AMS-02 Telemetry Interface Control Document

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AMS-02 Telemetry Interface Control Document

Author:	**Peter Dennett/PADSOFT, Inc**		
	Name and Organization	Signature	Date
Author:	**Alexei Lebedev/MIT**		
	Name and Organization	Signature	Date
Checked:	**Michael H. Capell/MIT**		
	Name and Organization	Signature	Date
Approved:			
	Name and Organization	Signature	Date

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1 Introduction

This document presents the formats and strategies for AMS-02 telemetry handling during its three-year mission to ISS.

2 Telemetry Types

All AMS-02 telemetry, except the Critical Health Data, is composed of AMS Blocks. An AMS Block represents a particular set of data from a particular node within the AMS-02 system (more details later in this document). AMS Blocks are gathered together to form streams of data.

There is no fixed mapping of AMS Blocks to a particular stream and in fact any particular AMS Block can occur in any or many streams. NASA assigned "Application Process Ids" - APID numbers are used to identify AMS Streams.

The following sections describe the types of streams and data types that exist in the AMS-02 system. Most stream types have only a single manifestation. Some stream types may be manifested on more then one interface.

2.1 AMS-02 House Keeping Data Stream

AMS-02 produces a stream of data indicating the state of most components within the experiment. This includes measured observations such as voltages, pressures, and temperatures, performance statistics, detector operational information, and other information needed to assess the condition of the experiment.

The proper operation of AMS-02 requires near real time ground access to all of this data.

2.2 AMS-02 Science Data Stream

The purpose of AMS-02 is to gather observations of particles entering its detectors. Each observation of such particles is called an event. The frequency of events varies considerably based on acceptance algorithms, natural phenomena, and orbital position. The data size of each event varies significantly upon the type or nature of the observation. Event data is gathered into a stream.

Much or all of the House Keeping Data Stream is required to produce valid science. Thus most, if not all, AMS Blocks that are included within the House Keeping Data Stream are introduced into this data stream to preserve its temporal position within the event data.

AMS-02 has considerable buffering abilities used to average the event data rates to the targeted 2Mbits/second rate. The successful gathering of science from AMS-02 requires near real time access to at least a statistical sampling of this data. The quality control data is used to provide calibration and tuning for the detectors.

2.3 Critical Health Data

AMS-02 is always safe toward the ISS facility and crew but it is not always safe to itself. The Critical Health Data is an AMS-02 caution and warning summary of the health of the experiment. This summarizes temperature, voltage, and other measurements into the fewest possible bits for inclusion with the ISS S-Band data.

The proper operation of AMS-02 requires continuous near real time access to this data. To resolve any anomalies reported by the Critical Health Data requires access to the House Keeping Data.

2.4 AMS-02 Ground and Crew Command Stream

AMS-02 requires direction from ground controllers to operate. The commands will originate from both the AMS-02 POCC and NASA systems (JSC or HOSC).

Additionally a means for crew commanding has been provided for. On ISS crew commands originate ether from ACOP or the ISS laptop associated with the PLMDM servicing AMS-02. During checkout on STS crew commands originate from the Digital Data Recording System 2 (DDRS2).

2.5 AMS-02 Command Reply Data Stream

All commands to AMS-02 result in a reply. For each command stream there is a reply stream. Replies for a command stream are directed to the appropriate reply stream.

2.6 Payload to Payload Communications

AMS-02 requires full time full duplex communication with its pressure volume support systems DDRS2 and ACOP. Since the data volumes in both directions are substantial it is only foreseen to utilize the high-speed links, RS422 and HRDL, for these communications. No usage of payload-to-payload commanding via 1553 is foreseen.

Payload to payload communications is implemented as paired command/reply streams.

3 AMS-02 CCSDS and Frame Headers

3.1 Supporting Documents

The document SSP57003 “International Space Station Program Attached Payload Interface Requirements Document” levies requirements on AMS-02. This document defers the definitions for CCSDS headers to SSP52050 “SOFTWARE INTERFACE CONTROL DOCUMENT PART 1, INTERNATIONAL STANDARD PAYLOAD RACK TO INTERNATIONAL SPACE STATION”. This document in turn refers the base definitions of CCSDS headers to SSP41175-2 “SOFTWARE INTERFACE CONTROL DOCUMENT STATION MANAGEMENT AND CONTROL TO INTERNATIONAL SPACE STATION BOOK 2, GENERAL SOFTWARE INTERFACE REQUIREMENTS”.

Used to prepare this document:

SSP57003 Version A Aug 5, 2002
SSP52050 Revision D June 8, 2001
SSP41175-2 Revision F March 1, 2002

3.2 Frame Header Layout

All AMS-02 data communicated externally is transmitted and received as AMS Frames of data. Each AMS Frame begins with a set of CCSDS and AMS headers. The CCSDS system has two headers, a required primary header and an optional (but required by NASA in most cases) secondary header. AMS-02 attaches a required AMS Primary Frame Header after the CCSDS header(s) and optionally an AMS Secondary Frame Header.

The CCSDS headers and AMS-02 data are organized in terms of 16-bit words. The following table introduces the various values within the AMS Frame headers. The details of implementation of these headers and data layouts is addressed later on a per interface basis.

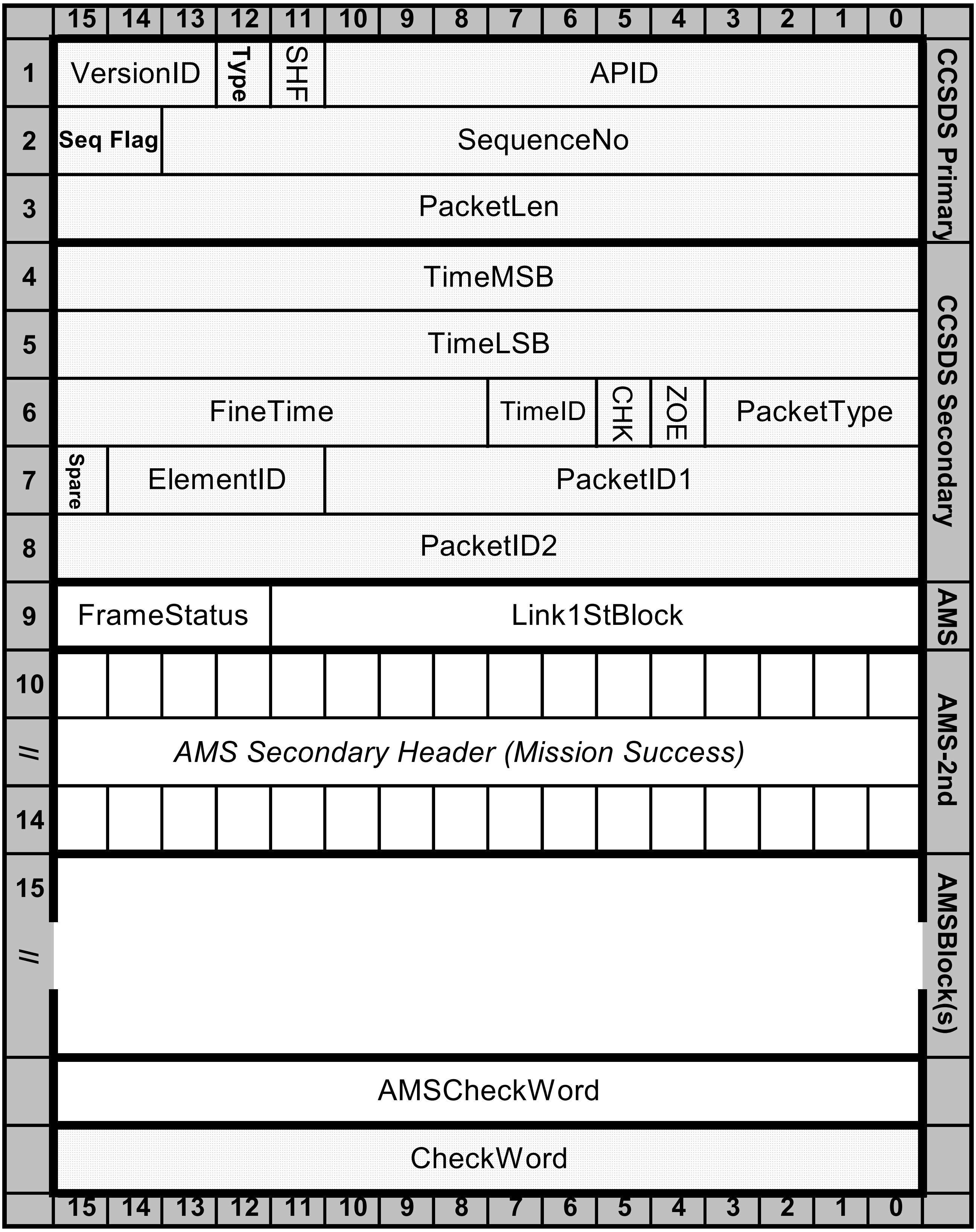

Figure 1 AMS Frame Header Layout

3.3 Definition of Fields in Headers

This table defines the valid values, the values AMS-02 utilizes, and comments on the purpose of each field.

Item Location [1]	**Valid Values**	**AMS-02 Usage for frames received**	**AMS-02 Usage for frames transmitted**	**Comment**
VersionID 1.15.3	0	Ignore for frames received.	0 for frames generated	Version number for CCSDS packet format (does not change)
Type 1.12.1	0=Core 1=Payload	Ignored on frames received.	1 for frames generated.	Distinguishes between core and payload packet types to extend the APID space to 4032
SHF 1.11.1	1=Present 0=Not present	On receipt is honored.	1 for frames generated.	Indicates whether, or not, a Secondary Header follows the primary header. Currently required (always set to 1). AMS-02 however supports this value being 0 or 1 on all interfaces.
APID 1.10.11	0 – 2031	As assigned by NASA. See Section 3.4 Frames received with invalid APIDs are an error and should be handled as appropriate. (TBD)	As assigned by NASA, usage as defined within this ICD.	Application Process ID. Used to determine the data path by NASA and the data stream by AMS-02.

[1] This area contains the word.start-bit.number-bits

Item Location [1]	Valid Values	AMS-02 Usage for frames received	AMS-02 Usage for frames transmitted	Comment
SeqFlag 2.15.2	00 – Continuation 01 – First segment 10 – Last segment 11 – Unsegmented	Ignored for frames received.	00 for frames generated.	Not used by C&DH – Maybe used per source/destination ICDs.
SequenceNo 2.13.14	0 – 16383	Used for de-frame of frames received to detected number of lost blocks.	For frames generated this is a sequence within the APID (stream).	Sequential count which numbers each packet on a Logical Data Path, i.e., a separate counter is maintained for each source-destination pair (APID)
PacketLen 3.15.16	0 – 65535	0 – 4084	0-4084	Sequential count which expresses the length of the remainder of the CCSDS packet including checkword if present. The value is the number of bytes (octets) following this field minus 1.
TimeMSB 4.15.16	0 – 65535	Most significant 16 bits of time in seconds.	Most significant 16 bits of time in seconds	The time value represents the elapsed time since midnight 5-6 January 1980. The least significant bit (LSB) of the least significant octet of coarse time is equal to 1 second.
TimeLSB 5.15.16	0 – 65535	Least significant 16 bits of time in seconds.	Least significant 16 bits of time in seconds	See above.
FineTime 6.15.8	0 – 255	TBD	TBD	The LSB of this field is equal to 2^{-8} second or about 4 ms

Item Location [1]	Valid Values	AMS-02 Usage for frames received	AMS-02 Usage for frames transmitted	Comment
TimeID 6.7.2	00 – Time not used 01 – Cmd auth or data 10 – Time tag cmd 11 – Not used	Ignored for frames received.	01 – for frames generated.	The time field is always present. This field indicates its use. For Data Packets, the field is always 01 and the time fields contain the time at the beginning of the processing frame when the packet was generated Other values are for command processing
CHK 6.5.1	0 - Not present 1 – Present See comments.	If present in received frames the last word of the frame is not considered to be AMS data. It may be checked.	0 – for frames generated.	This field indicates if a checkword (add without carry checksum) is contained in the CCSDS packet. When present, the checkword is the last 16-bit word of the packet. All commands must contain a checkword. Data packets do not contain a checkword.
ZOE 6.4.1	0 – Frame from onboard ZOE recording 1 – All others	Ignored for frames received.	0 for frames generated.	Used in a telemetry data packet to indicate that the telemetry packet is from the onboard ZOE recording.

Item Location [1]	Valid Values	AMS-02 Usage for frames received	AMS-02 Usage for frames transmitted	Comment
PacketType 6.3.4	0001 – Data dump 0100 – Telemetry 0110 – Private Sci 0111 – Ancillary 1000 – Ess Cmd 1001 – Sys Cmd 1010 – RT/PL Cmd 1011 – Data Load	Ignored for frames received (all frames received are treated as commands in NASA speak).	0110 – for frames generated.	Used to distinguish type of packet for data packets and command packets.
Spare 7.15.1		Ignore on receipt.	0 for frames generated	Not used - set to zero (NOTE: AMS-02 might be able to use this.)

