HESSI

High Energy Spectroscopic Imager (HESSI)
Telemetry Formats

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B	1998-May-20	Preliminary Draft	-
C	1998-Aug-20	Minor corrections, change Rejected Events field to Live Time	-
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1. Introduction

This document describes the telemetry formats to be used by the HESSI spacecraft. HESSI will use CCSDS compatible telemetry formatting.

HESSI telemetry data packets will be generated by the spacecraft C&DH system (state-of-health data), the Aspect system, and the IDPU. Data sources will format data into CCSDS compatible Source Packets as described below. Packets will be passed to the C&DH system which will add Telemetry Frame header, Reed-Solomon coding, and Attached Sync Marker. Recorded and Real-time data will be passed to the RF system during ground passes which will perform the physical layer of the link to the ground. On the ground, the Mission Operations Center (MOC) will decode the telemetry stream, extract source packets from telemetry frames, and pass the source packets on to the analysis software. Ground analysis software should expect to receive source packets, plus information on how to convert spacecraft time to UTC, and other ancillary information such as Orbit & Attitude.

Note that the CCSDS standard numbers bits starting at zero with the Most Significant Bit (MSB) of the first byte, which is the first bit of the byte transmitted. A byte is a set of 8 bits. Unless otherwise stated, multi-byte fields shall be transmitted MSB first.

1.1. Document Conventions

In this document, TBD (To Be Determined) means that no data currently exists. A value followed by TBR (To Be Resolved) means that this value is preliminary. In either case, the value is typically followed by UCB (University of California at Berkeley) and / or SA (Spectrum Astro) indicating who is responsible for providing the data, and a unique reference number.

1.2. Applicable Documents

1. CCSDS 100.0-G-1: Telemetry Summary of Concept and Rationale. Green Book. Issue December 1987
2. CCSDS 102.0-B-4: Packet Telemetry. Blue Book. Issue 4. November 1995.
3. CCSDS 101.0-B-3: Telemetry Channel Coding. Blue Book. Issue 3. May 1992.
4. CCSDS 301.0-B-2: Time Code Formats. Blue Book. Issue 2. April 1990.
5. CCSDS 202.0-B-2: Telecommand Part 2, Data Routing Service, November 1992.
6. HESSI Spacecraft State Of Health and Diagnostic Telemetry Packet Format [TBR-SA-401].
7. HESSI Aspect Data System Packet Formats – [HSI_SYS_032]
8. HESSI Spacecraft to IDPU ICD, file HSI_SYS_001D
9. HESSI Instrument command & telemetry database [HSI_CTM.XLS]
10. HESSI Instrument Science Header format [HSI_IDPU_021]

CCSDS Standards documents may be found at:
http://www.ccsds.org/ccsds/ccsds_home.html
HESSI documents can be found at:
ftp://apollo.ssl.berkeley.edu/pub/hessi/released/icd

2. Common Telemetry Format

2.1. Physical Layer

NRZM data format at 4.0 Mbps. There shall also be at least two lower telemetry rates – 1Mbps and 125kbps. Modulation will be BPSK.

2.2. Coding layer

HESSI will use both Reed-Solomon (255,223, I=5) and Pseudo-Randomization compatible with the CCSDS Coding standard (reference 3).

2.3. Transfer Layer

HESSI will use CCSDS standard telemetry packetization. Source Packets will be sized such that exactly one packet fits in each Transfer Frame. All Virtual Channels and all Source Packets will have the same header format, as shown in Figure 2.3-1.

