

Alpha Magnetic Spectrometer-02 (AMS-02) Software Interface Control Document

International Space Station Program

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INTERNATIONAL SPACE STATION PROGRAM
ALPHA MAGNETIC SPECTROMETER-02 (AMS-02)
SOFTWARE INTERFACE CONTROL DOCUMENT

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PREFACE

This document is the Alpha Magnetic Spectrometer-02 (AMS-02) Software Interface Control Document (ICD).

This Software ICD is the exclusive document used by the National Aeronautics and Space Administration (NASA) and the AMS-02 payload developer to identify software data formats, identification labels, packet sizes, and other software interface parameters. This Software ICD contains all the software interface parameters necessary to ensure that the AMS-02 payload data processing equipment can communicate properly with the on-board International Space Station data processing equipment.

The information contained in Appendix A, Payload Telemetry and Command Definition Tables, documents the Stage 1J Command and Data Handling (C&DH) Data Sets for the AMS-02, and is available electronically in Stage UF-5 in the Payload Data Library (PDL). The Stage 1J C&DH Data Sets for AMS-02 are documented in this ICD for use during Kennedy Space Center testing.

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LIST OF CHANGES

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

SSCBD	ENTRY DATE	CHANGE	PARAGRAPH(S)
0xxxxx	March 2008	Initial Release	All

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this Software Interface Control Document (ICD) is to define the flight unique software interface requirements between the Alpha Magnetic Spectrometer-02 (AMS-02) and the International Space Station (ISS) flight data handling elements. The term payload as used in this document refers to the AMS-02.

SSP 41162, Segment Specification for the United States On-Orbit, defines the performance of the integrated United States On-orbit Segment (USOS). SSP 57213, Alpha Magnetic Spectrometer-02 (AMS-02) Hardware Interface Control Document, documents the applicable requirements and corresponding verification requirements contained in SSP 57000, Pressurized Payloads Interface Requirements Document.

1.2 RESPONSIBILITY AND CHANGE AUTHORITY

This document is prepared and maintained by the ISS Prime Contractor in accordance with SSP 30459, International Space Station Interface Control Plan. The Payload Control Board has document baseline authority for this document and subsequent changes.

2.0 APPLICABLE AND REFERENCE DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein.

2.1.1 STANDARDS

DOCUMENT	TITLE
MIL-STD-1553B Rev. B 1/93	Military Standard Digital Time Division Command/Response Multiplex Data Bus

2.1.2 SPECIFICATIONS AND REQUIREMENTS

DOCUMENT	TITLE
D684-11372-01 Rev. C July 2006	Payload Software Identifier Interface Definition Document
SSP 41162 Rev. AW March 2007	Segment Specification for the United States On-Orbit
SSP 50184 Rev. B May 2001	Physical Media, Physical Signaling and Link-Level Protocol Specifications for Ensuring Interoperability of High Rate Data Link Stations on the International Space Station
SSP 50539 Rev. E September 2004	Software Interface Definition Document Application Process Identifier and Logical Data Path Identifier Definition
SSP 52050 Rev. G, Part 1 February 2007	International Standard Payload Rack to International Space Station, Software Interface Control Document Part 1
SSP 57000 Rev. G September 2003	Pressurized Payloads Interface Requirements Document
SSP 57213 Initial Release April 2008	Alpha Magnetic Spectrometer-02 (AMS-02) Hardware Interface Control Document

2.1.3 OTHER DOCUMENTS

DOCUMENT	TITLE
SSP 30459 Rev. G November 1995	International Space Station Interface Control Plan
SSP 41175-02 Rev. L, Book 2 September 2004	Software Interface Control Document, Station Management and Control to International Space Station Book 2, General Software Interface Requirements
SSP 57002 Rev. C April 2005	Payload Software Interface Control Document Template

2.2 REFERENCE DOCUMENTS

DOCUMENT	TITLE
CCSDS 701.0-B-2 Blue Book November 1992	Consultative Committee for Space Data Systems Advanced Orbiting Systems, Networks and Data Links: Architectural Specification
D684-11300-01 Rev. A February 2005	Unique Ancillary Data Sets Interface Definition Document
ISO/IEC 8802-3 1993	IEEE Standard for Information Technology-Telecommunications and Information Exchange Between Systems-Local and Metropolitan Area Networks-Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications, formerly known as ANSI/IEEE 802.3
MSFC-DOC-1949C Vol. 4	MSFC HOSC Database Definitions Vol. 4 Telemetry Databases
MSFC-DOC-1949C Vol. 5	MSFC HOSC Database Definitions Vol. 5 Command Database
MSFC-STD-1274B Vol. 1	MSFC HOSC Telemetry Format Standard Volume 1 Time Division Multiplexed (TDM) Data
SSP 41158 Rev. L February 2006	Software Interface Control Document Part 1 United States On-Orbit Segment to International Ground System Segment Ku-Band Telemetry Formats
SSP 41175-01 Rev. K, Book 1 September 2004	Software Interface Control Document, Station Management and Control to International Space Station Book 1, Hardware Architecture

3.0 PAYLOAD SOFTWARE INTERFACES TO THE ISS COMMAND AND DATA HANDLING (C&DH) SYSTEM

3.1 ISS SOFTWARE INTERFACES AND FORMATS

The AMS-02 payload to ISS C&DH interfaces are depicted in Figure 3.1-1, Command & Data Handling Interfaces Between the Payload and ISS. A summary of the software services required by AMS-02 for each of these interfaces is shown in Table 3.1-1, AMS-02 Software Interface Summary. Applicable software interface addresses (in ring hex and dot notation) and buffer sizes are shown in Table 3.1-2, Software Interface Addresses and Buffer Size.