Item Location [1]	Valid Values	AMS-02 Usage for frames received	AMS-02 Usage for frames transmitted	Comment
ElementID 7.14.4	0000 – NASA 0001 – NASA 0100 – RSA 0101 – CSA 0010 - ESA/APM 0110 – ESAATV 0011 – NASDA 0111 – ASI 1000 – ESA/ERA ~~1001 – NASA ISPR~~ 1010 – SPP 1011 – HTV 1100 - 1111 – Spare	Ignored for frames received.	For frames generated 1111 (TBR).	Packet ID is Element-dependent, as defined by these 4 bits. The remaining 27 bits will be parsed into additional fields to support command-processing functions. It identifies the agency responsible for packet definition.
PacketID1 7.10.11	Per SSP41175-02 Table 3.3.2.1.1-4	Ignored for frames received.	0x0 For frames generated.	This value depends on the ElementID field.
PacketID2 8.15.16	Per SSP41175-02 Table 3.3.2.1.1-4	Ignored for frames received. ISS 1553 HK: Bits 6-0 are a FrameID a 0-99 counter. I think we need to handle this and coordinate our Critical Health Data output with it.	0x0 For frames generated.	This value depends on the ElementID field. AMS GSE testing uses these two bytes to specify the test pattern format. See AALGEN for details.

Item Location [1]	**Valid Values**	**AMS-02 Usage for frames received**	**AMS-02 Usage for frames transmitted**	**Comment**
FrameStatus 9.15.4	Bit Mask 1xxx – Randomize x1xx – CRC xx1x – xxx1 – AMSSHF	Logical or of valid values	Logical or of valid values	CRC – This frame has a CRC placed at the end, similar to NASA check word. Randomize – This frame has been pseudo-randomized for STS KU transmission. See Section 7.2.2 AMSSHF – AMS Secondary Header Flag. If present the frame has a 10 byte AMS Secondary Header.
Link1StBlock 9.11.12	FFF – Fill frame FFE – No block starts 0 – FFD	As appropriate.	As appropriate	Pointer to first AMS Block in the frame. It is possible that no block starts in the frame in which case this pointer is 0xFFE. If the frame is a fill frame to be ignored the value is 0xFFF. The pointer is relative to the first byte after all headers for the frame.
AMSCheckWord	TBP			AMS CRC value if FrameStatus has CRC bit set.
CheckWord	TBP			AMS-02 supports the presence of, but does not use the NASA check word.

3.4 APID Utilization

AMS-02 Data is logically organized as streams of data. Each data stream is recognized by the APID of its frame. (See Section 2 for more details).

Symbolic APID	Stream Represented
AMS02HK	AMS-02 House Keeping Data Stream.
AMS02SCI	AMS-02 Science Data Stream.
AMS02CMD	Commands from ground to AMS-02
AMS02REPLY	Replies to commands from AMS02CMD.
ACOPHK	ACOP House Keeping Data Stream.
ACOPSCI	ACOP Science Data (telemetry down load of recorded data).
ACOPCMD[2]	Commands to and from ACOP.
ACOPREPLY[3]	Replies to and from ACOP.
AMS02FILL	NASA defined fill frame APID – 0x7FF

Figure 2 APID Symbolic Values

3.5 APID Test and Development Values

Pending assignment of flight values, this table defines the values used for the testing and development of AMS-02.

Symbolic Name	Testing Value	NASA Assigned Value
AMS02HK	0x10	**TBP**
AMS02SCI	0x11	
AMS02CMD	0x12	
AMS02REPLY	0x13	
ACOPHK	0x20	
ACOPSCI	0x21	
ACOPCMD	0x22	
ACOPREPLY	0x23	
AMS02FILL	0x7FF	0x7FF

Figure 3 APID Test and Development Values

4 Boot Command Format

Each telemetry interface to AMS-02, except 1553, supports a boot command. This command is used to reset and reboot one (by selection) of four Main Data Computers (MDC). The firmware in each interface uses well-known key values in each frame to determine if this frame represents a boot command. The boot command is in fact an AMS Frame containing a normal AMSBlock placed as the first (and only) AMSBlock within the frame.

[2] While this is a private payload-to-payload stream this APID will appear in downlink data due to the nature of the APS tee function.

[3] See note 2.

The following table addresses values used to determine if a frame represents a boot command.

Field	Tested For	Comments
VersionID		Not tested.
Type		Not tested.
SHF	1	Secondary header must be present
APID		Not tested
SeqFlag		Not tested
SequenceNo		Not tested
PacketLen	Upper four bits must be zero	All frames are less than 4096 bytes
TimeMSB		Not tested.
TimeLSB		Not tested.
FineTime		Not tested.
TimeID		Not tested.
CHK		Not tested.
ZOE		Not tested.
PacketType		Not tested.
Spare		Not tested.
ElementID		Not tested.
PacketID1		Not tested.
PacketID2		Not tested.
FrameStatus	Must equal 0	Must be all zero bits.
Link1StBlock	Must be zero	First AMS block header must start in next word.
AMS Frame Body	See comments	First 16-bit word not tested Second 16-bit word must be b'0100 0000 0000 xx00' where xx represents the MDC geographical address to boot. Remainder of AMSFrameBody field is do not care.
CheckWord		Not tested.

Figure 4 Boot Command Fields Checked

5 Introduction To 1553 [4]

MIL-STD-1553 is a military standard that defines the electrical, mechanical and timing specifications for a dual-redundant communication network that interconnects cooperating digital units in a system. This communication network, also referred to as a data bus. MIL-STD-1553 is a 1Mbit/sec bus. It is a highly reliable bus, both because of its extremely low error rate (one word fault per 10 million words), and because of its dual-redundant architecture.

[4] Paraphrased from various web pages

5.1 General

MIL-STD-1553 is a data bus that interconnects up to 31 terminals (referred to as Remote Terminals, or RT's), controlled by a single controller unit (referred to as the Bus Controller, or BC). All of the RT's, and the BC, are connected using two separate busses. These are named the Primary Bus (or bus 'A') and the Secondary Bus (bus 'B'). Messages are normally transferred only on the primary bus. If a message fails to be transferred over one bus, transfer may be retried on the other bus.

5.2 Bus Controller (BC)

The BC is the only entity that can initiate the transfer of a message over the bus. In a typical MIL-STD-1553 bus, the BC has a predefined sequence of messages that it repeats indefinitely.

5.3 Remote Terminal (RT)

An RT can send out up to 30 different messages (numbered 1 through 30), and receive up to 30 other messages (also numbered 1 through 30). The number of the message in an RT is referred to as a Sub Address. Each message can hold between 1 and 32 data words, 16 bits per word. An RT sends or receives data only when instructed to do so by the BC.

5.4 Message Types

There are four basic kinds of messages that the BC can cause to be transferred over the bus. These include RT to RT, RT to BC, BC to RT and Mode Commands.

- In an RT-to-RT message, the BC instructs one RT to be prepared to receive a certain number of words into one of its sub addresses, and then instructs another RT to send that number of data words from one of its sub addresses. Both RT's are ignorant of each other. All they concern themselves with are commands from the BC.

- In an RT to BC message, the BC instructs an RT to transmit a certain number of data words from one of its sub addresses, and then reads the data words that the RT transmits.

- In a BC to RT message, the BC instructs an RT to be prepared to receive a certain number of data words, and then transmits that number of data words to the RT.

- Mode Command messages are used for management of the bus. They include a variety of message, including, for example, requests from an RT to shut down it transmitter, or to send the results of the last built-in-test that it performed. Mode command message are short, and contain one or no data words.

5.5 Message Transfers

To understand how message transfer is accomplished, we must discuss the types of data words that MIL-STD-1553 uses. Words in MIL-STD-1553 always contain 16 bits of data. Each word is followed by a parity bit, and preceded by a special sync pattern, 3 bits in length. This sync pattern distinguishes between data words (words that carry pure data), and command and status words (non-data words). The BC sends Command Words to RT's to instruct them to receive or transmit data, or to perform some operation. RT's send out Status Words to notify the BC of any problems they experience while carrying out a BC's command, and of their general status.

To cause an RT to send data out, or to receive data, the BC must send out a command word that specifies the number of the RT and the sub-address within that RT. The command word specifies whether the RT should transmit or receive data words, and also indicates the number of these data words.

Whenever an RT is commanded to transmit data, it immediately responds with a status word that indicates to the BC that its command was accepted. The BC waits for this status word, up to a certain limit, after which it flags an RT Response Time error. After sending out the status word, the RT proceeds with transmission of the requested number of data words. The BC waits for the RT to send out the agreed number of words, after which the transmitting RT's job is done. If the RT sends out too few or too many data words, the BC flags an error.

Whenever an RT is commanded to receive data, it waits for the specified number of data words to appear on the bus (regardless of which entity transmits them). Once the specified number of data words is received, the RT responds with a status word that the BC waits for. In this status word, the RT indicates the success of the transfer, as far as it is concerned. If too few or too many words were received, the status word flags an error. Upon reception of the status word, the BC in turn examines the status word, and flags an error if one is flagged in that word. If the status word fails to arrive from the RT, the BC flags an RT Response Time error.

5.6 Mode Commands

Mode commands are special messages that are distinguished from normal messages (RT to RT, RT to BC and BC to RT) by making use of sub-addresses 0 or 31. These two sub-addresses are reserved for mode commands

5.7 Broadcast Messages

RT number 31 is reserved for broadcast messages. When the BC sends out a command word with this RT number, all RT's become prepared to receive the data words that follow. None of them responds with a status word once all data words are received, in order not to cause any collision.

6 Introduction to HRDL on ISS

The High Rate Data Link (HRDL) on ISS is a simplex link composed of a transmit station and receive station linked with optical fiber to the Automated Payload Switch (APS). Each payload site has both a transmit link and a receive link. The logical organization of HRDL is shown in Figure 5 High Rate Data Link Design.

The APS converts the optical signal to a copper based signal, provides an electrical cross bar switching and then optical signal regeneration to either one (point to point) or two (tee connection) HRDL devices on ISS. Cross bar connections within the APS are controlled by ground commanding as needed to manage telemetry and interconnections for ISS. Cross bar connections are independent for the transmit and receive links. The number of total connections supported within the APS is a limited resource requiring ISS program management as a shared resource.

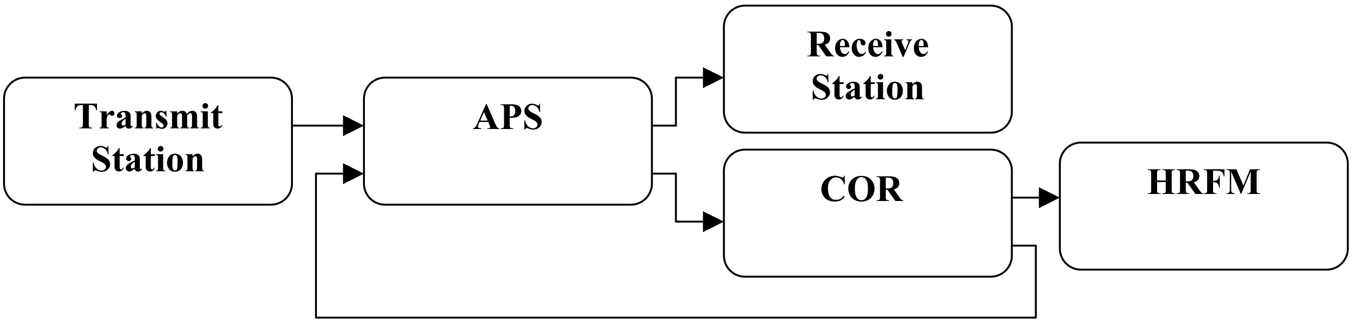

Figure 5 High Rate Data Link Design

Payloads have two targets for HRDL transfers. The first is the High Rate Frame Muliplexer (HRFM), which interleaves data to the KU-Band transmission system for downlink. The second target is another payload.

There is a some-what opaque box between payloads and the HRFM called the Communications Outage Recorder (there are two versions named MCOR and HCOR). The purpose of this box is to provide a recording of telemetry during periods where there is no KU-Band coverage. Due to the design of the overall ISS telemetry system, and the data volumes of AMS-02, this device is not foreseen as particularly helpful for AMS-02.

Information about HRDL is primarily derived from SSP 50184 Rev B dated 25-May-2001

6.1 HRDL Protocol and Framing

The HRFM Ku-Band system supports two rigidly defined downlink protocols: the Consultative Committee for Space Data Systems (CCSDS) Packet protocol and bitstream protocol.

6.2 Known Problems with HRDL

The APS and HRFM systems have documented problems that directly affect the HRDL operations. This section documents known issues with the use of the HRDL system and documents how AMS-02 (and ACOP) handles the issues.

6.2.1 Incorrect HRFM MPDU First Header Pointer

Documented in SSP 50184B Section 3.3.3.1.1.1 CCSDS Packet Data Frame Sizes.

TBP: How AMS-02 deals with this.

All packets transmitted via HRDL to and from AMS-02 and ACOP are a multiple of four bytes. This prevents this problem from occurring.

6.2.2 Maximum Contiguous Data Transfer

Documented in SSP 50184B Section 3.3.3.1.2.2.1 Maximum Contiguous Data Transfer.

