GCMS TELEMETRY FORMATS

INTRODUCTION

This Section defines the formats for all GCMS Telemetry for the Flight Model (FM) in four major sections, as follows:

1 Experiment Status Word (ESW)
2 TM Format
3 Science TM
4 Housekeeping TM

1 CDMU EXPERIMENT STATUS WORD

The ESW is the only real source of instrument and FC health during GSE testing that is available for display without the GCMS GSE consoles running. Also, before TC and TM begin, even the GSE screens are not any help. There are, however, Probe EGSE screens that display the GCMS ESW in all modes.

The ESW scheme implemented for the GCMS instrument multiplexes the data dependent upon Mode and Time provides diagnostics during integration testing. There are eight "Software Status" bits in the ESW available for use. These are used as follows:

#bits	Field
2	*GCMS Mode*
4	Status bits (Mode-specific)
1	*ESW Mode*
1	*Turnoff Request*

The *ESW Mode* serves dual purpose:

(a) as the FC "alive" indicator during Run mode;
(b) one state (CLEAR) would indicate that the remaining 6 bits give the 6 LSBs of the *ICC Index* during Run mode. The other state (SET) means that the remaining 6 bits are the *GCMS Mode* and "Status" fields (see below).

Thus, every 16 seconds when *ESW Mode* changes, the GSE receives either the Mode-dependent *Status* as shown below, or a partial *ICC Index* (0-63) from the TDIC software module. The test team also sees an "alive" indication status based on that bit only.

The four states of *GCMS Mode* are as follows:

0 = Bootstrap / CPU c/o 2 = Run, <t0
1 = Initialization 3 = Run, >t0

After FC reboot, the first mode entered is *Bootstrap* mode, defined by the processing in section 7.8 of the GCMS Software Requirements Document. Upon completion of bootstrap processing, *Initialization* mode begins, which includes the BA Pressure Security Sequence (see GCMS Software Requirements Document, §6.1). The *Run* modes are defined by the signal *Master Mode* (see GCMS Software Requirements Document, §7.5), further defined by the state of the *Before* t_0 internal signal (see GCMS Software Requirements Document, §6.2.4).

The *ESW Mode* bit is not toggled during Boot mode.

Refer to figure 1-1 for the layout of the bits in the various modes.

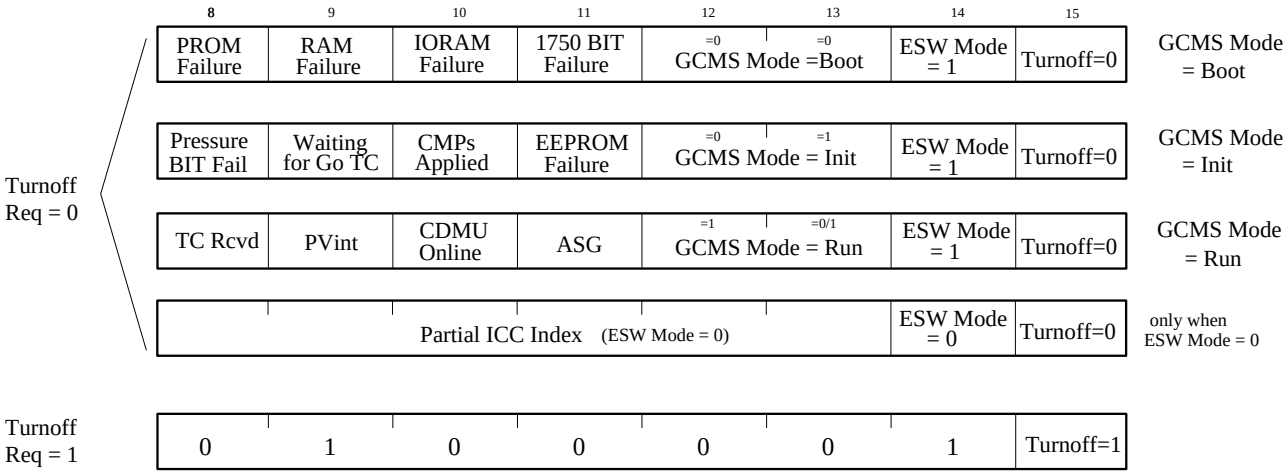


Figure 1-1 — Experiment Status Word Formats

Run Mode signals:

Turnoff	Ground Turnoff Request. Set by TC.
ESW Mode	Multiplexes ESW data and serves as "alive" indicator. Changed after every ESW read: 0 → bits 8-13 indicate Partial ICC Index 1 → bits 8-13 indicate status as per fig. 1.1
ASG	All Systems Go (from General Status word)
C*DMU Online*	clear when comm. failure for either TC or TM
PV_{int}	Processor Valid (internal)
TC Rcvd	set when TC has been received since last ESW (Mode 1) output

Initialization Mode signals:

Turnoff	Ground Turnoff Request. Set by TC.
EEPROM Failure	Failed EEPROM checksum test
Wait For GO	Indicates software is waiting for GO TC
CMPs Applies	Set if CMPs are applied
Pressure BIT Fail	Set if failed BA/Pressure test

Bootstrap Mode signals:

Turnoff	not applicable (set to 0)
1750 BIT Failure	Failed 1750 Built-In Test during boot test
IORAM Failure	Failed IORAM check during boot test
RAM Failure	Failed RAM check during boot test
PROM Failure	Failed PROM checksum during boot test

NOTES:

In Boot mode, the *Turnoff Request* bit will never be set.

In Boot and Initialization Modes, the *ESW Mode* bit is set (=1).

There are two independent ESWs that are transmitted: one for CDMU channel A, and one for channel B. The *TC Rcvd* and *CDMU Online* signals will reflect the status of their respective channels.

In order to aid in detecting spurious ESWs due to EGSE errors, the ESW will be set to the pattern indicated in Figure 1-1 (43_{16}) when the *Turnoff Request* bit is to be set.

2 TM FORMAT

The telemetry data received from the instrument is divided into three primary categories: Science, Queries, and Housekeeping. Each category is further divided as follows:

Science:
- Sweep Data

Queries:
- RAM Dump
- IORAM Dump
- EEPROM Dump

Housekeeping:
- H/K Startup
- Packet HK ("HK I")
- Low-Speed A/D H/K ("HK II")
- Mid-Speed A/D H/K
- High-Speed A/D H/K
- Link/Subsystem Summary
- TC/DDB Acknowledge
- ACP EI Acknowledge
- PS EI Acknowledge
- Over-pressure EI Acknowledge
- Idle subpacket

Furthermore, there are two basic methods of packing telemetry data into the ESA Packets: parallel and serial. These are described below.

2.1 Parallel TM Data Types.

Parallel TM data always occupies the same location in each ESA TM Packet (contrast with the Serial type, §2.2 below). Parallel TM data consist of the following types:

HK I
Link/Subsystem Summary
HKII (multiplexed)

The format and content of all parallel data types are described in detail elsewhere in this document.

2.2 Serial (Subpacket) Data Types.

Serial TM data is assembled into ESA TM Packet serially (contrast with the Parallel type, §2.1), in data blocks called "subpackets." Serial TM data consist of the following types:

Sweep Data	High-Speed A/D H/K
RAM Dump	TC Acknowledge
IORAM Dump	ACP EI Acknowledge
EEPROM Dump	PS EI Acknowledge
H/K Startup	Over-pressure EI Acknowledge
Mid-Speed A/D H/K	Idle subpacket

Starting with the second[1] TM packet generated by the instrument, the leading byte in the Serial Data Area (which is adjacent to the *link/subsystem summary* word) is used first (see figure 2.2-1). Subsequent subpacket bytes are then appended, filling the Serial Data Area. When a subpacket extends beyond the Serial Data Area for one TM Packet, it is continued on the next packet. (Refer also to the *link* field description, §4.3.1.) Packets with serial data are not transmitted until all bytes of the serial data area are filled. Refer also to §2.3 below. See also the description of the Idle subpacket, §4.8.