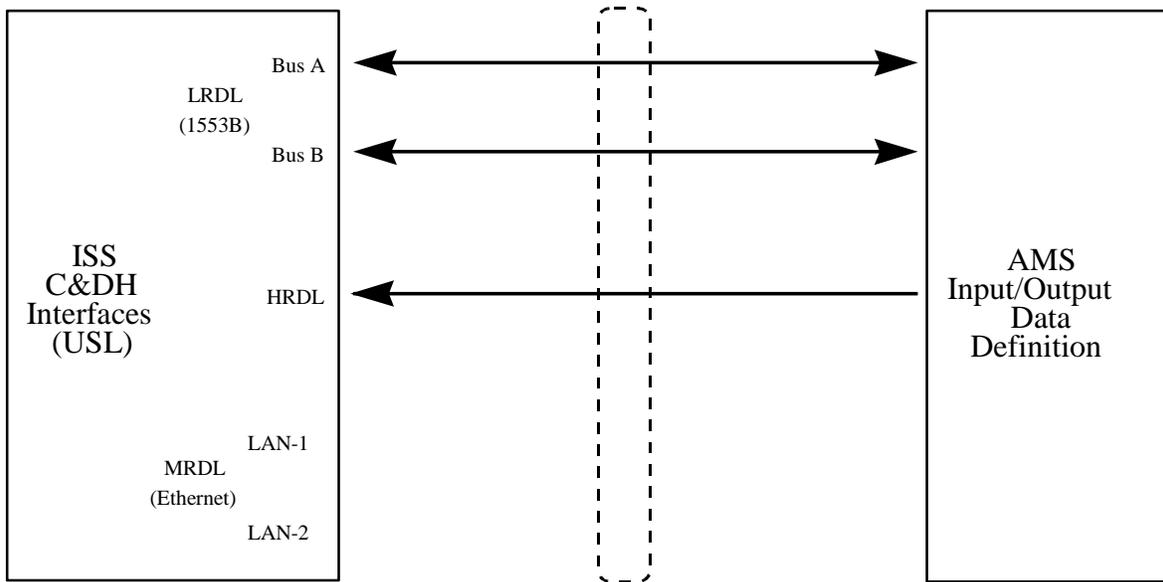


FIGURE 3.1-1 COMMAND & DATA HANDLING INTERFACES BETWEEN THE PAYLOAD AND ISS

The AMS-02 C&DH interface includes the following element:

- Alpha Magnetic Spectrometer-02 (AMS-02)

TABLE 3.1-1 AMS-02 SOFTWARE INTERFACE SUMMARY

Software Interface	AMS-02 C&DH Interface		
	LRDL	MRDL	HRDL
Low Rate Command	X		
Payload Multiplexer/Demultiplexer (PL MDM)	X		
PCS	X		
POIC Uplink	X		
Low Rate Telemetry (LRT)	X		
Ground Processing (POIC)			
POIC Throughput To Payload Remote Site	X		
Health and Status	X		
Request for Service	X		
Caution and Warning			
Safety Parameters	X		
Limit Exception			
PCS Display			
Ground Processing (POIC)	X		
POIC To Payload Remote Site	X		
Medium Rate Telemetry (MRT)			
Ground Processing (POIC)			
Rack to Rack Communications			
Laptop (direct socket)			
POIC Throughput To Payload Remote Site			
High Rate Telemetry (HRT)			X
Ground Processing (POIC)			
Rack to Rack Communications			
POIC Throughput To Payload Remote Site			X
Broadcast Time	X		
Broadcast Ancillary Data			
Unique Ancillary Data			
Payload Unique Ancillary Data Sets			
Additional Requested Ancillary Data Parameters			
File/Data Load (Payload Read)	X		
File Dump (Payload Write)	X		
Timeliner			

TABLE 3.1-2 SOFTWARE INTERFACE ADDRESSES AND BUFFER SIZE

Network Interface	Address	Buffer Size (kBytes)	Maximum Acceptable Latency (millisec)
Local Bus Remote Terminal (ISPR-S3_2)	21	3	
LAN-1 Source	N/A	N/A	
LAN-2 Source	N/A	N/A	
LAN-1 Gateway destination	N/A	N/A	
LAN-2 Gateway destination	N/A	N/A	

3.1.1 DATA BIT/BYTE NUMBERING CONVENTION

Within this document, bits are numbered from 0 to N-1 with bit 0 being the Most Significant Bit (MSB) and N-1 the Least Significant Bit (LSB). This definition is illustrated pictorially in SSP 52050, International Standard Payload Rack to International Space Station, Software Interface Control Document Part 1, Figure 3.1.1-1. Bytes contain 8 bits or 1 octet with bytes numbered from 1 to N with byte 1 being the first byte transmitted and byte N being the last.

3.1.2 CONSULTATIVE COMMITTEE FOR SPACE DATA SYSTEMS (CCSDS) HEADER

3.1.2.1 HEADER FORMATS

The CCSDS and SSP 50184, Physical Media, Physical Signaling and Link-Level Protocol Specifications for Ensuring Interoperability of High Rate Data Link Stations on the International Space Station, define the protocol used for packet data transfer containing primary and secondary headers. The definitions of the format of these headers are found in SSP 41175-02, Software Interface Control Document, Station Management and Control to International Space Station Book 2, General Software Interface Requirements, as tailored in SSP 52050.