TBP: How AMS-02 deals with this.

Both JIM_HRDL and ACOP6T boards provide a configuration register specifying the current data to sync ratio used to meter data rates. This value must always have a data symbol count less then 25 and a non-zero sync symbol count.

6.2.3 Distribution Of Sync Symbols

Documented in SSP 50184B Section 3.3.1.2.2 Distribution of Sync Symbols.

TBP: How AMS-02 deals with this.

The "parsing of sync symbols" is governed by section 6.2.2.

6.2.4 Loss of Lock-On State by APS

Documented in SSP 50184B Section 3.3.1.1.2 Lock-On State.

TBP: How AMS-02 deals with this.

Both JIM_HRDL and ACOP6T provides a inter-frame sync count. This count must be checked to be less then a maximum value should the transmit FIFO be found empty before submitting a new block for transmit. If the value is exceeded "invalid symbols" must be injected into the transmission stream to force the APS to re-acquire the signal lock.

6.3 Telemetry Data Rate Management

The ISS program requires that a payload have the ability to control its HRFM telemetry rate from 0Mbits/second to not to exceed 100Mbits/second in increments of 0.43195 Mbits/second.

At the link level HRDL is always clocked at a 100 Mbits/sec data rate. Payloads must be able to limit their data transmission rate to the HRFM by controlling the insertion of syncs between packets and within packets. Details regarding data rate control are found in SSP 50184B section 3.3.1 HRDL Protocol Common Rules.

This is implemented in AMS-02 by providing commanding to set the desired communication rate.

7 STS Telemetry Implementation

This section discusses what telemetry is present, and which interface that it is present on, when AMS-02 is operational for checkout during transportation on STS to ISS. Details of protocol and sequencing are contained in LMSO/MMO Level C ICD Appendix A. In the event of conflict the LMSO document should be considered authoritative.

7.1 STS OIU 1553 Interface Utilization

A 1553 bus connection to AMS-02 while in the Orbiter cargo bay shall be utilized to provide commands to and telemetry from the AMS-02. In operation of this interface, the Orbiter Interface Unit (OIU) performs as the 1553 Bus Controller (BC) and the AMS functions as a 1553 Remote Terminal (RT).

This link carries the AMS02HK and AMS02REPLY, data streams to be down linked, and AMS02CMD, which is being up linked. Critical Health Data is possible, but not foreseen.

Ok I've given up now on making OIU and PLMDM the same. Once we've crossed that hurdle, its not clear to me now we benefit from even keeping them "similar"..

7.1.1 1553 House Keeping (Down Link)

The AMS02HK and AMS02REPLY data streams are created by AMS-02 and down linked via this path. While not required by NASA, AMS-02 utilizes CCSDS headers for this link simplifying the development of ground processing systems.

The frame size of data (including all headers) carried on this link is 128 bytes.

The data down linked is delivered to either JSC-CIP or MSFC-HOSC TBD. (See paragraph 10.3.1).

The following describes the mechanics of transferring data over this link:

The OIU broadcasts a "Synchronize With Data Word" Mode Command (Mode Code 10001) as the first message in sub-frame zero of each processing frame at a 10 Hz +/- 10 microseconds rate on a 100 ms boundary. The OIU then polls the predefined "health and status" 1553 sub-address (supplied by the LMSO Level C Appendix A) twice to obtain the data for an AMS Frame.

The pair of 1553 replies generated by AMS-02 in this ten-hertz cycle is assembled by the OIU into a format suitable for transfer to the Payload Data Interleaver (PDI).

7.1.2 OIU/PDI 1553 Data Layout Implementation Details

The implementation details for the data layout follows in Figure 6 OIU/PDI HK 1st 1553 Sub Address Blockand Figure 7 OIU/PDI HK 2nd 1553 Sub Address Block.

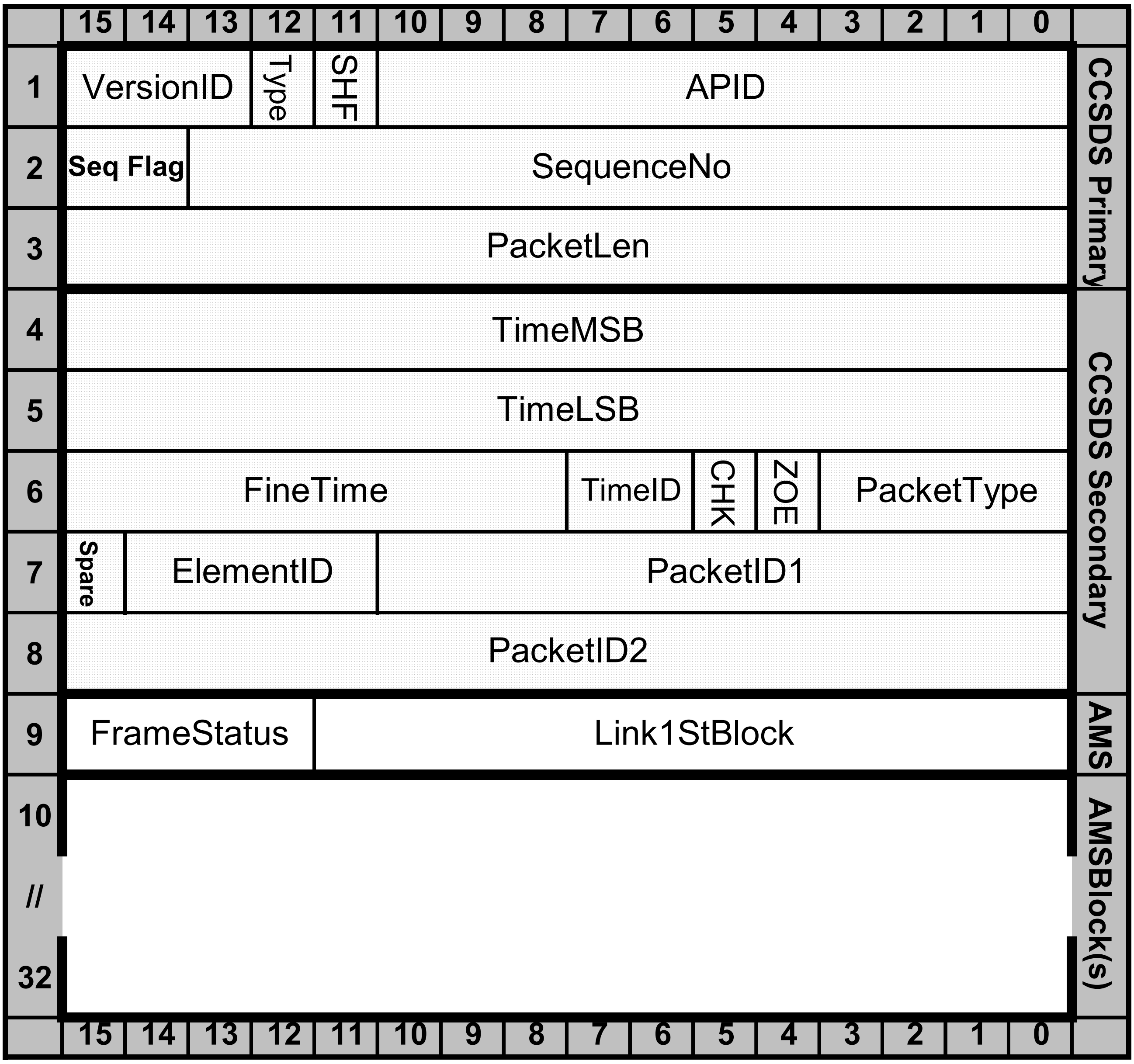

Figure 6 OIU/PDI HK 1st 1553 Sub Address Block

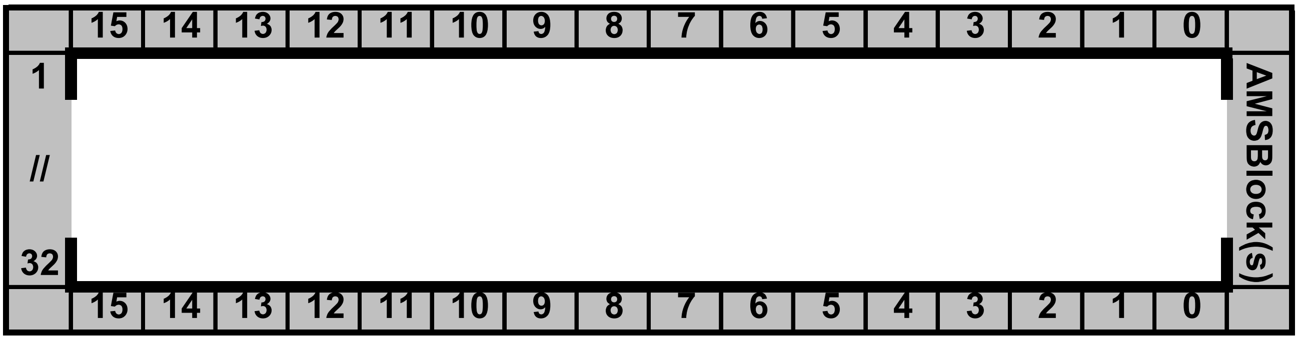

Figure 7 OIU/PDI HK 2nd 1553 Sub Address Block

All values, unless discussed below, are as per section 3.2.

Item	Valid Values	AMS-02 Usage	Comment
FrameLen	TBD	Fixed	FrameLen is fixed at TBD bytes
FrameStatus			TBD: Do we want Critical Health Data on STS? The FrameStatus value AMSSHF should be cleared.

Figure 8 OIU/PDI Implementation Notes

7.1.3 1553 Commanding (Up Link)

This link carries the AMS02CMD Data Stream.

Command data consists of AMS Frames (with CCSDS headers and containing AMS Blocks). Command data is framed using a frame size of 124 bytes (inclusive of headers and check words). Again, neither the CCSDS Secondary or AMS Secondary Headers are used.

The command data originates from ether JSC/MSFC ground equipment (predefined “fixed” commands) or from the AMS-02 POCC (any form of command). TBR: The AMS-02 POCC delivers commands to the CIP at JSC.

All commands are up linked to STS and delivered to the PSP.

The OIU receives the command frames from the PSP interface. The OIU interface places a frame header and trailer on each AMS Frame and transfers it to AMS-02 via the 1553 interface.

The OIU limits the command rate to 1 Hz.

By definition STS OIU command data is two 1553 messages (or sub-addresses). The OIU always transmits both sub-addresses within one processing frame to two consecutive sub-addresses as defined by the Level C ICD, Appendix A.

7.1.4 OIU/PSP 1553 Data Layout Implementation Details

The following table shows the layout of the 1553 blocks received by AMS-02 for ground commands sent via the OIU.

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
	0	0	0	0	0	0	0	0	Length								
1	VersionID			Type	SHF	APID											CCSDS Primary
2	Seq Flag		SequenceNo														
3	PacketLen																
4	TimeMSB																CCSDS Secondary
5	TimeLSB																
6	FineTime								TimeID		CHK	ZOE	PacketType				
7	Spare	ElementID				PacketID1											
8	PacketID2																
9	FrameStatus				Link1StBlock												AMS
10 // 32																	AMSBlock(s)
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	

Figure 9 OIU/PSP Command 1st 1553 Sub Address Block

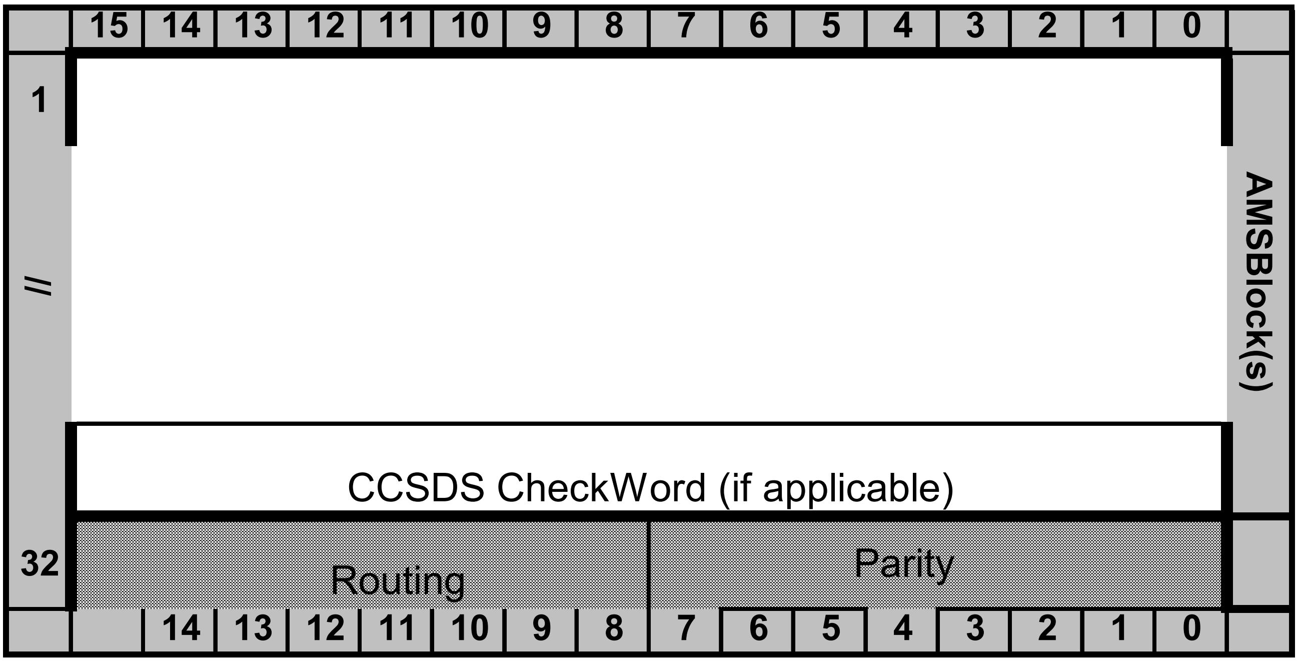

Figure 10 OIU/PSP Command 2nd Sub Address Block

Item	Valid Values	AMS-02 Usage	Comment
Length	0-124	Always 124. Ignored.	Number of bytes of command data in this frame.
Routing	0-255	Ignored.	OIU the logical destination of the command. (Fixed value, always “AMS’s number” Was 7 on STS91)
Parity	0-255	Computed and validated. Commands in error are ignored.	Odd parity is calculated on a columnar basis of the first byte through the Routing byte.

