Full	21	Possible response to any payload request	3.2.3.7
LRT_Already_Being_Provided	27	Possible response to Low Rate Telemetry Start request	3.2.3.1 0
LRT_Not_Being_Provided	28	Possible response to Low Rate Telemetry Stop request	3.2.3.10
Invalid_LRT_Downlink_Rate	29	Possible response to Low Rate Telemetry Start request	3.2.3.10
Invalid_Sequence_ID	30	Possible response to Procedure Execution Start, Procedure Execution Stop, or Procedure Execution Resume request	3.2.3.11
Invalid_Bundle_ID	31	Possible response to Install Bundle, Halt bundle, or Remove Bundle request	3.2.3.11
Sequence_ID_Not_Found	32	Possible response to Procedure Execution Start, Procedure Execution Stop, or Procedure Execution Resume request	3.2.3.11
Bundle_ID_Not_Found	33	Possible response to Install Bundle, Halt Bundle, or Remove Bundle request	3.2.3.11
Unauthorized_Sequence_Execution_Request	34	Possible response to Procedure Execution Start, Procedure Execution Stop, or Procedure Execution Resume request	3.2.3.11

TABLE 3.2.3.7-3 PAYLOAD REQUEST RESPONSE FAULT CODE VALUES (2 PAGES)

Fault Code Name	Value	Meaning	Paragraph
Unauthorized_Bundle_Execution_Request	35	Possible response to Install Bundle, Halt Bundle, or Remove Bundle request	3.2.3.11
Timeliner_Cmd_Queue_Full	36	Possible response to Install Bundle, Halt Bundle, Remove Bundle, Procedure Execution Start,Procedure Execution Stop, or Procedure Execution Resume request	3.2.3.11
Insufficient Bandwidth	38	Possible response to Low Rate Telemetry Start or Ancillary Data Start request	3.2.3.10, 3.2.3.8.2
Invalid_LRT_Packets	43	Possible response to a Low Rate Telemetry Start request	3.2.3.10
Local_Bus_Queue_Full	39	Commands destined for the local bus could not be routed because the command queue was full.	3.2.3.3.1
Unconfigured_RT_Requested	40	The RT specified in the command is unknown	3.2.3.3.1
Bus_ID_Undefined	41	The Bus ID specified in the command is unknown	3.2.3.3.1
Device_Not_Available	42	The command for the CHeCS device or PCS cannot be sent to the device because the device is not active	3.2.3.3.1
FMT_Timeout	68	Possible response to Start File Read request	3.2.3.9.2
Unauthorized File Request	76	Possible response to Start File Read or Start File Write request	3.2.3.9.1, 3.2.3.9.2
File Transfer Completed	79	Possible response to Start File Write request	3.2.3.9.1
Restart File Transfer	80	Possible response to Start File Write request	3.2.3.9.1
File Transfer Error	82	Possible response to Start File Read or Start File Write request	3.2.3.9.1, 3.2.3.9.2

3.2.3.8 ANCILLARY DATA

Ancillary data is ISS systems or PL generated data that describes the environment in which a PL is operating. This data is made available to ISPR and non-rack end item RTs in two formats: broadcast and unique sets.

3.2.3.8.1 BROADCAST ANCILLARY DATA

Broadcast Ancillary Data is sent at 10 Hz to all RTs as described in Paragraph 3.3.2.2.3 of SSP 41175-02. Two 32-word messages are broadcast during each 100 ms frame to each and every RT, to two consecutive subaddresses (#13 and #14) as shown in Table 3.2.3.2.1.4-1. Each 64-word transfer of Broadcast Ancillary Data contains a 10 Hz, 1 Hz, and 1/10 Hz data segment. The first eight words contain the CCSDS header and comprise the 10 Hz segment. The next 36 words comprise the 1 Hz segment, and the last 20 words comprise the 1/10 Hz segment. Transmission of the complete set of Broadcast Ancillary Data repeats every 10 seconds. Parameters contained in the 100 separately defined Broadcast Ancillary Data packets are contained in SSP 50540, Software Interface Definition Document Broadcast Ancillary Data.

A Broadcast Frame Count in the range of 0..99 is contained as word #8 of the CCSDS header. RTs requiring access to Broadcast Ancillary Data should use the Broadcast Frame Count to decommutate the data. It should be noted that the Broadcast Frame Count contained in the Broadcast Ancillary Data and the Frame Count contained in Broadcast Sync with Data may have different values, and thus the reason for decommutating the Broadcast Ancillary Data based upon its own Broadcast Frame Count.

3.2.3.8.2 UNIQUE ANCILLARY DATA SETS

PD/PIs will identify their unique requirements for Ancillary Data as a part of their Command and Data Handling data sets in conjunction with the development of the SSP 57002 series ICDs. From these requirements, unique Ancillary Data Sets will be created, and each unique Ancillary Data Set will be assigned an Ancillary Data Set ID in the range of 1..100 by the PEP sustaining engineers or the PL Utilization/Engineering and Integration function.

Once the sets have been grouped and an Ancillary Data Set ID has been assigned, the sets will be identified in the SSP 57002 series ICDs. At that point, the PD/PIs can identify the unique Ancillary Data Set(s) that their required data is contained in, and from that they will know which Ancillary Data Set ID(s) to use when sending an Ancillary Data Service Request to the PEP.

The PEP can be configured to support up to 100 unique Ancillary Data Sets without reconfiguration.

Unique Ancillary Data Sets will be predefined data groups with a predefined cyclic update rate of 1.0 Hz or 0.1 Hz. The unique Ancillary Data Sets will be transferred to an RT either cyclically at the predefined update rate, or transferred once (“one-shot”) as specified in the PEP Service Request.

Each set will include eight words of CCSDS header, one word containing the Ancillary Data Set ID, and 23 data words as described in Table 3.2.3.8.2-1, Ancillary Data Packet Format. The RT must be capable of processing ancillary data whenever the data is received at the specified subaddress. No “handshaking” between the BC and the RT is required prior to the PEP sending ancillary data.

TABLE 3.2.3.8.2-1 ANCILLARY DATA PACKET FORMAT

Source:	BC	Transfer Type:	BC->RT
Destination:	RT	Data Word Count:	1-32
Subaddress:	Receive Data	Transmit/Receive	R-SA# 7

Word #	Description	Function
CW	MIL-STD-1553B Command Word	
1	Data Word 1	CCSDS Primary Header
through		
3	Data Word 3	CCSDS Primary Header
4	Data Word 4	CCSDS Secondary Header
through		
8	Data Word 8	CCSDS Secondary Header (contains the Subset ID of target payload or subrack payload that requested the set)
9	Data Word 9	Data Set ID
10	Data Word 10	Ancillary Data
through		
32	Data Word 32	Ancillary Data

An Ancillary Data Set provided to an RT in response to a PEP Service Request is sent in one 32-word message to subaddress #7 as specified in Table 3.2.3.2.1.4-1. For each PL RT, the PL MDM supports 1-10 data sets for Ancillary Data at a 1 Hz rate, or 1-100 data sets for Ancillary Data at a 0.1 Hz rate, or a combination of the two which does not exceed 100 Ancillary Data packets within a 10 second period.

The Request ID associated with a PEP Service Request in a Subset ID's H&S data will indicate that the request is either to start or stop the transmission of an Ancillary Data Set for that Subset ID. The parameters associated with the request identify the ancillary data set that is requested, and indicate whether the set is to be provided cyclically or aperiodically as a one-shot delivery.

If an Ancillary Data Request is received from a Subset ID, and if the requesting Subset ID is in a rack containing multiple PLs (e.g., an EXPRESS rack), then the RT (i.e., ISPR controller) is responsible for receiving and distributing the Ancillary Data Sets to the multiple Subset IDs within that rack per rack specified protocols.

When the PL MDM provides an Ancillary Data Set to an RT, the Subset ID of the target entity for which the Ancillary Data Set is intended is contained in Word #8 of the CCSDS header.

If the PEP receives a valid request for an Ancillary Data Set, no response is provided to the requesting entity other than the transmission or termination of the requested set at the next processing cycle. When the PEP receives an invalid request, it will provide a Request Response with one of the fault codes shown in Table 3.2.3.7-3. The Request Response will indicate the reason that the request was denied. There are five possible Request Responses specific to an Ancillary Data Start Request.

A Request Response of Invalid_Anc_Data_Set_Requested will be issued when a PL requests the transmission of a Unique Ancillary Data Set and the Data Set ID associated with the request is not in the valid range of 1-100.

A Request Response of Undefined_Anc_Data_Set_Requested will be issued when a PL requests the transmission of a Unique Ancillary Data Set with a Data Set ID that is in the valid range of 1-100, but the PL MDM has not been configured to be able to transmit that particular Unique Ancillary Data Set.

A Request Response of Req_Anc_Data_Already_Being_Provided will be issued when a PL requests that the PL MDM transmit a Unique Ancillary Data Set that the PL MDM is already providing to that PL.

A Request Response of Invalid_Cyclic_Flag will be issued when the Cyclic/Aperiodic data byte associated with an Ancillary Data Start Request contains an invalid value. Though the data byte is 8 bits long, the only legal values are 0 (Aperiodic) and 1 (Cyclic). If the data byte contains any value other than 0 or 1, then this Fault Code is issued.

A Request Response of Insufficient_Bandwidth will be issued when the PL MDM receives an Ancillary Data Start Request but the PL MDM is already transmitting the maximum amount of Unique Ancillary Data Sets (10 Unique Ancillary Data Sets per second) to that ISPR or non-rack end item RT.

Additionally, an Ancillary Data Stop Request can generate a Request Response of Req_Anc_Data_Is_Not_Being_Provided, which will be issued when a PL requests that the PL MDM stop transmitting a Unique Ancillary Data Set that the PL MDM is not providing to that PL.

3.2.3.9 FILE TRANSFER

Transfers of bulk file data between a PL RT and the PEP are initiated through the PEP Service Request mechanism. The mechanism for causing the PEP Service Request to be issued by the PL RT is determined by the developer of each ISPR or non-rack end item. For example, the EXPRESS developers have defined a Rack Interface Controller (RIC) command that causes the RIC to request a PEP file transfer.

The File ID provided with a file service request is an unsigned 16-bit integer in the range of 0..65,535. The File ID is assigned by PL Engineering Integration (PEI) office during the development of the PL-unique ICD per SSP 57002. When a file request and associated File ID are received by the PEP, through configuration data it will associate the File ID with a particular file name that was provided in the PL-unique ICD. If the PEP is unable to find the associated File ID in its configuration data, it will return a PL Request Response Fault Code value of Invalid_File_ID.

Transfers of bulk file data between PEP and a PL RT are limited to one per bus per direction at any one time. The implications of this are as follows:

A. One RT can both transmit and receive file data during the same 100 millisecond processing frame, if no other RTs on the same PL MDM local bus are using the PEP File Transfer Service.

B. No two RTs can transfer file data to the PEP simultaneously on the same PL MDM local bus.

C. No two RTs can receive file data from the PEP simultaneously on the same PL MDM local bus. The only exception to this occurs when a data load must be performed to a PCS on the same local bus, as explained in Paragraph 3.2.3.9-2.

D. The PEP can transfer file data to one RT and receive file data from another RT on the same PL MDM local bus simultaneously.

E. Access to the PEP File Transfer Service should be controlled by PL Operations Personnel in cases where immediate access to the file is required.

F. In cases where immediate access to the file is not required, developers of payloads/subrack PLs should develop their file transfer software to expect delays of reception and to handle delays in transmission of file data. Also, payload/subrack payloads may have to request the PEP File Transfer Service more than once before that service is granted.

Each file data packet shall {3.2.3.9-A} be structured as shown in Table 3.2.3.9-1, File Data Packet Format.

The transfer of file data in either direction (PEP to RT, or RT to PEP) requires a degree of handshaking between the source and destination to ensure completeness and accuracy. To achieve a complete and accurate data transfer, the file data will be passed in 256 word blocks that are enclosed in nine separate 32-word messages (288 words). Also included in the 288 words is CCSDS header information and checksum, the total file length in bytes (which must be an even number of bytes), the number of words (of the 256 words) in the data field, and a Block Number. The checksum will be placed in the next word immediately following the last word of meaningful file data; word #17 of message #9 is the last possible location where the checksum can appear (in the case where 256 words of meaningful file data are being transferred).

TABLE 3.2.3.9-1 FILE DATA PACKET FORMAT

Source:	BC	Transfer Type:	BC->RT / RT->BC
Destination:	RT	Data Word Count:	1-288
Subaddress:	Receive Data	Transmit/Receive	R/T-SA# 15-23/17-25

Word #	Description	Function
Message #1		
CW	MIL-STD-1553B Command Word	
1	Data Word 1	CCSDS Primary Header
through		
3	Data Word 3	CCSDS Primary Header
4	Data Word 4	CCSDS Secondary Header
through		
8	Data Word 8	CCSDS Secondary Header
9	Data Word 9	Not Used
through		
11	Data Word 11	Not Used
12	Data Word 12	Block number being transferred
13	Data Word 13	Not Used
14	Data Word 14	Length of file in bytes (MSW)
15	Data Word 15	Length of file in bytes (LSW)
16	Data Word 16	Number of words in data field
17	Data Word 17	File Data
through		
32	Data Word 32	File Data
Messages #2 through #8		
CW	MIL-STD-1553B Command Word	
1	Data Word 1	File Data
through		
32	Data Word 32	File Data
Message #9		
CW	MIL-STD-1553B Command Word	
1	Data Word 1	File Data
through		
16	Data Word 16	File Data
17	Data Word 17	Checksum
18	Data Word 18	Not Used
through		
32	Data Word 32	Not Used

Note: Table 3.2.3.9-1 shows the case where 256 words of meaningful file data are to be transferred. For file transfer packets containing less than 256 words of meaningful file data, the checksum will be located in the next word immediately following the last word of meaningful file data, and all subsequent words will be “don’t care”.

The Block Number is a sequence number (starting at 1) that shall {3.2.3.9-B} be incremented by the sender of the file data for each 288-word packet transferred. The receiver of the data should use the block number to detect receipt of an out-of-sequence data transmittal and to initiate a restart of transmission from the missing block, or to ensure that the complete set of data is received and can be reassembled properly.

The transfer of file data is performed with a new block of nine 32-word messages every 100 milliseconds until the file transfer is complete. The nine messages are allocated to nine contiguous subaddresses as shown in Table 3.2.3.2.1.4-1, Subaddress Assignments.

The sender of file data packet(s) shall {3.2.3.9-C} prepare each packet as nine 32-word messages. Packets which do not require 288 words shall {3.2.3.9-D} be "don't care" from the checksum to the end of the packet.

3.2.3.9.1 ISPR OR NON-RACK END ITEM TO PEP FILE TRANSFER (PEP FILE WRITE)

The PL MDM shall {3.2.3.9.1-A} collect file data during the last half of the 100 ms processing frames as shown in Appendix D.

ISPR or non-rack end item RTs shall {3.2.3.9.1-B} update file data such that the data is ready to be read at the appropriate time within the 100 millisecond processing frame as the messages are requested by the PEP. This requirement allows freedom of design such that the ISPR or non-rack end item RT may update the file data whenever it chooses. The RT can accomplish this by updating the file data during the first half of a 100 millisecond processing frame (see example of file data update shown in Figure 3.2.3.9.1-1, File Transfer Data Update), or by any other method it chooses, as long as the data is ready when requested by the PEP.

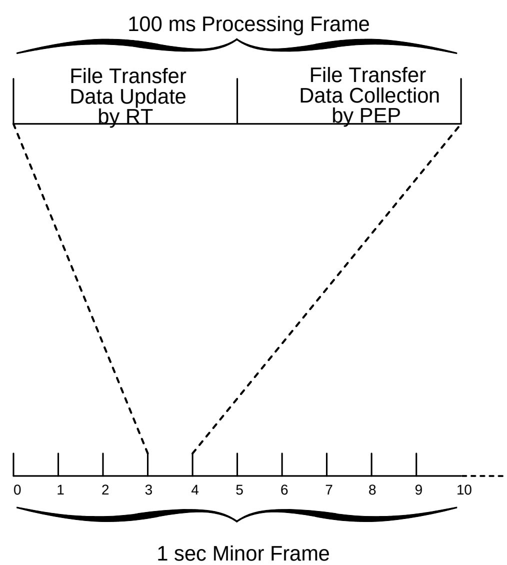


FIGURE 3.2.3.9.1-1 FILE TRANSFER DATA UPDATE

For any file data packet provided to the PL MDM, APID number 0 (PLs to PL MDM) can be used in the CCSDS Primary Header.

For the bulk transfer of file data from the PL RT to the PEP, nine 32-word messages are transmitted to the PEP in each 100 ms processing frame. The messages are received by the PEP from nine consecutive message slots of the 128 possible, and the nine messages are allocated to subaddresses 17-25. The PEP must reconstruct the file data by concatenating each block in a sequential fashion. The process is repeated each 100 milliseconds until the last block is received. Once the entire file is transferred successfully, the PEP will issue a Request Response of File_Transfer_Completed and close the file. This completes PEP processing of the file transfer transaction.

When the PEP detects a Start File Write service request, the following validation tests are performed:

A. If the File ID passed as a parameter to the request is not found in the PEP configuration data, a Request Response of Invalid_File_ID is generated and the transaction is terminated.

B. If the PEP configuration data does not indicate that the requesting entity is authorized to write to the target file, a Request Response of Unauthorized_File_Request is generated and the transaction is terminated.

C. If a file write is already in progress for another RT on the bus that generated the PEP File Write, a Request Response of File_Transfer_Error is generated and the transaction is terminated.

If the request passes the validation tests listed in items 'A' through 'C' above, PEP will create and open the requested file for write (if it exists, it is first deleted).

Upon issuing the request for service, the RT will place the first block of nine 32-word messages into subaddresses 17-25 for transmission to the PEP. Word 12 of the first 32-word message contains the Block Number (1 for the first block), words 14 and 15 contain the file length (in bytes), while word 16 contains the number of data words in the current block. If the request is successful, no positive response is generated by the PEP, and the transfer of data is initiated automatically.

If a problem is detected in the middle of a file transfer with one of the blocks transferred to the PEP, the PEP will issue a Request Response of Restart_File_Transfer, with word 12 of the message containing the Block Number at which to restart. The PEP will discard the file data subsequently received from the RT until the proper Block Number is received. Once the proper Block Number is received, the process will continue. PEP will terminate the file transfer if a response with the proper Block Number is not received within 10 seconds.

If a PEP storage problem is detected while the file transfer is in progress (e.g., HRDL MSD Write Error, HRDL Mass Storage Device (MSD) Error, File and Memory Transfer (FMT) Timeout, HRDL Request Failure, etc.), a Request Response of File_Transfer_Error is issued. The transaction is then terminated. A Request Response of File_Transfer_Error can also be generated when a PL requests a Start File Write but that service is already active on that bus, whether for another PL or the requesting PL. Another condition that will generate a File_Transfer_Error is when a PL requests a Stop File Write but that service is not being provided to that PL.

At any time during the file transfer the RT can issue a Stop File Write request to terminate the transfer. PEP will immediately terminate the transaction but will provide no further Request Response(s) related to the transaction.

3.2.3.9.2 PEP TO ISPR OR NON-RACK END ITEM FILE TRANSFER (PEP FILE READ)

The PEP file data transfer is performed with a new block of nine 32-word messages every 100 milliseconds until the file transfer is complete. The only exception to this 10 Hz rate occurs when a data load must be performed to a PCS on the same local bus (only during PCS initialization). In this case, the PCS data loads are multiplexed with the file transfer transmissions. The PCS data loads require two 100 millisecond processing frames, which implies that during PCS initialization, a PL RT receiving file transfer data may have a 200 millisecond delay between file transfer blocks.

Prior to issuing a request for a PEP File Read service, the ISPR or non-rack end item should perform the necessary initialization to enable capturing 288 words per 100 milliseconds from the PL MDM local bus.

When the PEP detects a Start File Read service request, the following validation tests are performed:

A. If the File ID passed as a parameter to the Start File Read request is not found in the PEP configuration data, a Request Response of Invalid_File_ID is generated and the transaction is terminated.

B. If the PEP configuration data does not indicate that the requesting entity is authorized to read from the target file, a Request Response of Unauthorized_File_Request is generated and the transaction is terminated.

C. If a file read is already in progress for another RT on the bus that generated the PEP File Read, a Request Response of File_Transfer_Error is generated and the transaction is terminated.

If the request passes the validation tests listed in items ‘A’ through ‘C’ above, the PEP will open the requested file to read. If the file is opened successfully, the PEP will place the first block of nine 32-word messages into subaddresses 15-23 for transmission to the PL RT. Word 12 of the first 32-word message contains the Block Number (1 for the first block), words 14 and 15 contain the file length (in bytes) while word 16 contains the number of data words in the current block. The data is then sent to the RT via nine consecutive receive messages.

A PEP service request of Start File Read, issued by a PL RT while a PEP file write for the same File ID is not yet finished, will not be rejected by the PEP, however the resulting file transfer from the PEP to the PL RT will not be reliable with respect to the transmitted file content.

The transfer of data is performed with a new block of nine 32-word messages every 100 milliseconds. Each block transferred will cause the PEP to increment the Block Number. The RT must reconstruct the file data by concatenating each block in as sequential fashion (after removing headers). PEP will continue to transmit the last block of file data until the RT issues a Stop File Read service request or until the transfer timeout value is exceeded (the Stop File Read service request must be received by the PEP within 10 seconds after the last block of data is received). Once the Stop File Read is received, PEP processing of the transaction is complete. If a timeout occurs before receipt of a Stop File Read service request, PEP will issue a FMT Timeout request response and cease transmitting the last block of file data. PEP will then close the file.