The CCSDS standard header format definition is shown in Figure 3.1.2.1-1, Consultative Committee for Space Data Systems Header Format. Typical content of CCSDS headers is summarized in Table 3.1.2.1-1, Typical Header Content - Payload Transmit Data Headers, and Table 3.1.2.1-2, Typical Header Content - Payload Receive Data Header and Command Header. All data to be downlinked from the payload must use CCSDS headers. CCSDS headers are comprised of a primary and secondary header. The Application Process Identifier (ID) (APID) is part of the CCSDS primary header and is used to define a unique source-destination pair. For telemetry, it represents the logical path between the data source and destination. For commands, a Logical Data Path (LDP) value is part of the secondary header, is assigned to each command end point, and uniquely identifies the logical destination of USOS commands.

APIDs are used for commanding and telemetry routing and are documented in this Payload Unique Software ICD. Telemetry APIDs are assigned by Payload Software Integration (PSI) per D684-11372-01, Payload Software Identifier Interface Definition Document. More than one

telemetry APID may be assigned to a single payload if required and once assigned, the telemetry APID will not change regardless of payload relocation. The Payload Operations Integration Center (POIC) will use the telemetry APID for routing payload telemetry data to multiple destinations.

Possible command sources include POIC, Mission Control Center, International Partner Control Centers, Portable Computer System (PCS), PL MDM, and Timeliner. Command destinations are fixed by Remote Terminal (RT) and include International Standard Payload Rack (ISPR) and Attached Payload locations.

Telemetry sources may be assigned at the rack, subrack, or attached payload level and are not fixed to RTs. Possible telemetry destinations include the POIC, International Partner Control Centers, or User Facilities.

The CCSDS secondary header is required for the Low Rate Data Link (LRDL) data transfers and is normally optional for Medium Rate Data Link (MRDL) and High Rate Data Link (HRDL) data transfers. Primary and secondary headers are required for the AMS-02 LRDL and HRDL transfers if telemetry data is to be processed at the POIC. User data follows the header data and has a specific data format based on parameters located in the secondary header. Since AMS-02 telemetry data is processed only at the user site, the contents of the secondary header is user-unique and is not documented here.

In a similar manner, AMS-02 health and status data contains a secondary header, but the PL MDM does not process it, it is “don’t care” and is not documented here.

These CCSDS headers are not required for payload to payload data transfers on MRDL and HRDL. The data fields denoted by “Real Time Assigned” will vary from packet to packet and can only be defined in real-time when the packets are generated.

Field ID	Bit# Wd#	MSB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	LSB
		Primary Header	1	Version (000)			Type	Sec Hdr	Application Process ID (APID)								
2	Seq. Flags		Packet Sequence Count														
3	Packet Length (# Bytes-1 following this field)																
Secondary Header	4	Time (MSBs of Coarse Time)															
	5	Time (LSBs of Coarse Time, LSB=1 second)															
	6	Fine Time								Time ID	Check Word	Spare	Packet Type				
	7	Packet ID Word #1 (Element and Usage Dependent)															
	8	Packet ID Word #2 (Element and Usage Dependent)															

FIGURE 3.1.2.1-1 CONSULTATIVE COMMITTEE FOR SPACE DATA SYSTEMS HEADER FORMAT

TABLE 3.1.2.1-1 TYPICAL HEADER CONTENT - PAYLOAD TRANSMIT DATA HEADERS

	DESCRIPTION				TRANSMIT DATA HEADERS			
	Field	Word #	Bit Offset	Length	Health & Status Data	Low, Medium, Or High Rate Telemetry Data*	File Transfer (Write)	
Primary Header	Version Number	1	0	3	000	000	000	
	Type		3	1	1	1	1	
	Secondary Header Flag		4	1	1	1	1	
	Application Process ID		5	11	don't care	Assigned by PSI using Rack Assignment and APID look-up table from Mission Build Facility	don't care	
	Sequence Flags	2	0	2	11	11	11	
			0	2	00**	00**	00**	
	Packet Sequence Count		2	14	Real Time Assigned	Real Time Assigned	Real Time Assigned	
Packet Length	3	0	16	Real Time Assigned	Real Time Assigned	Real Time Assigned		
Secondary Header	MSB of Coarse Time	4	0	16	↑	Real Time Assigned	↑	
	LSB of Coarse Time	5	0	16		Real Time Assigned		
	Fine Time	6	0	8		Real Time Assigned		
	Time ID		8	2		01		
	Check Sum Word		10	1			0	
	ZOE		11	1			0	
	Packet Type		12	4			0000	
	Packet Type		12	4		don't care	0100**	don't care
	Version ID	7	0	16		Assigned by PD		
	Data Cycle Counter	8	0	16		Real Time Assigned		
	Spare	7**	0	1		0		
	Packet/Element ID		1	4		1001		
	Data Packet		5	1		1		
	Version ID		6	4		0001		
	Format ID		10	6		000111		
	Spare	8**	0	9		00000000		
Frame ID	9		7		0000000	↓		