Figure 11 OIU/PSP Values in OIU Commands

7.1.5 Command Replies

Command replies from the AMS02CMD stream are directed to the stream AMS02REPLY and carried on this 1553 link.

7.1.6 Time Distribution

The OIU broadcasts its time once per second in sub-address 29. The following table defines the format of this data[5]:

Word #	Bits	Description	Function/Units	Limits or Range
CW		1553 Command Word		N/A
1	0-7	CCSDS preamble	Preamble field "01010000"	N/A
1	8-15	Time Code – year high	Most significant 8 bits of BCD year field	19 to 20
2	0-7	Time Code – year low	Least significant 8 bits of BCD year field	0 to 99
2	8-15	Time code - month	BCD month field	1 to 12
3	0-7	Time code – day of month	BCD day of month field	1 to 31
3	8-15	Time code - hour	BCD hour field	0 to 23
4	0-7	Time code - minute	BCD minute field	0 to 59
4	8-15	Time code - seconds	BCD second field	0 to 59
5	0-11	Spare (unused bits)	N/A	0
5	12-15	Binary sub seconds high	Most significant 4 bits	0 to 15
6	0-15	Binary sub seconds low	Least significant 16 (1 bit=1 microsecond)	0 to 65535
7	0-15	UTC conversion parameters	UTC leap seconds (BCD)	0 to 9999
8	0-15	Not Used		0

Figure 12 OIU Broadcast Time Format

7.1.7 Mode Commands

The following table indicates the disposition of all mode codes supported.[6]

T/R BIT	MODE CODE	FUNCTION	ASSO CIATED DATA WORD	BROADCAST ALLOWED	IMPLE MENTED By OIU	IMPLEMENTED By AMS	AMS Action
1	00000	Dynamic Bus Control	No	No	No	No	N/A
1	00001	Synchronize W/O Data Word	No	Yes	No	No	N/A

[5] Level C ICD, Appendix A

[6] Level C ICD, Appendix A

T/R BIT	MODE CODE	FUNCTION	ASSO CIATED DATA WORD	BROADCAST ALLOWED	IMPLE MENTED By OIU	IMPLEMENTED By AMS	AMS Action
1	00010	Transmit Status Word	No	No	Yes	Yes	TBP
1	00011	Initiate Self-Test	No	Yes	Yes	Yes	TBP
1	00100	Transmitter Shutdown	No	Yes	Yes	Yes	TBP
1	00101	Override Transmitter Shutdown	No	Yes	Yes	Yes	TBP
1	00110	Inhibit Terminal Flag Bit	No	Yes	No	No	N/A
1	00111	Override Inhibit Terminal Flag Bit	NO	Yes	No	No	N/A
1	01000	Reset Remote Terminal	No	Yes	Yes	Yes	TBP
1	10000	Transmit Vector Word	Yes	No	No	No	N/A
0	10001	Synchronize With Data Word	Yes	Yes	Yes	Yes	TBP
1	10010	Transmit Last Command	Yes	No	No	Yes	TBP
1	10011	Transmit BIT Word	Yes	No	No	Yes	TBP
0	10100	Selected Transmitter Shutdown	Yes	Yes	No	No	N/A
0	10101	Override Selected Transmitter Shutdown	Yes	Yes	No	No	N/A

Figure 13 AMS Mode Code Implementation For OIU

7.1.8 OIU Sub-Address Assignments

Note: This does not currently reconcile with Level C ICD, Appendix A [7]

SA#	Transmit (T/R=1)	Receive (T/R=0)
0	Mode Code (SAM=00000) Command	Mode Code Command
1	Not Assigned	Not Assigned
2	Not Assigned	Not Assigned
3	Not Assigned	Not Assigned
4	Not Assigned	Not Assigned
5	Not Assigned	Not Assigned
6	Not Assigned	Not Assigned

[7] Level C ICD, Appendix A

SA#	Transmit (T/R=1)	Receive (T/R=0)
7	Not Assigned	Not Assigned
8	Low Rate Telemetry Data (N/A)	Command, Request Response (1)
9	Health and Status Data	Command, Request Response (2)
10	Not Assigned	Not Assigned
11	Not Assigned	Not Assigned
12	Not Assigned	Not Assigned
13	Not Assigned	Not Assigned
14	Not Assigned	Not Assigned
15	Not Assigned	Not Assigned
16	Not Assigned	Not Assigned
17	Not Assigned	Not Assigned
18	Not Assigned	Not Assigned
19	Not Assigned	Not Assigned
20	Not Assigned	Not Assigned
21	Not Assigned	Not Assigned
22	Not Assigned	Not Assigned
23	Not Assigned	Not Assigned
24	Not Assigned	Not Assigned
25	Not Assigned	Not Assigned
26	Not Assigned	Not Assigned
27	Not Assigned	Not Assigned
28	Not Assigned	Not Assigned
29	Not Assigned	Broadcast Time
30	Not Assigned	Not Assigned
31	Mode Code (SAM=11111) Command	Mode Code Command

Figure 14 OIU Sub-Address Assignments

7.2 STS RS422 Link Utilization

AMS-02 provides two transmit and two receive links to the aft flight deck. These are not independent but rather are duplicate connections for a single serial connection. Nominally one connection is made to the KU band for downlink (TX only) and the other to DDRS2. (Pre-launch the DDRS2 link is connected to the T0 cable.)

The frame size utilized on this link is 4084 bytes, including the ASM, in both directions.

Carried from AMS-02 to the aft flight deck on this link are the following streams: AMS02HK, AMS02SCI, ACOPREPLY, and ACOPCMD.

All streams transmitted on this link by AMS-02 are down linked if the KU system is active. DDRS2 monitors this link and processes the AMS02HK and ACOPCMD streams only.

DDRS2 can direct back ACOPCMD and ACOPREPLY on this link.

Data transmitted on the KU-Band by this connection will be obtained at the JSC CIP as discussed in paragraph 10.3.2.

7.2.1 Attached Sync Marker (ASM)

Each block transferred begins with an attached sync marker. This is a four-byte value. The first three bytes are the constants: 0xFA 0xF3 0x20. The final byte is a rolling sequence frame number, 0x00 to 0xFF.

7.2.2 Pseudo-Randomization

To meet KU Band modulation requirements the data stream must be “pseudo-randomized” to support clock recovery while using Pulse Code Modulation (PCM) for the transmission. There can be no more then 64 successive bits without a bit transition and at least 128 bit transitions must occur within any 512 bits of data. To assure continuous clock recovery the data stream shall be designed to ensure continuous transmission of data meeting these modulation requirements. Should no data be available for transmission fill frames must be generated.

By inspection the frame headers themselves meet the above requirements. To support efficient handling of the RS422 link by DDRS2 the frame headers are not processed by pseudo-randomization. If specified the pseudo-randomization begins at the first byte past the AMS Frame Header and continues to include the remaining bytes in the frame, including any AMS-02 check word present. Pseudo-Randomization is always used during the flight.

7.2.3 RS422 Data Layout Implementation Details

The following diagram illustrates the layout for RS422 data streams.

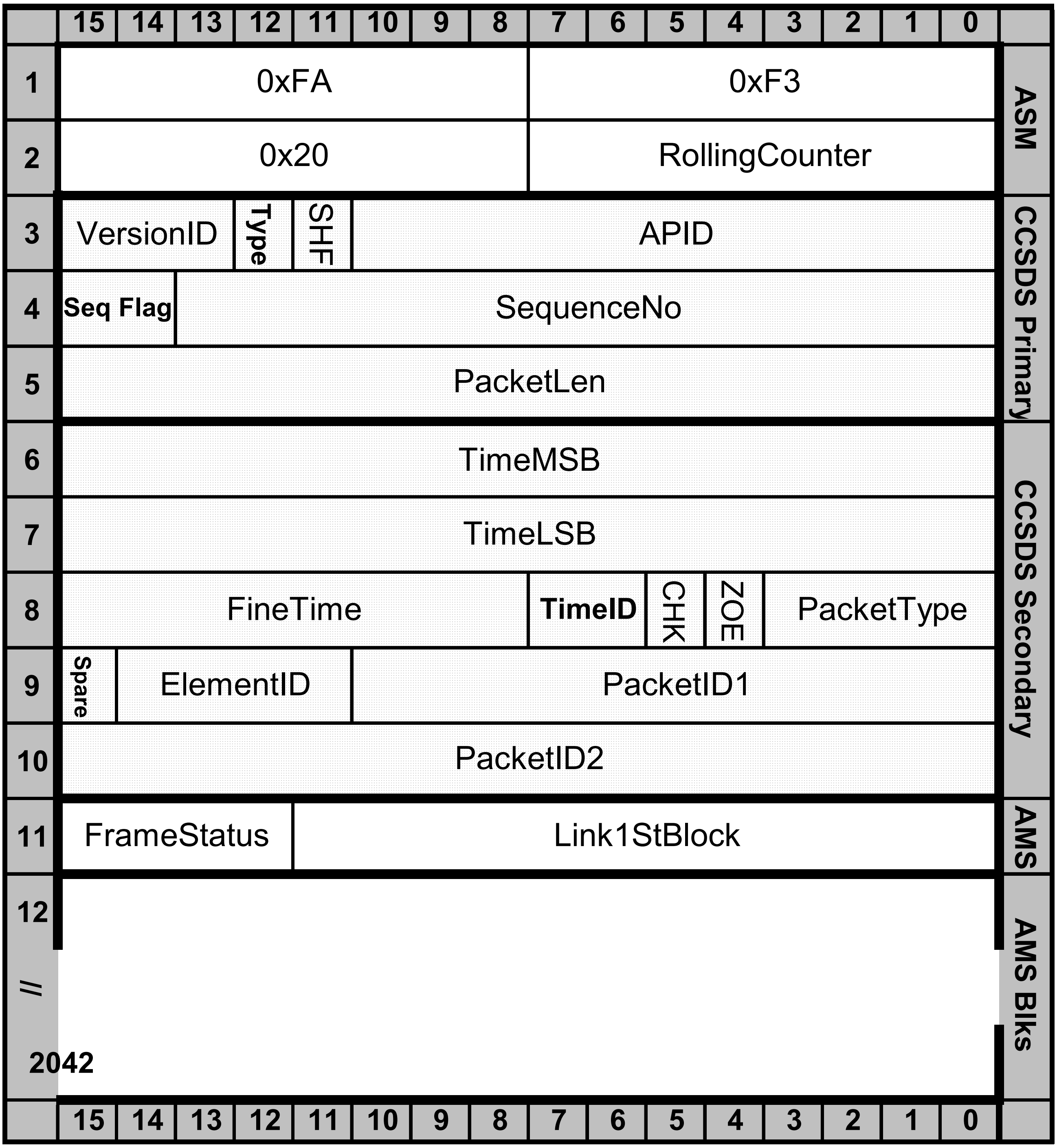

Figure 15 RS422 Data Layout

Notes:

1. RollingCounter is simply incremented and rolls around from 255 to 0.

2. Pseudo-randomization is performed for all data transmit by AMS-02 to the KU/DDRS link. DDRS2 does not perform pseudo-randomization on data it transmits to AMS-02.

3. If performed, the pseudo-randomization is preformed from word 12 to the end of the packet.

4. Frame sizes are fixed a 4080 bytes.

7.3 STS KU Link

Nominally all data transmitted by AMS-02 is sent to the KU system for down link.

7.4 STS DDRS2 Link

7.4.1 DDRS2 Data Recording and Monitoring

Nominally the AMS02HK and AMS02CMD streams are recorded by DDRS2. Additionally DDRS2 de-frames the AMS02HK stream to provide crew-monitoring abilities.