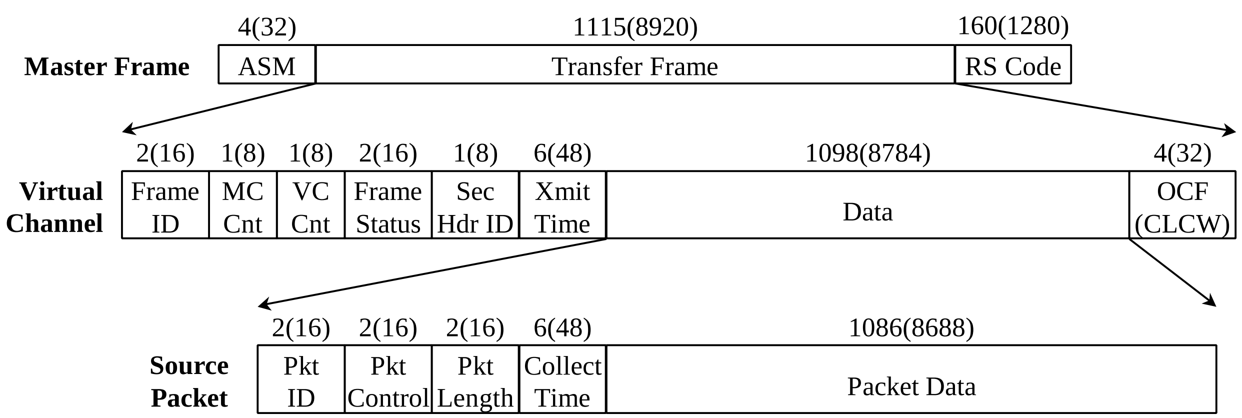

Figure 2.3-1 HESSI Telemetry Format

Master Frame and Virtual Channel formatting shall be done by the spacecraft at transmit time. Source Packet formatting shall be done by the telemetry source (IDPU or spacecraft) at data collect time.

2.3.1. Master Frame Format

Telemetry shall be transmitted to the ground in a contiguous stream of 1279 byte Master Frames.

2.3.1.1. Attached Synchronization Marker (ASM)

The *ASM* is a 32 bit fixed pattern to allow synchronization of the frame boundaries by the ground segment. The value shall be:

ASM = 1ACFFC1D (Hexadecimal, transferred Most Significant Byte first)

2.3.1.2. Transfer Frame

The transfer frame consists of 1115 bytes as described in section 2.3.2.

2.3.1.3. Reed-Soloman (RS) Code

The *RS* code is attached to each Master Frame for error detection and correction. The format used is described in section 2.2, and more fully in Reference 3.

2.3.2. Virtual Channel Format

Each Master Frame includes one Transfer Frame. The Transfer Frame consists of a Transfer Frame header, Transfer Frame data, and a Transfer Frame Trailer. Each Transfer Frames is built from one of four different telemetry streams called 'Virtual Channels'. At transmit time, the spacecraft takes data in the form of Source Packets from a selected Virtual Channel into the Transfer Frame Data field, and adds Transfer Frame Headers & Trailers.

The spacecraft multiplexes data from the different Virtual Channels by the following scheme:

- Real Time SOH & Diagnostic Data - as soon as collected (top priority)
- Recorded SOH & Diagnostic Data - dumped by ground command (second priority)
- Real Time Science - dumped by command (third priority)
- Recorded Science – dumped by command (fourth priority)
- Fill Frames – when nothing else is ready to send

When the transmitter is turned on, only Real Time SOH & Diagnostic and Fill Frames are sent until the ground established lock and commands one or more of the other Virtual Channels to start sending data. When more than one Virtual Channel has been enabled to transmit and has data ready, data will be selected according to the priority scheme indicated.

2.3.2.1. Transfer Frame Header

2.3.2.1.1. Frame Identification (Frame ID)

The *Frame ID* describes the Transfer Frame source, including *Spacecraft ID* and Virtual Channel ID, as shown in figure 2.3.2.1.1-1

	2	10	3	1
Frame ID:	Version #	Spacecraft ID	Virt. Chan. ID	OCFF

Figure 2.3.2.1.1-1 Frame ID Format

2.3.2.1.1.1. Version #

This field indicates the version of CCSDS Transfer Frame Format that is used. It shall contain the value '00'.

2.3.2.1.1.2. Spacecraft ID

This field shall contain a fixed spacecraft identifier to be assigned by CCSDS (0A7 hexadecimal was assigned 12/1998).