If a PEP MSD problem is detected while the file transfer is in progress (e.g., HRDL MSD Write Error, HRDL MSD Error, FMT Timeout, HRDL Request Failure, etc.), PEP will issue a Request

Response of File_Transfer_Error. PEP processing of the transaction is then terminated. A Request Response of File_Transfer_Error can also be generated when a PL requests a Start File Read but that service is already active on that bus, whether for another PL or the requesting PL. Another condition that will generate a File_Transfer_Error is when a PL requests a Stop File Read but that service is not being provided to that PL.

If the RT detects a fatal problem in the middle of a file transfer, a Stop File Read service request should be issued to the PEP to stop the file transfer. PEP will close the file and terminate the transaction but provide no further Request Response(s) related to the transaction.

If the RT detects a problem in the middle of a file transfer with one of the blocks, the RT should issue a Restart_File_Transfer service request to restart the file transfer, with word 12 indicating the Block Number at which to restart. The RT should discard the file data subsequently received from the PEP until the proper block number is received.

3.2.3.10 LOW RATE TELEMETRY

The LRT packets shall {3.2.3.10-A} be up to 640 data words in length as shown in Table 3.2.3.10-1. Each LRT packet contains a CCSDS Primary and Secondary Header. The CCSDS header identifies the appropriate ground facility as the destination, and identifies the total packet length. Note that LRT packets are subject to the CCSDS minimum packet length requirement of 100 bytes as shown in Figure 3.4.2.4.1.1-1, High Rate Data Link CCSDS Packet Format and as described in Paragraph 3.4.2.4.1.2.

The PL MDM shall {3.2.3.10-B} acquire the data in twenty 32-word messages.

Each data transaction shall {3.2.3.10-C} be 20 messages regardless of CCSDS packet length.

The PL MDM supports 100 LRT transactions per MIL-STD-1553B bus per 10 seconds. (i.e., on each PL MDM local bus, the PL MDM supports 1-10 transactions at a 1 Hz rate, or 1-100 transactions at a 0.1 Hz rate, or any combination of the two which does not exceed 100 LRT packets within a 10 second period). If the total amount of LRT requests received by the PEP for one local bus exceed 10 transactions per second, then the RT(s) that requests the LRT service that would force the PEP to exceed 10 transactions per second will be denied the service. That RT will receive a Request Response Packet with a Fault Code of ’38’D indicating “Insufficient_Bandwidth”. Detailed descriptions of Request Response Fault Codes specific to the LRT service are given below.

TABLE 3.2.3.10-1 LOW RATE TELEMETRY FORMAT

Source:	RT	Transfer Type:	RT->BC
Destination:	BC	Data Word Count:	1- 640
Subaddress:	Transmit Data	Transmit/Receive	T-SA# 8

Word #	Description	Function
Message #1		
CW	MIL-STD-1553B Command Word	
1	Data Word 1	CCSDS Primary Header
through		
3	Data Word 3	CCSDS Primary Header
4	Data Word 4	CCSDS Secondary Header
through		
8	Data Word 8	CCSDS Secondary Header
9	Data Word 9	Low-rate Telemetry Data
through		
32	Data Word 32	Low-rate Telemetry Data
Message #2 through 20		
CW	MIL-STD-1553B Command Word	
1	Data Word 1	Low-rate Telemetry Data
through		
32	Data Word 32	Low-rate Telemetry Data

Onboard access to PEP LRT Service is controlled by ground operators through configuration data tables within PEP. This configuration data is used by PEP during its validation of Subset ID LRT requests. That data specifies, for each Subset ID, one of the following three conditions: Not Authorized for LRT; Authorized for LRT at 1 Hz; Authorized for LRT at 0.1 Hz. The rate (i.e., 1.0 Hz or 0.1 Hz) at which a PL/subrack PL requires the LRT service and the number of packets required at that rate is captured via development of the PL-unique ICD per SSP 57002. The PEP will support LRT transactions by a PL/subrack PL at either a 1.0 Hz rate or a 0.1 Hz rate, but not both. If a PL/subrack PL is authorized LRT services, those services are requested via the Request Data contained in H&S data as shown in Figure 3.2.3.5-1 or 3.2.3.5-2. Because the PEP LRT service is a bounded resource, access to those services will be controlled by negotiations between the PL Operations function and the PD/PIs.

For PEP LRT Service, a mechanism similar to that used for H&S is employed by the PEP to collect twenty 32-word messages in each 100 millisecond processing frame from subaddress #8, as shown in Table 3.2.3.2.1.4-1. The messages are received by PEP into twenty consecutive message slots of the 128 possible during the processing frame. The slots in any given 100 millisecond processing frame are allocated to a single RT, but allocation across frames is left to the discretion of PEP, and is based upon previously received PEP Service Requests.

As shown in Table 3.2.3.7-1, each Subset ID’s LRT request contains a parameter identifying the number of LRT packets (twenty 32-word transactions) that are required. This number, along with the rate specified in the authorization data for the PL, is used by PEP to assign bus message slots for the LRT transmission. The LRT message slots assigned a given PL will remain allocated until that LRT service is terminated. The ten packets per second allocated to a PL MDM local bus may be divided among the RTs/PLs/Subset IDs on that bus or may be assigned to a single RT/PL/Subset ID as determined by PL Operations personnel.

The PL MDM shall {3.2.3.10-D} collect LRT data during the last half of the 100 ms processing frames as shown in Appendix D. ISPR or non-rack end item RTs shall {3.2.3.10-E} update LRT such that the data is ready to be read at the appropriate time within the 100 millisecond processing frame as the messages are requested. This requirement allows freedom of design such that the ISPR or non-rack end item RT may update the LRT data whenever it chooses. The RT can accomplish this by updating the LRT data during the first half of a 100 millisecond processing frame (see example of LRT data update shown in Figure 3.2.3.10-1), or by any other method it chooses, as long as the data is ready when requested by the PEP.

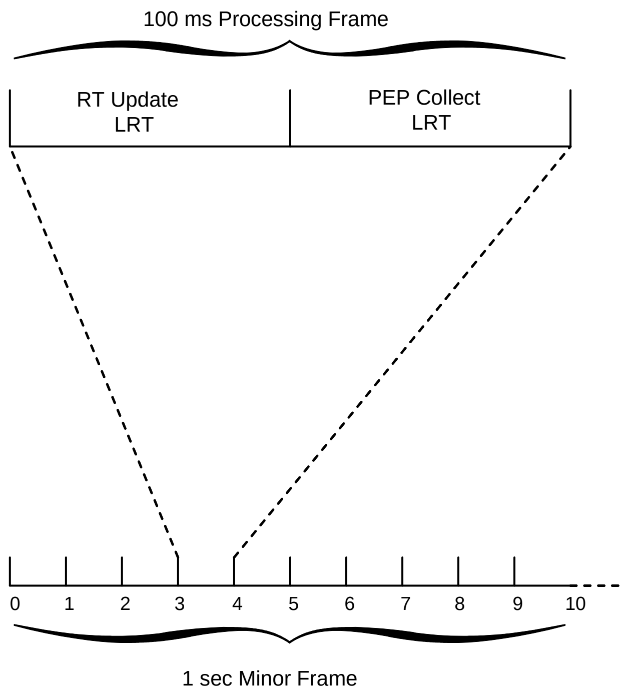


FIGURE 3.2.3.10-1 LOW RATE TELEMETRY DATA UPDATE

If the PEP receives a valid request for an LRT Service, no response is provided to the requesting entity other than the collection or termination of the requested set at the next processing cycle. When the PEP receives an invalid request, it will provide one of the Request Responses shown in Table 3.2.3.7-3. The Fault Code will indicate the reason that the request was denied. There are four possible Request Responses specific to a LRT Start request.

LRT_Already_Being_Provided will be issued when a PL requests to start the LRT service but that service is already being provided to that PL.

Invalid_LRT_Downlink_Rate will be issued when a PL requests to start the LRT service but the PL MDM configuration information indicates a value other than 1.0 Hz or 0.1 Hz as the collection rate. The requirement for the LRT service to be provided at one (but not both) of these particular rates is captured within the PL data in the PDL and the PL MDM Configuration Tables are built from that data. If the PL MDM Configuration Tables have been developed correctly from the PL PDL data, then ideally the PL should never see this Fault Code. However, if the PL MDM Configuration Tables are not built correctly then there is the possibility that a PL could receive this Fault Code.

Insufficient_Bandwidth will be issued when the PL MDM receives a LRT Start request but the PL MDM does not have sufficient bandwidth to accommodate the request. For example, if the PL MDM is already collecting 8 packets of LRT per second from the PLs on one of its local buses, and if PL ’x’ then requests to receive 3 packets per second on that same local bus, then the request from PL ’x’ will be denied and this Fault Code will be returned. PL ’x’ will not receive even the 2 packets per second that the PL MDM could accommodate. (The PL MDM can only accommodate 10 packets per second of LRT for all PLs combined on any given bus.)

Invalid_LRT_Packets will be returned when the PL requests an invalid number of LRT packets. For example, if the PL MDM has been configured (based upon PL data inputs into the PDL) to collect LRT packets from a PL at a 1.0 Hz rate, and the PL then requests the PL MDM (on-orbit) to start LRT, and the associated Number of Packets data word is not in the range of 1-10, then the request would be denied and this Fault Code would be returned. Similarly, if the PL MDM has been configured (based upon PL data inputs into the PDL) to collect LRT packets from a PL at a 0.1 Hz rate, and the PL then requests the PL MDM (on-orbit) to start LRT, and the associated Number of Packets data word is not in the range of 1-100, then the request would be denied and this Fault Code would be returned.

PEP maintains an LRT invalid packet length indicator that is set when the payload sends an LRT packet with a CCSDS packet length field between 1 and 9 bytes inclusive or greater than 1273 (decimal) bytes.

Once the RT sends the last packet of LRT data, it should send either an LRT Stop request (to halt LRT until the next LRT Start service request) or a Packet Length of ‘0’ (to indicate a temporary pause in live data) to the PEP. If LRT Stop request is sent, there is also potential for the PEP to continue to collect LRT data for a few cycles after the RT has sent the request. In this case the RT should continue to place an LRT packet at the subaddress with the CCSDS header showing a Packet Length of ‘0’ until the 1553 “handshaking” indicates that the PEP has ceased to collect the data. The Packet Length of ‘0’ will indicate to the PEP that the packet is to be discarded.

When the payload sends an LRT packet with the CCSDS packet length field set to ‘0’, PEP will set the LRT paused indicator and will discard the packet. When the payload sends an LRT packet with the CCSDS packet length field set to any other value, the LRT paused indicator is cleared. If a PL should send a LRT Stop request when that service is not currently being provided to that PL, PEP will respond by sending a Request Response of LRT_Not_Being_Provided to the PL.

3.2.3.11 PROCEDURE EXECUTION SERVICE

This section is provided for informational purposes.

The Procedure Execution Service of the PEP allows automated control of PLs and processes via Timeliner procedures. The Procedure Execution Service capability is designed to meet the requirements to service requests from PLs/Subset IDs to control the execution of automated sequences. This capability, in conjunction with the Timeliner software, provides an on-orbit configurable capability to control PL operations based on command input or PL status feedback.

PD/PI will enter their requirements for automated Timeliner procedure execution as a part of their C&DH requirements data set in conjunction with the development of the SSP 57002 series ICDs. For each bundle and procedure to be initiated, the requirements must include an associated Bundle Name and Procedure Name. The Bundle Name and Procedure Name may be up to 32 characters in length. These entries are made at L-11 months.

Once the PD/PI has entered the automated procedure requirements, Procedure IDs will be assigned to the procedures and Bundle IDs to the Timeliner bundles that they are contained in. Bundle IDs and Procedure IDs will be assigned as unsigned integers in the range 0...65535. Once the Bundle IDs and Procedure IDs have been assigned, the PD/PI will be provided access to them for use as needed. The PEP will support up to 500 total procedures and 50 total bundles without reconfiguration of the PEP. The procedures may all be used by one PL/Subset ID or - at the discretion of Payload Operations personnel - the procedures may be divided among PLs/Subset IDs.

In order for a Subset ID to successfully start a procedure, the bundle that it is contained in must first be Installed.

The Procedure Execution Service capability is activated when a Procedure Execution Request is received from a Subset ID via its H&S data, or when commanded by the crew or the ground. The request format for a Subset ID to request this service is as shown in Table 3.2.3.7-1. Commands for procedure execution which are generated by the crew (via PCS) or the ground will come to the PEP in the standard 64-word command format (which includes the CCSDS header) and are routed directly to the Timeliner software.

If the PEP receives a valid request for an Procedure Execution Service, a Request Response will be returned to the requesting entity with a Fault Code of ‘0’, indicating No Error, per Table 3.2.3.7-3. When the PEP receives an invalid request, it will provide one of the other Request Response Fault Codes shown in that table as appropriate. The Fault Code will indicate the reason that the request was denied. There are seven possible Request Responses specific to the Procedure Execution Service.

A Request Response of Invalid_Sequence_ID will be issued when a PL requests to start, stop, or resume a Timeliner Sequence and the associated Sequence ID data parameter provided with the request is out of the valid range of 0-65,535. (Since the data type of the Sequence ID data parameter is a 16 bit integer, in theory a PL should never see this Fault Code.)

A Request Response of Invalid_Bundle_ID will be issued when a PL requests to install, halt, or remove a Timeliner Bundle and the associated Bundle ID data parameter provided with the request is out of the valid range of 0-65,535. (Since the data type of the Bundle ID data parameter is a 16 bit integer, in theory a PL should never see this Fault Code.)

A Request Response of Sequence_ID_Not_Found will be issued when a PL requests to start, stop, or resume a Timeliner Sequence, and the associated Sequence ID data parameter provided with the request is in the valid range of 0-65,535, but the PL MDM cannot find the file associated with the Sequence ID in its memory.

A Request Response of Bundle_ID_Not_Found will be issued when a PL requests to install, halt, or remove a Timeliner Bundle, and the associated Bundle ID data parameter provided with the request is in the valid range of 0-65,535, but the PL MDM cannot find the file associated with the Bundle ID in its memory.

A Request Response of Unauthorized_Sequence_Execution_Request will be issued when a PL requests to start, stop, or resume a Timeliner Sequence and the PL MDM is not configured to allow that particular request. For example, a PL may be allowed to start a particular Sequence but not be allowed to stop it. These permissions are captured during the development of the PL-unique software ICD per inputs to the PDL.

A Request Response of Unauthorized_Bundle_Execution_Request will be issued when a PL requests to install, halt, or remove a Timeliner Bundle and the PL MDM is not configured to allow that particular request. For example, a PL may be allowed to install a particular Bundle but not be allowed to remove it. These permissions are captured during the development of the PL-unique software ICD per inputs to the PDL.

A Request Response of Timeliner_Cmd_Queue_Full will be issued when a PL requests any Timeliner service but the Timeliner Command Queue is already full because of commands from sources other than the PL that just made the request.

3.2.3.12 BROADCAST TIME

The PL MDM shall {3.2.3.12-A} provide Broadcast Time at a 1 Hz rate, to subaddress 29, per Paragraph 3.3.2.2.2 of SSP 41175-02.

3.3 MEDIUM RATE DATA LINK

The MRDL network connects payloads to payloads, or payloads to the ground through a gateway function. The payload Ethernet architecture is a switched network implemented with three (3) improved Payload Ethernet Hub Gateway (PEHG) units configured to operate as Ethernet switches at protocol Layer 2 or Layer 3. All subsequent PEHG references herein apply to the improved PEHG by implication. Previous PEHG repeater hubs are referred to as legacy PEHGs.

The network includes a Layer 2 Ethernet Hub and Multiplexer (LEHX) in the Japanese Experiment Module (JEM) which also operates as an Ethernet switch to support U.S. payloads in the JEM or JEM Exposed Facility (EF).

(Protocol “layers” in this context refer to a conceptual sequence of processing steps that a packet traverses on the way to or from a MRDL station. Three “layers” have been defined: physical or PHY (cables and transceivers defining electrical characteristics), data link (logical mechanisms that send and receive packets using Media Access Control (MAC) addressing), and application (higher level software mechanisms that provide error recovery, perform file transfers, etc.) as described in SSP 41175-02, as tailored to the MRDL data bus. For convenience, these three mechanisms or protocols are assigned a number starting from the lowest physical layer (Layer 1) up to the highest application layer (Layer 3)).

The MRDL network is a part of the High Rate Communication System. It operates as a Payload-dedicated Local Area Network (LAN) that is part of the ISS Joint Station LAN. LAN-1 and LAN-2 are no longer separate LANs with separate collision domains, but are both connected to the switched network. The switched network is implemented as an IEEE 802 LAN in accordance with ISO/IEC 8802-3 Information Technology-Local and Metropolitan Area Networks-Part 3: Carrier Sensed Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications, 10/100BASE-T (ref. IEEE 802.3) and ISO/IEC 15802-3, Information Technology-Local and Metropolitan Area Networks-Part 3: Media Access Control (MAC) Bridges specification (ref. IEEE 802.1D).

Besides providing a communication path between payloads, MRDL provides a path for downlink of payload data using individual PEHG or LEHX gateways which convert incoming CCSDS space packets to HRDL (ref. paragraph 3.3.5.1 and 3.3.6) for Ku-Band return link processing. An additional downlink path is provided by another PEHG gateway in the form of CCSDS Internet Protocol Encapsulation packets (ref. paragraph 3.3.5.2) routed to the ground via the ICU

The MRDL is implemented on the ISS using twisted shielded pair cables configured in a hub and spoke topology, and operates at a signaling rate of 10 or 100 Mbps (equivalent to a maximum packet throughput rate of 9.7 Mbps or 97 Mbps excluding overhead). The ISO/IEC 8802-3 and ISO/IEC 15802-3 specifications are international standards commonly known as 10/100BASE-T Ethernet and Bridge/Switching Hub Ethernet respectively. Payloads that conform with ISO/IEC 8802-3 (10/100BASE-T) will be in compliance with the requirements for the switched network.

A block diagram of the ISS payload wired Ethernet Medium Rate Data Link architecture is shown in Figure 3.3-1.

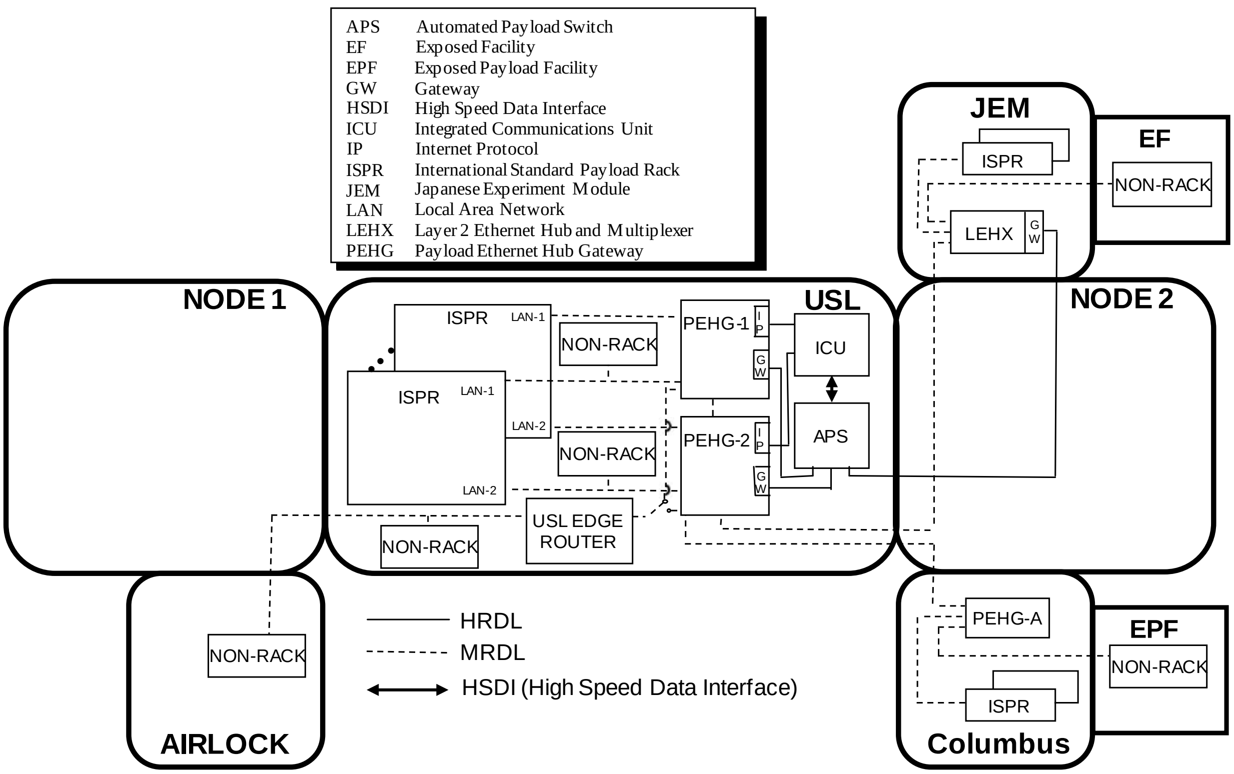


FIGURE 3.3-1 PAYLOAD WIRED ETHERNET MEDIUM RATE DATA LINK ARCHITECTURE

3.3.1 MRDL SWITCHING HUBS AS MEDIA ACCESS CONTROL (MAC) BRIDGES

The MRDL switched network conforms with the Ethernet frame format and physical layer protocol defined in ISO/IEC 8802-3. However, since PEHG units are switching hubs rather than legacy PEHG repeaters, each point-to-point segment linked with a switching hub operates as a separate collision domain. This eliminates collisions between user segments, although collisions and deferrals can still occur on a single segment.