The format and content of all serial subpackets are described in detail elsewhere in this document.

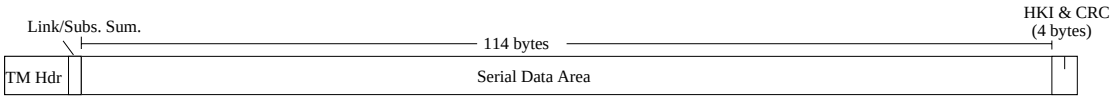


Figure 2.2-1 — Serial Data Area

2.2.1 *Type* Field. All serial telemetry subpackets contain a *type* field in bits 4-7 of the first word. This field indicates the type of data in the subpacket as follows:

0 = Science Sweep Data (see §3)
1 = not used
2 = H/K Startup (see §4.1)
3 = HS A/D H/K (see §4.5)
4 = MS A/D H/K (see §4.6)
5 = not used
6 = Acknowledge (see §4.7)
7 = not used
8 = Idle subpacket (see §4.8)
9 = RAM Dump (see §4.9)
10= EEPROM Dump (see §4.9)
11= IORAM Dump (see §4.9)
12..15= not used

2.3 TM Philosophy.

Science and H/K data serial "subpackets" are collected independently, and are assembled serially into the TM stream, along with "parallel" data:

ESA packet headers
Parallel HK Data (see §2.1)
CRC.

This scheme takes advantage of the philosophy behind packetization in general, namely: (1) the various data types may vary in length; (2) they are essentially independent of one another; and (3) they are placed into the TM stream on order of arrival, without the "Source" (Transmitter) or "Sink" (Receiver) needing to be closely coupled temporally (i.e., data communication is effectively asynchronous, while synchronous handshaking with the CDMU is maintained).

Science subpackets are always 93 words long (~1.6 ESA TM Packets). Other packets are shorter. A Sample TM Packet Sequence is shown in Figure 2.3-1 below, showing Science, Mid-Speed HK, High-Speed HK, and HK-II subpackets.

[1] The first TM packet generated has a Source Sequence Count of zero, and therefore contains a HK Type II packet and no serial (subpacket) data.