2.3.2.1.1.3. Virtual Channel ID

The *Virtual Channel ID* contains a number identifying which telemetry source generated this Transfer Frame. The VC identifier allocation is shown in Table 2.3.2.1.1.3-1.

Table 2.3.2.1.1.3-1 Virtual Channel ID Allocation

VC ID #	Contents
0	Real Time State-of-Health & Diagnostics
1	Recorded State-of-Health & Diagnostics
2	Real Time Science
3	Recorded Science
4	Unused
5	Unused
6	Unused
7	Fill Frames

2.3.2.1.1.4. Operational Control Field Flag (OCFF)

The *OCFF* indicates if the Transfer Frame includes and Operational Control Field as a trailer. It shall '1', indicating the OCF is present.

2.3.2.1.2. Master Channel Count (*MC Cnt*)

The Master Channel count shall be an 8-bit binary counter (modulo 256) that increments once each Master Frame transmitted.

2.3.2.1.3. Virtual Channel Count (*VC Cnt*)

The Virtual Channel count shall be an 8-bit binary counter (modulo 256) that increments once each Master Frame transmitted that includes the Virtual Channel indicated in the Frame ID.

2.3.2.1.4. Frame Status

The *Frame Status* contains a number of sub-fields as shown in Figure 2.3.2.1.4-1.

	1	1	1	2	11
Frame Status:	SecHdr Flag	Sync Flag	PktOrd Flag	SegLen ID	FirstHdr Ptr

Figure 2.3.2.1.4-1 Frame Status Format

2.3.2.1.4.1. Secondary Header Flag (SecHdr Flag)

This field shall contain the value '1' indicating that the Transfer Frame header includes a secondary header.

2.3.2.1.4.2. Synchronization Flag (Sync Flag)

This field shall contain the value ‘0’, indicating byte-synchronized, forward-ordereed Source Packets included in the Transfer Frame Data.

2.3.2.1.4.3. Packet Order Flag (PktOrd Flag)

This field shall contain the value ‘0’.

2.3.2.1.4.4. Segment Length Identifier (SegLen ID)

This field shall contain the value ‘11’.

2.3.2.1.4.5. First Header Pointer (FirstHdr Ptr)

This field shall contain the value ‘0’, indicating that the first Source Packet Header is located at the start of the Transfer Frame Data field.

2.3.2.1.5. Secondary Header Identifier (Sec Hdr ID)

The Secondary Header Identifier contains a version number in the two MSB, which shall be ‘00’, and a length code in the 6 LSB, which shall be ‘6’ (indicating a 7 byte length; 6 time code bytes plus the Secondary Header ID byte). Thus the Secondary Header ID shall contain the fixed value ‘06’.

2.3.2.1.6. Transmit Time (*Xmit Time*)

The Telemetry Frames shall have a secondary header containing the Transfer Frame transmit time, with a known, fixed delay between the time tag and the transmit time of the first bit of the Master Frame (value TBD-SA-404). The time will be coded per CCSDS 301.0-B-2, in unsegmented (binary) format WITHOUT preamble field, and with 48 bits of time counter (see Figure 2.3.2.1.6-1). The time format is spacecraft time, measured from a TBD-UCB-405 epoch, counted from the spacecraft stable clock, which is stable to 20 ppb (see reference 8 for details of the stable clock). Time resolution is 1/65536 second, and range is 136 years. Transmit time, combined with Earth Receive Time, is used to compute the conversion from spacecraft time to UTC by the MOC.

	4 (32)	2 (16)
Transmit Time:	Seconds	Sub-seconds

Figure 2.3.2.1.6-1 Transfer Frame Transmit Time Format

2.3.2.2. Transfer Frame Data

Each Transfer Frame Data field shall contain exactly one Source Packet in the format described in section 2.3.3, except for Fill Frames, which shall contain idle data (value TBD-SA-407).

2.3.2.3. Transfer Frame Trailer (OCF / CLCW)

This Operational Control Field shall contain a CCSDS standard Type 1 Report, which is a Command Link Control Word (CLCW). The CLCW is used for automated command uplink verification. Refer to the CCSDS standard for a description of the CLCW format and usage (Reference 5).