7.4.2 DDRS2 Crew Commanding

Crew commanding of AMS-02 is only supported via the Digital Data Recorder System 2 (DDRS2) – a JSC/MMO/LMSO provided system. This system directs commands to AMS-02 via its RS422 transmit link on stream AMS02CMD and expects command replies to AMS02REPLY. Nominally the frames sent to AMS-02 will not have the pseudo-randomization performed. They do have full frame headers as described above.

7.5 Cargo PC Utilization

Cargo PC is an emerging component of STS. Its utility is being studied.

8 ISS AMS-02 Telemetry Implementation

This section discusses what telemetry is present, and which interface that it is present on, when AMS-02 is operational on ISS. I wish I could cite an authoritative source for this…. SSP57003 defers the definition of 1553 handling to SSP 52050. Section 3.2.3.5 of 52050 covers health and status collection by the PLMDM. There are plenty of other books that chip in with conflicting information.

8.1 ISS AMS-02 LRDL (1553) Utilization

A 1553 bus connection in the UMA connects AMS-02 to a PLMDM (Payload Multiplexer/De-multiplexer). In operation of this interface, the PLMDM performs as the 1553 Bus Controller (BC) and the AMS functions as a 1553 Remote Terminal (RT).

This link carries the AMS02HK, AMS02REPLY, and Critical Health Data streams to be down linked, and AMS02CMD, which is being up linked.

8.1.1 Down Link Telemetry (House Keeping Data)

The AMS02HK, AMS02REPLY, and Critical Health data streams are created by AMS-02 and down linked via this path. As required by NASA, AMS-02 utilizes CCSDS headers for this link complete with secondary headers (SHF must be set).

The frame size of data (including all headers) carried on this link is nominally 128 bytes (this can be up to 2560 bytes). Frames are polled at 10 hz.

The data down linked is delivered by MSFC-HOSC via TReK to the AMS POCC. (See paragraph 10.1.2).

Assuming two 1553 messages per house keeping set the rate transmitted is 1kbits/second.

The following describes the mechanics of transferring data over this link:

The down linked is performed by the PLMDM Payload Health and Status (PHS) service.

The PLMDM issues a "Broadcast Sync With Data" mode command at the start of each 100-millisecond processing frame. During a processing frame the PLMDM can read one CCSDS packet of data from AMS. The CCSDS packet of data is transferred using multiple reads (in sets of four) to a single sub-address. The total length cannot exceed 1280 16-bit words. Note: need a cleaner description that covers what happens for packets longer the 4 - 1553 messages.

8.1.2 Commanding (Up Link Telemetry)

This link carries the AMS02CMD Data Stream.

Command data consists of AMS Frames (with CCSDS headers and containing AMS Blocks). Command data is framed using a frame size of 124 bytes (inclusive of headers and check words). The CCSDS Secondary is required but no AMS Secondary Headers is. (Reconcile with OIU)

The command data originates from ether JSC/MSFC ground equipment (predefined "fixed" commands) or from the AMS-02 POCC (any form of command). TBR: The AMS-02 POCC delivers commands to MSFC via TReK.

All ground commands are up linked to ISS and delivered to the PLMDM for transmission on 1553. Commands can originate on board for ISS facilities (PCS and Timeliner).

The PLMDM design limits the over all command rate to AMS-02 to 10 commands/second.

By definition command data is two 1553 messages (or sub-addresses). The PLMDM always transmits both sub-addresses within one processing frame to two consecutive sub-addresses (see: Figure 20 PLMDM Address Assignments).

8.1.3 PLMDM 1553 Command Data Layout Implementation Details

Figure 16 and Figure 17 shows the layout of the 1553 blocks received by AMS-02 for PLMDM commands. **Note:** this does not contain a valid AMS Frame since NASA injects a "Reserved Word" and "Legal Station Mode".

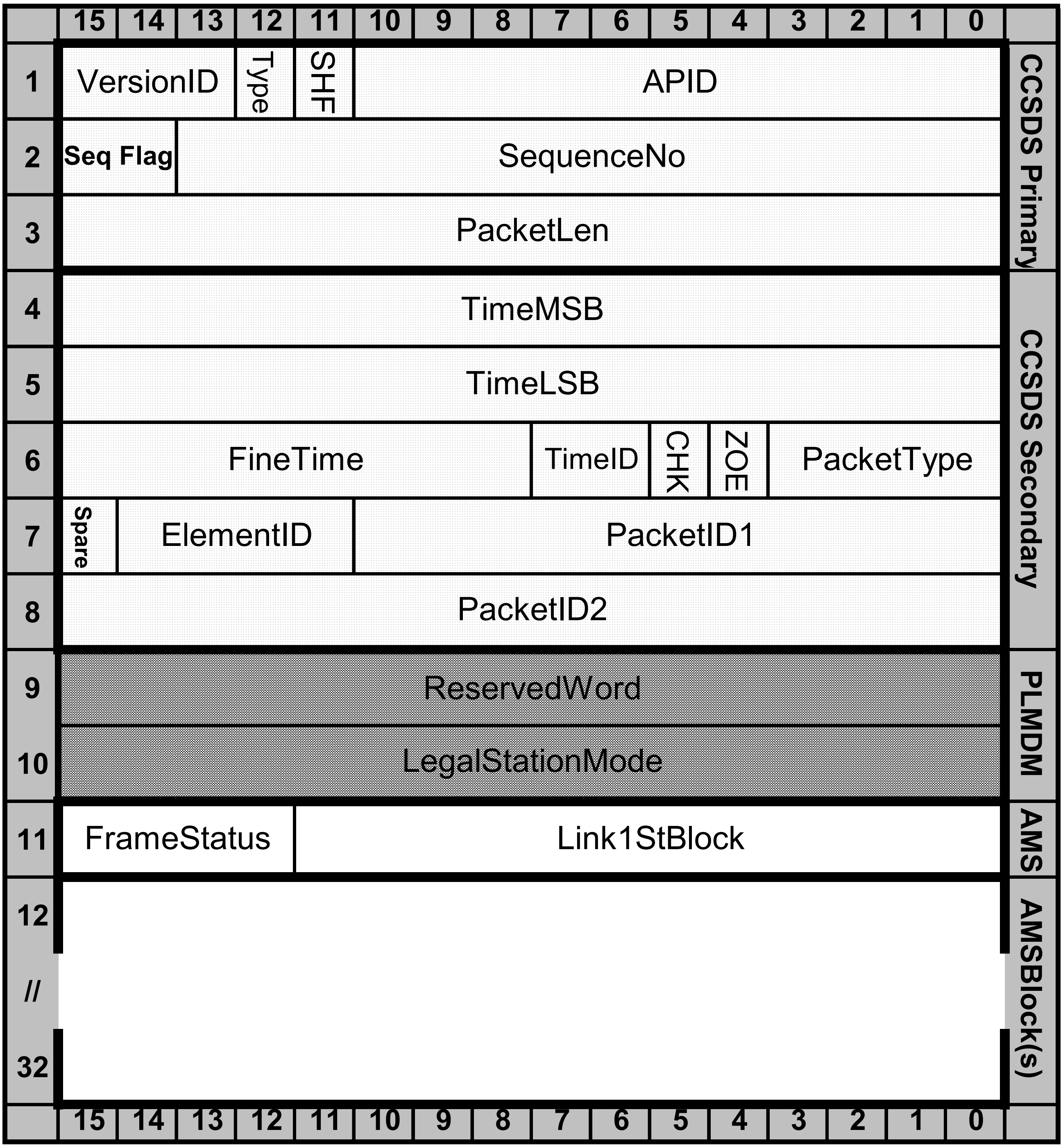

Figure 16 PLMDM Command 1st 1553 Sub Address Block

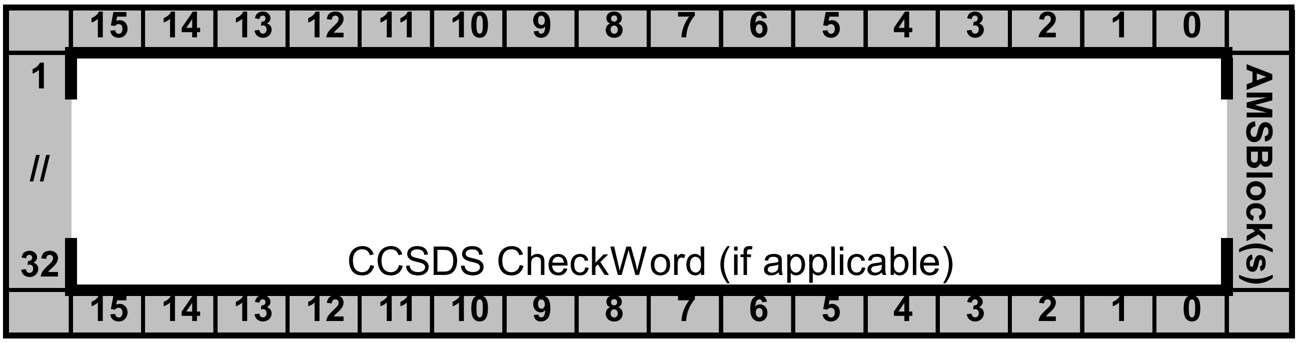

Figure 17 PLMDM Command 2nd 1553 Sub Address Block

All values, unless discussed below, are as per section 3.2.

Item	Valid Values	AMS-02 Usage	Comment
ReservedWord	TBD		TBP
LegalStationMode	TBD		TBP

8.1.4 Time Distribution

The broadcast time signal will be updated once per second and is accurate to +2.5 ms with respect to the Global Positioning System (GPS) receiver.

The time broadcast is at sub-address 0x29. The format is specified below

Word #	Description	
1	CCSDS Preamble field '01010000'B	Most significant 8 bits of BCD Year field, range 19-20
2	Least significant 8 bits of BCD Year field, range 0-99	BCD Month field, 8 bits, range 1-12
3	BCD Day of Month field, 8 bits, range 1-31	BCD Hours field, 8 bits, range 0-23
4	BCD Minutes field, 8 Bits, range 0-59	BCD Seconds field, 8 Bits, range 0-59
5	Spare, 12 bits	Binary Sub seconds Most Significant 4-bits
6	Binary Sub-seconds continued - least significant 16 Bits, total range = 0 to 1,048,575 at one microsecond per count	
7	UTC Conversion Parameters, 16 bits, range 0-65,535 Always set to zero. Note this data is contained in Broadcast Ancillary Data	
8	Non CCSDS Seconds/Sub-seconds, 16 bits, range 0-65,535 The one's portion of the seconds plus the sub-seconds information of the CCSDS time converted to a straight binary count rounded to the nearest 256 microseconds (LSB = 256 µseconds)	

Figure 18 PLMDM Broadcast Time Format [8]

[8] SSP41175-02 Revision F Table 3.3.2.2.2-1

8.1.5 Broadcast Ancillary Data

The ISS system provides certain ancillary data on a broadcast basis to all payloads. Included are such interesting items as the attitude vector. Possible use should be investigated.

8.1.5.1 Attitude Vector

Used to determine entry and exit from the South Atlantic Magnetic Anomaly.

8.1.5.2 Solar Array Position

Used to determine impingement of solar array into the field of view.

8.1.6 Critical Health Data

Note: In the "PLMDM Users Manual rcs5A", *Table 7-7 - Operational Status Data Table (OSDT) File Format* has some disturbing implications that CHD must be frame cyclic.

TBP

8.1.7 Mode Commands

The following table details the requirements and support for all mode commands. [9]

T/R BIT	MODE CODE	FUNCTION	ASSO CIATED DATA WORD	BROADCAST ALLOWED	IMPLE MENTED By PLMDM	IMPLEMENTED By AMS	AMS Action
1	00000	Dynamic Bus Control	No	No	No	No	N/A
1	00001	Synchronize W/O Data Word	No	Yes	No	No	N/A
1	00010	Transmit Status Word	No	No	Yes	Yes	TBP
1	00011	Initiate Self-Test	No	Yes	Yes	Yes	TBP
1	00100	Transmitter Shutdown	No	Yes	Yes	Yes	TBP
1	00101	Override Transmitter Shutdown	No	Yes	Yes	Yes	TBP
1	00110	Inhibit Terminal Flag Bit	No	Yes	No	No	N/A
1	00111	Override Inhibit Terminal Flag Bit	NO	Yes	No	No	N/A
1	01000	Reset Remote Terminal	No	Yes	Yes	Yes	TBP

[9] SSP52050, Revision D

T/R BIT	MODE CODE	FUNCTION	ASSO CIATED DATA WORD	BROADCAST ALLOWED	IMPLE MENTED By PLMDM	IMPLEMENTED By AMS	AMS Action
1	01001	Reserved to 01111	No				Ignored.
1	10000	Transmit Vector Word	Yes	Yes	Yes	Yes	TBP
0	10001	Synchronize With Data Word	Yes	Yes	Yes	Yes	See note[10]. TBP Used to sync to frame??
1	10010	Transmit Last Command	Yes	No	No	Yes	TBP
1	10011	Transmit BIT Word	Yes	No	No	Yes	TBP
0	10100	Selected Transmitter Shutdown	Yes	Yes	No	No	N/A
0	10101	Override Selected Transmitter Shutdown	Yes	Yes	No	No	N/A
0	10110	Reserved to 11111	Yes				Ignored.