Additional characteristics of the switched network include the following:

A. The elimination of contention for the network increases the bandwidth available thereby improving throughput.

B. Each user segment can operate at different signaling rates (10 Mbps or 100 Mbps) and different modes (half-duplex or full-duplex).

C. Since packet forwarding is based on address learning, port flooding and resultant packet transmissions from the PEHG will occur if a destination address is not recognized.

D. The PEHG is configured for payload use as a switching hub and in general accepts both Layer 2 and Layer 3 packets.

E. The PEHG supports Auto-Negotiation protocol which enables the automatic detection and setting of either the 10/100BASE-T signaling rate or full/half-duplex mode between a station and a PEHG port.

3.3.2 MRDL CARRIER SENSED MULTIPLE ACCESS WITH COLLISION DETECTION (CSMA/CD) PROTOCOL

A station that has data to transmit on its own PEHG segment will not encounter contention for that segment from another station, and therefore will not experience collisions with other stations. However, it is still possible that the PHY state machine will report collisions between a station transmission and the PEHG switch port. If the port is operating in half duplex mode, and the station has a packet queued for transmission to the PEHG at the same time that the PEHG has a packet queued for transmission to the station, then there will be a virtual collision between the station and the PEHG. In this case standard Collision Detection will apply.

The Collision Detection is as follows:

If both the station and the PEHG are waiting to transmit and both sense the media is available to use, both may wait the same Interframe gap and begin at the same time. If this happens a collision will occur. When a collision is detected, 32 jam bits are sent which enforces the collision. The colliding stations then will retry using a “truncated binary exponential backoff” algorithm and a slot time of 512 bits. If two stations keep offending each other then additional delays can be added to one station, i.e. lengthen the Interframe gap on one station.

The PEHG shall provide a Bit Error Rate (BER), through any input to output interfaces, not to exceed 1E-09.

3.3.3 ISPR MRDL CONNECTIVITY

ISPRs and non-rack end items located in the U.S. Lab have the ability to connect to either LAN-1 (PEHG-1) or LAN-2 (PEHG-2) for access to the payload LAN switched network. U.S. ISPRs and non-rack end items located in the ESA Columbus module or on the Columbus Exposed Payload Facility (EPF) connect to LAN-2 via PEHG-A. ISPRs and non-rack end items located in the JAXA JEM module or on the JEM EF connect to LAN-2 via the LEHX.

ISPRs and non-rack end items are not allowed to have their internal MRDL networks become a part of the ISS MRDL networks. ISPRs or non-rack end items with internal MRDL networks may use a gateway function to the ISS MRDL networks which will provide the required isolation.

3.3.4 MRDL FRAME FORMAT

MRDL Frame Format is shown in Figure 3.3.4-1, MRDL Frame Format.

MRDL Header Format					User Data Field		
Preamble	**SFD**	**Destination Address**	**Source Address**	**Length/ Type**	**LLC/User Data**	**PAD**	**Frame Check Sequence**
7	1	6	6	2	Variable		4

(0) octet (n) octet

All field sizes are in Octets.

FIGURE 3.3.4-1 MRDL FRAME FORMAT

3.3.4.1 TRANSMISSION ORDER

The octet of the MRDL frame, with the exception of the Frame Check Sequence (FCS), is transmitted low order bit first, b0 to b7. Octets are transmitted from 0 octet to the nth octet. The transmission order is shown in Figure 3.3.4.1-1, MRDL Transmission Order.

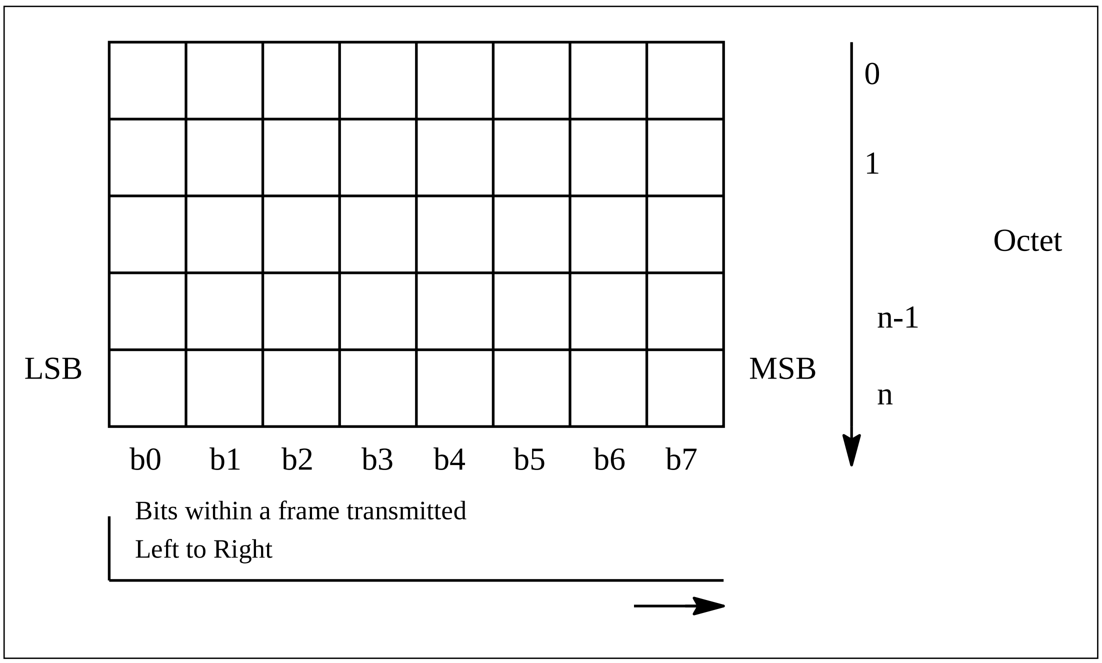


FIGURE 3.3.4.1-1 MRDL TRANSMISSION ORDER

3.3.4.2 PREAMBLE FIELD

The Preamble Field is a 7-octet field that is used to allow the physical layer circuitry to reach its steady-state synchronization with the received frame timing. The preamble pattern is:

10101010 10101010 10101010 10101010 10101010 10101010 10101010

3.3.4.3 START FRAME DELIMITER FIELD

The Start Frame Delimiter (SFD) is the sequence immediately following the Preamble Field. The SFD sequence is 10101011.

3.3.4.4 ADDRESSES FIELDS

Each MRDL frame contains a Destination Address Field and a Source Address Field.

3.3.4.4.1 ADDRESS FIELD LENGTH

IEEE 802.3 supports both 16 bit and 48 bit length address fields as an implementation option. The ISS MRDL network uses only the 48 bit length address format. The 48 bit Address Format is shown in Figure 3.3.4.4.1-1, 48 Bit Address Format.

Type	Administration	Address
1 bit	1 bit	46 Bits

Type	=	0	Individual Address
Type	=	1	Group Address
Administration	=	0	Globally administered Address
Administration	=	1	Locally administered Address

FIGURE 3.3.4.4.1-1 48 BIT ADDRESS FORMAT

3.3.4.4.2 ADDRESS TYPE

The first bit indicates the type Address. A ‘0’ b indicates the address field contains an individual address. A ‘1’ b indicates the address field contains a group address that identifies none, one or more, or all of the PLs connected to the MRDL.

The second bit is used for address administration information. This bit distinguishes between locally or globally (universally) administered addresses. A ‘0’ b indicates a globally administered address. A ‘1’ b indicates a locally administered address. This bit is also a ‘1’ b in the broadcast address.

The ISS uses globally administered address, see the section on address administration.

3.3.4.4.3 BROADCAST ADDRESS FIELD

The MRDL network address for a broadcast message is all ‘1’ bs in the Destination Address Field.

3.3.4.4.4 DESTINATION ADDRESS FIELD

The Destination Address field specifies the MRDL ‘station’ for which the MRDL frame is intended. This may be another PL or the PEHG address being used to downlink data from the ISS to the ground. The type field is used to indicate if the destination is an individual address or if the address is a group address. A PL transmitting MRDL frames will use an individual address for the Destination.

3.3.4.4.5 SOURCE ADDRESS FIELD

The Source Address field specifies the “station” on the MRDL network sending the MRDL frame. The type of the source address shall {3.3.4.4.5-A} be individual. The type bit is set to ‘0’ b. The source address is globally administered. The administration bit shall {3.3.4.4.5-B} be set to ‘0’ b. This address shall {3.3.4.4.5-C} either be down-loadable via the MIL-STD-1553B, or permanently encoded into the MRDL “station”. Address assignments are described in the Paragraph 3.3.4.5 Address Administration.

3.3.4.5 ADDRESS ADMINISTRATION

ISS MRDL (Ethernet) reserved MAC addresses are given in D684-13406-01, Table H-1, ISS Ethernet Reserved MAC Addresses.

For the transmission order on line, refer to Paragraph 3.3.4.1.

3.3.4.6 LENGTH/TYPE FIELD

The Length/Type field is a 2-octet field whose value indicates either 1) the number of Logical Link Control (LLC) or User Data octets in the data field not including the Frame Check Sequence, or 2) the type of protocol data being carried in the User Data field. The Length field will specify a LLC/User Data range from 32 to 1500 bytes not including any PAD. The Length/Type field is transmitted and received with the high order octet first.

3.3.4.7 USER DATA FIELD

The User Data Field contains a sequence of octets including any PAD. Full data transparency is provided in the sense that any arbitrary sequence of octet values may appear in the data field up to a maximum number specified by the implementation of this standard that is used. The User Data Field does not include the FCS, since in most cases the FCS is appended to a transmitted packet by hardware.

3.3.4.8 PAD FIELD

The PAD is a field created by the IEEE 802.3 Station to provide the minimum frame size of 512 bits, that is required for correct CSMA/CD protocol operation. The PAD field size equals the greater of 0 bits or (512 bits — (8x(Data field length in octets) + 144(Addresses + Length + Frame Check Sequence))) bits. The minimum User Data + PAD size = 32 + 14 = 46 bytes.

3.3.4.9 FRAME CHECK SEQUENCE FIELD

A Cyclic Redundancy Check (CRC) is used by the transmit and receive algorithms to generate a CRC value for the Frame Check Sequence (FCS) field. The FCS field contains a 4-octet (32-bit) CRC value. This value is computed as a function of the contents of the source address, destination address, length, user data and pad (that is, all fields except the preamble, SFD, and FCS). It is typically appended by hardware and is used to detect errors in transmission.

3.3.5 PEHG GATEWAY PROTOCOL

The PEHG provides two paths for downlink. One path uses the PEHG HRDL gateway to convert incoming packets to HRDL optical fiber which are transmitted to the APS, followed by conversion to a High Speed Data Interface (HSDI) and transmission to the ICU. A second path is available which uses the PEHG Internet Protocol gateway to directly transfer IP packets to the ICU over MRDL.

3.3.5.1 PEHG HRDL GATEWAY PROTOCOL

The PEHG HRDL gateway function provides a simple forwarding capability for incoming MRDL frames with a specific destination address. See Figure 3.3.5.1-1, MRDL (PEHG) to ICU Data Flow via HRDL Gateway. The PEHG gateway function operates at either protocol Layer 2

(Length/Type field = packet length) or Layer 3 (Length/Type field = packet type = 0x0800 (= IP(v4)) and checks the destination address of all incoming MRDL frames.

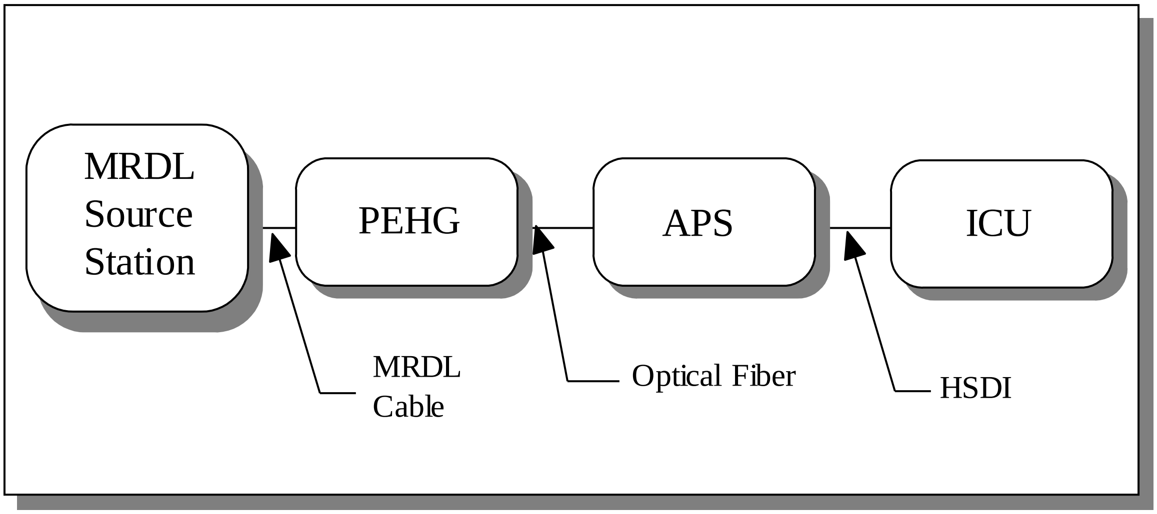


FIGURE 3.3.5.1-1 MRDL (PEHG) TO ICU DATA FLOW VIA HRDL GATEWAY

Figure 3.3.5.1-2, Port-to-Port and Port-to- Gateway Packet Formats, illustrates the Layer 2 and Layer 3 port-to-gateway packet formats as well as a non-gateway destined port-to-port packet format for comparison. A MRDL frame destined for the gateway must have a minimum User Data length of 100 bytes and may have up to a maximum User Data length of 1500 bytes. For Layer 3 port-to-gateway packet formats, the UDP/IP Header shall (3.3.5.1-A) be a fixed length of 28 bytes.

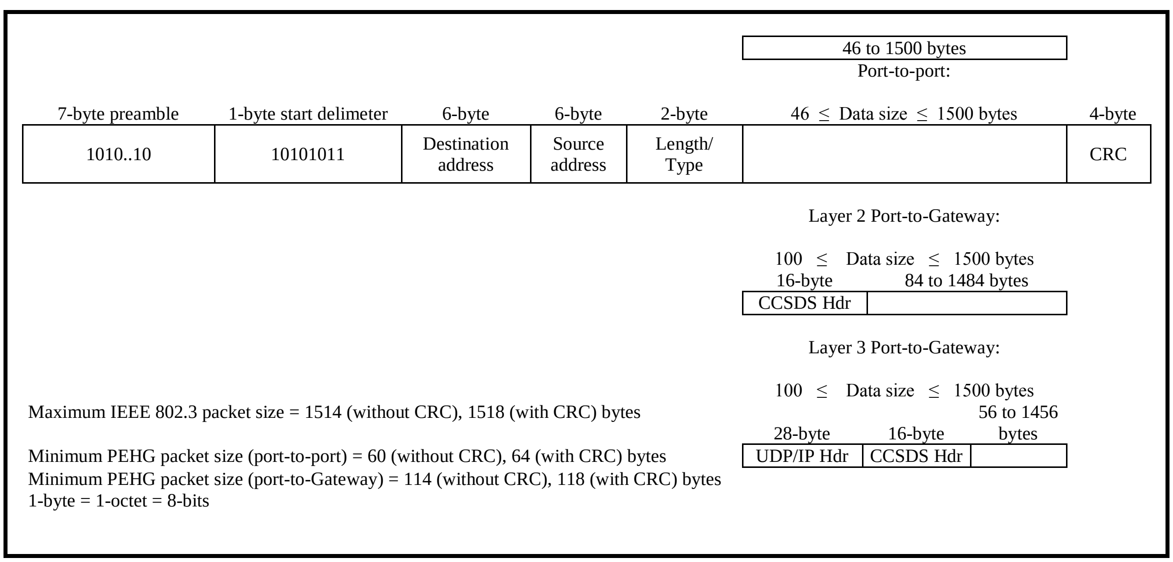


FIGURE 3.3.5.1-2 PORT-TO-PORT AND PORT-TO-GATEWAY PACKET FORMATS

The gateway function ignores packets with non-gateway MRDL destination addresses. The PEHG HRDL gateway function can be configured to generate either CCSDS packets or Bitstream data.

The HRDL gateway function is available via PEHG units located on the Payload LAN in the US Lab as well as within individual EXPRESS Racks and EXPRESS derivatives. As result, there are separate MAC addresses to target each HRDL gateway. Subrack payloads within each rack have the option to target the HRDL gateway address for downlink from the PEHG in that rack.

When addressing MRDL frames to any PEHG HRDL gateway function using protocol Layer 2 for subsequent downlink via Ku-Band, the MAC destination addresses shown in D684-13406-01 per the following format should be used:

HRDL Gateway MAC Address = DD:DD:DD:DD:DD:YY (where YY = 01 through 13)

When addressing MRDL frames to any HRDL gateway function using protocol Layer 3 (User Datagram Protocol/Internet Protocol (UDP/IP)) for subsequent downlink via Ku-Band, the IP addresses and port number shown in D684-13406-01 per the following format should be used:

HRDL Gateway UDP/IP Address = XX.XX.XX.YY (where YY = 01 through 13)

3.3.5.1.1 PEHG HRDL GATEWAY PACKET VERIFICATION

When a MRDL frame is addressed to the PEHG HRDL gateway function the following is performed:

A. If protocol Layer 2, the incoming frame destination address is verified to match the configured gateway Layer 2 address

B. If protocol Layer 3, the incoming frame destination UDP/IP address is verified to match the configured gateway Layer 3 address. The UDP destination port number is also verified to match the configured gateway UDP port number.

C. The incoming frame length field is verified to match the amount of data received

D. In CCSDS mode, incoming packets are checked for proper length compared to the length field in the CCSDS header

E. The PEHG gateway function removes the MRDL frame header and frame check sequence. The unwrapped user data will be referred to as User Data.

F Each unwrapped User Data, in the order received, is encoded in the HRDL format for transmission over the optical HRDL. In CCSDS mode, packets are output at the configured data rate with START/STOP symbols appended. In Bitstream mode, valid data is output at the configured data rate without START/STOP symbols appended.

The PEHG gateway’s output data rate is determined from a downloadable parameter, received from the PL MDM via the PL MDM MIL-STD-1553B. The output rate is adjustable from 0.5 Mbps to 100 Mbps in increments of 0.5 Mbps. This is the raw data rate and includes the CCSDS overhead. The true data rate is determined by extracting this overhead.

The PEHG gateway function provides 64 Kbytes of buffering for incoming user data. When an incoming MRDL frame encounters a buffer full condition, the PEHG gateway function discards the entire packet and increments the discarded packet counter by one.

Note: A payload data source may be connected to either LAN-1 or LAN-2. However, a connection to LAN-1 does not constrain the data source to the PEHG-1 gateway; nor does a connection to LAN-2 constrain the data source to the PEHG-2 gateway. The Joint Station LAN gateway configuration will be subject to real-time data flow analysis. Therefore a payload shall

{3.3.5-A} use a programmable gateway address within its downlink packet destination address to accommodate multiple MRDL configurations.

3.3.5.2 PEHG INTERNET PROTOCOL (IP) GATEWAY PROTOCOL

The PEHG is configured to detect and forward to the ICU any MRDL IP-formatted packets that have a destination IP address and subnet format that conforms with a specific ground infrastructure. See Figure 3.3.5.2-1, MRDL to ICU Data Flow via Internet Protocol Gateway. This IP packet forwarding function is an alternative gateway for MRDL packets containing headers specific to a user destination on the ground. After receipt of these user IP packets, the ICU provides a CCSDS Internet Protocol Encapsulation (IPEncap) service per CCSDS 133.1-B-2, Encapsulation Service, using the Encapsulation Packet Header with Internet Protocol Extension (IPE) per CCSDS 135.0-B-4, Space Link Identifiers. Payload packets destined for the IP gateway must conform with an Internet Protocol Version 4 (IPv4) datagram structure as previously illustrated in Figure 3.1.4-1, Internet Protocol Version 4 Datagram Structure. A typical IPv4 data structure including field definitions compatible with the ICU is described in the previously referenced SSP 41158, Paragraph E.5.1.3, Internet Protocol Version 4 (IPv4) Datagram Structure.