* Secondary Header required if telemetry processed at POIC

** Content applicable to EXPRESS, Human Research Facility (HRF), and Window Observation Research Facility (WORF) Racks

TABLE 3.1.2.1-2 TYPICAL HEADER CONTENT - PAYLOAD RECEIVE DATA HEADER AND COMMAND HEADER

	DESCRIPTION				RECEIVE DATA HEADERS				COMMAND HEADER	
	Field	Word #	Bit Offset	Length	Unique Ancillary Data	File Transfer (Read)	Broadcast Ancillary Data	Request Response		
Primary Header	Version Number	1	0	3	000	000	000	000	000	
	Type		3	1	1	1	0	1	1	
	Secondary Header Flag		4	1	1	1	1	1	1	
	Application Process ID		5	11	Assigned by PSI using Rack Assignment and APID look-up table from Mission Build Facility	Assigned by PSI using Rack Assignment and APID look-up table from Mission Build Facility	11111010000 (2000 decimal)	Assigned by PSI using Rack Assignment and APID look-up table from Mission Build Facility	Assigned by PSI using Rack Assignment and APID look-up table from Mission Build Facility	
	Sequence Flags	2	0	2	00	11	11	11	11	
	Packet Sequence Count		2	14	Real Time Assigned	Real Time Assigned	Real Time Assigned	Real Time Assigned	Real Time Assigned	
	Packet Length		3	0	16	Real Time Assigned	Real Time Assigned	Real Time Assigned	Real Time Assigned	
Secondary Header	MSB of Coarse Time	4	0	16	Real Time Assigned	Real Time Assigned	Real Time Assigned	Real Time Assigned	Real Time Assigned	
	LSB of Coarse Time		5	0	16	Real Time Assigned	Real Time Assigned	Real Time Assigned	Real Time Assigned	
	Fine Time		6	0	8	Real Time Assigned	Real Time Assigned	Real Time Assigned	Real Time Assigned	
	Time ID			8	2	01	01	01	01	01
	Check Sum Word		10	1	0	0	0	0	1	
	ZOE		11	1	0	0	0	0	0	
	Packet Type		12	4	0111	don't care	0111	0100	1010	
	Spare		7 (cmd)	0	1	N/A	N/A	N/A	N/A	0
	Packet/Element ID			1	4	N/A	N/A	N/A	N/A	0001
	Cmd/Data Packet			5	1	N/A	N/A	N/A	N/A	0
	Spare			6	2	N/A	N/A	N/A	N/A	00
	LDP Endpoint			8	8	N/A	N/A	N/A	N/A	Assigned from SSP 50539, Software Interface Definition Document, Application Process Identifier and Logical Data Path Identifier Definition
	Spare		7 (data)	0	1	↑	↑	0	↑	N/A
	Packet/Element ID			1	4			0001		N/A
	CMD/Data Packet			5	1	don't care		1	don't care	N/A
	Version ID			6	4		don't care	0001		N/A
	Format ID			10	6	↓		001011	↓	N/A
Subset ID	8 or	0	16	Assigned by PSI		N/A	Assigned by PSI	Assigned by PSI		
Spare		8	0	9	N/A		000000000	N/A		
Frame ID		9	7	N/A		↓	Real Time Assigned	N/A		

3.1.2.2 AMS-02 HEADER DEFINITION

Examples of the AMS-02 primary and secondary headers for both the telemetry and command packets are shown in Figures 3.1.2.2-1 through 3.1.2.2-8. If the Secondary Header (Sec Hdr) field = 1, a secondary header is appended during downlink but may not be shown here because it is not processed at the POIC.

Field ID	Bit# Wd#	MSB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	LSB
		Primary Header	1	Version			Type	Sec Hdr	APID								
	0		0	0	1	1	0	1	1	1	1	0	1	0	0	0	0
2	Seq. Flags		Packet Sequence Count														
		0	0														
	3	Packet Length															

APID: 976

FIGURE 3.1.2.2-1 PRIMARY HEADER – AMS-02 SCIENCE DATA

Field ID	Bit# Wd#	MSB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	LSB
		Primary Header	1	Version			Type	Sec Hdr	APID								
	0		0	0	1	1	0	1	1	1	1	0	1	0	0	0	1
2	Seq. Flags		Packet Sequence Count														
		0	0														
	3	Packet Length															

APID: 977

FIGURE 3.1.2.2-2 PRIMARY HEADER – AMS-02 HOUSEKEEPING DATA

Field ID	Bit# Wd#	MSB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	LSB
		Primary Header	1	Version			Type	Sec Hdr	APID								
	0		0	0	1	1	0	1	1	1	1	0	1	0	1	0	0
2	Seq. Flags		Packet Sequence Count														
		0	0														
	3	Packet Length															

APID: 980, 981

FIGURE 3.1.2.2-3 PRIMARY HEADER – AMS-02 PAYLOAD-TO-PAYLOAD

Field ID	Bit# Wd#	MSB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	LSB
		Primary Header	1	Version 0 0 0			Type 1	Sec Hdr 1	APID X X X X X X X X X X X X X X X								
2	Seq. Flags 0 0		Packet Sequence Count														
3	Packet Length																
Secondary Header	4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	7	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

APID: N/A
X: DON'T CARE

FIGURE 3.1.2.2-4 PAYLOAD DATA HEADER – HEALTH AND STATUS TO PAYLOAD MULTIPLEXER/DEMULTIPLEXER

Field ID	Bit# Wd#	MSB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	LSB	
		Primary Header	1	Version 0 0 0			Type 1	Sec Hdr 1	1	0	0	0	0	0	0	0	0	0
2	Seq. Flags 1 1		Packet Sequence Count															
3	Packet Length																	
Secondary Header	4	Time (MSB)																
	5	Time (LSB)																
	6	Fine Time								Time ID 0 1		Chk Wd 0	Spare 0	Packet Type 0 1 0 0				
	7	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
	8	Subset ID																