2.3.3. Source Packet Format

Each Transfer Frame includes exactly one Source Packet. The Source Packet consists of a Packet header followed by Packet Data. Source Packets are formatted by the telemetry source (the IDPU or Spacecraft), and the Packet headers are attached at collect time.

2.3.3.1. Source Packet Header

2.3.3.1.1. Packet ID

The Packet ID field contains a number of sub-fields as shown in Figure 2.3.3.1-1.

	3	1	1	11
Packet ID:	Version #	Type	SecHdr Flag	AP ID

Figure 2.3.3.1.1-1 Packet ID Format

2.3.3.1.1.1. Version #

This field shall contain the value '000', indicating a standard CCSDS packet header format.

2.3.3.1.1.2. Type

This field shall contain the value '0', indicating a Telemetry rather than a Telecommand packet.

2.3.3.1.1.3. Secondary Header Flag (SecHdr Flag)

This field shall contain the value '1', indicating that a secondary header (Collect Time) is attached to the Packet Header.

2.3.3.1.1.4. Application Process Identifier (AP ID)

This field shall contain an identifier indicating the process that collected the data (i.e. the format of the Packet Data field). Table 2.3.3.1.1.4-1 indicates the AD ID allocations for HESSI.

Table 2.3.3.1.1.4-1 AP-ID Allocations

Ap. ID #	Contents
0	State-of-Health (SOH) Packets
1-99	Reserved for Spacecraft diagnostic data – TBD-SA-408
100	Event data
101	Fast Rates data
102	Monitor Rates
103-149	Unused - Reserved for Spectrometer Science
150	Diagnostic IDPU Memory dump
151-199	Reserved for other Spectrometer/IDPU diagnostic data – [see reference 9]
200-249	Reserved for Aspect/ADP Science data – [see reference 7]
250-299	Reserved for Aspect/ADP diagnostic data – [see reference 7]
300-2046	Unused
2047	Fill packet

2.3.3.1.2. Packet Sequence Control (*Packet Control*)

The Packet Sequence Control field contains two sub-fields as shown in Figure 2.3.3.1.2-1.

	2	14
Packet Sequence Control:	Grouping Flags	Source Sequence Count

Figure 2.3.3.1.3-1 Packet Sequence Control Format

2.3.3.1.2.1. Grouping Flags

The *Grouping Flags* field shall contain the value '11', indicating no packet grouping.

2.3.3.1.2.2. Source Sequence Count

The *Source Sequence Count* field shall contain a binary count (modulo 16384) of the number of Source Packets generated for the Application ID indicated in the AP ID field for this Source Packet.

2.3.3.1.3. Packet Length

This field shall contain the value 1091 (decimal, Most Significant Byte first), indicating 1092 bytes in the Source Packet Data Field (including Packet Secondary header).

2.3.3.1.4. Collect Time

Source packets will be marked with the packet collection time in the Packet Secondary header "Collect Time" field. The timing of data collection for all data in the source packet should be reconstructible from this time tag. The format of the time tag will be the same as the Transmit Time in the Transfer Frame secondary header (see section 2.3.2.1.6), and shall be based on the same stable clock and epoch.

2.3.3.2. Packet Data

The Packet Data field shall contain data formatted as specified for the AP ID indicated in the Source Packet Header.

3. Packet Data Formats

This section describes packet data formats for each Application Process.

3.1. State Of Health Packets

The spacecraft C&DH system shall collect spacecraft and instrument state-of-health data and format it into a single fixed format state-of-health (SOH) source packet. This shall be the only telemetry stream for spacecraft data, and in addition shall include SOH data collected from the aspect system and IDPU.

SOH data shall include operating mode and status information from all systems, command verification information, and any other information required to determine the health of the spacecraft.

SOH data will be collected into a source packet once a second. Instrument SOH Data shall be transferred over the serial interface from the IDPU once a second to be included in the SOH packet (see IDPU to Spacecraft ICD, reference 8).