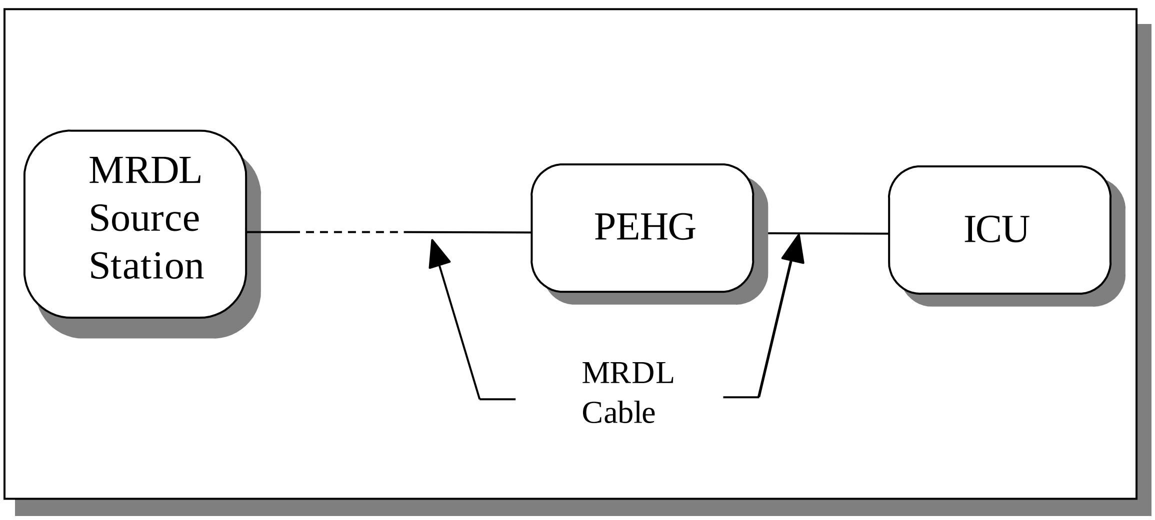


FIGURE 3.3.5.2-1 MRDL TO ICU DATA FLOW VIA INTERNET PROTOCOL GATEWAY

3.3.5.3 INTERFRAME GAP

Interframe gap is the minimum time period from the last bit of the current MRDL frame and the first bit of the next MRDL frame. In the operation of the CSMA/CD with a MRDL frame waiting to be transmitted, transmission is initiated immediately when the Interframe spacing has occurred. The minimum Interframe time takes into account the end to end propagation of the MRDL network. The minimum Interframe gap for IEEE 802.3 10BASE-T or 100BASE-T is 96 bit times.

3.3.6 LEHX GATEWAY PROTOCOL

The Layer 2 Ethernet Hub and Multiplexer (LEHX) is provided by JAXA and replaces the PEHG-J in the Japanese Experiment Module (JEM). The LEHX gateway function provides a similar forwarding capability for incoming MRDL frames with a specific destination address. See Figure 3.3.6-1, MRDL (LEHX) to ICU Data Flow via HRDL Gateway.

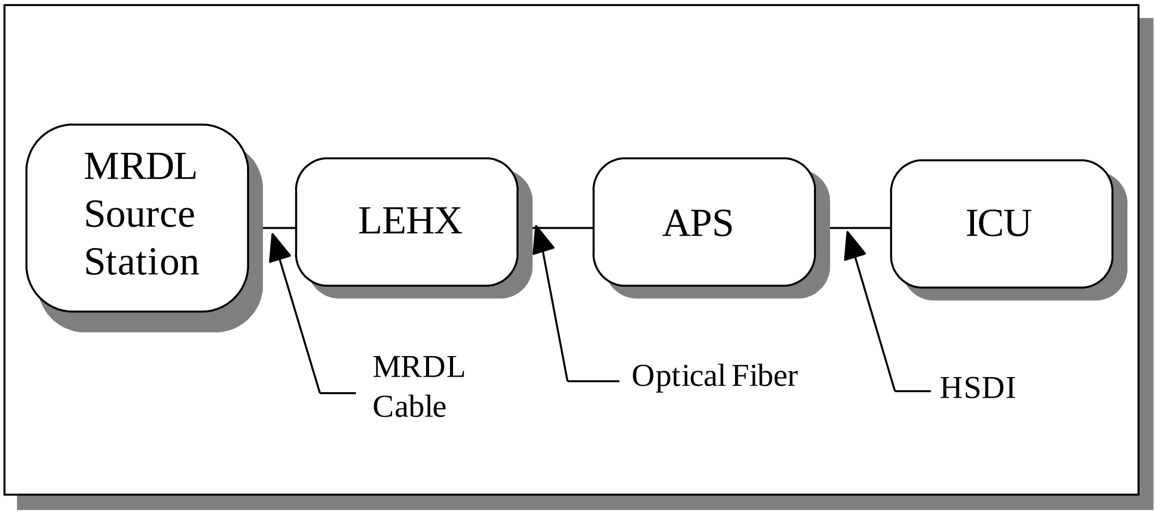


FIGURE 3.3.6-1 MRDL (LEHX) TO ICU DATA FLOW VIA HRDL GATEWAY

The LEHX Ethernet interface is compatible with the legacy PEHG interface and no changes are required to a payload for standard MRDL operation. However, the LEHX differs from the legacy PEHG in several respects:

A. The LEHX Hub is an Ethernet switch which can operate at protocol Layer 2

B. The LEHX Ethernet ports are configured to Auto-Negotiate by default, and can be configured for 10BASE-T/100BASE-T and half/full duplex operation, (Note: The LEHX is not compatible with 100BASE-T fixed full duplex operation)

C. The LEHX Multiplexer functions as a gateway and supports Layer 2 (all users) and Layer 3 (JAXA only) protocols

D The LEHX Multiplexer verifies additional CCSDS header content (see Paragraph 3.3.6.1, LEHX Gateway Packet Verification)

Figure 3.3.5.1-2, Port-to-Port and Port-to-Gateway Packet Formats, illustrates the Layer 2 and Layer 3 port-to-gateway packet formats as well as a non-gateway destined port-to-port packet format for comparison. Note that downlink packets from U.S. payloads in the JEM shall {3.3.6-A) only use the Layer 2 port-to-gateway protocol when using the LEHX gateway.

When addressing MRDL frames to the LEHX gateway function for subsequent downlink via Ku-band, the address shown in D684-13406-01 per the following format should be used:

HRDL Gateway MAC Address = DD:DD:DD:DD:DD:00

3.3.6.1 LEHX GATEWAY PACKET VERIFICATION

When a MRDL frame is addressed to the LEHX gateway function the following is performed:

A. The incoming frame destination address is verified to match the configured gateway Layer 2 address

B. The incoming frame length field is used to strip out the data portion of the frame

C. The incoming CCSDS packet length field is verified to be consistent with the length field in the CCSDS Primary header

D. The incoming CCSDS packet length is verified to be greater than or equal to 100 bytes

E. The following is verified in the CCSDS Primary header (1^{st} word):

CCSDS Header Version ID = ‘000’b

Packet Type = ‘1’b

Secondary Header Flag = ‘1’b

F. Each unwrapped user data, in the order received, is encoded in the HRDL format for transmission over the optical HRDL. Packets are output at the configured data rate with START/STOP symbols appended.

The LEHX Hub functions are based on the Hewlett Packard ProCurve Switch 2524. The LEHX Multiplexer functions as a gateway and accepts downlink packets that conform with the Layer 2 packet format defined in Figure 3.3.4-1, MRDL Frame Format, and use the gateway address specified in 3.3.6, LEHX Gateway Protocol. Packets from U.S. payloads in the JEM that are assigned to the LEHX gateway for downlink shall {3.3.6-A} only use the Layer 2 port-to-gateway protocol as shown in Figure 3.3.5.1-2, Port-to-Port and Port-to-Gateway Packet Formats.

3.3.7 KU-BAND IP SERVICES

S-Band and Ku-Band communication links exist between the International Space Station and the NASA Ground System. The legacy space-to-ground and ground-to-space communication links provide users the capability to command and configure payload systems via the S-Band forward link and receive telemetry data via the Ku-Band return link. Incorporation of the ICU provides legacy equivalent functions as well as enhanced bi-directional Ku-Band communications. ISPR and non-rack end items that connect to the MRDL have the option to utilize these ICU communication enhancements, which will henceforth be referred to as Ku-band IP (KuIP) Services . Ku-Band communication enhancements include the following:

- Ku-Band return link rate of 300 Mbps versus legacy rate of 150 Mbps
- Aggregate forward link rate of 25 Mbps with connection to the JSL
- Ku-Band forward link packetization per CCSDS 732.0-B-2, AOS Space Data Link Protocol (CCSDS Data Link Layer Recommendation), and CCSDS 135.0-B-4, Space Link Identifiers (CCSDS Identifiers for space link protocols)
- Pass-through of digital data into bitstream channels per CCSDS 732.0-B-2, AOS Space Data Link Protocol (CCSDS Data Link Layer Recommendation)
- Ku-Band return and forward file transfer protocol per CCSDS 727.0-B-4, CCSDS File Delivery Protocol (CFDP)
- Ku-Band Delay Tolerant Networking (DTN) per the Internet Research Task Force (IRTF) defined in CCSDS 734.1-R-3, Licklider Transmission Protocol (LTP)
- Ku-Band Delay Tolerant Networking (DTN) per the CCSDS recommendation for end-to-end exchange of messages per CCSDS 734.2-R-3, CCSDS Bundle Protocol Specification

- Ku-Band return link packetization per CCSDS 732.0-B-2, AOS Space Data Link Protocol (CCSDS Data Link Layer Recommendation), CCSDS 133.1-B-2, Encapsulation Service (CCSDS IPEncap Recommendation), CCSDS 133.0-B-1, Space Packet Protocol (CCSDS User Application Layer Recommendation), and CCSDS 135.0-B-4, Space Link Identifiers (CCSDS Identifiers for space link protocols)
- Management of payload public/private keys and certificates (see Section 3.3.7.1)

The approved ISS payload Internet suite of protocols that operate in the space-to-ground and ground-to-space directions via the KuIP Services shall {3.3.7-A} be established in this document. Payloads utilizing KuIP Services via space-to-ground and ground-to-space communication links on the MRDL shall {3.3.7-B} adhere to the protocols specified per Table 3.3.7-1, Ku-Band IP Services Protocol Assignments.

Payloads utilizing KuIP Services shall {3.3.7-C} be prohibited from using port numbers less than or equal to 1023, except for those specific ports listed in Table 3.3.7-1, Ku-band IP Services Protocol Assignments. This restriction applies to Protocol and Port designations labeled “Port assigned based on services”.

TABLE 3.3.7-1 KU-BAND IP SERVICES PROTOCOL ASSIGNMENTS (4 PAGES)

Service Name	Protocol and Port	Notes
Secure Shell Version 2 (SSHv2)	TCP, Port 22	SSHv2 is a protocol for secure remote login and other secure network services over an insecure network.
Secure Copy (SCP)	TCP, Port 22	SCP is a network protocol based on the remote procedure call program in the Berkeley Software Distribution (BSD) source code (sometimes called Berkeley Unix). A client initiates an SSH connection to the remote host, and requests an SCP process to be started on the remote server for data transfer.
FTP Secure (FTPS)	TCP, Port 989 (Data), TCP, Port 990 (Control)	FTPS provides a secure FTP with the Transport Layer Security (TLS) protocol and the Secure Sockets Layer (SSL) cryptographic protocols.
Remote Desktop Protocol (RDP)	TCP, Port 3389	Usage of RDP is dependent on ISSP security review. RDP is a proprietary protocol developed by Microsoft for their Terminal Server services.

TABLE 3.3.7-1 KU-BAND IP SERVICES PROTOCOL ASSIGNMENTS (4 PAGES)		
Service Name	**Protocol and Port**	**Notes**
Remote Framebuffer (RFB) Protocol	TCP, Port assigned based on services.	Usage of RFB is dependent on ISSP security review. The Remote Framebuffer (RFB) protocol is a simple "remote framebuffer" protocol for remote access to graphical user interfaces. RFB operates at the framebuffer level which roughly corresponds to the rendered screen image and it is applicable to all windowing systems and applications, including Unix/Linux (using the X11 Network Protocol), Microsoft Windows and Apple OSX operating systems.
Hypertext Transfer Protocol Secure (HTTPS)	TCP, Port 443	HTTPS secures HTTP with the TLS 1.2 or greater protocol and the SSL cryptographic protocols.
CCSDS File Delivery Protocol (CFDP)	UDP, 4560	CFDP is a CCSDS recommended file transfer protocol standard that promotes sharing of files. CFDP operates in the space-to-ground and ground-to-space directions for file transfers.
Bundle Protocol (BP)	UDP, 4556	BP is a CCSDS recommended end-to-end protocol standard for the exchange of messages in Delay Tolerant Networking (DTN).
Licklider Transmission Protocol (LTP)	UDP 1113	The LTP represents the consensus of the Delay Tolerant Networking (DTN) Research Group of the Internet Research Task Force (IRTF). The LTP is designed to provide retransmission-based reliability over links characterized by extremely long message round-trip times (RTTs) and/or frequent interruptions in connectivity.
Custom User Datagram Protocol (UDP)	UDP, Port assigned based on services.	UDP is a simple connectionless and transaction oriented protocol, which does not guarantee data delivery, ordering, or duplicate protection, and assumes that IP is the underlying protocol. UDP provides checksums for data integrity, and port numbers for addressing different functions at the source and destination of the datagram.

TABLE 3.3.7-1 KU-BAND IP SERVICES PROTOCOL ASSIGNMENTS (4 PAGES)		
Service Name	**Protocol and Port**	**Notes**
UDP Video	UDP, Port assigned based on services.	Payload IP Addresses are assignable via D684-13406-01, Internet Protocol (IP) Address Management Plan for the International Space Station (ISS).
Custom Transmission Control Protocol (TCP)	TCP, Port assigned based on services.	TCP is a connection oriented protocol, intended for reliable host-to-host protocol communications, which provides reliable, ordered, and error-checked delivery of a data between applications running on hosts communicating over an IP network.
Internet Control Message Protocol (ICMP) Ping	N/A	ICMP Ping messages report errors in the processing of datagrams. For example, the network utility ping operates by sending ICMP echo request packets to the target host and waiting for an ICMP response.
RTP Control Protocol (RTCP)	UDP, Port assigned based on services.	RTCP is designed to be independent of the underlying transport and network layers with the primary function of providing feedback on the Quality of Service (QoS) in media distribution by periodically sending statistics information to participants in a streaming multimedia session. RTCP transports statistics for a media connection and information such as transmitted octet and packet counts, packet loss, packet delay variation, and round-trip delay time. An application may use this information to control quality of service parameters, perhaps by limiting flow, or using a different codec.

TABLE 3.3.7-1 KU-BAND IP SERVICES PROTOCOL ASSIGNMENTS (4 PAGES)		
Service Name	**Protocol and Port**	**Notes**
Real-time Transport Protocol (RTP)	UDP, Port assigned based on services.	RTP provides end-to-end network transport functions suitable for applications transmitting real-time audio, video or simulation data, over multicast or unicast network services. RTP does not address resource reservation and does not guarantee quality-of-service for real-time services. The data transport is augmented by a control protocol (RTCP) to allow monitoring of the data delivery in a manner scalable to large multicast networks, and to provide minimal control and identification functionality. RTP and RTCP are designed to be independent of the underlying transport and network layers.
Real Time Streaming Protocol (RTSP)	TCP, Port assigned based on services.	RTSP is an application-level protocol for control over the delivery of data with real-time properties. RTSP provides an extensible framework to enable controlled, on-demand delivery of real-time data, such as audio and video. Sources of data can include both live data feeds and stored clips. This protocol is intended to control multiple data delivery sessions, provide a means for choosing delivery channels such as UDP, multicast UDP and TCP, and provide a means for choosing delivery mechanisms based upon RTP.

TABLE 3.3.7-1 KU-BAND IP SERVICES PROTOCOL ASSIGNMENTS (4 PAGES)

Service Name	Protocol and Port	Notes
Windows Remote Management (WinRM) over HTTPS	TCP, Port 5986	WinRM is the Microsoft implementation of WS-Management Protocol, a standard Simple Object Access Protocol (SOAP)-based protocol that allows hardware and operating systems, from different vendors, to interoperate. WinRM shall {3.3.7-D} be configured to send and receive messages over HTTPS.

Note: Specific versions of protocols are required in certain cases as shown above.

SSP 50892, Ethernet Requirements for Interoperability with the Joint Station LAN (JSL) provides a repository of approved Ethernet physical and protocol requirements for the ISS. In addition, all ISS Payload IP Addresses are assignable via D684-13406-01, Internet Protocol (IP) Address Management Plan for the International Space Station (ISS).

SSP 50304, Payload Operations and Integration Center (POIC) Capabilities Document defines the ISSP ground services provided by POIC. The POIC resides in the Huntsville Operations Support Center (HOSC), and utilizes the Enhanced HOSC Systems (EHS) to implement the ground services that provide support for payload operations including telemetry acquisition and processing, data storage, data distribution, command services, payload operations management, payload planning, data, voice and video communications, and configuration/administrative management services. The EHS KuIP Services are defined in Sections 5.1.1.5, CCSDS IP Encapsulation Packets and 5.4.3, IP Based File Uplink/Downlink. In summary, section 5.1.1.5 states that the ISS downlink stream will be processed by maintaining the current CCSDS Space Packet format capability and also provide processing of CCSDS IP Encapsulation Packets. As a result, user payloads will be able to map private IP addresses on ISS for downlink, which results in the ability to proxy downlink science data streams directly to remote users. Section 5.4.3 states that authorized users will have the capability to initiate IP based file transfer directly to EXPRESS Racks and payloads.

See Figure 3.3.7-1, Typical KuIP Services OPS Scenario which depicts a payload on ISS configured with Microsoft (MS) Operating System (OS) or Linux OS, and protocol assignments of SSH, RDP, and CFDP. The PD Facility example is utilizing a PC Client with the Windows OS and the same protocol assignments as the on-board payload.

Note: Users of KuIP services should be aware that IPv4 network packets (e.g., PING, TCP/IP, UDP/IP) may not be deliverable from their onboard payload if their payload system configuration is implicitly depending on an MTU of 1500 being available end to end. Specifically, if the “Don’t Fragment (DF)” flag is set (= 1) in the payload packet IP header, and a packet exceeds 1500 bytes anywhere during transmission, or if a network device in the path has a lower MTU than 1500 bytes, the packet will be discarded.

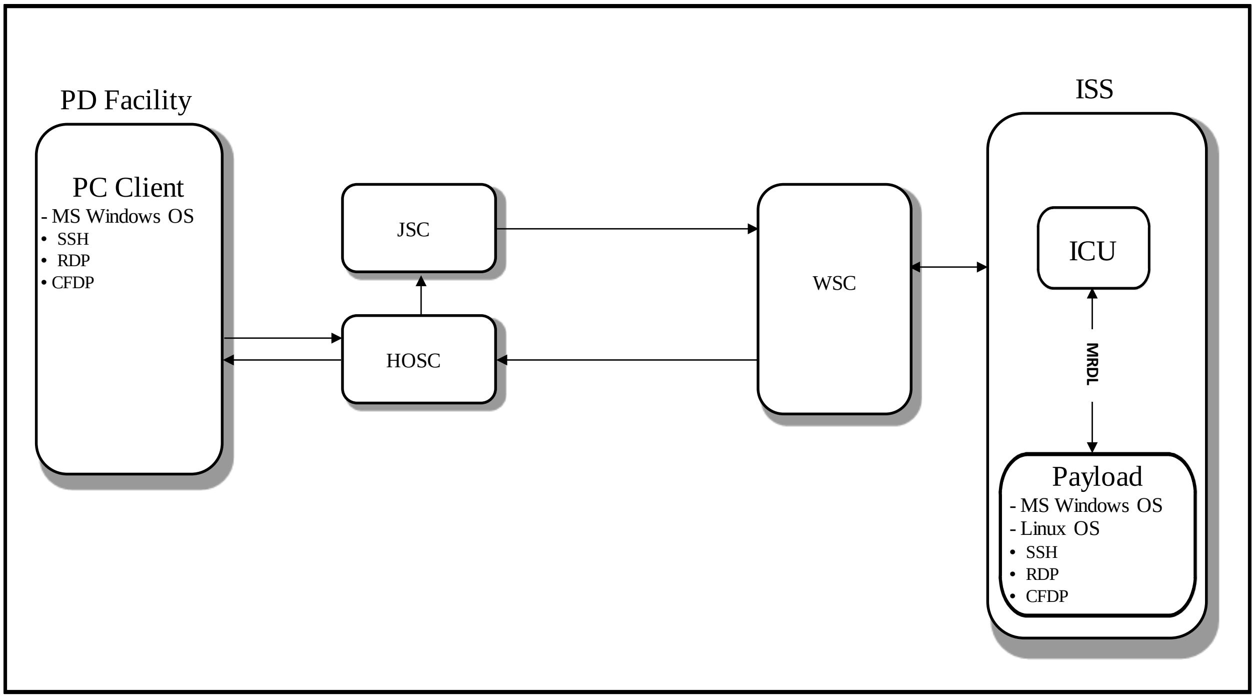


FIGURE 3.3.7-1 TYPICAL KU-BAND IP SERVICES OPS SCENARIO

3.3.7.1 ON-BOARD IT SECURITY

SSP 50974 (International Space Station Onboard IT Security Requirements for USOS Systems) and SSP 50989 (International Space Station IT Security Policy for Onboard Systems) are the IT security reference documents for payloads sending and receiving data utilizing KuIP services. To meet these requirements, the HOSC will be inspecting uplinks and associated return traffic. This will be accomplished using a firewall Intrusion Detection System (IDS) based on Deep Packet Inspection. For encrypted protocols, this includes management of payload public/private keys and certificates. The IDS will decrypt and scan the incoming payload stream, and re-encrypt if required for forwarding to the original destination. In order to perform this function, the payload must provide the applicable keys and certificates to the HOSC.

If the payload uses any encrypted protocols listed in Table 3.3.7-1 Ku-band IP Services Protocol Assignments, the following requirements are imposed:

- Payloads using SSH shall {3.3.7.1-A} provide SSHv2 keys to the HOSC Key Management System
- Payloads using SSL shall {3.3.7.1-B} provide X.509 certificates to the HOSC Key Management System

Payload X.509 certificates can be acquired from a set of DigiCert certificates provided by the HOSC. The certificates are required to be installed on the payload prior to integration.