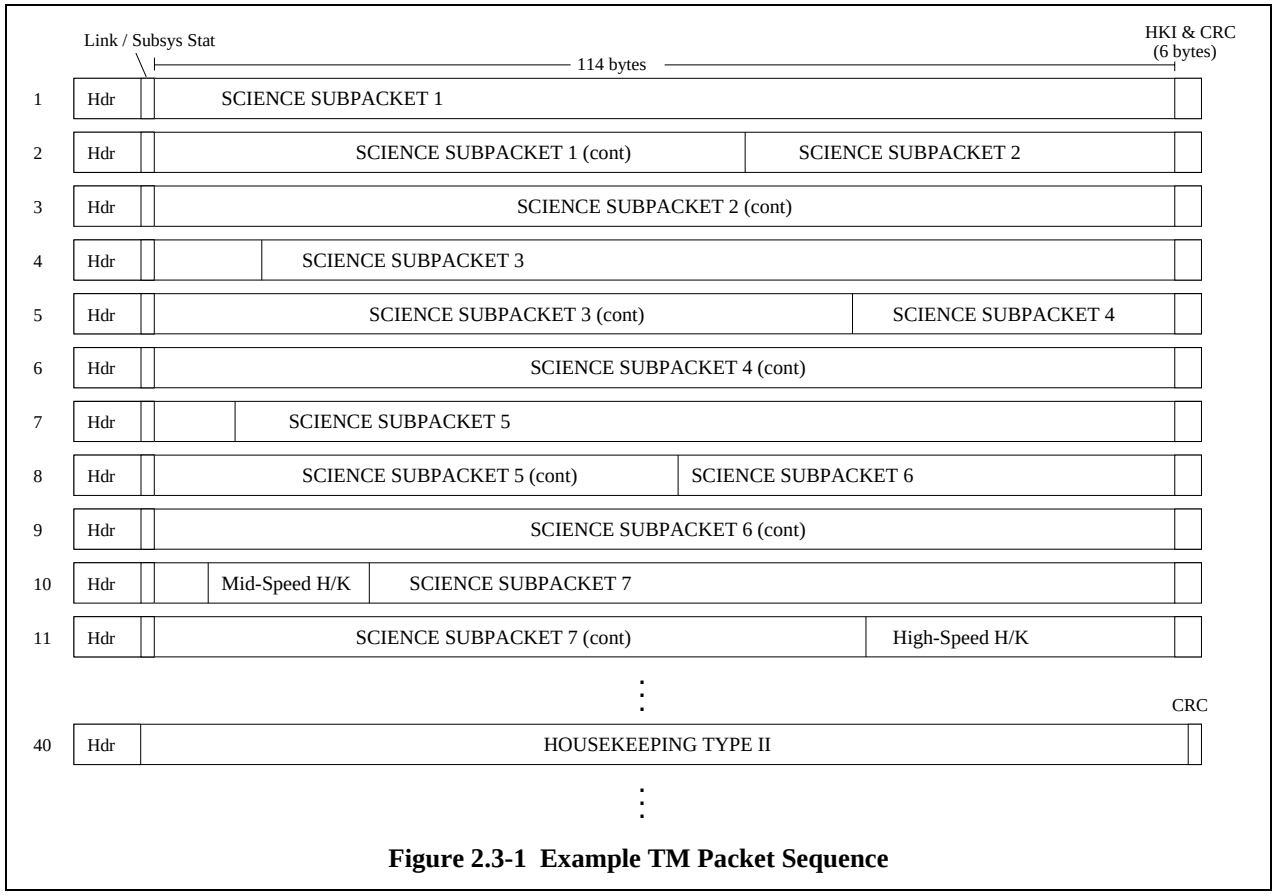


Figure 2.3-1 Example TM Packet Sequence

2.3.1 Sampling of amu Measurements and Alternating CDMUs. The "amu Measurement" portion of the scan is sampled as indicated in §7.2.1 of the GCMS Software Requirements Document. To reduce data generation to 50%, Science Sweep data is sent to the two CDMUs alternately (not redundantly). This is done on a "per Ion Source" basis as follows:

1. Five internal "*CDMU Last Time*" flags are maintained by the software -- one for each Ion Source.
2. When a scan is ready to be sent to TM, it represents data for just one Ion Source; software looks at the *CDMU Last Time* flag for that Ion Source, and send to the other CDMU.
3. Software updates the *CDMU Last Time* flag for that Ion Source.

High-speed and mid-speed housekeeping are similarly multiplexed to the two CDMU channels, maintaining separate "last time" flags that are used for the Science subpackets.

In summary, the Science Sweep data (*type*=0), High-Speed HK (*type*=3), and Mid-Speed HK (*type*=4), are sent alternately to CDMU A and B. All other TM data is transmitted redundantly (i.e., to both CDMUs).

3 SCIENCE TM

Science data is sampled by the instrument as indicated in §7.2.1 of the GCMS Software Requirements Document. It is formatted serially into the standard ESA TM packets.

This section describes the format of the Science TM Subpackets, including Descriptor, Pulse Counts, Total Counts, and sensitivity flags.

3.1 Sweep Subpacket Format.

Science Sweep Subpackets consist of "blocks" of related data as follows:

Block	#Wds	Description
1	4	Descriptor
2	71	142 8-bit Pulse Counts
3	8	15 8-bit Totals
4	9	142 1-bit Lo Sens flags for sweep
5	1	15 1-bit Lo Sens flags for totals
	=93	

Thus, 93 words will always be transmitted for science subpackets (when *Type*=0).