APID: 1024
X: DON'T CARE

FIGURE 3.1.2.2-5 HEADER – MULTIPLEXER/DEMULTIPLEXER TO PAYLOAD (RESPONSE TO REQUEST)

Field ID	Bit# Wd#	MSB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	LSB	
		Primary Header	1	Version			Type	Sec Hdr	APID									
2	Seq. Flags		Packet Sequence Count															
3	Packet Length																	
Secondary Header	4	Time (MSB)																
	5	Time (LSB)																
	6	Fine Time									Time ID		Chk Wd	Spare	Packet Type			
	7	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

APID: 1024
X: DON'T CARE

**FIGURE 3.1.2.2-6 HEADER – MULTIPLEXER/DEMULTIPLEXER TO PAYLOAD
(FILE TRANSFER – READ)**

Field ID	Bit# Wd#	MSB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	LSB
		Primary Header	1	Version			Type	Sec Hdr	APID								
2	Seq. Flags		Packet Sequence Count														
3	Packet Length																
Secondary Header	4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	7	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

APID: DON'T CARE
X: DON'T CARE

**FIGURE 3.1.2.2-7 HEADER – PAYLOAD TO MULTIPLEXER/DEMULTIPLEXER
(FILE TRANSFER – WRITE)**

Field ID	Bit# Wd#	MSB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	LSB	
		Primary Header	1	Version			Type	Sec Hdr	APID									
	0		0	0	1	1	0	0	0	0	1	1	1	1	1	0	0	
2	Seq. Flags		Packet Sequence Count															
	1	1																
	3	Packet Length																
Secondary Header	4	Time (MSB)																
	5	Time (LSB)																
	6	Fine Time									Time ID		Chk Wd	Spare	Packet Type			
											0	1	1	0	1	0	1	0
	7	Spare	Packet/Element ID				Cmd/ Data Pkt	Spare		LDP								
		0	0	0	0	1	0	0	0	1	1	1	1	0	0	1	0	
	8	Subset ID																

APID: 124
LDP: 183

FIGURE 3.1.2.2-8 HEADER - UPLINK

3.2 LOW RATE DATA LINK

3.2.1 LOW RATE DATA LINK INTERFACE

The LRDL is comprised of two types of packets: data and command. The AMS-02 payload C&DH interface to the ISS LRDL data handling system is depicted in Figure 3.2.1-1, AMS-02 LRDL Interface to the ISS C&DH System. All interfaces with the PL MDM will be accomplished via MIL-STD-1553B, Military Standard Digital Time Division Command/Response Multiplex Data Bus, with the payload acting as a RT.

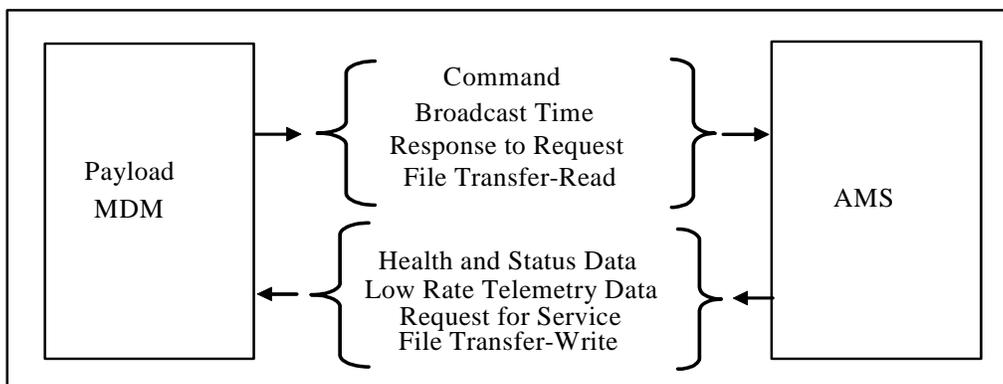


FIGURE 3.2.1-1 AMS-02 LRDL INTERFACE TO THE ISS C&DH SYSTEM

3.2.2 LOW RATE DATA LINK DATA PACKETS

All LRDL data packets are either a receive data packet (Multiplexer/Demultiplexer [MDM] to payload) or a transmit data packet (payload to MDM). AMS-02 uses LRDL transmit data packets for health and status, request for service, file transfer, and (when selected) Low Rate Telemetry (LRT). LRDL receive data packets are used for ancillary data, file transfer, time, and response to request functions.

3.2.2.1 LRT PACKET FORMAT

The LRT data packets must be greater than or equal to 50 words and cannot exceed 640 words. LRT data packets are transmitted in 32-word messages. The format of the first message of the AMS-02 LRT data packet is shown in Figure 3.2.2.1-1, AMS-02 LRT Data Packet First Message Format. For all subsequent messages, AMS-02 can use all 32 data words.

Field ID	Bit# Wd#	MSB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	LSB
		Headers	1 through 8	Header Words (see Paragraph 3.1.2.2)													
User Data	9	User Data Word # 1															
	10	User Data Word # 2															
	⋮	⋮															
	n	User Data Word # n-8															
	⋮	⋮															
	32	User Data Word # 24															

FIGURE 3.2.2.1-1 AMS-02 LRT DATA PACKET FIRST MESSAGE FORMAT

3.2.2.2 HEALTH AND STATUS (H&S) PACKET FORMAT

The format of the AMS-02 payload health and status data packet is shown in Figure 3.2.2.2-1, AMS-02 H&S Data Packet. The size of the health and status packet cannot exceed 1280 words.