Payloads shall {3.3.7.1-C} adhere to the NASA-approved public cipher suites for SSH keys as shown in Table 3.3.7.1, NASA-Approved Public Cipher Suites:

TABLE 3.3.7.1-1 NASA-APPROVED PUBLIC CIPHER SUITES*

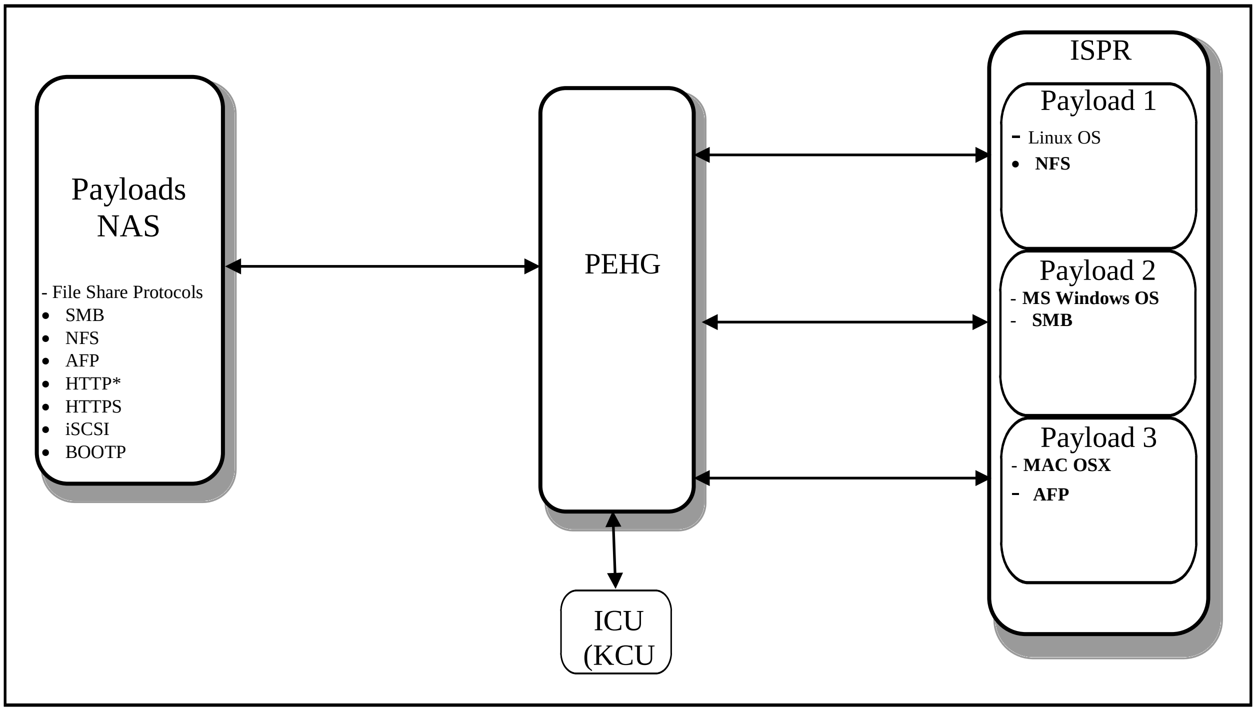
Cipher Suite Name	Key Length
ECDHE_ECDSA_WITH_AES_128_GCM_SHA256	2 Kb
ECDHE_RSA_WITH_AES_128_GCM_SHA256	2 Kb
ECDHE_ECDSA_WITH_AES_256_GCM_SHA384	2 Kb
ECDHE_RSA_WITH_AES_256_GCM_SHA384	2 Kb

* Reference NASA Enterprise Technology Assessments & Digital Standards (ETADS)

These cipher suites implement Elliptic-curve Diffie-Hellman Ephemeral (ECDHE) key exchange using the Elliptic-curve Digital Signature Algorithm (ECDSA) or Rivest-Shamir-Adelman (RSA) algorithm. Advanced Encryption Standard (AES) 128/256 is used as the block cipher, with Galois/Counter Mode and Secure Hash Algorithm (SHA)-256/384 for the authentication hash.

3.3.8 PAYLOADS NETWORK-ATTACHED STORAGE

A Commercial-Off-The- Shelf (COTS) networked data storage server located in the US Lab provides a convenient method of sharing and storing files. This network data storage server will henceforth be referred to as the Payloads Network-Attached Storage (NAS). The Payloads NAS is connected to the Joint Station LAN (JSL) via the Payload LAN providing data access to payloads (ISPRs and non-rack end items) via standard file-sharing protocols. Figure 3.3.8-1, Payloads NAS Connectivity Diagram is a depiction of the NAS connectivity and all NAS services that will be available to payloads utilizing the NAS on ISS. Note these NAS services are specified in Table 3.3.8-1, Payloads Network-Attached Storage Services and Protocol Assignments.



*Note: Use of HTTP is restricted and can *only* be used for onboard access to a read-only URL for the Payloads NAS Antivirus Definition location

FIGURE 3.3.8-1 PAYLOADS NAS CONNECTIVITY DIAGRAM

Payload Developers (PD) may request utilization of the NAS for their payload on ISS by defining a NAS Unique Agreement in the Payload Integration Agreement (PIA). When the PIA is available, the Payload Software Integration (PSI) Team will define the Payloads assigned Home Folder Name, Volume Space, Service Name(s) per the PIA, HTTPS KuIP Service for the payload and distribute the KuIP Payload Configuration to the HOSC Customer Support Team (CST). The HOSC CST will coordinate with the POIF and define NAS user accounts, group names, and privileges. The HTTPS KuIP Services will provide secure PD access to the NAS from their Remote Ground Site. PDs will have read and write access only to their assigned NAS Home Folder using HTTPS via the KuIP Interface. From their remote site the PD may uplink or downlink files to their NAS Home Folder. Note that the PD does not have the capability to change NAS privileges, disk volume allocation, or services.

The Payload Operations Integration Function (POIF) manages the configuration and operations of the Payloads NAS at the Payload Operations Integration Center (POIC). The POIF will define NAS user accounts, group names, and privileges. In addition, the POIF will manage all shared folder mappings, disk volume allocation, quota size on each disk volume, RAID Settings, Network Settings, Services, Protocols, and software applications specific to the NAS. The NAS provides Preboot Execution Environment (PXE) which allows client computers to boot appropriate software images using appropriate configuration parameters remotely through a network interface. Payloads that desire the use of PXE boot times will schedule all PXE Boot timelines with the POIF and adhere to any required ground procedures. Note that the POIF will manage and administer all EXPRESS Laptop Computer (ELC) NAS Services and Folder Settings. Reference Figure 3.3.8-2.

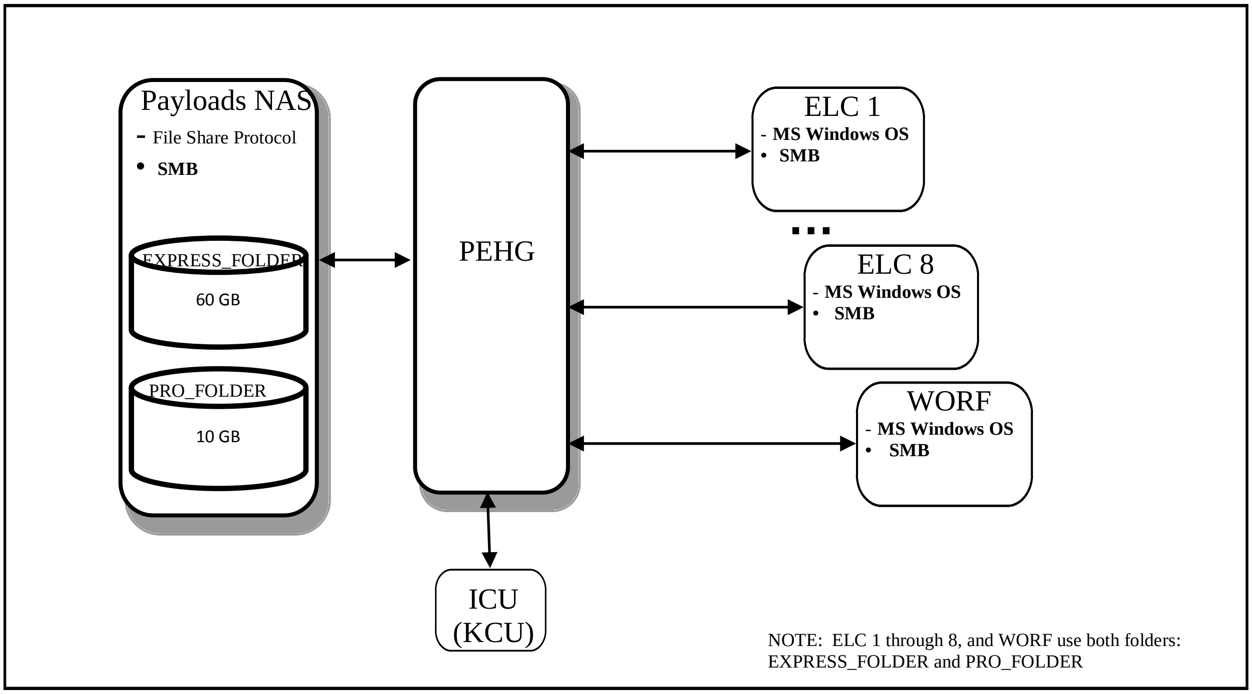


FIGURE 3.3.8-2 ELC PAYLOADS NAS CONNECTIVITY DIAGRAM

The Payloads NAS provides the following features:

- Total raw storage of 20 terabytes (five 5) hard drives with four (4) terabytes each
- Disk Management: Single Disk, Redundant Array of Independent Disks (RAID) 0/1/5/6
- Access Right Management: Max. User Accounts: 4096, Max. Groups: 512, Max. Share Folders: 512
- Support computing OS platforms such as: Microsoft Windows (XP, 7, Server 2003/2008), Apple MAC OSX, Linux, and Unix
- Protocols: SMB2, NFS, AFP, HTTPS, SSH, iSCSI, and BOOTP
- Internal Linux File System: Third Extended Journaling File System (EXT3), and Fourth Extended Journaling File System (EXT4)
- External Supported File System: EXT3, EXT4, New Technology File System (NTFS), File Allocation Table32 (FAT32), and Hierarchical File System Plus (HFS+)
- Preboot Execution Environment (PXE) Booting of Network Devices
- Security Level of Network Access Protection
- Antivirus scanning capability that will delete, quarantine, or report files infected by viruses, malware, Trojans, and other malicious threats.

Payload Developers that desire utilization of the Payloads NAS must request this service via the Payload Integration Agreement.

Payloads utilizing the Payloads NAS must meet the following requirements:

The Payload shall {3.3.8-A} implement a network default route to the Payload Ethernet Hub Gateway (PEHG2) to ensure connectivity with the Payloads NAS.

The Payload shall {3.3.8-B} be provided a minimum usable space of 10 GB of storage.

The Payload shall {3.3.8-C} adhere to the file-sharing services and protocols per Table 3.3.8-1, Payloads Network-Attached Storage Services and Protocol Assignments.

The payload shall {3.3.8-D} adhere to a centralized authentication service for access to the PL NAS.

TABLE 3.3.8-1 PAYLOADS NETWORK-ATTACHED STORAGE SERVICES AND PROTOCOL ASSIGNMENTS

Services	Protocol and Port	Notes
Server Message Block Version 2 (SMB2)	TCP, Port 139 (NetBIOS), Port 445 (Other)	The PL NAS implements SMB via the SAMBA Server.
Apple Filing Protocol (AFP)	TCP, Port 548	AFP is a proprietary network protocol that offers file services for Mac OS X and original Mac OS.
Network File System (NFS)	TCP/UDP, Port 2049	NFS is a distributed file system protocol developed by Sun Microsystems that provides transparent remote access to shared file systems across networks.
Hypertext Transfer Protocol Secure (HTTPS)	TCP, Port 443	HTTPS secures HTTP with the TLS protocol and the SSL cryptographic protocols.
iSCSI	TCP, Port 3260	iSCSI utilizes IP as the transport layer to carry SCSI traffic.
Bootstrap Protocol (BOOTP)	UDP, Port 67 (Server), Port 68 (Client)	BOOTP is an IP/UDP bootstrap protocol which allows a diskless client machine to discover its own IP address, address of a server host, the name of a file to be loaded into memory and executed. BOOTP uses reserved protocol ports for sending and receiving messages between servers and clients. BOOTP servers use UDP port 67 to listen for and receive client request messages and BOOTP clients reserve UDP port 68 for accepting messages.

3.4 HIGH RATE DATA LINK

The HRDL is a simplex link composed of a source station and a receive station linked by a length of optical fiber and an improved Automated PL Switch (APS) as shown in Figure 3.4-1, High Rate Data Link Block Diagram. Hereinafter all references to the APS will apply to the improved APS by implication.

The HRDL network protocols discussed herein are divided into two protocol groups: Station-to-Station protocol between transmit and receive stations, and Station-to-APS followed by non-HRDL APS-to-ICU protocols for data destined for the USOS Ku-Band system. Detailed performance specifications for HRDL are documented in SSP 50184, Physical Media, Physical Signaling & Link-Level Protocol Specifications for Ensuring Interoperability of High Rate Data Link Stations on the International Space Station. Throughout this section, reference will be made to SSP 50184 for detailed requirements. The developer is to be especially aware of the special packet sizing and data parsing techniques that must be implemented to ensure data integrity. These techniques are described in Paragraphs 3.4.2.4.1 and 3.4.2.4.2.

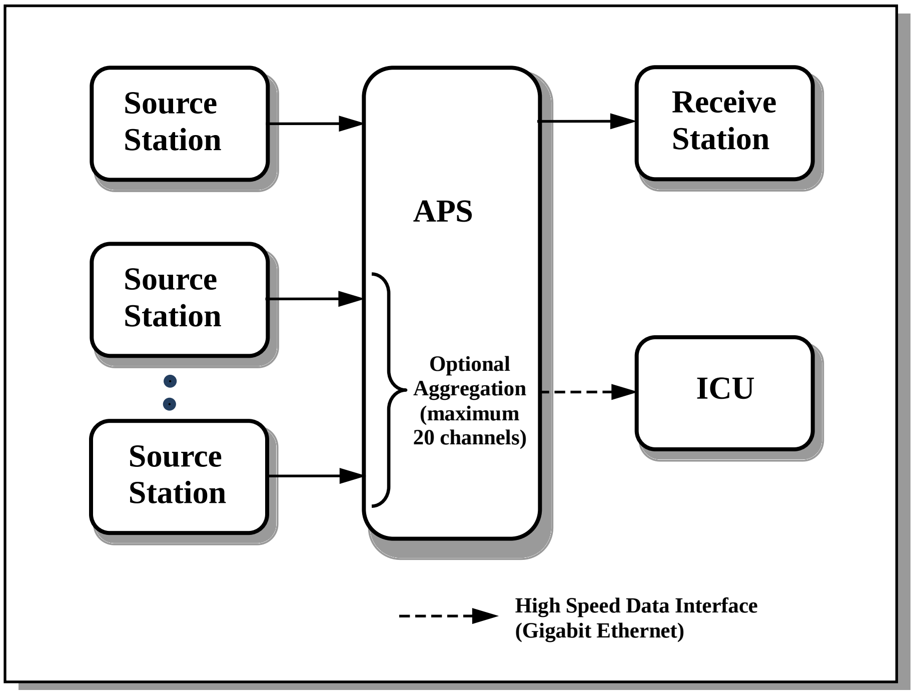


FIGURE 3.4-1 HIGH RATE DATA LINK BLOCK DIAGRAM

3.4.1 SIGNALING

The HRDL is a Fiber Optic (FO) interface which transmits data as light over a glass medium. The HRDL has a fixed signaling (Baud) rate of 125 MHz. Non-Return to Zero Invert on Ones (NRZI) only changes from light to dark or dark to light when a ‘1’ is transmitted. NRZI is used in the HRDL.

A system was devised to use a pattern of 5 bits to represent four bits (half of an octet), with the patterns selected in such a way that no matter which pattern follows another, the clocking and sync are maintained. The combinations of patterns include continuous repetitions. Out of the 32 bit combinations eight are not usable. This leaves 24 combinations with 16 representing the 0 through F hexadecimal digits and the remaining 8 representing control codes. With this 4B/5B encoding, the maximum data rate is 100 Mbps.

Reference for this section is SSP 50184, Paragraph 3.1.3.

3.4.1.1 DATA ENCODING

Data is presented on the HRDL with the following encoding as 4B/5B symbols representing the data symbols as shown in Table 3.4.1.1-1, 4B/5B Symbol Encoding.

TABLE 3.4.1.1-1 4B/5B SYMBOL ENCODING

Symbol	Binary Data MSB-LSB	4B/5B Encoded Data MSB-LSB	Symbol Type
0	0000	11110	Data
1	0001	01001	Data
2	0010	10100	Data
3	0011	10101	Data
4	0100	01010	Data
5	0101	01011	Data
6	0110	01110	Data
7	0111	01111	Data
8	1000	10010	Data
9	1001	10011	Data
A	1010	10110	Data
B	1011	10111	Data
C	1100	11010	Data
D	1101	11011	Data
E	1110	11100	Data
F	1111	11101	Data
H		00100	Symbol (Halt)
I		11111	Symbol (Idle)
J		11000	Symbol (Sync 1st)
K		10001	Symbol (Sync 2nd)
Q		00000	Symbol (Quiet)
R		00111	Symbol (Reset)
S		11001	Symbol (Set)
T		01101	Symbol (Terminate)

Note: Symbols presented on link Most Significant Bit first

3.4.1.2 CONTROL SYMBOL

Control symbols presented on the HRDL are encoded as 4B/5B symbols as shown in Table 3.4.1.2-1. Control Symbols are presented as pair symbols. Other Control Symbols are not to be used at anytime with HRDL signals being routed to the APS for downlink via the ICU. These codes may be used in PL to PL communications on the HRDL.

TABLE 3.4.1.2-1 CONTROL SYMBOLS

Symbol Name	Symbol Pair	4B/5B Encoded Data MSB-LSB
Sync	JK	11000 10001
Start Delimiter	SR	11001 00111
End Delimiter	RS	00111 11001

Note: Symbols presented on link Most Significant Bit first

3.4.1.2.1 SYNC SYMBOL

The Sync symbols are used to: 1) modulate data transfer rates and 2) act as a signal to keep link receivers acquired when data is not presented on link. During a communications session, Sync symbols are to be present on the link whenever data, End Delimiters or Start Delimiters are not present.

3.4.1.2.2 START DELIMITER SYMBOLS

Start Delimiters, ‘SR’, are used to mark the beginning of a data frame and are not used for any other purpose.

3.4.1.2.3 END DELIMITER SYMBOLS

End Delimiters, ‘RS’, are used to mark the end of a data frame and are not used for any other purpose.

3.4.1.3 INVALID SYMBOLS

These following code patterns violate consecutive code-bit zeros or duty cycle requirements and are not to be transmitted. Encoded symbols other than the data symbols and special symbols described herein are forbidden. Invalid Symbols are shown in Table 3.4.1.3-1, 4B/5B Invalid Symbols.

TABLE 3.4.1.3-1 4B/5B INVALID SYMBOLS

Symbol	4B/5B Encoded Data MSB-LSB
V or H	00001
V	00010
V	00011
V	00101
V	00110
V or H	01000
V	01100
V or H	10000

Note: Symbols presented on link Most Significant Bit first

3.4.2 HRDL PROTOCOL REQUIREMENTS

The HRDL protocols are simple point-to-point protocols to ensure simplex communications. The protocols are divided into two protocol groups that provide sub-protocols for different data structures and destinations.

Station-to-Station protocol provides for open communications between transmit stations and receive stations.

Station-to-APS (downlink) protocol has specific requirements for data transmitted to the USOS Ku-Band system.

Reference for this section is SSP 50184, Paragraph 3.3.

3.4.2.1 HRDL PROTOCOL COMMON RULES

The minimum required HRDL state diagram is shown in Figure 3.4.2.1-1, Minimum HRDL Protocol State Diagram. The rules for initialization, lock-on, data send and reconfigure states apply to all HRDL protocols per SSP 50184, Paragraph 3.3.1.1.

A typical HRDL implementation uses a vendor-supplied microcircuit called a Transparent Asynchronous Transmitter-Receiver Interface (TAXI). The Lock-On state, for example, is consistent with the Phase-locked Loop (PLL) state within the TAXI device.

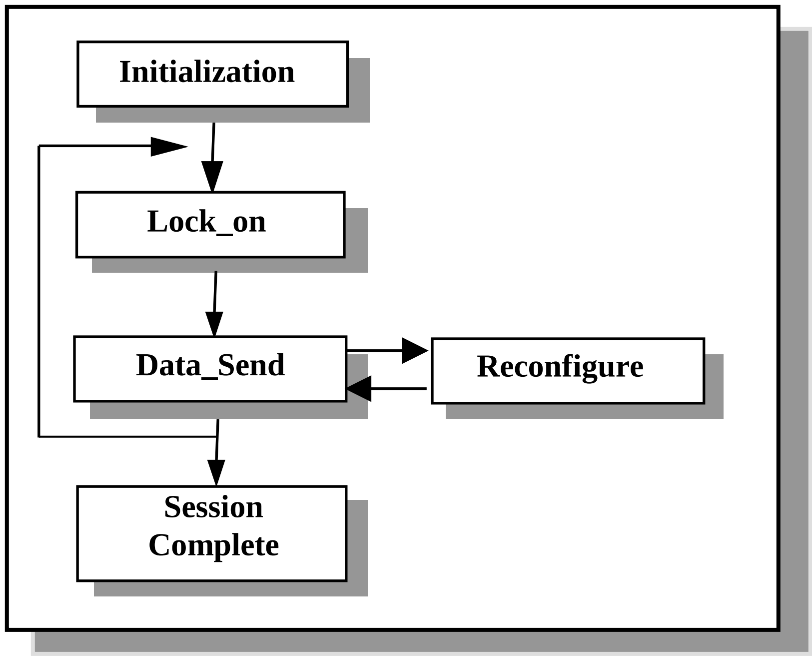


FIGURE 3.4.2.1-1 MINIMUM HRDL PROTOCOL STATE DIAGRAM

During Station-to-Station transmissions, the APS may not lock on during the Lock-On State, hence the designer of receiving stations should consider reporting TAXI errors in telemetry. This will provide visibility of the condition to the ground. The designer should also consider providing the ability to re-send any data critical to the successful completion of experimentation on orbit. Consideration should be given to waiting to send data until commanded, at which point the Data-Send state would be entered. This will allow the integrity of the link to be verified by the ground prior to data transmission.