During telemetry passes, SOH source packets will be sent in real time via VC 0. In addition, every N^{th} SOH source packet shall be saved in memory continuously in time. (N may be programmable, typically about 10 – TBR-SA-412). During telemetry passes recorded SOH data shall be played back from the memory and transmitted via VC 1 when the spacecraft is commanded to do so.

The format of SOH packets is described in Reference 6. It includes 350 bytes of instrument, with the remainder from the spacecraft. The format of the Instrument part of the packet is described below.

3.1.1. Instrument SOH Data Format

The format of the Instrument SOH data is defined in reference 9.

3.2. Diagnostic Packets

In addition to SOH packets, VC0 and VC1 shall include diagnostic packets. Diagnostic packets may be provided by the IDPU over the telemetry serial interface up to once a second (see IDPU to Spacecraft ICD, reference 8), or may be generated by the spacecraft. When in ground contact (VC0 is active), all diagnostic packets shall be directed to VC0 only (not recorded). When not in ground contact, diagnostic packets will be recorded for later transmission with the VC1 recorded SOH data. The spacecraft only needs to record up to 1000 diagnostic packets from the IDPU; any packets sent by the IDPU after the 1000 packet limit is reached will be lost.

3.2.1. Spacecraft Diagnostic Packets

Spacecraft Diagnostic packets shall include TBD-SA-414.

3.2.2. IDPU Diagnostic Packets

IDPU Diagnostic packets are described in reference 9.

3.2.3. Aspect System Diagnostic Packets

Aspect system diagnostic packets are described in reference 7.

3.3. Spectrometer Packet Formats

Spectrometer packets are formatted by the IDPU and passed to the spacecraft over the high-speed parallel bus on demand by the IDPU. The IDPU shall interleave the packet types as required, and shall control the data collection rate (using shutters and event decimators) to avoid overflowing the spacecraft memory capacity.

3.3.1. Spectrometer Packet Data Headers

The Packet Data of all spectrometer packets shall start with a header describing the state of the spectrometer data processing. This includes shutter position, event decimation settings, test pulser settings, etc. The first 6 bytes of the packet are allocated for this purpose. The format is described in references 9 and 10. The remaining 1080 bytes contain source-specific data as described below.

3.3.2. Event Data Packets

Event Packets include 1080/4 = 270 32-bit events. Events types include detector events and time stamps, as indicated in the Source field (bits 0-4 of each event).

Table 3.3.2-1 Event Source Numbers

Source #	Contents
0-8	Front segment event, detector 0-8
9-17	Rear segment low energy event, detector 0-9
18-26	Rear segment high energy event, detector 0-9
27	CSA Reset Event
28	Oversized Event
29-30	Unused
31	Time Stamp

Time for a given event is computed by starting with the packet time tag or most recent time stamp event if there is one. Next add 1/1024 seconds for every event from the start of the packet or time stamp event, up to the selected event, which has a time tag less than the previous event's time tag (i.e. count time roll-overs). Then truncate the time to 10 sub-second bits and append the event's time tag bits.

It may be necessary to modify this algorithm slightly to account for a race condition in the packet formatting. If two detectors get an event nearly simultaneously, the order they get put into the packet is somewhat arbitrary. In some cases this may cause time tags to get out of order (an event with time tag N+1 may be put into the packet before an event with time tag N). The method of counting time-tag roll-overs should take this into account.

3.3.2.1. Detector Event Format

Front and Rear segment detector events have the same format. They can be distinguished by the Source number included in the event. There are two energy ranges associated with rear segment events. This information is also encoded in the Source number.

	5	13	10	4
Detector Event Format	Source	Energy	Time	Live Time

Figure 3.3.2.1-1 Detector Event Format

3.3.2.1.1. Source

The detector number and type of event are coded in the *Source* field using the code indicated in Table 3.3.2-1.

3.3.2.1.2. Energy

The *Energy* field is the 13 MSB of the pulse height ADC output for the event.