Figure 19 AMS Mode Code Implementation For PLMDM

8.1.8 PLMDM Sub-Address 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

[10] Format of this word is given in Table 3.3.2.2.1–1 of SSP 41175–2

SA#	Transmit (T/R=1)	Receive (T/R=0)
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

Figure 20 PLMDM Address Assignments [11]

8.2 ISS AMS-02 HRDL Utilization

AMS-02 has two prime targets for HRDL transfers. The first is the High Rate Frame Muliplexer (HRFM), which interleaves data to the KU-Band transmission system for downlink. The second target is the AMS-02 Crew Operations Post (ACOP) which provides on board recording of AMS-02 data. The APS can be configured to tee data transmitted by AMS-02 to both the HRFM and ACOP.

Nominally there should be a dedicated (24x7x365x3) link for both transmit and receive between AMS-02 and ACOP. A link between ACOP and HRFM can be configured based upon program scheduling for AMS-02 downlink.

8.2.1 HRDL Protocol and Framing

AMS-02 utilizes the Consultative Committee for Space Data Systems (CCSDS) Packet protocol for all systems, including HRDL. (The bit-stream protocol is not supported.)

JIM-HRDL implements fixed size frames (per “session”) of not more then 4095 bytes. In order to change its frame size JIM-HRDL must be reset and reconfigured, disrupting any activity on the HRDL link and starting a new “session”.

8.2.2 AMS-02 HRDL Transmissions

AMS-02 only has a single HRDL transmit connection. The supported connections via the APS for this connection are

- No connection
- Connection to ACOP
- Connection to HRFM for KU-Band transmission

[11] SSP52050, Revision D – Table 3.2.3.2.1.4-1

- Connection to both HRFM for KU-Band transmission and to ACOP

This link carries the following data streams: AMS02HK (a second copy), AMS02SCI, ACOPCMD, and ACOPREPLY.

Note: Strictly speaking by ISS documents, an APID represents a single simplex point-to-point link. AMS-02 utilizes APIDs to delineate data streams. The connection between AMS-02 and ACOP by HRDL represents a private payload-to-payload connection and as such is not governed by ISS regs. However due to the APS tee function the ACOPCMD and ACOPREPLY streams may appear in ISS traffic to the KU-Band. Since the ISS program does not see the ACOP to AMS-02 traffic this should be fine. The second copy of AMS02HK may represent a problem to ground handling systems. This needs to be investigated.

8.2.3 AMS-02 HRDL Reception

AMS-02 has a single HRDL receiver connection. The supported connections via the APS for this connection are:

- No connection
- Connection to ACOP

This link carries the following data streams: ACOPREPLY, ACOPCMD

8.2.4 AMS-02 HDRL Data Layout Implementation

Figure 21documents the HRDL data layout.

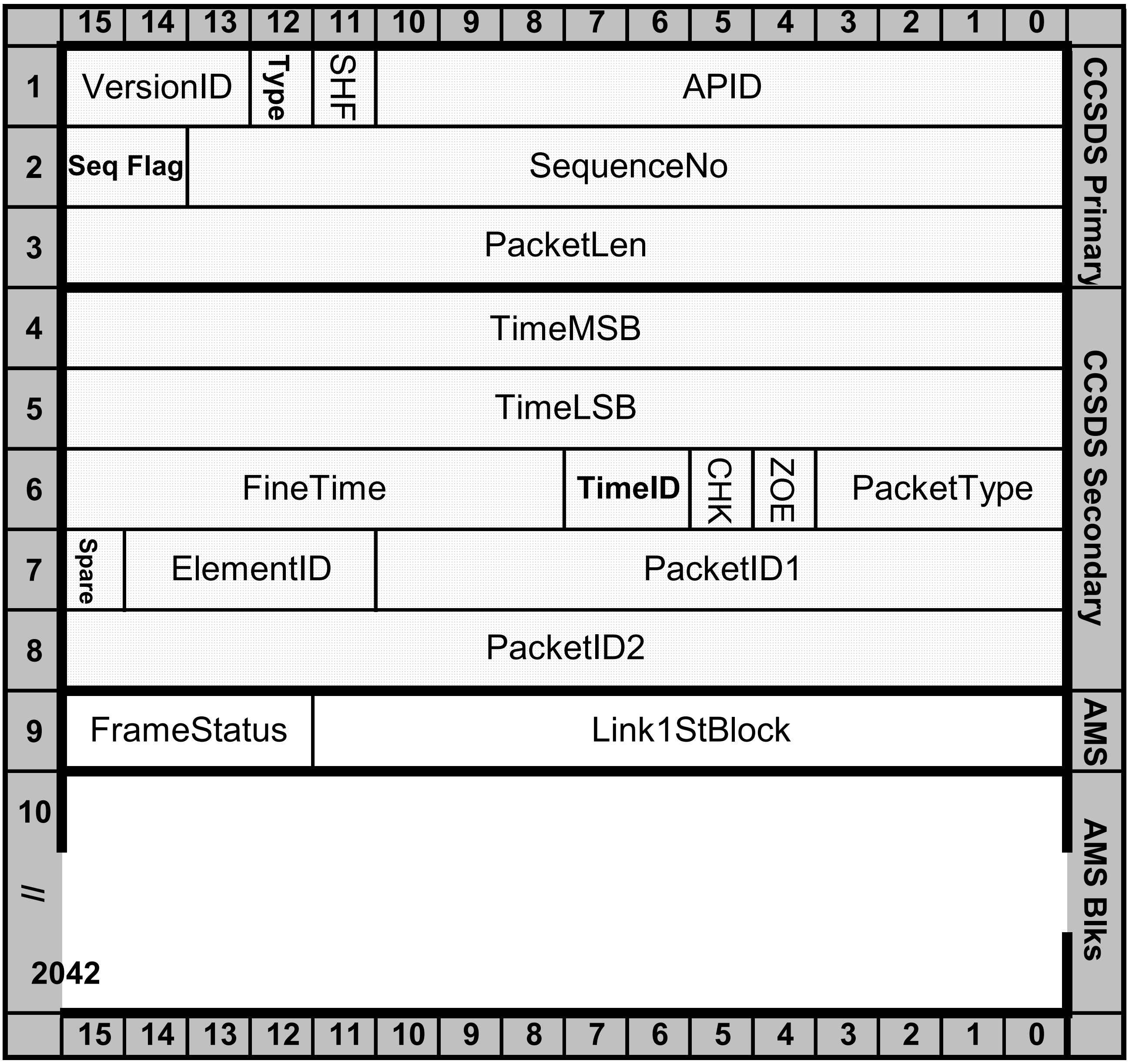

Figure 21 HRDL Data Layout Implementation

9 ISS ACOP Telemetry Implementation

This section under development

9.1 ISS ACOP LRDL (via MRDL) Utilization

TBP

9.2 ISS ACOP HRDL Utilization

TBP

9.3 ISS ACOP MRDL Utilization

TBP

10 Ground Segment Telemetry Interfaces

This section address issues with the ground segment processing the impacts the design of the telemetry systems for AMS-02. For instance the HOSC at MSFC both interprets and manipulates CCSDSD headers. The telemetry design for AMS-02 must be consistent with these issues.

10.1 MSFC – HOSC

This section under development

10.1.1 GSE At HOSC

TBP

10.1.2 TReK Interfaces

TBP

10.2 KSC – Pad Support

10.2.1 1553 Support

The AMS-02 1553 bus can optionally be switched to the T0 cable. Prior to launch this switch option will be selected providing connectivity to room 10A in the pad blockhouse. AMS provided GSE will be used to receive and distribute the 1553 data from this location during pad operations.

Data layout is per the OIU implementation as discussed in Section 7.1

10.2.2 RS422 Support

The AMS-02 RS422 cable will be patched to the T0 cable at the aft flight deck prior to launch providing connectivity to room 10A in the pad blockhouse. AMS provided GSE will be used to receive and distribute the RS422 data from this location during pad operations.

10.3 JSC – CIP

10.3.1 AMS-02 Health and Status via STS OIU

Note: TBD where this data goes on the ground on STS91 it went to the CIP, we may be able to get it on the NET now…

The 12800 bits per second into the PDI and provided to the AMS POCC consist of the following:

Item	Number of bits per PDI minor frame (100 ms.)	Function
1.	32	Four (4) – 8 bit sync and counter words
2.	64	Eight (8) - 8 bit OIU health and status words
3.	1024	64 - 16 bit AMS words
4.	32	Two (2) - 16 bit 1553 transaction status words inserted by the OIU

Item	Number of bits per PDI minor frame (100 ms.)	Function
5.	128	Eight (8) - 16 bit fill words attached by the OIU

Figure 22 Health and Status Data At the CIP

Total 1280 bits or 12800 bits/second

10.3.2 AMS-02 Science Data Via STS KU-Band

Note: TBD where this data goes on the ground. On STS91 it went to the CIP, we may be able to get it on the NET now…

11 AMS Block Master/Slave Synchronization Over RS422, HRDL, and 1553

AL: I still need some input on this. It is not clear to me how (or if) the slave acknowledges across these links.

This section will address how commands and replies are synchronized over these links.

12 Fixed Predefined Commands For AMS-02

The following commands are defined as fixed commands for NASA use to control AMS-02. These are conceived to allow NASA facilities to control AMS-02 in the event of interruption of service of the AMS-02 POCC, network interruptions, or other contingencies. They are by no means a robust set of AMS-02 commands. They are intended to allow NASA to have the ability to control AMS-02 assuming AMS-02 is operating nominally.

12.1 Set Base Power Step

AMS-02 hardware does not have per se “power states or steps”. There are many systems and subsystems that can be powered on or off independently. Selecting a “Base Power Step” requests a pre-configuration of switches to be set. After selecting a Base Power Step power switches can be changed independently. AMS-02 reports only the last Base Power Step requested.

Power Steps are discussed within the PDB documentation.

NodeAddress:	TBD
DataType:	TBD
BlockType:	TBD
Data:	TBD
Hex Command:	TBD

Figure 23 Set Base Power Step Command

12.2 Set Base Operation Condition

AMS-02 has many configuration and parameter values that impact the operation condition. There are a small number of pre-defined conditions.

Operations State 0 – AMS-02 House Keeping only
Operations State 1 – AMS-02 Science Data Gathering

NodeAddress:	TBD
DataType:	TBD
BlockType:	TBD
Data:	TBD
Hex Command:	TBD

Figure 24 Set Base Operations Condition Command

12.3 Set Base Telemetry Condition

AMS-02 has several paths to send telemetry and several streams of telemetry that can be sent. There are a small number of pre-defined conditions that can be selected.

Telemetry State 0 – AMS-02 Critical Health Data Only
Telemetry State 1 – AMS-02 Housekeeping Data plus Critical Health Data
Telemetry State 2 – AMS-02 Science Data, Housekeeping, Data, and Critical Health Data

NodeAddress:	TBD
DataType:	TBD
BlockType:	TBD
Data:	TBD
Hex Command:	TBD

Figure 25 Set Base Telemetry Condition Command

12.4 Magnet Watch Dog Reset

The AMS-02 magnet has a watchdog timer. If this timer is not reset in a timely basis the magnet quenches. This is very undesirable. This command resets the magnet watchdog timer.

NodeAddress:	TBD
DataType:	TBD
BlockType:	TBD
Data:	TBD
Hex Command:	TBD

Figure 26 Magnet Watch Dog Reset Command

12.5 Big Red Button

Should we consider a big red button command?

AMS-02 is safe without services but mission success can be compromised from an extended lack of service. If this command is issued, the magnet quenches and AMS-02 powers down. In terms of mission success this is considered a VERY dangerous command due to helium consumption.

NodeAddress:	TBD
DataType:	TBD
BlockType:	TBD
Data:	TBD
Hex Command:	TBD

Figure 27 Big Red Button Command

13 Critical Health Data Format

The Critical Health Data consists of ten bytes. This data is conditionally present in the 1553 data presented to the PLMDM as house keeping data. The frame status byte AMSSHF indicates its existence of the data in the frame. When Critical Health Data is present the AMS Block data starts ten bytes later in the frame.

This section is really just a place holder for notes while we develop what we want.

TBD: Can PEP use the AMSSHF bit to predicate processing of this data?

13.1 Peter Dennett's Proposal

Most major subsystem in AMS-02 reports their status via the following bit mappings.

Temperature ‘xx000000’b	**Nominal** ‘00’b	**Hot Warn** ‘10’b	**Cold Warn** ‘01’b	**Temp Fault** ‘11’b
Voltage ’00xx0000’b	**Nominal** ’00’b	**Over Warn** ’10’b	**Under Warn** ’01’b	**Voltage Fault** ’11’b
Current ’0000xx00’b	**Nominal** ’00’b	**Over Warn** ’10’b	**Under Warn** ’01’b	**Current Fault** ’11’b
Operations ’000000xx’b	**Nominal** ’00’b	**TBD** ’10’b	**TBD** ’01’	**Operations Fault** ’11’b

Figure 28 Critical Health Data Bit Mappings

Each major subsystem in AMS-02 reports their status via the above bit mappings. Each subsystem is assigned an index number. Every status reported contributes to the System Summary. Statuses are sorted into order using as the first key the severity of the error, worst case first. The second key is the subsystem index ascending. More critical subsystems are given smaller indices.