The APS is susceptible to SEUs in the stream of data passing through the APS. This data corruption cannot be detected at the APS, therefore it is recommended that designers protect critical data by placing a 16 bit add without carry checkword as the last word of the CCSDS packet's data field, as indicated in SSP 50184, Figure 3.3.3-2, CCSDS Packet Format. If the checkword as computed by the system that decommutates the packet is different than the checkword embedded in the data field, the packet should be flagged as corrupt. If loss of data is unacceptable, the only way to recover the corrupted data is to retransmit all or part of the original transmission.

3.4.2.2 GENERAL DATA RATE

HRDL stations shall {3.4.2.2-A} provide the capability to transmit and/or receive data at a maximum rate of 100 Mbps using the 4B/5B encoded scheme as defined in Section 3.4.1.1. The data rate can be adjusted to data rates less than 100 Mbps by parsing the data with Sync and/or Delimiter symbols per guidelines defined in SSP 50184, Paragraph 3.3.1.2.2.

The modulated output rate can be calculated from the following basic rate equation:

$$\text{rate} = \left[\frac{\text{data\_bytes}}{\text{data\_bytes + parsing\_symbols}} \right] * 100 \text{ Mbps}$$

where data bytes = number of bytes in the data frame
parsing symbols = number of Sync and Delimiter symbols inserted between the start of one data frame and the start of the next data frame.

3.4.2.3 STATION-TO-STATION PROTOCOL

The station-to-station protocol allows users to develop their own data transmission structures. There are no special requirements beyond Paragraph 3.4.2.1, HRDL Protocol Common Rules.

3.4.2.4 STATION-TO-APS (DOWNLINK) PROTOCOLS

HRDL stations which require a high rate telemetry downlink interface through the USOS Ku-Band system shall {3.4.2.4-A} operate under the downlink protocols. Downlink protocols consist of two rigidly defined protocols: CCSDS Packet Protocol and a Bitstream protocol.

3.4.2.4.1 CCSDS PACKET PROTOCOL

HRDL transmit stations implementing CCSDS packet protocol must comply with the rules and requirements per SSP 50184, Paragraph 3.3.3.1. A summary of these rules and requirements is provided below.

3.4.2.4.1.1 CCSDS PACKET FORMAT

The HRDL transmit station shall {3.4.2.4.1.1-A} implement data packets as shown in Figure 3.4.2.4.1.1-1, High Rate Data Link CCSDS Packet Format. Start and End Delimiters shall {3.4.2.4.1.1-B} be used to denote the beginning and end of a packet per Table 3.4.1.2-1.

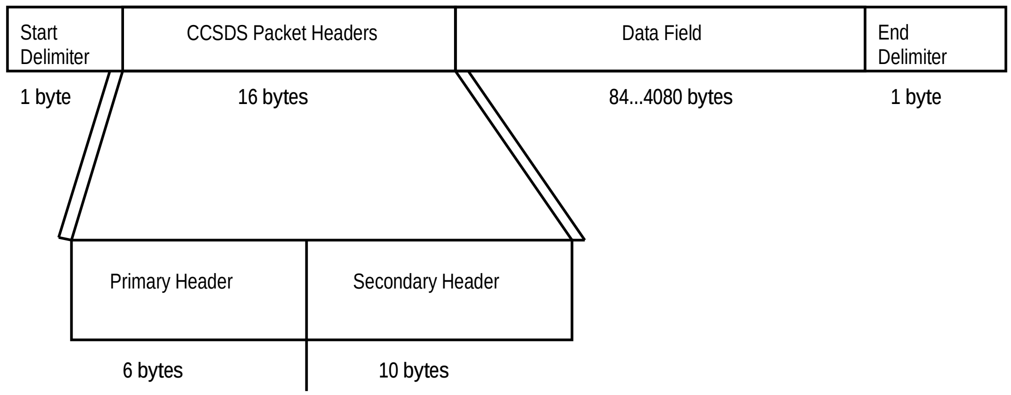


FIGURE 3.4.2.4.1.1-1 HIGH RATE DATA LINK CCSDS PACKET FORMAT

3.4.2.4.1.2 CCSDS PACKET SIZE

CCSDS packets shall {3.4.2.4.1.2-A} consist of an even number of bytes, between 100 and 4096 inclusive, including the primary and secondary headers per SSP 50184, Paragraph 3.3.3.1.1.1. A minimum of 25 Sync symbols shall {3.4.2.4.1.2-B} be transmitted as the inter-packet gap between the end of one packet (RS) and the start of the next packet (SR).

3.4.2.4.1.3 CCSDS PACKET RATES

The HRDL transmit station shall {3.4.2.4.1.3-A} modulate the HRDL data rate by the insertion of Sync symbols in the data stream. The number and distribution of Sync symbols shall {3.4.2.4.1.3-B} be per SSP 50184, Paragraph 3.3.3.1.2. The minimum number of sync symbols to be inserted between the start of one data frame and the start of the next data frame is given by the equation:

$$\mathbf{Syncs = ceiling} \left\lceil \frac{\mathbf{frame\_size}}{\mathbf{rate / 100}} \right\rceil \mathbf{- frame\_size - 2}$$

Where rate = allocated data rate in Mbps

frame size = data frame (packet) size in bytes

Syncs = minimum number of Sync symbols

ceiling function = selection of the next integral value greater than or equal to the expression within brackets

No more than 20 contiguous data bytes shall {3.4.2.4.1.3-C} be transmitted before at least one Sync symbol is inserted into the data stream. Note that maximum data rates may not be achievable for certain packet sizes.

3.4.2.4.2 BITSTREAM PROTOCOL

HRDL transmit stations implementing Bitstream protocol must comply with the rules and requirements per SSP 50184, Paragraph 3.3.3.2. A summary of these rules and requirements is provided below.

3.4.2.4.2.1 BITSTREAM FORMAT

The HRDL transmit station shall {3.4.2.4.2.1-A} implement Bitstream data without Start or End Delimiters as shown in Figure 3.4.2.4.2.1-1, High Rate Data Link Bitstream Format. The only valid symbols for transmission are data symbols and Sync symbols.

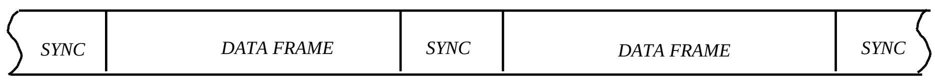


FIGURE 3.4.2.4.2.1-1 HIGH RATE DATA LINK BITSTREAM FORMAT

3.4.2.4.2.2 BITSTREAM DATA FRAME SIZE

Bitstream data frames are user definable and consist of an even number of bytes up to 4096 per SSP 50184, Paragraph 3.3.3.2.1.1. A minimum of 25 Sync symbols shall {3.4.2.4.2.2-A} be inserted after the data frame transmission. Within a data frame, no more than 1092 contiguous data bytes shall {3.4.2.4.2.2-B} be transmitted before Sync symbols are inserted in the data stream. At least one (1) Sync symbol shall {3.4.2.4.2.2-C} be inserted after transmission of up to 135 data bytes. Note that the presence of 25 Sync symbols is a necessary but not sufficient condition to denote the end of a frame. It is up to the user to define where the frame ends. However, if a data frame is defined by a user to be greater than or equal to 136 and less than or equal to 1092 bytes, the 25 Sync symbols will be a necessary and sufficient condition to meet the minimum inter-frame gap requirement.

3.4.2.4.2.3 BITSTREAM DATA RATES

The HRDL transmit station shall {3.4.2.4.2.3-A} modulate the HRDL data rate by the insertion of Sync symbols in the data stream. The number and distribution of Sync symbols shall {3.4.2.4.2.3-B} be per SSP 50184, Paragraph 3.3.3.2.2. The transmit station can average down to the allocated data rate by parsing the data and/or placing Sync symbols in the inter-frame gap. The minimum number of Sync symbols to be inserted between the start of one data frame and the start of the next data frame is given by the equation:

$$\textbf{Syncs} = \textbf{ceiling}\left\lceil \frac{\textbf{frame\_size}}{\textbf{rate / 100}} \right\rceil - \textbf{frame\_size}$$

Where rate = allocated data rate in Mbps
frame size = data frame (packet) size in bytes
Syncs = minimum number of Sync symbols
ceiling function = selection of the next integral value greater than or equal to the expression within brackets

3.4.3 IMPROVED APS

The improved APS replaces the legacy APS with a new set of controller and switch matrix modules to alleviate inefficiencies. Up to twenty (20) input channels may be combined into one aggregated output channel to improve overall data throughput. The aggregation function also performs validation of incoming CCSDS packets. The aggregation function is determined from a downloadable parameter received from the PL MDM via the PL MDM MIL-STD-1553B. A microprocessor based controller provides command, status and diagnostic capabilities including Extended Telemetry in the form of CCSDS packets via the aggregation function. A High Speed Data Interface provides connectivity to the ICU for Ku-Band downlink.

3.5 WIRELESS DATA LINK

The Wireless Data Link consists of a two-way high data rate communications link using radio frequencies per IEEE 802.11n, Wireless Local Area Network (LAN) Media Access Control (MAC) and Physical Layer (PHY) Specifications: Enhancements for Higher Throughput.

IEEE 802.11n is an update to the general IEEE 802.11 specification which accommodates the unique characteristics of wireless radio communication. IEEE 802.11 wireless characteristics differ from IEEE 802.3 wired Ethernet sufficiently to require several unique features implemented at the physical and MAC layer, including collision mitigation using Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), data security using packet encryption, and user authentication via exchange of management packets. IEEE 802.11n adds the additional features of Multiple Input/Multiple Output (MIMO) technology, frame aggregation and enhanced block acknowledgment for an order of magnitude improvement in data throughput.

Multiple Input/Multiple Output (MIMO) is a technology which uses multiple antennas to coherently resolve more information than possible using a single antenna.

Frame Aggregation is a feature of the IEEE 802.11n wireless LAN standards that increases throughput by sending two or more data frames in a single transmission.

Enhanced Block Acknowledgement is a Block Acknowledgment (BA) technique whereby multiple Multiplex Protocol Data Units are acknowledged by a single BA frame.

3.5.1 EXTERNAL WIRELESS COMMUNICATIONS SYSTEM

The External Wireless Communications (EWC) system provides two-way data transfer between the EXPRESS Logistics Carrier (ELC) payload sites and the PEHG in the USL. Locations of the external elements are shown in Figure 3.5.1-1, External Wireless Communications Elements and Express Logistics Carrier Payloads Relative Locations.

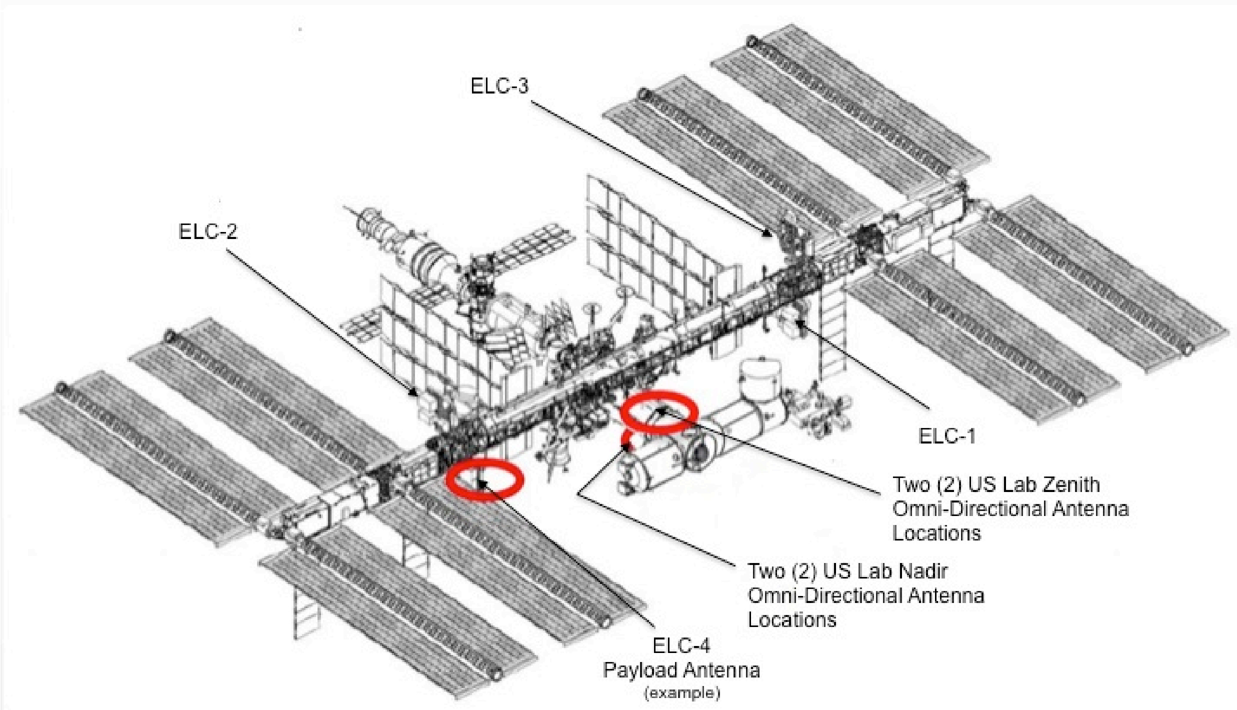


FIGURE 3.5.1-1 EXTERNAL WIRELESS COMMUNICATIONS ELEMENTS AND EXPRESS LOGISTICS CARRIER PAYLOADS RELATIVE LOCATIONS

The External Wireless Communications system is based on Modified Commercial Off-The-Shelf (MCOTS) hardware. Major elements include two (2) redundant Wireless Access Point (WAP) units within the US Lab, four (4) dual band linear polarized omni-directional antennas mounted externally to the US Lab, a payload-integrated WAP and/or Network Interface Card (NIC), and associated payload-integrated antennas. The EWC architecture provides redundant communications to ISS ELCs. Architecture of the External Wireless Communications data link is shown in Figure 3.5.1-2, External Wireless Communications Data Link Architecture.

The EWC payload shall (3.5.1-A) use either a Wireless Access Point in client mode or a Network Interface Card (NIC) for communications with the USL WAP. Dual communications paths provided by two Zenith and two Nadir USL external antennas are provided for reliability and throughput improvement via 2 x 1 MIMO.

Communication between the ELC payload and the USL WAP requires adherence to the following guidelines:

1. Valid combination of channel, antenna gain and transmit power subject to ISS compatibility requirements. Reference EWC RF requirements in SSP 57003, Attached Payload Interface Requirements Document.

2. Valid Configuration Parameters for either WAP or NIC
3. Use of assigned Service Set Identifier (SSID) (example: ISS_EXT_Payload _5GHZ)
4. Use of assigned Internet Protocol (IP) Address (Ref. D684-13406-01, Internet Protocol Address Management Plan)

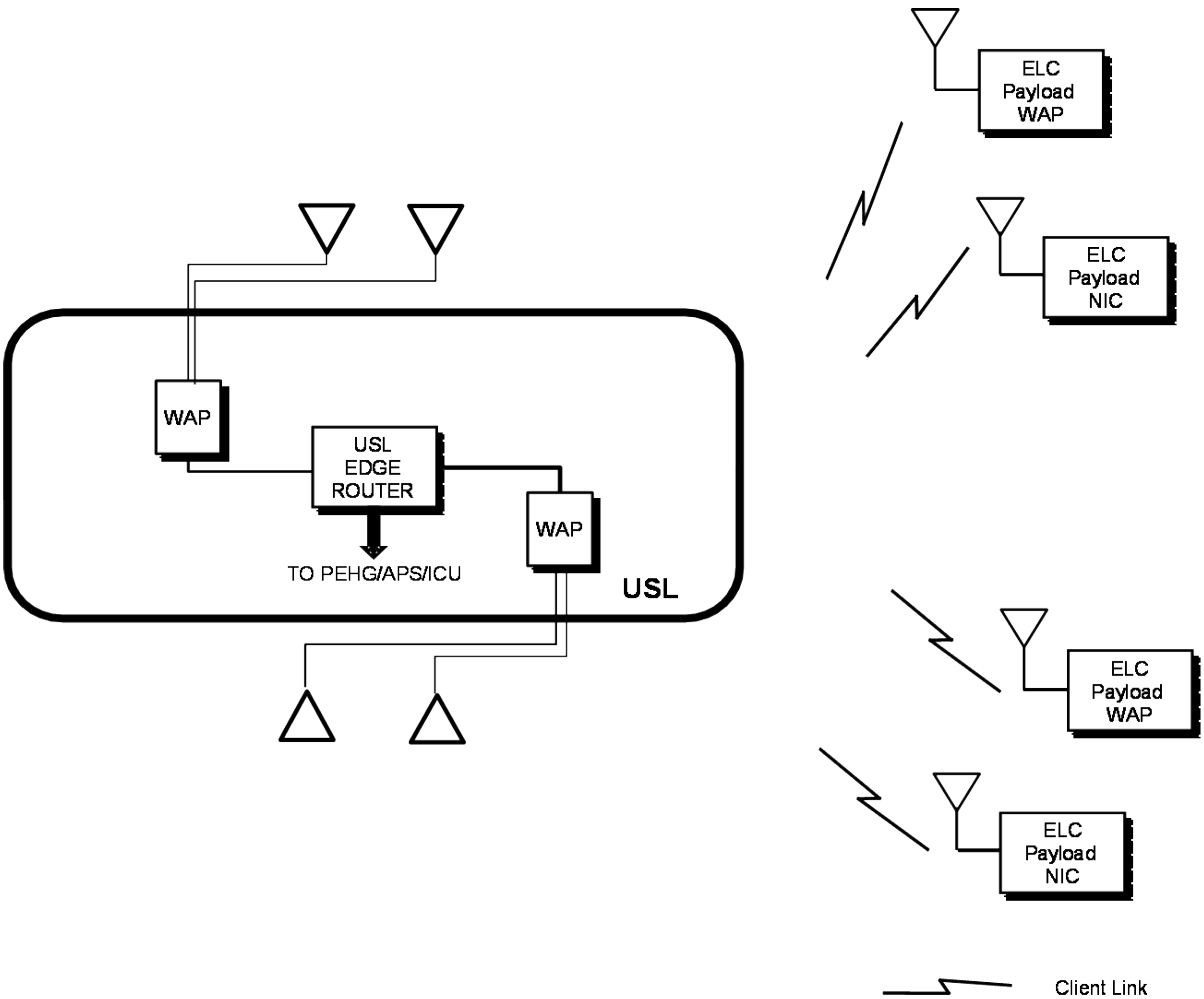


FIGURE 3.5.1-2 EXTERNAL WIRELESS COMMUNICATIONS DATA LINK ARCHITECTURE (2 X 1 MIMO SHOWN)

Typical EWC link characteristics are defined in Table 3.5.1-1, Payload External Wireless Data Link Characteristics.

TABLE 3.5.1-1 PAYLOAD EXTERNAL WIRELESS DATA LINK CHARACTERISTICS

Characteristic	Range/Value	Comment
Data Rate	135 Mbps (1 user) (theoretical maximum) 30 Mbps (typical)*	Maximum Data Rate Using the following: Channel= 40 MHz Modulation=64-QAM Coding Rate=5/6 SGI=800 ns
Frequency Band	The frequency range is the entire 5 GHz band**	Channel 56 bwMode=ht40minus Channel 149 bwMode=ht40plus
Modulation Coding Scheme	0 – 15	
MTU Size	1500 bytes maximum	Wire side MTU is 1500 bytes. Aggregation provides the option for larger wireless MTU.
Topology	Star	
Aggregation	A-MAC Service Data Unit (MSDU) A-Message Protocol Data Unit (MPDU)	
Encryption	WPA2-PSK (AES)	
MIMO	1x1, 2 x 1, 2 x 2	Setting in USL WAP
IP addressing	IPv4, unique and known, static	
Protocols	ICMP, TCP, UDP, Layer-2, SNMP, SNTP, HTTPS, ARP, DTN/BP, sFTP, SSH, TDP	
Architecture	Point-to-point, point-to-multipoint	

SGI = Symbol Guard Interval

*Note: Peak and nominal data rates are based on detailed RF coverage analysis. Wireless bandwidth will be actively managed by the payload organization.

** Note: EWC supports clients within a subset of the U.S. Regulatory Domain (US FCC) channels, with 40 MHz bandwidth, in the 5 – 6 GHz frequency band. Some of these channels require Dynamic Frequency Selection (DFS).

3.5.1.1 EWC PAYLOAD WIRELESS ACCESS POINT PARAMETERS

The EWC Payload Wireless Access Point programmable parameters are based on a Moxa AWK-4131 Wi-Fi access point that meets IEEE 802.11n standards. It provides a transparent, wireless high speed data communications path to the wired LAN in the US Lab.