3.3.2.1.3. Time

The *Time* field contains a count of the spacecraft clock with about 1us resolution (2^{-20} seconds) and about 1ms range (2^{-10} seconds). It is based on the stable spacecraft clock, with the same epoch.

3.3.2.1.4. Live Time

The *Live Time* field contains information about the current live time measurement. The live time measurement is made with a 9-bit counter counting at 1MHz (2^{20} Hz), gated by the detector dead time (using the same scheme as the Monitor Rate live time measurement). A separate counter is maintained for each detector segment, and is read out with the associated segment's events. Each counter is latched and reset every 1/2048th of a second, synchronous with the spacecraft 1Hz clock. If the previously latched value for a detector segment has not started to be read out before a new measurement is latched, the new measurement over-writes the previous measurement. Once a measurement has started being read out, it continues to completion. A new measurement may be latched while the previous is being read out without disturbing the readout (i.e. a measurement is either completely read out or not read out at all). The latched counter value is included in the *Live Time* field of the next 3 available detector events. The 9-bit counter value is broken into 3 3-bit pieces for transmission in the 3 LSB of the *Live Time* field of the 3 events. The 3 pieces are read out Most Significant Bits first. The MSB of each *Live Time* field contains a flag that is set to 1 for the first of the 3 readouts, and zero for the rest. If any additional events occur after all available live time measurements are read out and before the next time the counter is latched, the *Live Time* field shall contain the value 0000.

3.3.2.2. CSA Reset and Oversized Event Format

When HESSI CSA has transistor reset baseline restoration. When the reset occurs, the preamp is dead for a short interval. Reset events can be included to aid in dead-time measurement, and as a measure of total energy deposition in the detector during times of high count rate when the normal event stream may be off (e.g. during SAA passes). Note that a count of reset events is included in the Monitor rates once a second, so reset events are only needed to get accurate timing. Inclusion of reset events is selected by command.

Oversized events are generated when the Upper Level Discriminator (ULD) for the detector is exceeded. Oversized events can be caused by cosmic rays, and can be large enough to drive the CSA into saturation, causing a significant dead time interval for the detector. Oversized events aid in measuring this dead time, and also may be used to accurately time these events for cosmic science objectives. Again, a count of these events is included in the Monitor Rates , so they are only needed as events for accurate timing. Inclusion of oversized events is selected by ground command.

CSA Reset and Oversized Event Format

5	5	8	10	4
Source	Detector	Unused	Time	Unused

Figure 3.3.2.2-1 CSA Reset & Oversized Event Format

3.3.2.2.1. Source

The type of event is coded in the *Source* field using the code indicated in Table 3.3.2-1.

3.3.2.2.2. Detector

This field indicates which detector generated the event: 0-8 is detector 0-8 front segment, while 9-17 is detector 0-8 rear segment.

3.3.2.2.3. Time

This field contains a count of the spacecraft clock with about 1us resolution (2^{-20} seconds) and about 1ms range (2^{-10} seconds). It is based on the stable spacecraft clock, with the same epoch.

3.3.2.3. Time Stamp Event Format

Time stamp events are included as needed to resolve timing ambiguity in the event stream (longer than 1/1024 seconds between events).

Time Stamp Event Format

5	27
Source	Time

Figure 3.3.2.3-1 Time Stamp Event Format

3.3.2.3.1. Source

The type of event is coded in the *Source* field using the code indicated in Table 3.3.2-1.

3.3.2.3.2. Time

This field contains a time stamp with 1/1024th second resolution (2^{-10} seconds), and 36 hours (2^{17} seconds) range.

3.3.3. Fast Rates Data Packets

Fast Rate packets are included in the telemetry stream when the front segment event rate is so large that the pile-up rejection is eliminating a large fraction of the events. This is not expected to happen very often. Fast Rates includes front segment event counters in four broad energy bands for each front segment detector. The broadband counters can run 5-10x faster than the high-energy resolution channel. The counters are read out with sufficient time resolution for imaging (up to 16KHz for the finest grids). This allows the system to continue to generate coarse energy resolution to higher event rates. Rear segment detectors do not have fast rate counters since their event rates are not expected to be as large.