Byte	Usage	Comment
1	Heartbeat rolling counter	0-255
2	Command count	Rolling counter 0-255 of valid commands received.
3	TBD	8bits Power Step 8bits Magnet State?
4	AMS-02 System Summary	As above named two bit fields ‘00’b = Nominal ‘01’b

Byte	Usage	Comment
		= Warn ‘10’b = Fault ‘11’b = fault and warning.
5	Subsystem Index 1	Subsystem index of first item in above sort
6	Caution and warning 1	Value for caution and warning of the worst case
7	Subsystem Index 2	Subsystem index of second item in above sort
8	Caution and warning 2	Value for caution and warning of the second worse
9	Subsystem Index 3	Subsystem index of third item in above sort
10	Caution and warning 3	Value for caution and warning of the third worse

Figure 29 Mission Success Byte Mappings

13.2 Mike Capell’s Input

My imagination is that one JMDC (call it JMDC-MCC) will prepare the 10bytes and put them in a buffer, and then which ever way they are being sent out (can be any and all ways) will grab them as needed...

1b Heartbeat rolling counter 0-255.
  Note: I don't expect any exact synchronization between JMDC and frame
  emission, just that approx 1/sec the JMDC-MCC will increment this.
  So on receipt this counter may stick for one count, or jump a couple....
  None the less it provides a warm fuzzy that things are happening.

1b Commands received OK rolling counter 0-255

1b Power:
  3Bits : power step
    0=power step undefined, in transition.
    1-4 power step set (just looking at the circuit breakers in PDB).
    5 power step 2A (magnet charging)
    6 power step 3A (tracker thermal)
    7 power step 4a (TBD).
  2Bits: Bus A, B 1=Hot/0=not
  3Bits: input power (units 300W, =7 means >2100W).

1b Magnet:
  2Bits: State, 0=not available, 1=charging, 2=rampdown, 3=normal
  1Bit : Quench 1=detected/0=not
  2Bits: UPS A,B 1=OK, 0=not.
  1Bit : free
  2Bits: Cryocoolers (0= not avail, 1=not OK, 2=not OK, 3=OK)

1b Thermal:
  2Bits: sensors in over temp alarm = 0,1,2,>2
      over temp warn =
      under temp warn =
      under temp alarm =

1b DAQ & Links
  2Bits: JMDC ID that prepared this CHD
  1Bit : 1=ISS mode,0=STS mode

1Bit : Hrdl(rs422) is 1=active, 0=not
1Bit : LRDL is 1=active, 0=not
1Bit : trigger is 1=active, 0=not
1Bit : DAQ Buffer 1=Full, 0=not
1Bit : (free)

1b Magnet:
2Bits: State, 0=not available, 1=charging, 2=ramp down, 3=normal
1Bit : Quench 1=detected, 0=not
2Bits: UPS A,B 1=OK, 0=not
1Bit : free
2Bits: Cryocoolers (0= not avail, 1=not OK, 2=not OK, 3=OK)

2bytes left - need data from
TRD Gas, Tracker thermal, ...
Some things that would be nice:
last command received (2b).
Or maybe we could squeeze some bits from the above and implement peter's scheme......

14 AMS Block Format

This section discusses the format of AMS Blocks. All AMS-02 data, with the exception of Critical Health Data, is formatted using this mechanism.

14.1 Block Length

The length field is not considered to be part of the block. When in serial streams like HRDL, RS422, and 1553 it is placed before the AMS Block. If zero, it signals end-of-data for this frame. This value is a byte count. There are two formats, normal (0-32676 bytes), and extended (0-2,147,483,647 bytes).

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	ByteCount														
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Figure 30 Normal AMS Block Length

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	ByteCount														
2	ByteCount															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Figure 31 Extended AMS Block Length

14.2 AMS Block Header

Each AMS Block has a header. There are two formats of the AMS Block Header, normal and extended. The normal format supports Data Types between 0 and 31. The extended format supports Data Types between 2031616 and 2097151.

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	BLKTYP		NodeAddress									DataType				
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Figure 32 Normal Block Header

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	BLKTYP		NodeAddress									1	1	1	1	1
	DataType															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Figure 33 Extended Block Header

14.2.1 AMS Block BLKTYP - Block Type

The following table defines Block Type:

15	14	Block Type
0	X	Request
1	X	Reply
X	0	Write then read
X	1	Write

Figure 34 AMS Block Type

14.2.2 AMS Block NodeAddress

AMS-02 Node Numbers are enumerated in Appendix B.

14.2.3 AMS Block DataType

This field defines the contents of the block. Data types are defined according to the needs a node. There are a few required types. These must be implemented.

14.2.4 Required Data Types

Each node must provide a valid response to the following data types.

AL: TBP.

DataType	Name	Length	Comments
0	Ping	Any	Pings back to sender
1	Status	As Required	Returns the nodes status report - ASCII
?	Boot	As Required	Boot command

Figure 35 Data Types Every Node Must Provide

14.2.5 Common Data Types

The following are common data types that can be implemented on any node. These are not required but if the DataType value is used the data must be in the prescribed format.

AL: TBP

Suggestions are:

Config – Configuration parameters. Writing this block should re-initialize the node using the provided values (subject to the validation). These could be stored by MDC.

DataType	Name	Length	Comments
?	?	?	?

Figure 36 Command Data Types Any Node Can Provide

15 AMS Block Framing

This section discusses how AMS Blocks are packed into frames. TBP

16 Defined Data Types For Nodes

This section documents the known data types for each node.

17 AMS Block Envelop Addressing

This section describes how AMS Blocks are packaged into envelopes for distribution on the AMS-02 system.

AL: So far you have not explained your data mechanics for this to me..

18 AMS-02 Path Addressing

This section describes how paths thru the AMS-02 DAQ tree are defined.

AL: I need help here also. All I have is an old viewgraph that I do not understand.

19 Node Addresses

This is a tabular presentation of each node address in AMS-02 organized by node type.

19.1 JMDC Addresses

There are both physical and functional node addresses in this table. For instance 0x13 is the functional address for the housekeeping task.

Nb.	Hex	What's this is
0	000	JMDC-0 on CAN bus
1	001	JMDC-1 on CAN bus
2	002	JMDC-2 on CAN bus
3	003	JMDC-3 on CAN bus
4	004	JMDC-0 on HRDL/RS422/1553
5	005	JMDC-1 on HRDL/RS422/1553
6	006	JMDC-2 on HRDL/RS422/1553
7	007	JMDC-3 on HRDL/RS422/1553
8	008	JMDC-0 via AMS-Wire
9	009	JMDC-1 via AMS-Wire
10	00A	JMDC-2 via AMS-Wire
11	00B	JMDC-3 via AMS-Wire
12	00C	JMDC-0
13	00D	JMDC-1
14	00E	JMDC-2
15	00F	JMDC-3
16	010	JMDC - HRDL/RS422 Owner (TX allowed)
17	011	JMDC - 1553 Owner (Remote Terminal)
18	012	JMDC - DAQ Owner (Event Builder)
19	013	JMDC - MCC (Q-list Executioner, Tracker Thermal Controller, TRD Gas Controller/Mixer)
20	014	free
21	015	free
22	016	ACOP on HRDL/MRDL/1553
23	017	JMDC Broadcast Address

19.2 Slow Control Addresses

The names are of the form:

<subsystem> [-][{<crate>|<unit>|<crate>-<unit>}] - {A|B|P|S} Where:

- A, B - 2 different physical units
- P, S Primary, Secondary

Nominally the primary node is the hot module and the secondary is the cold module. Exceptionally both modules are on.

Nb.	Hex	What's this is
24	018	CAB-A
25	019	CAB-B

Nb.	Hex	What's this is
26	01A	CAB-P
27	01B	CAB-S

Nb.	Hex	What's this is
28	01C	USCM-CCEB-A
29	01D	USCM-CCEB-B
30	01E	USCM-CCEB-P
31	01F	USCM-CCEB-S
32	020	USCM-E-0-A
33	021	USCM-E-0-B
34	022	USCM-E-0-P
35	023	USCM-E-0-S
36	024	USCM-E-1-A
37	025	USCM-E-1-B
38	026	USCM-E-1-P
39	027	USCM-E-1-S
40	028	USCM-JPD-A
41	029	USCM-JPD-B
42	02A	USCM-JPD-P
43	02B	USCM-JPD-S
44	02C	USCM-M-A
45	02D	USCM-M-B
46	02E	USCM-M-P
47	02F	USCM-M-S
48	030	PDB-A
49	031	PDB-B
50	032	PDB-P
51	033	PDB-S
52	034	USCM-R-0-A
53	035	USCM-R-0-B
54	036	USCM-R-0-P
55	037	USCM-R-0-S
56	038	USCM-R-1-A
57	039	USCM-R-1-B
58	03A	USCM-R-1-P
59	03B	USCM-R-1-S
60	03C	USCM-S-0-A
61	03D	USCM-S-0-B
62	03E	USCM-S-0-P
63	03F	USCM-S-0-S
64	040	USCM-S-1-A
65	041	USCM-S-1-B
66	042	USCM-S-1-P
67	043	USCM-S-1-S
68	044	USCM-S-2-A
69	045	USCM-S-2-B
70	046	USCM-S-2-P
71	047	USCM-S-2-S
72	048	USCM-S-3-A
73	049	USCM-S-3-B
74	04A	USCM-S-3-P
75	04B	USCM-S-3-S

Nb.	Hex	What's this is
76	04C	USCM-T-0-A
77	04D	USCM-T-0-B
78	04E	USCM-T-0-P
79	04F	USCM-T-0-S
80	050	USCM-T-1-A
81	051	USCM-T-1-B
82	052	USCM-T-1-P
83	053	USCM-T-1-S
84	054	USCM-T-2-A
85	055	USCM-T-2-B
86	056	USCM-T-2-P
87	057	USCM-T-2-S
88	058	USCM-T-3-A
89	059	USCM-T-3-B
90	05A	USCM-T-3-P
91	05B	USCM-T-3-S
92	05C	USCM-T-4-A
93	05D	USCM-T-4-B
94	05E	USCM-T-4-P
95	05F	USCM-T-4-S
96	060	USCM-T-5-A
97	061	USCM-T-5-B
98	062	USCM-T-5-P
99	063	USCM-T-5-S
100	064	USCM-T-6-A
101	065	USCM-T-6-B
102	066	USCM-T-6-P
103	067	USCM-T-6-S
104	068	USCM-T-7-A
105	069	USCM-T-7-B
106	06A	USCM-T-7-P
107	06B	USCM-T-7-S
108	06C	USCM-TT-A
109	06D	USCM-TT-B
110	06E	USCM-TT-P
111	06F	USCM-TT-S
112	070	USCM-U-0-A
113	071	USCM-U-0-B
114	072	USCM-U-0-P
115	073	USCM-U-0-S
116	074	USCM-U-1-A
117	075	USCM-U-1-B
118	076	USCM-U-1-P
119	077	USCM-U-1-S
120	078	USCM-UG-A
121	079	USCM-UG-B
122	07A	USCM-UG-P
123	07B	USCM-UG-S

Nb.	Hex	What's this is
124	07C	CAB-A
125	07D	CAB-B
126	07E	CAB-P
127	07F	CAB-S

19.3 JINJ and Trigger Addresses

0, -1, -2, -3, -A, -B label physical modules

P = Primary
S = Secondary
T = Tertiary
Q = Quaternary (?)

All four JINJ may be on. Both JLV1 may be on!!