Typical EWC Payload WAP configuration parameters include those listed in Table 3.5.1.1-1, Typical EWC Payload WAP Configuration Parameters (ref. Moxa AWK-4131 User's Manual for more detail).

TABLE 3.5.1.1-1 TYPICAL EWC PAYLOAD WAP CONFIGURATION PARAMETERS

Parameter	Range/Value	Comment
Frequency Band	The frequency range is the entire 5 GHz band*	
Country Code	US	
Channel	52	
Channel Width	40 MHz	
External Antenna Gain	19 dBi (Based on Myers Payload Antenna)	
TX Power	0.0 – 12 dBm (1 mW – 16 mW)	MCS15 40 MHz
SSID	ISS_EXT_Payload_5GHZ	(Discover using Site Survey feature in the Moxa WAP)
IP Address	(Ref. to D684-13406-01, Internet Protocol (IP) Address Management Plan for the International Space Station (ISS))	
Moxa Client Config: Operation Mode RF Type Transmission Rate Transmission Power Security Mode WPA Type Encryption Method	 Client N Only (5 GHz) Auto Full WPA2 Personal AES	Only supports 5 GHz IEEE 802.11n standard

*Note: EWC supports clients within a subset of the U.S. Regulatory Domain (US FCC) channels, with 40 MHz bandwidth, in the 5 – 6 GHz frequency band. Some of these channels require Dynamic Frequency Selection (DFS).

3.5.1.2 EWC PAYLOAD WIRELESS NETWORK INTERFACE CARD PARAMETERS

The EWC Payload Network Interface Card programmable parameters are based on a typical Wi-Fi NIC that meets IEEE 802.11n standards. It provides a client-server, wireless high speed data communications path to the wired LAN in the US Lab.

Typical EWC payload NIC configuration parameters are shown in Table 3.5.1.2-1, Typical EWC Payload NIC Configuration Parameters (ref. D684-14957-01, External Wireless Communications User Guide).

TABLE 3.5.1.2-1 TYPICAL EWC PAYLOAD NIC CONFIGURATION PARAMETERS

Parameter	Range/Value	Comment
Frequency	N/A	System Parameter
Country Code Selection	N/A	System Parameter
Channel	N/A	System Parameter
Mode	N/A	System Parameter
External Antenna Gain	N/A	System Parameter
TX Power	0 – 12 dBm (1 mW – 16 mW)	MCS15 40 MHz
IP Address	N/A	System Parameter
SSID	ISS_EXT_Payload_5GHZ	

N/A = Not Applicable.

3.5.1.3 EWC DOWNLINK DATA RATES

The EWC expected downlink data rates for various payload antenna gains and 0dB link margin are shown in D684-14957-01.

3.5.1.4 EWC DOWNLINK FRAME FORMAT

The EWC Frame Format for Ethernet Layer 2 or Layer 3 (UDP) downlink is the same as described in Sections 3.3.4 and 3.3.5 and as shown in Figure 3.3.4-1, MRDL Frame Format, and Figure 3.3.5.1-2, Port-to-Port and Port-to-Gateway Packet Formats.

3.5.2 INTERNAL WIRELESS COMMUNICATIONS SYSTEM

The ISS Internal Wireless Communications system provides two-way data transfer between Payloads/Ethernet-devices across the Node 1, Node 2, Japanese Experiment Module (JEM), Columbus, and the United States Laboratory (USL).

The Internal Wireless Communications system is based on Modified Commercial Off-The-Shelf (MCOTS) hardware. Major elements include two (2) BelAir Wireless Access Points (WAPs) units within Node 1 (N1) and Node 2 (N2). Node 1 WAP covers USL, Node 3, and Airlock (AL). Node 2 WAP covers the Japanese Experiment Module (JEM) and Columbus (COL).

Both WAPs support IEEE 802.11b/g/n in 2.4 GHz frequency band, and IEEE 802.11n in the 5 GHz frequency band. The payload shall use either a Wireless Access Point in client mode or a Network Interface Card (NIC) for communication with the Node 1 or Node 2 WAP.

Architecture of the Internal Wireless Communications data link is shown in Figure 3.5.2-1, Internal Wireless Communications Data Link Architecture.

Communication between the internal payload and the BelAir WAP requires adherence to the following guidelines:

1. Valid combination of channel, antenna gain and transmit power subject to ISS compatibility requirements.
2. Valid Configuration Parameters for either WAP or NIC
3. Use of assigned Internet Protocol (IP) Address (Ref. to D684-13406-01, Internet Protocol (IP) Address Management Plan for the International Space Station (ISS))

4. Use of assigned Service Set Identifier (SSID)
(Example, for 5 GHz: ISS_Payload_5GHZ, for 2.4 GHz: ISS_Payload_2.4GHZ)

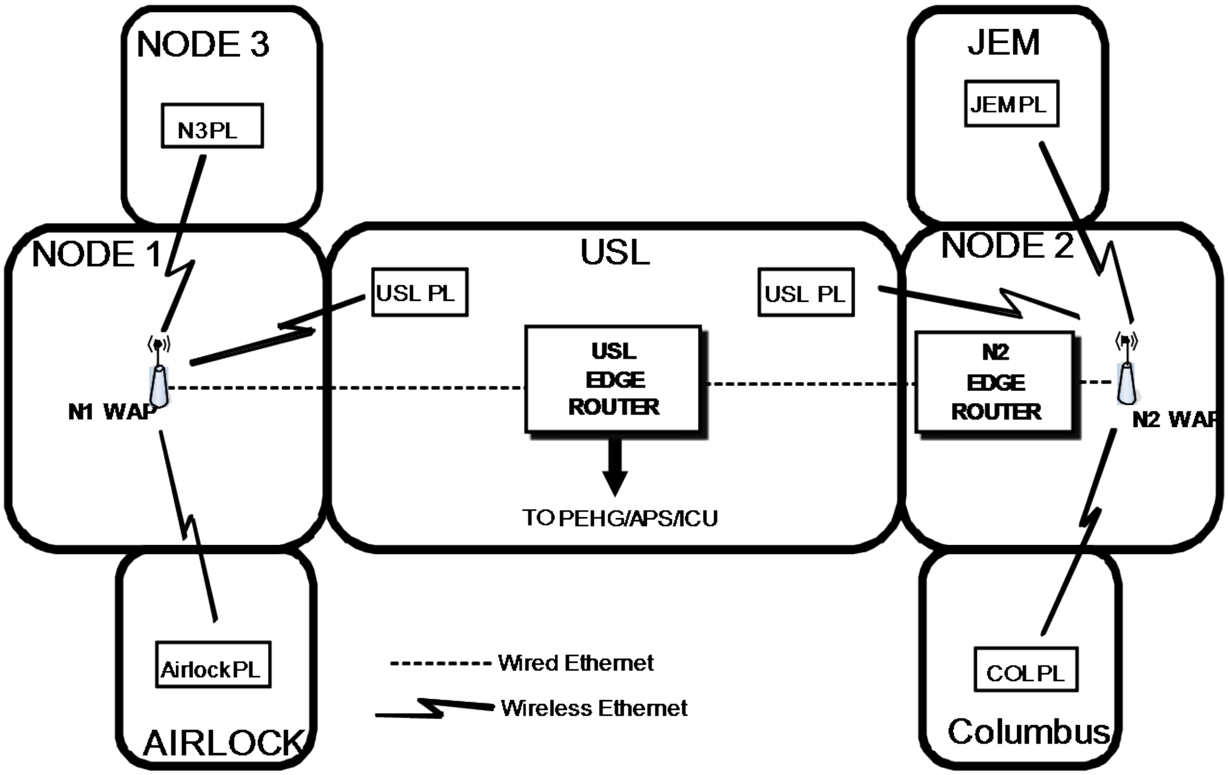


FIGURE 3.5.2-1 INTERNAL WIRELESS COMMUNICATIONS DATA LINK ARCHITECTURE

Typical Internal Wireless link characteristics are defined in Table 3.5.2-1, Payload Internal Wireless Data Link Characteristics.

TABLE 3.5.2-1 PAYLOAD INTERNAL WIRELESS DATA LINK CHARACTERISTICS

Characteristic	Range/Value	Comment
Data Rate	135 Mbps (1 user) (theoretical maximum) 30 Mbps (typical)*	Maximum Data Rate Using the following: Channel Width= 40 MHz Modulation=64-QAM @ MCS7 Coding Rate=5/6 GI=800 ns
Frequency Band	2.402 GHz – 2.472 GHz 5.735 GHz – 5.815 GHz	NOD1: Channel 11 bwMode=ht20 NOD2: Channel 8 bwMode=ht20 NOD1: Channel 149 bwMode=ht40plus NOD2: Channel 157 bwMode=ht40plus
Modulation Coding Scheme (MCS)	0 – 15	
MTU Size	1500 bytes maximum	Wire side MTU is 1500 bytes. Aggregation provides the option for larger wireless MTU.
Topology	Star	
Aggregation	A-MAC Service Data Unit (MSDU) A-Message Protocol Data Unit (MPDU)	
Encryption	WPA2-PSK (AES)	
MIMO	2 x 2	Setting in Node-1 & Node-2 WAP
IP addressing	IPv4, unique	
Protocols	ICMP, TCP, UDP, Layer-2, SNMP- V2/V3, SNTP, HTTPs, ARP, RARP, DTN/BP, sFTP, SSH, TDP	
Architecture	Point-to-point, point-to-multipoint	

GI = Guard Interval

*Note: Peak and nominal data rates are based on detailed RF coverage analysis. Wireless bandwidth will be actively managed by the payload organization.

3.5.2.1 INTERNAL PAYLOAD WIRELESS ACCESS POINT PARAMETERS

The Internal Payload Wireless Access Point programmable parameters are based on a BelAir 100N Wi-Fi access point that meets IEEE 802.11b/g/n standards. It provides a transparent, wireless high speed data communications path to the Joint Station LAN (JSL).

Typical Internal Payload WAP configuration parameters include those listed in Table 3.5.2.1-1, Typical Internal Payload WAP Configuration Parameters (ref. BDTM11201-A01, BelAir 100N User Guide for more detail).

TABLE 3.5.2.1-1 TYPICAL INTERNAL PAYLOAD WAP CONFIGURATION PARAMETERS

Parameter	Range/Value	Comment
Frequency	**2.4 GHz:** NOD1 (2.462 GHz), NOD2 (2.447 GHz) **5 GHz:** NOD1 (5.745 GHz), NOD2 (5.785 GHz)	
Country Code	**US**	
Channel	**2.4 GHz:** Channel 11 for N1 WAP Channel 8 for N2 WAP **5 GHz:** Channel 149 for N1 WAP Channel 157 for N2 WAP	
Channel Width	2.4 GHz = 20 MHz 5.0 GHz = 40 MHz	
External Antenna Gain	2400 – 2500 MHz = 4.5 dBi 5150 – 5875 MHz = 7.0 dBi (Based on Hirschmann SAA04-22008A Antenna Data Sheet)	for 2.4 GHz for 5 GHz
TX Power	23 dBm	Configured on all WAPs and Frequency Bands
SSID	for **5 GHz:** ISS_Payload_5GHZ, for **2.4 GHz:** ISS_Payload_2.4GHZ	
IP Address	(Ref. to D684-13406-01, Internet Protocol (IP) Address Management Plan for the International Space Station (ISS))	

3.5.2.2 INTERNAL PAYLOAD WIRELESS NETWORK INTERFACE CARD PARAMETERS

The Internal Payload Network Interface Card programmable parameters are based on a typical Wi-Fi NIC that meets IEEE 802.11n standards. It provides a client-server, wireless high speed data communications path to the Joint Station LAN (JSL).

Typical Internal payload NIC configuration parameters are shown in Table 3.5.2.2-1, Typical Internal Payload NIC Configuration Parameters.

TABLE 3.5.2.2-1 TYPICAL INTERNAL PAYLOAD NIC CONFIGURATION PARAMETERS

Parameter	Range/Value	Comment
Frequency	Not able to set this on Client NIC	Client will adapt to the WAP parameters
Country Code Selection	Not able to set this on Client NIC	Client will adapt to the WAP parameters
Channel	Not able to set this on Client NIC	Client will adapt to the WAP parameters
Mode	Not able to set this on Client NIC	Client will adapt to the WAP parameters
External Antenna Gain	5 dBi	
TX Power	Up to 24 dBm (2.4 GHz) Up to 20 dBm (5 GHz)	
IP Address	(Ref. to D684-13406-01, Internet Protocol (IP) Address Management Plan for the International Space Station (ISS))	System Parameter
SSID	for **5 GHz:** ISS_Payload_5GHZ, for **2.4 GHz:** ISS_Payload_2.4GHZ	

3.5.2.3 INTERNAL WIRELESS DATA RATES

The Internal Wireless expected data rates for various payload antenna gains and 0dB link margin are shown in D684-14957-01, External Wireless Communications User Guide.

3.5.2.4 INTERNAL WIRELESS FRAME FORMAT

The Internal Wireless Frame Format for Ethernet Layer 2 or UDP downlink via PEHG gateway is the same as described in Section 3.3.3 and as shown in Figure 3.3.4-1, MRDL Frame Format , and Figure 3.3.5.1-2, Port-to-Port and Port-to-Gateway Packet Formats.

APPENDIX A

ABBREVIATIONS AND ACRONYMS

AES	Advanced Encryption Standard
AFP	Apple Filing Protocol
AL	Airlock
APID	Application Process Identifier
APS	Automated Payload Switch
ARP	Address Resolution Protocol
ASCB	Avionics and Software Control Board
ASCII	American Standard Code for Information Interchange
BA	Block Acknowledgment
BC	Bus Controller
BIT	Built In Test
BOOTP	Bootstrap Protocol
BP	Bundle Protocol
BSD	Berkeley Software Distribution
C&DH	Command and Data Handling
C&W	Caution & Warning
CCS	Command and Control Software
CCSDS	Consultative Committee for Space Data Systems
CFDP	CCSDS File Delivery Protocol
COL	Columbus
CRC	Cyclic Redundancy Check
CSMA/CA	Carrier Sense Multiple Access with Collision Avoidance
CSMA/CD	Carrier Sensed Multiple Access with Collision Detection
CST	Customer Support Team
CW	Command Words
dBi	decibel isotropic
dBm	Decibels Referenced to one Milliwatt
DF	Don’t Fragment

DFS	Dynamic Frequency Selection
DTN	Delay Tolerant Networking
DW	Data Word
ECDHE	Elliptic-curve Diffie-Hellman Ephemeral
ECDSA	Elliptic-curve Digital Signature Algorithm
ECW	Emergency, Caution, and Warning
EF	Exposed Facility
EHS	Enhanced HOSC System
ELC	EXPRESS Logistics Carrier
EPF	Exposed Payload Facility
ESA	European Space Agency
ETADS	Enterprise Technology Assessments & Digital Standards
EWC	External Wireless Communications
EXPRESS	EXpedite the PRocessing of Experiments to Space Station
EXT3	Third Extended Journaling File System for Linux
EXT4	Fourth Extended Journaling File System for Linux
FAT32	File Allocation Table32
FCC	Federal Communications Commission
FCS	Frame Check Sequence
FMT	File and Memory Transfer
FO	Fiber Optic
FTP	File Transfer Protocol
FTPS	File Transfer Protocol Secure
GCM	Galois/Counter Mode
GHz	Gigahertz
GI	Guard Interval
GW	Gateway
H&S	Health and Status
HFS+	Hierarchical File System Plus
HOSC	Huntsville Operations Support Center

HRCS	High Rate Communication System
HRDL	High Rate Data Link
HSDI	High Speed Data Interface
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
Hz	Hertz
ICD	Interface Control Document
ICMP	Internet Control Message Protocol
ICU	Integrated Communications Unit
ID	Identifier
IDS	Intrusion Detection System
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
IPE	Internet Protocol Extension
IPEncap	Internet Protocol Encapsulation
IPv4	Internet Protocol Version 4
IRTF	Internet Research Task Force
iSCSI	Internet Small Computer System Interface
ISO	International Standards Organization
ISPR	International Standard Payload Rack
ISS	International Space Station
ISSP	International Space Station Program
IT	Information Technology
JAXA	Japan Aerospace Exploration Agency
JEM	Japanese Experiment Module
JSC	Johnson Space Center
JSL	Joint Station LAN
Kb	kilobit
KB	kilobyte
KCU	Ku-band Communications Unit

KuIP	Ku-band Internet Protocol
LAN	Local Area Network
LEHX	Layer 2 Ethernet Hub and Multiplexer
LLC	Logical Link Control
LRDL	Low Rate Data Link
LRT	Low Rate Telemetry
LSB	Least Significant Bit
LTP	Licklider Transmission Protocol
MAC	Media Access Control
MAC OS X	Macintosh Operating System X (Ten)
max	maximum
Mb	megabit
MB	megabyte
MBaud	Megabaud
Mbps	megabits per second
MBps	megabytes per second
MCOTS	Modified Commercial Off-The-Shelf
MCS	Modulation Coding Scheme
MDM	Multiplexer/Demultiplexer Module
MHz	MegaHertz
MIMO	Multiple Input/Multiple Output
MPDU	A-Message Protocol Data Unit
MRDL	Medium Rate Data Link
ms	millisecond
MS	Microsoft
MSB	Most Significant Bit
MSD	Mass Storage Device
MSDU	A-MAC Service Data Unit
MTU	Maximum Transmission Unit
mW	Milliwatt
NAS	Network-Attached Storage

NASA	National Aeronautics and Space Administration
NASDA	National Space and Development Agency of Japan
NetBIOS	Network Basic Input/Output System
NFS	Network File System
NIC	Network Interface Card
NRZI	Non-Return to Zero Invert on Ones
ns	Nanosecond
NTFS	New Technology File System
OPS	Operations
OS	Operating System
OSI	Open Systems Interconnection
PC	Personal Computer
PCS	Portable Computer System
PD	Payload Developer
PD/PI	Payload Developer/Payload Integrator
PDL	Payload Data Library
PDU	Protocol Data Unit
PEHG	Payload Ethernet Hub/Gateway
PEI	Payload Engineering Integration
PEP	Payload Executive Processor
PG	Product Group
PHY	Physical Layer
PI	Payload Integrator
PIA	Payload Integration Agreement
PL	Payload
PL NAS	Payload Network-Attached Storage
PLL	Phase Locked Loop
POIC	Payload Operations and Integration Center
POIF	Payload Operations Integration Function
PSE&I	Payload Software Engineering and Integration
PSK	Phase Shift Keying

PSRP	Payload Safety Review Panel
PXE	Preboot Execution Environment
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RAID	Redundant Array of Independent Disks
RARP	Reverse Address Resolution Protocol
RDP	Remote Desktop Protocol
RF	Radio Frequency
RFB	Remote Framebuffer
RFC	Request for Comments
RIC	Rack Interface Controller
RSA	Rivest-Shamir-Adelman
RT	Remote Terminal
RTCP	RTP Control Protocol
RTP	Real-time Transport Protocol
RTSP	Real Time Streaming Protocol
RTTs	Round Trip Times
SA	Subaddress
SAM	Subaddress Mode
SCP	Secure Copy
SCSI	Small Computer System Interface
SD	Shutdown
sec	seconds
SEU	Single Event Upset
SFD	Start Frame Delimiter
sFTP	Secure File Transfer Protocol
SGI	Symbol Guard Interval
SHA	Secure Hash Algorithm
SMB	Server Message Block
SNMP	Simple Network Management Protocol
SNTP	Simple Network Time Protocol

SOAP	Simple Object Access Protocol
SRS	Software Requirements Specification
SSH	Secure Shell
SSID	Service Set Identifier
SSL	Secure Sockets Layer
SW	Status Words
T/R	Transmit/Receive
TAXI	Transparent Asynchronous Transmitter-Receiver Interface
TCP	Transmission Control Protocol
TDP	Tag Distribution Protocol
TLS	Transport Layer Security
TX	Transmission
UDP	User Datagram Protocol
URL	Uniform Resource Locator
US or U.S.	United States
USL	United States Laboratory
USOS	United States On-Orbit Segment
WAP	Wireless Access Point
WinRM	Windows Remote Management
WPA	Wi-Fi Protected Access
WPA2	Wi-Fi Protected Access 2
WSC	White Sands Complex

APPENDIX B

GLOSSARY OF TERMS

4B/5B Encoding: On the HRDL link, five (5) signaling bits are used to represent four (4) data bits (i.e., 4B/5B). Consequently, using 4B/5B encoding, it takes 125 MBaud to encode 100 Mbps of data.

Allocated Data Rate: See Negotiated Data Rate.

Application Process Identifier (APID): APID is an 11 bit field within the primary header of the CCSDS Packet, which identifies a particular source and destination for commands and telemetry packets.

Baud: A HRDL signaling bit. For the HRDL, five (5) signaling bits are used to represent four (4) data bits (i.e., 4B/5B). Consequently, using 4B/5B encoding, it takes 125 MBaud to encode 100 Mbps of data.

Data Rate: The rate that data is actually being sent across the HRDL. Data rates lower than the maximum data rate do not necessitate a change in the 125 MBaud Signaling rate due to the insertion of Sync symbols on the link.

Element: Refers to the module or truss segment for which a Product Group (PG) or International Partner has final integration responsibility. Consequently, they are also referred to as “End-Items”.

End-Item: See Element.

Frame: One or more packets forming a delineated group of packets. This packet group is delineated from other packet groups by Start and End Delimiters, and uniquely identified by its six (6) byte Frame Header.