Fast Rate counters are read out periodically, but at different rates for different detectors (corresponding to the pitch of the grid above the detector). The Fast rate counters for the finest grids need to be read out at 16,384 Hz to match the modulation time resolution, while coarser grids can have proportionally slower time sampling.

Things are complicated somewhat by the fact that longer time integrations require more dynamic range in the counters. On the other hand, Fast rates produces a high data rate, so we do not want to waste telemetry by using a large number of bits in the counters for all detectors.

3.3.3.1. Fast Rate Counter Sampling & Sizing

Table 3.3.3.1-1 describes the sample rate and number of bits per counter for each of the nine detectors. The number of bits is designed to handle over 500,000 counts per second in the lowest energy band (Ctr0), with progressively lower rates in higher energy bands (corresponding to the expected fall off in counts with increasing energy). The highest energy channel (Ctr3) can handle up to ¼ of 500,000 counts per second.

Table 3.3.3.1-1 Fast Rate Counter Sampling & Counter Sizing

Detector #	**Sample Rate** Samples/sec	**Ctr0 Bits**	**Ctr1 Bits**	**Ctr2 Bits**	**Ctr3 Bits**	**Total Bits**
0,1,2 (Finest)	16,384	5	4	4	3	16
3,4,5	4,096	9	8	8	7	32
6,7,8 (Coarsest)	1,024	9	8	8	7	32

3.3.3.2. Fast Rate Counter Readout Format

Figures 3.3.3.2-1 and 3.3.3.2-2 show the counter readout format for 16 and 32 bit counter formatrs respectively.

16-bit Fast Rates Counter Readout Format

5	4	4	3
Ctr0	Ctr1	Ctr2	Ctr3

Figure 3.3.3.2-1 16-Bit Fast Rate Counter Format

32-bit Fast Rates Counter Readout Format

9	8	8	7
Ctr0	Ctr1	Ctr2	Ctr3

Figure 3.3.3.2-2 32-Bit Fast Rate Counter Format

3.3.3.3. Fast Rate Counter Readout Cycle

Fast Rates source packet shall consist of 6 readout cycles of the Fast Rates counters. Each cycle shall contain 1080/6 = 180 bytes. A cycle is collected every $1/1024^{th}$ second, and includes 16 samples of fast rate counters for detectors 0,1,2; 4 samples of fast rate counters for detectors 3,4,5; and 1 sample of fast rate counters for detectors 6,7,8. The cycle format shall be as shown in Table 3.3.3.3-1.

Table 3.3.3.3-1 Fast Rate Packet 180-byte Cycle Format

Cycle Byte #	Contents
0,1	Detector 0 Sample 0 (16-bit)
2,3	Detector 1 Sample 0 (16-bit)
4,5	Detector 2 Sample 0 (16-bit)
6,7	Detector 0 Sample 1 (16-bit)
8,9	Detector 1 Sample 1 (16-bit)
10,11	Detector 2 Sample 1 (16-bit)
12,13	Detector 0 Sample 2 (16-bit)
14,15	Detector 1 Sample 2 (16-bit)
16,17	Detector 2 Sample 2 (16-bit)
18,19	Detector 0 Sample 3 (16-bit)
20,21	Detector 1 Sample 3 (16-bit)
22,23	Detector 2 Sample 3 (16-bit)
24-27	Detector 3 Sample 0 (32-bit)
28-31	Detector 4 Sample 0 (32-bit)
32-35	Detector 5 Sample 0 (32-bit)
36-59	Same as 0-23, Samples 4,5,6,7 (16 bit)
60-71	Same as 24-33, Sample 1 (32 bit)
72-95	Same as 0-23, Samples 8,9,10,11 (16 bit)
96-107	Same as 24-33, Sample 2 (32 bit)
108-131	Same as 0-23, Samples 12,13,14,15 (16 bit)
132-143	Same as 24-33, Sample 3 (32 bit)
144-147	Detector 6 Sample 0 (32 Bit)
148-151	Detector 7 Sample 0 (32 Bit)
152-155	Detector 8 Sample 0 (32 Bit)
156-179	TBD-UCB-420