Unity Full Sweeps contain 142 pulse-counts:
range 2 .. 141 amu
amu #2 is repeated
amu #20 is repeated.

Fractional Full (not short) "Sub-sweeps" contain 142 pulse-counts:
first amu of each subsweep is repeated [2]
amu #20 is repeated.

Therefore, there are 8 fractional subsweeps, together spanning from 0.5 to 141.125 amu.

The general format for Sweep Subpackets is illustrated in figure 3.1-1.

[2] That is, repeated masses are: 0.5 amu, 18.125 amu, etc. -- see table 5.1.1.3-1 in GCMS Software User's Manual.

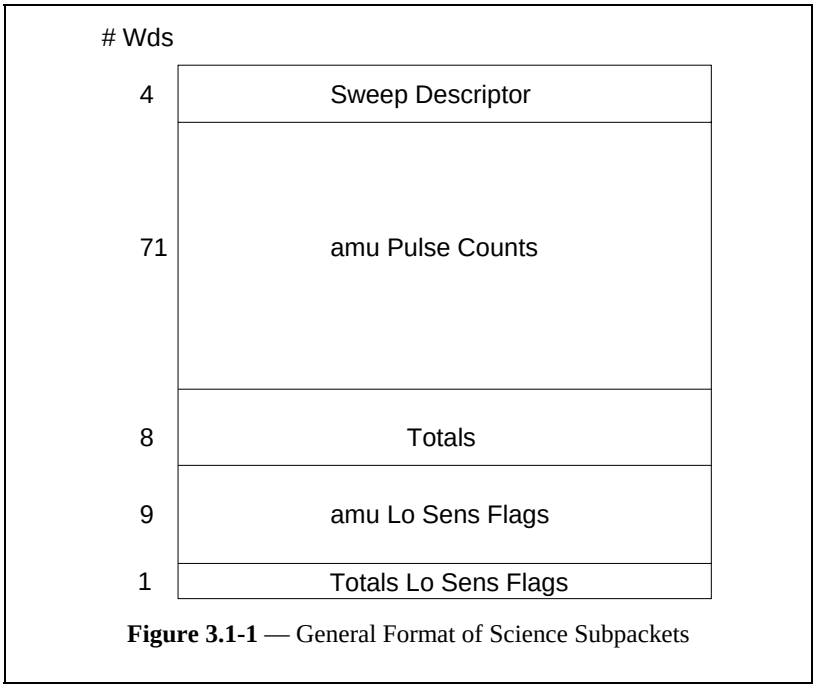


Figure 3.1-1 — General Format of Science Subpackets

3.2 Descriptor Format.

The format of the Science Subpacket Descriptor is illustrated in figure 3.2-1. The individual bits and fields are described below.