Interpacket Gap: When using the HRDL CCSDS packet protocol, the Interpacket Gap is defined as the minimum number of Sync symbols which must be inserted between the end of one packet and the start of the next packet. The use of the Interpacket Gap is mandatory.

Negotiated Data Rate: The maximum HRDL data rate that has been agreed to by the parties responsible for the transmitting and receiving HRDL stations. This data rate is determined prior to the initialization of HRDL communications.

Packet: A contiguous string of HRDL bits whose maximum length may not exceed 32768 bits (i.e., 4096 bytes).

Receive Station: The receive station is the destination of the HRDL data transmission, where the data is ultimately retrieved from the HRDL network. **Signaling Rate:** The number of Baud (i.e., signaling bits) which are transmitted per second. The HRDL Signaling Rate is a fixed 125 MBaud.

Single Event Upset: A radiation-induced error in a microelectronic circuit caused when a charged particle loses energy by ionizing the medium through which it passes.

Station: Stations are all entities which transmit and/or receive data across the HRDL. By this definition, the APS is a station.

Transmit Station: The transmit station is the source of the HRDL data transmission, where the data is initially placed onto the HRDL network. By this definition, the APS is not a transmit station.

APPENDIX C

OPEN ITEMS

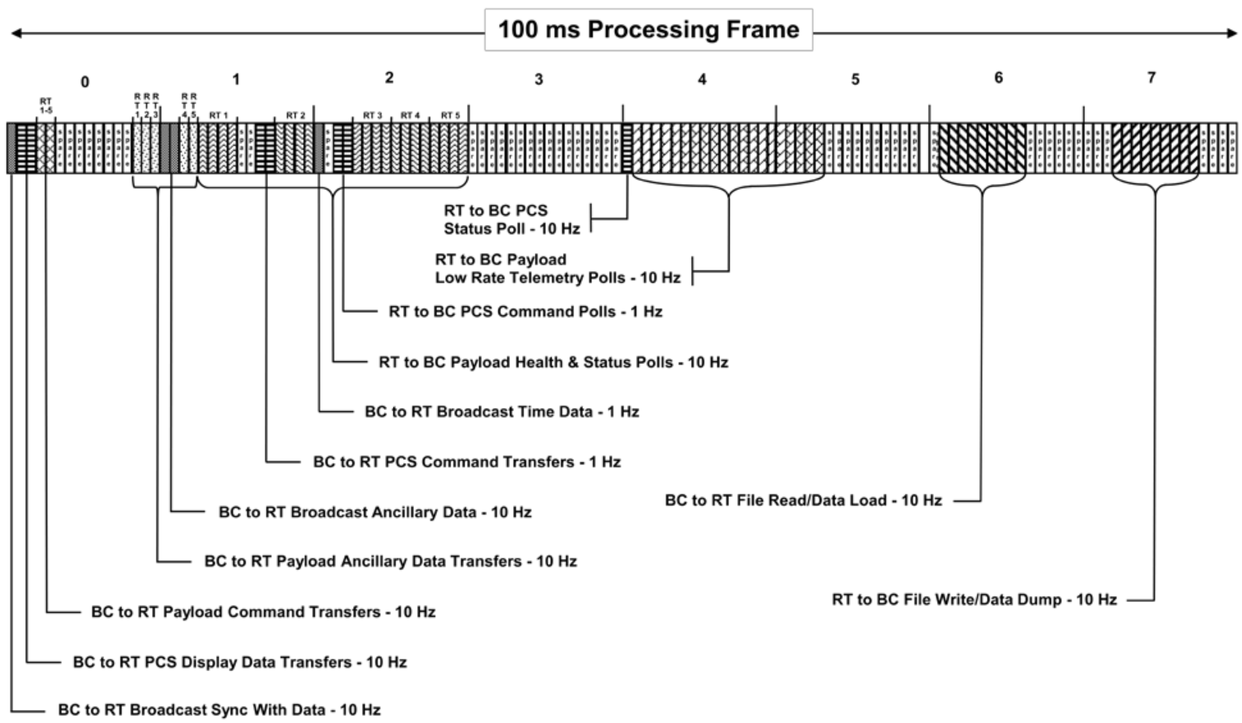
<RESERVED>

APPENDIX D

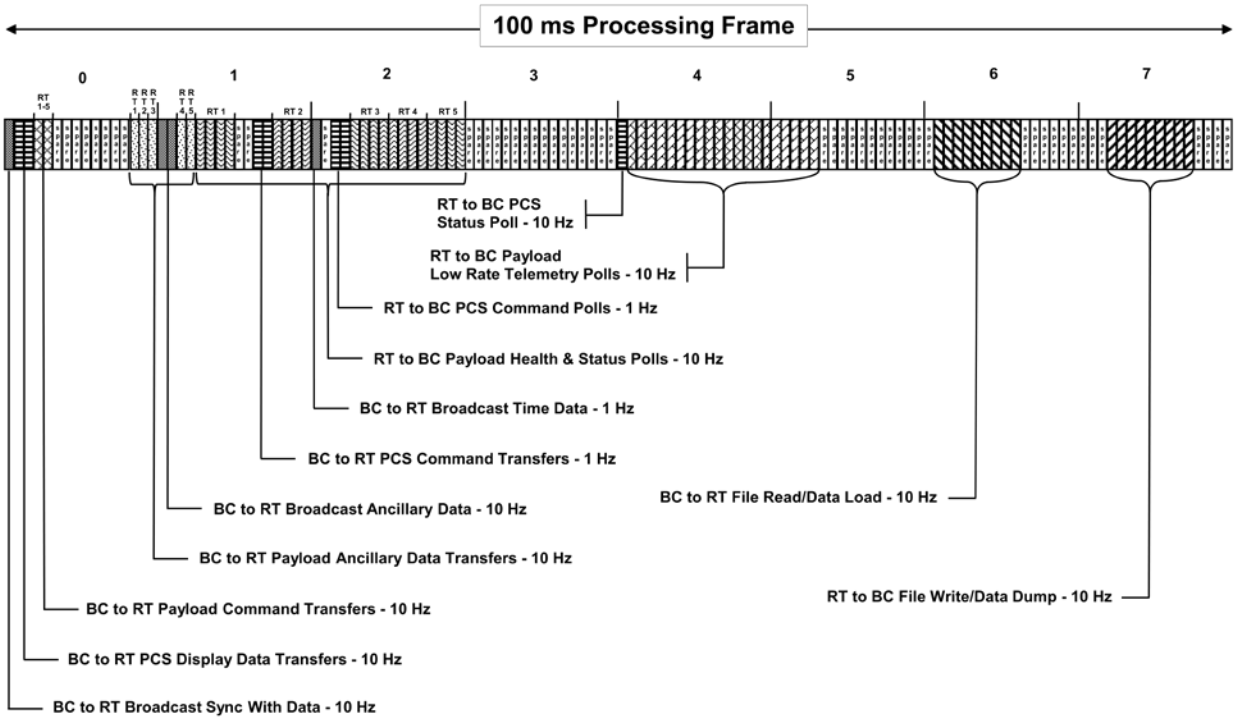
PAYLOAD MDM LOCAL BUS PROFILES

The Payload MDM Local Bus Profiles may be found on the following six pages.

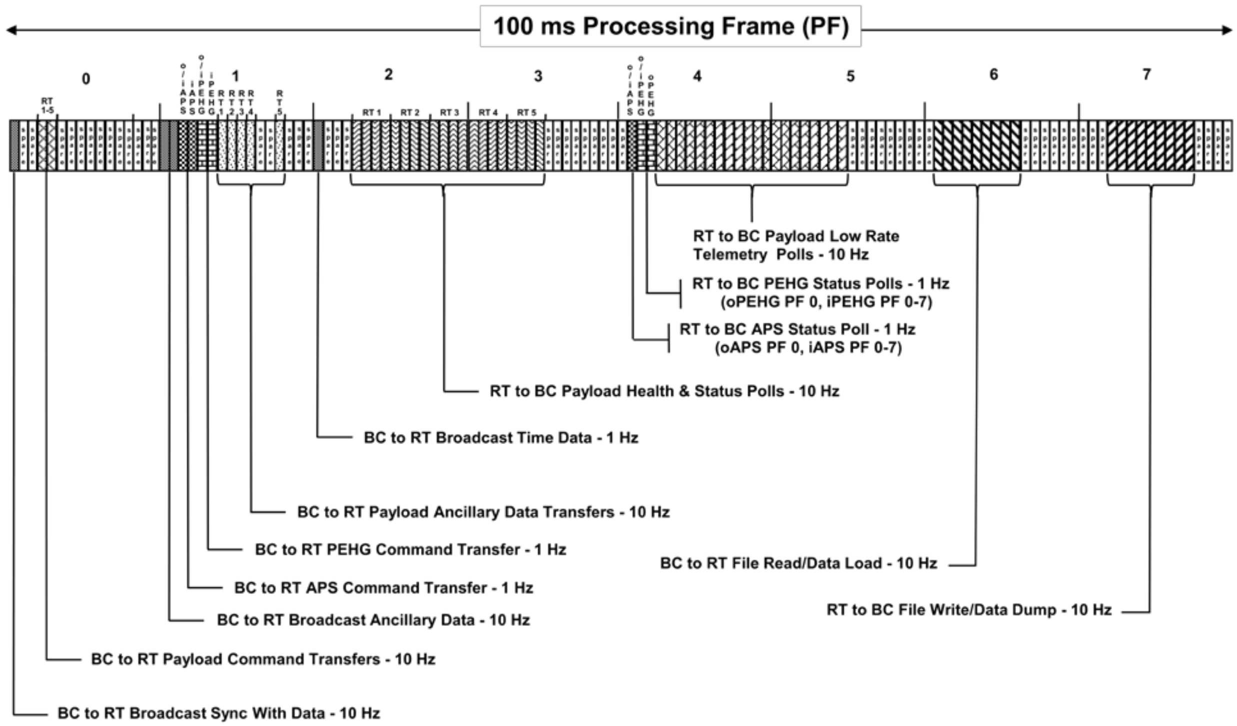
Payload MDM Local Bus PL-1 I/O Profile



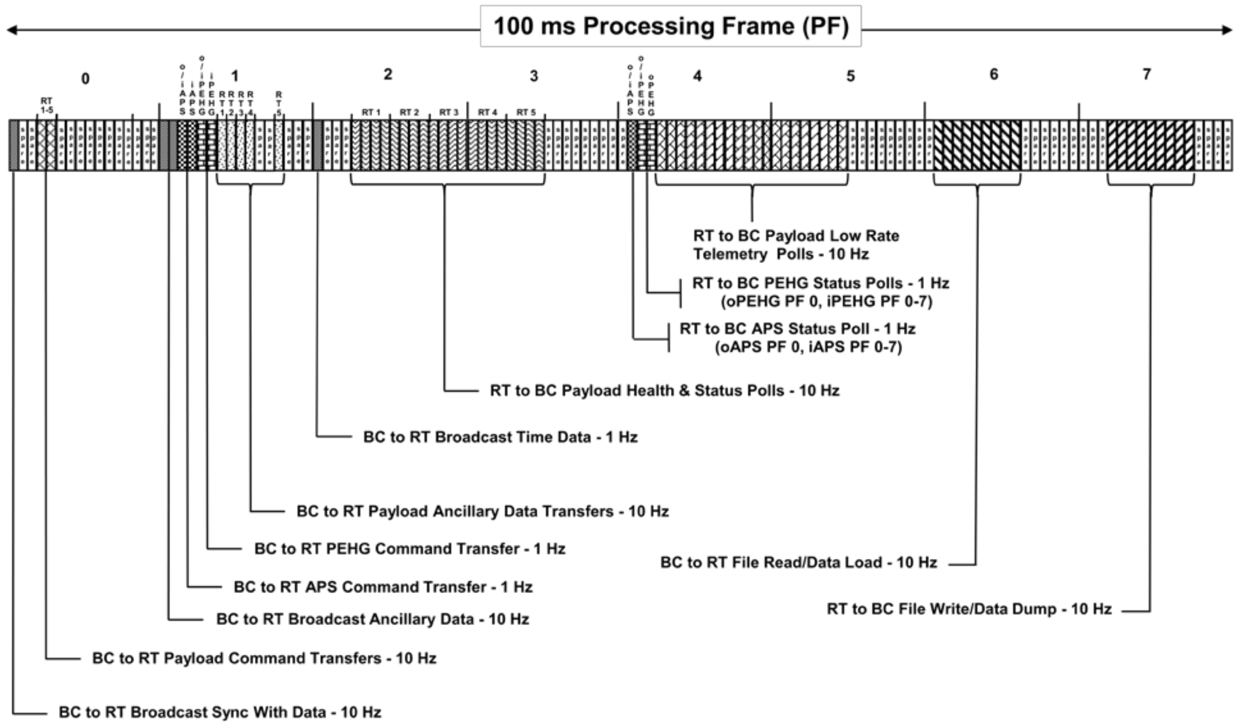
Payload MDM Local Bus PL-2 I/O Profile



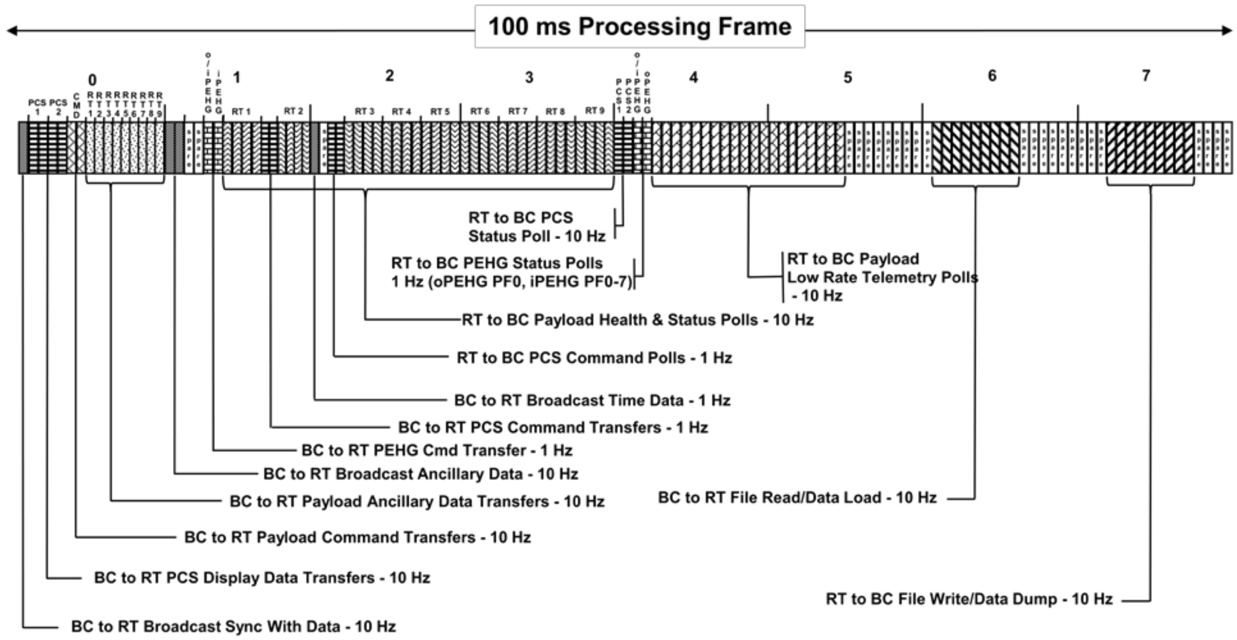
Payload MDM Local Bus PL-3 I/O Profile



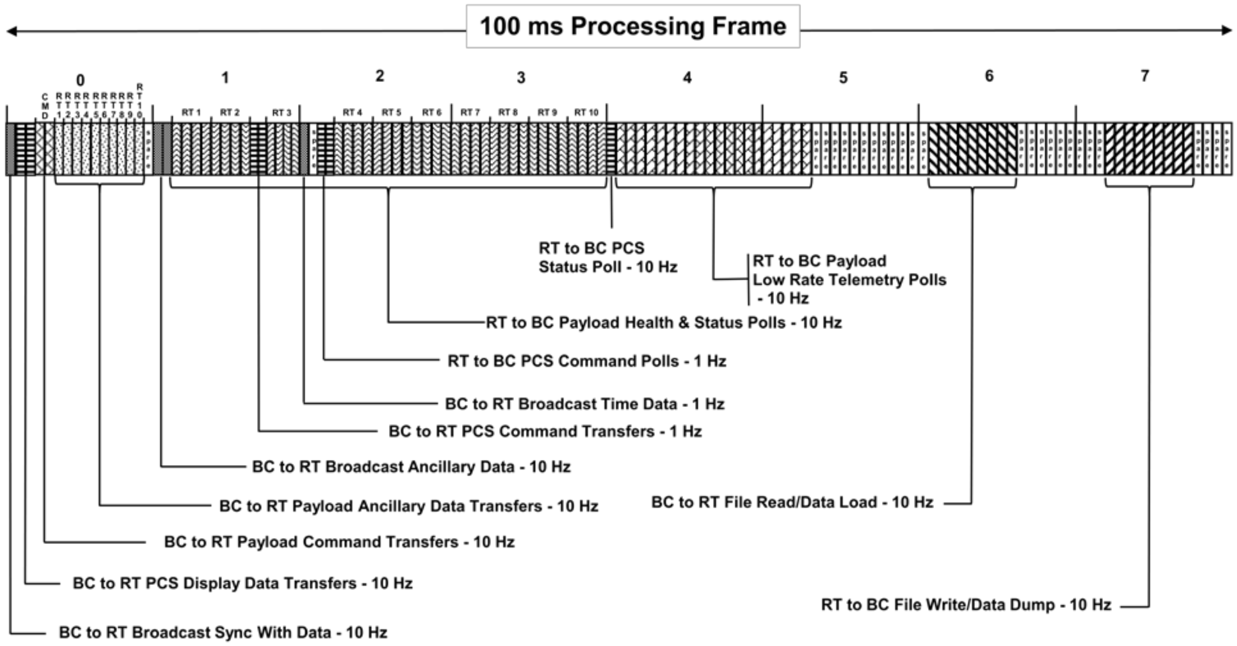
Payload MDM Local Bus PL-4 I/O Profile



Payload MDM Local Bus PL-APM I/O Profile



Payload MDM Local Bus PL-JEM I/O Profile



APPENDIX E

SUMMARY OF CCSDS SECONDARY HEADER TAILORING

The CCSDS secondary header is tailored as follows:

A. Commands from the ground, PCS, or Timeliner to the ISPR or non-rack end item:

   1. Word #6: The Packet Type will contain a value of '1010'b (RT/Payload Command) per Table 3.3.2.1.1-2 of SSP 41175-02.
   2. Word #7: Per SSP 41175-02, Paragraph 3.3.2.1.1, Figure 3.3.2.1.1-2 and Table 3.3.2.1.1-2. The Packet ID-Element ID will contain a value of '0001b' (NASA) per Table 3.3.2.1.1-2 of SSP 41175-02.
   3. Word #8: Will contain the 16 bit Subset ID of the payload/subrack payload being commanded.

B. File Transfer Data from the PEP to the ISPR or non-rack end item:

   1. Word #6: The Packet Type is not processed by the PEP and should not be processed by the RT.
   2. Word #7 and Word #8: Will contain "meaningless" data and should not be processed by the RT.

C. Request Responses from the PEP to the ISPR or non-rack end item:

   1.) Word #6: The Packet Type will contain a value of '0100'b (Telemetry/Status) per Table 3.3.2.1.1-2 of SSP 41175-02.
   2. Word #7: This word contains no useful data for an ISPR or non-rack end item and should be considered "don't care".
   3. Word #8: Will contain the 16 bit Subset ID of the entity which made the request.

D. Ancillary Data from the PEP to the ISPR or non-rack end item:

   1. Word #6: The Packet Type will contain a value of '0111'b (Ancillary Data) per Table 3.3.2.1.1-2 of SSP 41175-02.
   2. Word #7: This word contains no useful data for an ISPR or non-rack end item and should be considered "don't care".
   3. Word #8: Will contain the 16 bit Subset ID of the entity which requested the Ancillary Data Set.

E. Telemetry (Low Rate, Medium Rate, or High Rate) from the ISPR or non-rack end item:

   1. For payload telemetry data to be processed at the HOSC:
      a. Word #6: The Packet Type value is not processed by the PEP or the ground systems and is "don't care".
      b. Word #7: Will contain a Version ID, which is an unsigned integer and identifies the overall data structure of the data in the packet, and serves as a reference to a specific pre-defined Ku-Band telemetry data format. (See SSP 41158, Paragraph 4.1.2, CCSDS Packet Extensions/Modifications for further detail.)

c. Word #8: Will contain a Data Cycle Counter, which is an unsigned integer ranging from 1..65535, and will identify a given packet as being packet number “n” in an “m” packet data cycle set. (See SSP 41158, Paragraph 4.1.2, CCSDS Packet Extensions/Modifications for further detail.)

2. For payload telemetry data that is processed only at the Telescience Support Center or PD/PI site:

a. Tailoring of the CCSDS secondary header is left to the discretion of the PD/PI.

F. File Transfer Data from the ISPR or non-rack end item to the PEP

1. The PL MDM does not process the CCSDS secondary header. Rather, it reads the packet length in the primary header and then removes the entire CCSDS header from the data packets. Therefore, all values in the CCSDS secondary header are “don’t care”.

G. Health & Status Data from the ISPR or non-rack end item to the PEP

1. The PL MDM does not process the CCSDS secondary header. Rather, it reads the packet length in the primary header and then removes the entire CCSDS header from the data packets. Therefore, the values in the CCSDS secondary header are “don’t care”.