Field ID	Bit# Wd#	MSB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	LSB
		Headers	1 through 8	Header Words (see Paragraph 3.1.2.2)													
User Data	9	Subset ID (308)															
	10	Service Request ID															
	11	Service Request Data															
	12	Caution and Warning															
	13	H&S Cycle Counter															
	14	Payload Message (optional)															
	15	Data Word 1 (CHD Word 1) of Subset (308)															
	⋮	⋮															
	24	Data Word 10 (CHD Word 10) of Subset (308)															
	⋮	⋮															
n	Data Word n ₁ of Subset (308)																

FIGURE 3.2.2.2-1 AMS-02 H&S DATA PACKET

3.2.2.2.1 CRITICAL HEALTH DATA

With regard to the ISS vehicle, AMS-02 is “safe without services”, but with regard to mission success, AMS-02 requires continuous visibility into the current payload state. The AMS-02 defined Critical Health Data (CHD) consists of the first 10 bytes of data in subset 308 and provides the required visibility. Pending Payload Safety Review Panel (PSRP) and Avionics Software Control Board (ASCB) approval, the CHD bytes are to be marked as “Safety Data” (as per SSP 52050, Paragraph 3.2.3.6) in the PL MDM’s Operational Status Data Table (OSDT) configuration such that they are transmitted to the Command and Control (C&C) MDM and are hence transmitted down the S-Band link as part of the ISS Payloads Safety dataset.

3.2.2.3 LRDL PACKET DEFINITION

The AMS-02 packet definition, conversion coefficients, exception monitoring limits, and ground processing requirements are defined in Appendix A, Payload Telemetry and Command Definition Tables.

3.2.2.4 ISS SUBSYSTEM ANCILLARY DATA SETS

Payloads can select from a list of existing ancillary data sets or request additional parameters be added to a data set. Unique Ancillary Data that is required by the AMS-02 is identified in Appendix B.

3.2.3 LRDL COMMAND PACKETS

LRDL command packets are executable commands issued to the payload. All LRDL command packets consist of two 32-word messages. This includes CCSDS header words, spare word, Legal Station Mode word, and checksum word as overhead and up to 53 command data words.

3.2.3.1 LRDL COMMAND PACKET FORMAT

The format of a maximum length (64 words including overhead) AMS-02 LRDL command packet is shown in Figure 3.2.3.1-1, AMS-02 LRDL Command Packet Message Format. In the second message all 32 words (including checksum) are available. All CCSDS command packets contain a checksum. The checksum is calculated by adding the set of 16 bit words and ignoring any overflow. All AMS-02 commands are padded up to 64 words by the PL MDM prior to transmission over the 1553 bus.

MESSAGE #1		
Word #	Description	Function
1	Header Word 1	CCSDS Primary Header
⋮	⋮	⋮
3	Header Word 3	CCSDS Primary Header
4	Header Word 4	CCSDS Secondary Header
⋮	⋮	⋮
8	Header Word 8	CCSDS Secondary Header
9	Spare	Spare
10	Mode	Legal Station Mode
11	Data Word 1	Command Data
⋮	⋮	⋮
23	Data Word 13	Last PD defined word (minimum length command)
24	Data Word 14 / Checksum	Checksum (minimum length command)
⋮	⋮	⋮
32	Data Word 22	Command Data
MESSAGE #2		
Word #	Description	Function
1	Data Word 23	Command Data
⋮	⋮	⋮
32	Checksum	Checksum (maximum length command)

FIGURE 3.2.3.1-1 AMS-02 LRDL COMMAND PACKET MESSAGE FORMAT

3.2.3.2 LRDL COMMAND PACKET DEFINITION

The AMS-02 payload LRDL command parameters, content, and packets are defined in Appendix A.

3.3 MEDIUM RATE DATA LINK

3.3.1 MRDL INTERFACE

AMS-02 does not have a payload software interface to the ISS MRDL data handling system.

3.3.2 MRDL 802.3 ETHERNET FORMAT

This section is not applicable to AMS-02.

3.3.3 MRDL DATA PACKETS

3.3.3.1 MRDL DATA PACKET DEFINITION

AMS-02 does not have MRDL telemetry data packets.

3.4 HIGH RATE DATA LINK

3.4.1 HRDL INTERFACE

The payload software interface to the ISS HRDL data handling system is depicted in Figure 3.4.1-1, AMS-02 HRDL Interface to the ISS C&DH System. Payload high rate data is routed to the Automated Payload Switch (APS).