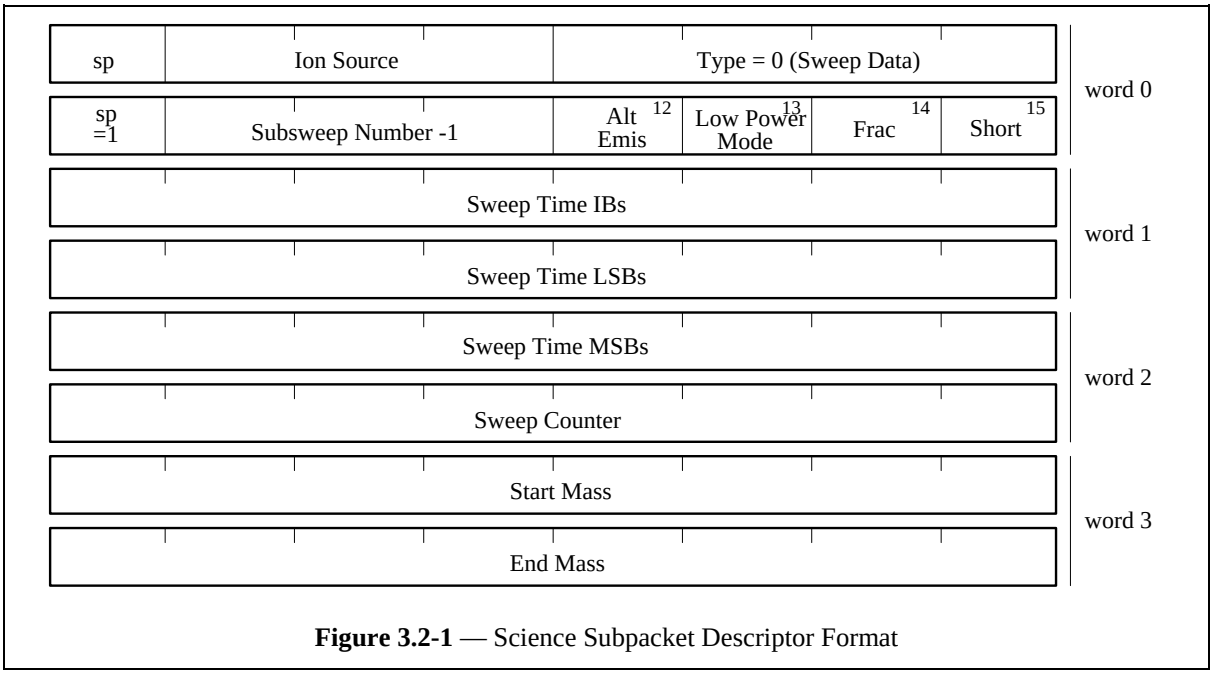


Figure 3.2-1 — Science Subpacket Descriptor Format

3.2.1 ***Frac***. When set, indicates fractional sweep mode. When clear, indicates unity sweep mode. Refer to GCMS Software Users Manual, §5.1.1.3.

3.2.2 ***Ion Source #***. This is simply a number 0-6 identifying from which Ion Source the data was sampled. For all data fields indicating *Ion Source*, both in commands and data, the following standard is used:

0 = None	4 = GC2 (VC2)
1 = Direct Source	5 = GC3 (VC3)
2 = ACP Direct (e.g. VL4)	6 = Cal Filament
3 = GC1 (VC1)	7 = invalid

3.2.3 ***Short***. When this bit is set, it indicates that a shorter range than 2 to 141 amu was scanned during the sweep. The "amu measurement" portion of the subpacket still is the same size (142 bytes), but additional masses are repeated depending upon the amu limits. Refer to the GCMS Software Users Manual, §5.1.1.2, for details.

When this bit is clear, it indicates the subpacket contains "full sweeps," and in this case the S*tart Mass* and *End Mass* fields will always indicate 2 and 141 respectively. Data points for masses 2 and 20 are repeated (refer to the GCMS Software Users Manual, §5.1.1.1). Thus for full sweeps, the correlation of the 142 counts to the byte # position in the amu counts portion of the subpacket is as follows:

#	amu	#	amu	#	amu	#	amu	#	amu
1	2	31	30	61	60	91	90	121	120
2	2	32	31	62	61	92	91	122	121
3	3	33	32	63	62	93	92	123	122
4	4	34	33	64	63	94	93	124	123
5	5	35	34	65	64	95	94	125	124
6	6	36	35	66	65	96	95	126	125
7	7	37	36	67	66	97	96	127	126
8	8	38	37	68	67	98	97	128	127
9	9	39	38	69	68	99	98	129	128
10	10	40	39	70	69	100	99	130	129
11	11	41	40	71	70	101	100	131	130
12	12	42	41	72	71	102	101	132	131
13	13	43	42	73	72	103	102	133	132
14	14	44	43	74	73	104	103	134	133
15	15	45	44	75	74	105	104	135	134
16	16	46	45	76	75	106	105	136	135
17	17	47	46	77	76	107	106	137	136
18	18	48	47	78	77	108	107	138	137
19	19	49	48	79	78	109	108	139	138
20	20	50	49	80	79	110	109	140	139
21	20	51	50	81	80	111	110	141	140
22	21	52	51	82	81	112	111	142	141
23	22	53	52	83	82	113	112	141	140
24	23	54	53	84	83	114	113	142	141
25	24	55	54	85	84	115	114		
26	25	56	55	86	85	116	115		
27	26	57	56	87	86	117	116		
28	27	58	57	88	87	118	117		
29	28	59	58	89	88	119	118		
30	29	60	59	90	89	120	119		