Nb.	Hex	What's this is
128	080	JINJ-0
129	081	JINJ-1
130	082	JINJ-2
131	083	JINJ-3
132	084	JINJ-P
133	085	JINJ-S
134	086	JINJ-T
135	087	JINJ-Q
136	088	JLV1-A
137	089	JLV1-B
138	08A	JLV1-P
139	08B	JLV1-S
140	08C	ETRG-0-A
141	08D	ETRG-0-B
142	08E	ETRG-0-P
143	08F	ETRG-0-S
144	090	ETRG-1-A
145	091	ETRG-1-B
146	092	ETRG-1-P
147	093	ETRG-1-S
148	094	free
149	095	free

19.4 DAQ Addresses

E = ECAL
R = RICH
T = Tracker
U = TRD
0 -1, -2,... = Crate #
A, -B = redundant halves
P = Primary
S = Secondary
Both JINF halves may be on!
EDR – one hot, one cold (?)
RDR – no redundancy (?)
SDR – both may be on (?)
TDR – no redundancy
UDR – one hot, one cold
no Address for “cold”

Nb.	Hex	What's this is
151	097	JINF-E-0-B
152	098	JINF-E-0-P

Nb.	Hex	What's this is
153	099	JINF-E-0-S
154	09A	JINF-E-1-A
155	09B	JINF-E-1-B
156	09C	JINF-E-1-P
157	09D	JINF-E-1-S
158	09E	JINF-R-0-A
159	09F	JINF-R-0-B
160	0A0	JINF-R-0-P
161	0A1	JINF-R-0-S
162	0A2	JINF-R-1-A
163	0A3	JINF-R-1-B
164	0A4	JINF-R-1-P
165	0A5	JINF-R-1-S
166	0A6	JINF-T-0-A
167	0A7	JINF-T-0-B
168	0A8	JINF-T-0-P
169	0A9	JINF-T-0-S
170	0AA	JINF-T-1-A
171	0AB	JINF-T-1-B
172	0AC	JINF-T-1-P
173	0AD	JINF-T-1-S
174	0AE	JINF-T-2-A
175	0AF	JINF-T-2-B
176	0B0	JINF-T-2-P
177	0B1	JINF-T-2-S
178	0B2	JINF-T-3-A
179	0B3	JINF-T-3-B
180	0B4	JINF-T-3-P
181	0B5	JINF-T-3-S
182	0B6	JINF-T-4-A
183	0B7	JINF-T-4-B
184	0B8	JINF-T-4-P
185	0B9	JINF-T-4-S
186	0BA	JINF-T-5-A
187	0BB	JINF-T-5-B
188	0BC	JINF-T-5-P
189	0BD	JINF-T-5-S
190	0BE	JINF-T-6-A
191	0BF	JINF-T-6-B
192	0C0	JINF-T-6-P
193	0C1	JINF-T-6-S
194	0C2	JINF-T-7-A
195	0C3	JINF-T-7-B
196	0C4	JINF-T-7-P
197	0C5	JINF-T-7-S
198	0C6	JINF-U-0-A
199	0C7	JINF-U-0-B
200	0C8	JINF-U-0-P

Nb.	Hex	What's this is
201	0C9	JINF-U-0-S
202	0CA	JINF-U-1-A
203	0CB	JINF-U-1-B
204	0CC	JINF-U-1-P
205	0CD	JINF-U-1-S
206	0CE	EDR-0-0-A
207	0CF	EDR-0-0-B
208	0D0	EDR-0-0-P
209	0D1	EDR-0-1-A
210	0D2	EDR-0-1-B
211	0D3	EDR-0-1-P
212	0D4	EDR-0-2-A
213	0D5	EDR-0-2-B
214	0D6	EDR-0-2-P
215	0D7	EDR-0-3-A
216	0D8	EDR-0-3-B
217	0D9	EDR-0-3-P
218	0DA	EDR-0-4-A
219	0DB	EDR-0-4-B
220	0DC	EDR-0-4-P
221	0DD	EDR-0-5-A
222	0DE	EDR-0-5-B
223	0DF	EDR-0-5-P
224	0E0	EDR-1-0-A
225	0E1	EDR-1-0-B
226	0E2	EDR-1-0-P
227	0E3	EDR-1-1-A
228	0E4	EDR-1-1-B
229	0E5	EDR-1-1-P
230	0E6	EDR-1-2-A
231	0E7	EDR-1-2-B
232	0E8	EDR-1-2-P
233	0E9	EDR-1-3-A
234	0EA	EDR-1-3-B
235	0EB	EDR-1-3-P
236	0EC	EDR-1-4-A
237	0ED	EDR-1-4-B
238	0EE	EDR-1-4-P
239	0EF	EDR-1-5-A
240	0F0	EDR-1-5-B
241	0F1	EDR-1-5-P
242	0F2	RDR-0-0-A
243	0F3	RDR-0-0-B
244	0F4	RDR-0-1-A
245	0F5	RDR-0-1-B
246	0F6	RDR-0-2-A
247	0F7	RDR-0-2-B
248	0F8	RDR-0-3-A

Nb.	Hex	What's this is
249	0F9	RDR-0-3-B
250	0FA	RDR-0-4-A
251	0FB	RDR-0-4-B
252	0FC	RDR-0-5-A
253	0FD	RDR-0-5-B
254	0FE	RDR-1-0-A
255	0FF	RDR-1-0-B
256	100	RDR-1-1-A
257	101	RDR-1-1-B
258	102	RDR-1-2-A
259	103	RDR-1-2-B
260	104	RDR-1-3-A
261	105	RDR-1-3-B
262	106	RDR-1-4-A
263	107	RDR-1-4-B
264	108	RDR-1-5-A
265	109	RDR-1-5-B
266	10A	SDR-0-A
267	10B	SDR-0-B
268	10C	SDR-0-P
269	10D	SDR-0-S
270	10E	SDR-1-A
271	10F	SDR-1-B
272	110	SDR-1-P
273	111	SDR-1-S
274	112	SDR-2-A
275	113	SDR-2-B
276	114	SDR-2-P
277	115	SDR-2-S
278	116	SDR-3-A
279	117	SDR-3-B
280	118	SDR-3-P
281	119	SDR-3-S
282	11A	TDR-0-00-A
283	11B	TDR-0-00-B
284	11C	TDR-0-01-A
285	11D	TDR-0-01-B
286	11E	TDR-0-02-A
287	11F	TDR-0-02-B
288	120	TDR-0-03-A
289	121	TDR-0-03-B
290	122	TDR-0-04-A
291	123	TDR-0-04-B
292	124	TDR-0-05-A
293	125	TDR-0-05-B
294	126	TDR-0-06-A
295	127	TDR-0-06-B
296	128	TDR-0-07-A

Nb.	Hex	What's this is
297	129	TDR-0-07-B
298	12A	TDR-0-08-A
299	12B	TDR-0-08-B
300	12C	TDR-0-09-A
301	12D	TDR-0-09-B
302	12E	TDR-0-10-A
303	12F	TDR-0-10-B
304	130	TDR-0-11-A
305	131	TDR-0-11-B
306	132	TDR-1-00-A
307	133	TDR-1-00-B
308	134	TDR-1-01-A
309	135	TDR-1-01-B
310	136	TDR-1-02-A
311	137	TDR-1-02-B
312	138	TDR-1-03-A
313	139	TDR-1-03-B
314	13A	TDR-1-04-A
315	13B	TDR-1-04-B
316	13C	TDR-1-05-A
317	13D	TDR-1-05-B
318	13E	TDR-1-06-A
319	13F	TDR-1-06-B
320	140	TDR-1-07-A
321	141	TDR-1-07-B
322	142	TDR-1-08-A
323	143	TDR-1-08-B
324	144	TDR-1-09-A
325	145	TDR-1-09-B
326	146	TDR-1-10-A
327	147	TDR-1-10-B
328	148	TDR-1-11-A
329	149	TDR-1-11-B
330	14A	TDR-2-00-A
331	14B	TDR-2-00-B
332	14C	TDR-2-01-A
333	14D	TDR-2-01-B
334	14E	TDR-2-02-A
335	14F	TDR-2-02-B
336	150	TDR-2-03-A
337	151	TDR-2-03-B
338	152	TDR-2-04-A
339	153	TDR-2-04-B
340	154	TDR-2-05-A
341	155	TDR-2-05-B
342	156	TDR-2-06-A
343	157	TDR-2-06-B
344	158	TDR-2-07-A

Nb.	Hex	What's this is
345	159	TDR-2-07-B
346	15A	TDR-2-08-A
347	15B	TDR-2-08-B
348	15C	TDR-2-09-A
349	15D	TDR-2-09-B
350	15E	TDR-2-10-A
351	15F	TDR-2-10-B
352	160	TDR-2-11-A
353	161	TDR-2-11-B
354	162	TDR-3-00-A
355	163	TDR-3-00-B
356	164	TDR-3-01-A
357	165	TDR-3-01-B
358	166	TDR-3-02-A
359	167	TDR-3-02-B
360	168	TDR-3-03-A
361	169	TDR-3-03-B
362	16A	TDR-3-04-A
363	16B	TDR-3-04-B
364	16C	TDR-3-05-A
365	16D	TDR-3-05-B
366	16E	TDR-3-06-A
367	16F	TDR-3-06-B
368	170	TDR-3-07-A
369	171	TDR-3-07-B
370	172	TDR-3-08-A
371	173	TDR-3-08-B
372	174	TDR-3-09-A
373	175	TDR-3-09-B
374	176	TDR-3-10-A
375	177	TDR-3-10-B
376	178	TDR-3-11-A
377	179	TDR-3-11-B
378	17A	TDR-4-00-A
379	17B	TDR-4-00-B
380	17C	TDR-4-01-A
381	17D	TDR-4-01-B
382	17E	TDR-4-02-A
383	17F	TDR-4-02-B
384	180	TDR-4-03-A
385	181	TDR-4-03-B
386	182	TDR-4-04-A
387	183	TDR-4-04-B
388	184	TDR-4-05-A
389	185	TDR-4-05-B
390	186	TDR-4-06-A
391	187	TDR-4-06-B
392	188	TDR-4-07-A

Nb.	Hex	What's this is
393	189	TDR-4-07-B
394	18A	TDR-4-08-A
395	18B	TDR-4-08-B
396	18C	TDR-4-09-A
397	18D	TDR-4-09-B
398	18E	TDR-4-10-A
399	18F	TDR-4-10-B
400	190	TDR-4-11-A
401	191	TDR-4-11-B
402	192	TDR-5-00-A
403	193	TDR-5-00-B
404	194	TDR-5-01-A
405	195	TDR-5-01-B
406	196	TDR-5-02-A
407	197	TDR-5-02-B
408	198	TDR-5-03-A
409	199	TDR-5-03-B
410	19A	TDR-5-04-A
411	19B	TDR-5-04-B
412	19C	TDR-5-05-A
413	19D	TDR-5-05-B
414	19E	TDR-5-06-A
415	19F	TDR-5-06-B
416	1A0	TDR-5-07-A
417	1A1	TDR-5-07-B
418	1A2	TDR-5-08-A
419	1A3	TDR-5-08-B
420	1A4	TDR-5-09-A
421	1A5	TDR-5-09-B
422	1A6	TDR-5-10-A
423	1A7	TDR-5-10-B
424	1A8	TDR-5-11-A
425	1A9	TDR-5-11-B
426	1AA	TDR-6-00-A
427	1AB	TDR-6-00-B
428	1AC	TDR-6-01-A
429	1AD	TDR-6-01-B
430	1AE	TDR-6-02-A
431	1AF	TDR-6-02-B
432	1B0	TDR-6-03-A
433	1B1	TDR-6-03-B
434	1B2	TDR-6-04-A
435	1B3	TDR-6-04-B
436	1B4	TDR-6-05-A
437	1B5	TDR-6-05-B
438	1B6	TDR-6-06-A
439	1B7	TDR-6-06-B
440	1B8	TDR-6-07-A

Nb.	Hex	What's this is
441	1B9	TDR-6-07-B
442	1BA	TDR-6-08-A
443	1BB	TDR-6-08-B
444	1BC	TDR-6-09-A
445	1BD	TDR-6-09-B
446	1BE	TDR-6-10-A
447	1BF	TDR-6-10-B
448	1C0	TDR-6-11-A
449	1C1	TDR-6-11-B
450	1C2	TDR-7-00-A
451	1C3	TDR-7-00-B
452	1C4	TDR-7-01-A
453	1C5	TDR-7-01-B
454	1C6	TDR-7-02-A
455	1C7	TDR-7-02-B
456	1C8	TDR-7-03-A
457	1C9	TDR-7-03-B
458	1CA	TDR-7-04-A
459	1CB	TDR-7-04-B
460	1CC	TDR-7-05-A
461	1CD	TDR-7-05-B
462	1CE	TDR-7-06-A
463	1CF	TDR-7-06-B
464	1D0	TDR-7-07-A
465	1D1	TDR-7-07-B
466	1D2	TDR-7-08-A
467	1D3	TDR-7-08-B
468	1D4	TDR-7-09-A
469	1D5	TDR-7-09-B
470	1D6	TDR-7-10-A
471	1D7	TDR-7-10-B
472	1D8	TDR-7-11-A
473	1D9	TDR-7-11-B
474	1DA	UDR-0-0-A
475	1DB	UDR-0-0-B
476	1DC	UDR-0-0-P
477	1DD	UDR-0-1-A
478	1DE	UDR-0-1-B
479	1DF	UDR-0-1-P
480	1E0	UDR-0-2-A
481	1E1	UDR-0-2-B
482	1E2	UDR-0-2-P
483	1E3	UDR-0-3-A
484	1E4	UDR-0-3-B
485	1E5	UDR-0-3-P
486	1E6	UDR-0-4-A
487	1E7	UDR-0-4-B
488	1E8	UDR-0-4-P

Nb.	Hex	What's this is
489	1E9	UDR-0-5-A
490	1EA	UDR-0-5-B
491	1EB	UDR-0-5-P
492	1EC	UDR-1-0-A
493	1ED	UDR-1-0-B
494	1EE	UDR-1-0-P
495	1EF	UDR-1-1-A
496	1F0	UDR-1-1-B
497	1F1	UDR-1-1-P
498	1F2	UDR-1-2-A
499	1F3	UDR-1-2-B
500	1F4	UDR-1-2-P
501	1F5	UDR-1-3-A
502	1F6	UDR-1-3-B
503	1F7	UDR-1-3-P
504	1F8	UDR-1-4-A
505	1F9	UDR-1-4-B
506	1FA	UDR-1-4-P
507	1FB	UDR-1-5-A
508	1FC	UDR-1-5-B
509	1FD	UDR-1-5-P
510	1FE	free
511	1FF	free