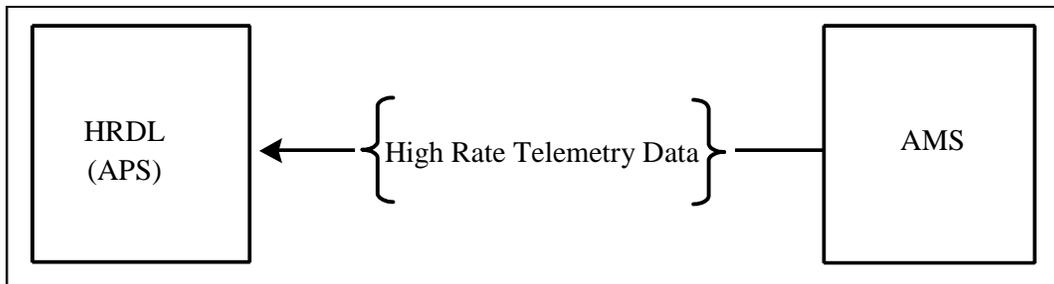


FIGURE 3.4.1-1 AMS-02 HRDL INTERFACE TO THE ISS C&DH SYSTEM

3.4.2 HRDL DATA PACKETS

3.4.2.1 BITSTREAM FORMAT

HRDL bitstream data is not used by AMS-02.

3.4.2.2 HRDL DATA PACKET FORMAT

The format of the CCSDS HRDL data packet is shown in Figure 3.4.2.2-1, AMS-02 HRDL Data Packet Format.

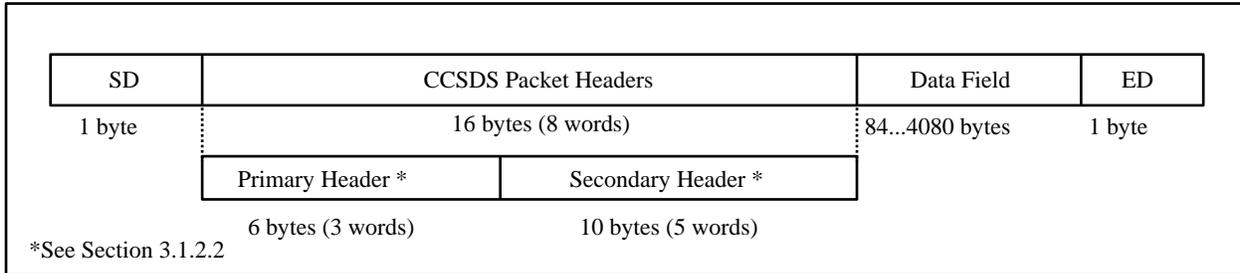


FIGURE 3.4.2.2-1 AMS-02 HRDL DATA PACKET FORMAT

3.4.2.3 HRDL DATA PACKET DEFINITION

The AMS-02 payload HRDL interface is defined in Appendix A.

4.0 ABBREVIATIONS, ACRONYMS AND DEFINITIONS

4.1 ABBREVIATIONS AND ACRONYMS

AMS-02	Alpha Magnetic Spectrometer-02
ANSI	American National Standards Institute
APID	Application Process Identifier
APS	Automated Payload Switch
ASCB	Avionics Software Control Board
C&C	Command and Control
C&DH	Command and Data Handling
CAL	Calibration
CCSDS	Consultative Committee for Space Data Systems
CHD	Critical Health Data
Chk	Check (Abbreviation)
Cmd	Command (Abbreviation)
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
Def	Definition (Abbreviation)
ED	End Delimiter
EXPRESS	EXpedite the PROcessing of Experiments to Space Station
H&S	Health & Status
Hdr	Header (Abbreviation)
HOSC	Huntsville Operations Support Center
HRDL	High Rate Data Link
HRF	Human Research Facility
HRFM	High Rate Frame Multiplexer
HRT	High Rate Telemetry
Hz	Hertz
ICD	Interface Control Document
ID	Identifier
IEEE	Institute of Electrical and Electronics Engineers

Init	Initialization (Abbreviation)
ISO/IEC	International Organization for Standardization/International Electrotechnical Commission
ISPR	International Standard Payload Rack
ISS	International Space Station
kBytes	Kilobytes
LAB1O2	United States Laboratory 1, Overhead Position 2 (Abbreviation)
LAN	Local Area Network
LDP	Logical Data Path
LES	Limits, Expected State
LRDL	Low Rate Data Link
LRT	Low Rate Telemetry
LSB	Least Significant Bit
Mbps	Megabits per second
MDM	Multiplexer/Demultiplexer
millisec	Millisecond(s) (Abbreviation)
MRDL	Medium Rate Data Link
MRT	Medium Rate Telemetry
MSB	Most Significant Bit
MSFC	Marshall Space Flight Center
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
OSDT	Operational Status Data Table
Param	Parameter (Abbreviation)
PCS	Portable Computer System
PD	Payload Developer
PDL	Payload Data Library
PEHG	Payload Ethernet Hub/Gateway
Pkt	Packet (Abbreviation)
PL	Payload

PL MDM	Payload Multiplexer/Demultiplexer
POIC	Payload Operations Integration Center
Proc	Process(ing) (Abbreviation)
PSI	Payload Software Integration
PSRP	Payload Safety Review Panel
PUI	Program Unique Identifier
Rev	Revision (Abbreviation)
RT	Remote Terminal
SD	Start Delimiter
Sec	Secondary (Abbreviation)
Seq	Sequence (Abbreviation)
TDM	Time Division Multiplexed
TLM	Telemetry
USL	United States Laboratory
USOS	United States On-orbit Segment
Wd	Word (Abbreviation)
WORF	Window Observational Research Facility
ZOE	Zone of Exclusion