3.3.4. Monitor Rates Packets

The Monitor Rates packet shall contain periodic samples of monitor rate counters. The nominal sampling interval shall be 1 second. Rates shall be log-compressed from 19 to 8 bits per counter (compression scheme shown in table 3.3.4-2). There are 5 monitor rates counters per detector segment (including live time), with 18 segments. In addition, the particle detector counter will be included (sampled 8 times per second). Each packet shall contain 10 cycles of 108 bytes each, generating a source packet every 10 seconds. The cycle format shall be as shown in Table 3.3.4-1.

Table 3.3.4-1 Monitor Rate Packet 108-byte Cycle Format

Cycle Byte #	Contents
0	Particle Detector low energy band event count, sample #0
1	Particle Detector high energy band event count, sample #0
2-15	Repeat of particle detector counts, sample #1-7 (sampled at 8Hz)
16	Detector 0 Front Segment Preamp Reset count
17	Detector 0 Front Segment 4us Shaper Valid event count
18	Detector 0 Front Segment 4us Shaper over ULD event count
19	Detector 0 Front Segment Delay Line valid event count
20	Detector 0 Front Segment Live Time
21	Detector 0 Rear Segment Preamp Reset count
22	Detector 0 Rear Segment 4us Shaper Valid event count
23	Detector 0 Rear Segment 4us Shaper over ULD event count
24	Detector 0 Rear Segment Delay Line valid event count
25	Detector 0 Rear Segment Live Time
26-35	Same as 16-25, for Detector 1
36-45	Same as 16-25, for Detector 2
46-55	Same as 16-25, for Detector 3
56-65	Same as 16-25, for Detector 4
66-75	Same as 16-25, for Detector 5
76-85	Same as 16-25, for Detector 6
86-95	Same as 16-25, for Detector 7
96-105	Same as 16-25, for Detector 8
106-107	TBD-UCB-421

Table 3.3.4-2 Log 19-8 Compression

Input Count Range, N, decimal	**Input Count Range, N, hex**	**Output Code**
0 – 31	0 - 1Fh	N
32 – 63	20h - 3Fh	20h+(N-20h)/2
63 – 127	40h - 7Fh	30h+(N-40h)/4
128 – 255	80h – FFh	40h+(N-80h)/8
256 – 511	100h – 1FFh	50h+(N-100h)/10h
512 – 1,023	200h – 3FFh	60h+(N-200h)/20h
1,024 – 2,047	400h – 7FFh	70h+(N-400h)/40h
2,048 – 4,095	800h – FFFh	80h+(N-800h)/80h
4,096 – 8,191	1000h – 1FFFh	90h+(N-1000h)/100h

8,192 – 16,383	2000h – 3FFFh	A0h+(N-2000h)/200h
16,384 – 32,767	4000h – 7FFFh	B0h+(N-4000h)/400h
32,768 – 65,535	8000h – FFFFh	C0h+(N-8000h)/800h
65,536 – 131,071	10000h – 1FFFFh	D0h+(N-10000h)/1000h
131,072 – 262,143	20000h – 3FFFFh	E0h+(N-20000h)/2000h
262,144 –524,287	40000h – 7FFFFh	F0h+(N-40000h)/4000h
>524,287	> 7FFFFh	FFh

[Note: output code division term truncates remainder; no rounding]

3.4. Aspect System Packet Formats

Separate packets shall be formatted for each asynchronous telemetry stream from the aspect system. This includes RAS packets (which are event-driven), and SAS packets (which are time-synchronous). There will be additional RAS and SAS packets to deal with monitoring data, such as a full-detector dump mode which gets a snapshot of the full detector response.

Types and formats of the Aspect packets is defined in reference 7.