3.2.4 ***Low Power*****.** This bit indicates Low Power (Sweeps Off) mode as specified in the Software Requirements Document, §7.5.1.

3.2.5 ***Subsweep-1*** **Field**. In fractional mode, this field indicates which subsweep, 1-8, is contained in the subpacket. The field, *Subsweep-1*, has the range 0-7, corresponding to subsweeps 1 through 8. .

3.2.6 ***Sweep Time*****.** This contains "Local Time" as specified in the Software Requirements Document. This is the time that the sweep started.

3.2.6.1 Quantization of Time Fields. There are two quantizations for Time: a 16-bit "Local" Time, and a periodic 24-bit "Absolute" Time in H/K Type II data. The *Local Time* would have a quantization with MSB = 512 sec (8.53 minutes), making the quantization in effect a "shifted" version of DDB *Mission Time* (bit 8 of *Local Time* will represent 2 seconds, the same as bit 15 of Probe's *Mission Time*). Thus the LSB of *Local Time* is 15.625 ms; this is more than adequate resolution. *Absolute Time* would assume the same format for its lower 16 bits, and would add one byte: seven *time* bits, and one bit for *After* t_0 indication (taken from the most recent DDB). Actual time can be determined from any Local Time by combining Local Time and the most recent Absolute Time (i.e. Local Time consists of the 16 LSBs of Absolute Time).

The MSB on 23-bit *Time* (within the 24-bit *Absolute Time* data) would thus be 9.1 hrs.

Summarizing: *Local Time* thus has a range of 0..17.05 minutes, and a granularity of 15.625 ms.

A*bsolute Time* has a range of 0..36.2 hrs and the same granularity as *Local Time*; its MSB represents *After* t_0 .

The GCMS instrument receives a Mission Time every 2 seconds via DDB. The GCMS software maintains the higher-resolution 24-bit Absolute Time and 16-bit Local Time values, extrapolated ad hoc and synchronized upon each new DDB (every 2 sec).

3.2.7 ***Sweep Counter***. This is a sequential Scan Number counter that starts at zero and increases by 1 each scan, wrapping at 255. Its intent is to facilitate data reduction and ordering.

3.2.8 ***Start Mass*** **and** ***End Mass*****.** These are the amu numbers for the lowest and highest masses in the sweep subpacket. It is possible for *Start Mass* and *End Mass* to be equal ("amu dwell" mode).

There is a special caveat for fractional mode — refer to the Software Users Manual, §5.1.4.3.

3.2.9 ***Alt Emis*****.** This bit indicates that the instrument is in the Alternate Emission mode. Refer to SRD, §7.6.3.

3.3 Pulse Counts Packing Format.

The amu *Pulse Counts* block consists of square-rooted counts in 8-bit format. It starts with the counter from IP#1 and end with the counter from IP#142 as follows:

Word#	MS Byte	LS Byte
1	IP1	IP2
2	IP3	IP4
...	...	...
71	IP141	IP142

3.4 Totals Counts Packing Format.

The *Totals Counts* block is formatted in the following order: Direct, ACP, GC1, GC2, GC3. For each of the ion sources there are "medium" cooked Totals — 3 bands for each of the five sources. The bands within each source are designated by "b1," "b2," and "b3" below.

Word#	MS Byte	LS Byte
1	Dir b1	Dir b2
2	Dir b3	ACP b1
3	ACP b2	ACP b3
4	GC1 b1	GC1 b2
5	GC1 b3	GC2 b1
6	GC2 b2	GC2 b3
7	GC3 b1	GC3 b2
8	GC3 b3	(spare)

3.5 Sweep Flags Format.

The amu Low Sens Flags block starts with a flag bit corresponding to IP #1, and progresses to IP #142. There are two unused bits at the end.