4.2 DEFINITIONS

Ancillary Data	Ancillary Data is a collection of data which is disseminated between various ISS/Payload components.
Application Process Identifier	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
Bitstream Data	An undelimited apparently equal weighted string of bits, which appears unstructured to a service provider.
Byte	A byte is a set of bits representing a value and can vary in number of bits per set such as 4 bits per byte, 8 bits per byte, etc. The bytes referenced in this document are assumed to be 8 bits per byte (octet).
Consultative Committee for Space Data Systems	CCSDS is an organization officially established by management of member space agencies for addressing data system problems with accompanying recommended technical solutions.
Data Packets	A variable length, delimited data structure encapsulating sets of higher-layer user data within a standard header message.
High Rate Data Link	HRDL is a fiber optic network interface capable of transferring up to 100 Megabits per second (Mbps) of data point to point. The length of a CCSDS packet for a HRDL interface with the High Rate Frame Multiplexer (HRFM) can range from 100 bytes to 4096 bytes. Payloads can also transfer data to other payloads over the HRDL and the protocols/format is payload-defined.
Least Significant Bit	The low-order bit within a multiple bit field.
Limit Sensing	The Payload MDM provided limit sensing feature was designed to support data sampled at a rate of 1 Hertz (Hz) or once per second. The parameter selected to be limit sensed is checked once per second and an out-of-limits counter will be incremented if the parameter is found to be out-of-limits.
Local Area Network	Local Area Network (LAN) is the Ethernet used for MRDL data with bit rates up to 10 Mbps.
Low Rate Data Link	LRDL refers to data packet communications over the MIL-STD-1553B data bus.

Logical Data Path	The Logical Data Path (LDP) is the path used for transferring user data between a known source and destination as derived from the APID table. The management between relay points in the link is predefined by configuration tables using the APID as a reference to select the proper path ID.
Medium Rate Data Link	MRDL refers to data packet communications over the Ethernet Local Area Network within a packet of 100 to 1500 8-bit bytes.
Most Significant Bit	The high-order bit within a multiple bit field.
Octet	A collection of 8 bits.
Payload Ethernet Hub/Gateway	Payload Ethernet Hub/Gateway (PEHG) is a central hub or repeater for distributing Ethernet IEEE 802.3 packets to all active output ports.
Program Unique Identifier	Program Unique Identifiers (PUIs) are uniquely defined and are used for identification of (1) software requirements, (2) ISS signals generated or utilized by the design elements, (3) hardware and software devices, (4) buses utilized by the ISS MDMs and Firmware Controllers, and (5) state conversion and calibration curves required to interpret data signals.
Telemetry	A term used to characterize the generation of continuous and predictable sets of space mission measurement data which have a large interaction with overall communications resources.
Timeliner	The Timeliner is a piece of Government Furnished Software that is included in the Command and Control (C&C) MDM and the Payload MDM. It is an automated procedure executive, which can be used to execute a string of commands based on both time of execution and/or logical expressions.
Timeliner Bundles	The Timeliner “bundles” refer to the set of procedures used to control the invocation of the 1 Hz cyclic Timeliner Executor tasks.
Word	Words as used in this document consist of 16 bits.

APPENDIX A
PAYLOAD TELEMETRY AND COMMAND
DEFINITION TABLES

The information provided in this section is for reference. This data is available in the AMS-02 C&DH data sets for Flight ULF-2 in PDL, and conforms to the definition provided in SSP 57002, Payload Software Interface Control Document Template.

AMS-02 REPORTS

A-1	PL Data	AMS-02
A-2	Rack Data	AMS-02
A-3	Param Init	AMS-02
A-4	Param Def	AMS-02
A-5	Ground Proc	AMS-02
A-6	CAL/LES Point Pairs	NONE
A-7	CAL/LES Polynomials	NONE
A-8	CAL/LES State Codes	NONE
A-9	Expected States	NONE
A-10	Limit Sensing	NONE
A-11	Onboard Proc	NONE
A-12	Onboard Proc PL MDM	NONE
A-13	PCS	NONE
A-14	Onboard Proc Polynomials	NONE
A-15	Linear	NONE
A-19	Packet	AMS-02
A-20	Content Def	AMS-02
A-21	Counter Def	NONE
A-22	Subset Format	AMS-02
A-23	Subset Content Def	AMS-02
A-24	Command Init	AMS-02

AMS-02 REPORTS

A-25	Command Def	AMS-02
A-26	Command PLMDM	AMS-02
A-27	POIC/Remote	AMS-02
A-28	TLM Verification	NONE
A-29	Field Init	AMS-02
A-30	Field Def	AMS-02
A-31	Command Point Pairs	NONE
A-32	Command Polynomials	NONE
A-33	Command State Codes	NONE
A-34	Broadcast	AMS-02
A-35	Ancillary	NONE
A-36	File Transfer	AMS-02
A-37	Timeliner	NONE
A-38	Video	NONE

APPENDIX B
ANCILLARY DATA SETS

AMS-02 does not require Ancillary Data Sets.

APPENDIX C

PAYLOAD SOFTWARE INTEGRATION AND VERIFICATION LIMITS REPORT

Not applicable to AMS-02

APPENDIX D

GENERAL

The information provided in this section is for reference.

APIDs for AMS-02 are:

(decimal)	(hex)	<u>FROM</u>	<u>TO</u>
124	7C	Uplink (POIC)	AMS-02
976	3D0	AMS-02	Ku-band Downlink
977	3D1	AMS-02	Ku-band Downlink
980	3D4	AMS-02	Ku-band Downlink
981	3D5	AMS-02	Ku-band Downlink
1024	400	Payload MDM	AMS-02

The following subset IDs are identified in Table A-2, and are repeated here for reference:

(decimal)	(hex)	
308	134	AMS-02