	Bit#																
Word	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
2	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
3	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	
4	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	**IP#**
5	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	
6	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	
7	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	
8	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	
9	129	130	131	132	133	134	135	136	137	138	139	140	141	142	sp	sp	

3.6 Totals Flags Format.

There are 15 *Totals Flags* -- one for each of the Counts in the *Totals Counts* block. The Totals Flags block starts with GC1 in MSB as follows:

Bit	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Band:	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	sp
ISS:	Dir			ACP			GC1			GC2			GC3			

4 HOUSEKEEPING TM

This section describes housekeeping telemetry formats for GCMS.

4.1 HK Startup.

This serial subpacket provides an indication of the status of initial subsystem tests, memory tests and pressure tests, along with an up-to-date indication of general instrument status at the time the HK Startup is sent.

The following fields and signals are included in the Startup Subpacket:

a) *Local Time*. See §3.2.6.1.

b) Software Version. Reserved software control word.

c) System Configuration. Reserved software control word.

d) *Phase 1 Pressure Security Fail*. This single-bit signal provides an indication of the outcome of Phase 1 of the Pressure Security Test.

e) *Phase 2 Pressure Security Fail*. This single-bit signal provides an indication of the outcome of Phase 2 of the Pressure Security Test.

d) *Mission Phase*. (From DDB).

e) *Mission Phase Latched*. The word value as specified in §7.5.1.1 of the GCMS Software Requirements Document.

f) General_Status. This 16-bit word is formatted as follows:

Bit	Signal
0	*Art#Quiet Count*
1	
2	
3	
4	(spare)
5	*All Systems Go*
6	*All Systems Go Latched*
7	*Exception No Handler*
8	(spare)
9	(spare)
10	(spare)
11	(spare)
12	*ACP Window*
13	(spare)
14	*System Initialized*
15	*System Configured*

.

g) General_Error_Status. This MSW consists of the following signals. "Latched" signals remain set upon each change.

Bit	Signal	Latched
0	*TGO Reset Occurred*	Y
1	*PS OC EI Occurred*	Y
2	*Wayward IC Reboot Occurred*	Y
3	*TGO Toggle*	N
4..7	*CSU#*	Y
8..9	*Trap Flag*	Y
10..15	*Module ID*	Y

h) BIT_Failure. This 16-bit word is formatted as follows:

Bit	Signal
0	*1750 Bit Fail*
1	*RAM Bit Fail*
2	*ROM Bit Fail*
3	*IORAM Bit Fail*
4..5	spares
6	*CDMUo Bit Fail*
7	*CDMUi Bit Fail*
8	spare
9	*CMPs Applied*
10	*TAP or ICCU Applied*
11	*Master EEPROM Fail*
12	*Shadow EEPROM Fail*
13..15	spares

4.2 HK Type I.

The HK Type I consists of one 16-bit word ("Descent_Status"), assembled in parallel in TM, and formatted as follows:

Bit	Signal
0	*All Systems Go*
1	*CDMU A Valid*
2	*TDIC Running*
3..5	*Active ICC*
6..15	*ICC Command Index*

NOTE: All Systems Go= all bits in Subsystem_Failure are clear.

The HK Type I word is output with every packet except those containing HKII data (see §4.4)

4.3 Link/Subsystem Summary.

This (parallel) HK word is output with every packet except those containing HKII data (see §4.4), placed in the fourth word of the packet (following the ESA header), and contains the following signals:

Bit	Signal	
0	*USeqo Offline*	
1	*USeqi Offline*	
2	*CDMUo Offline*	— *"SUBSYSTEM*
3	*CDMUi Offline*	*SUMMARY"*
4	*TMBuf Overflow*	
5	*CDMU Error*	
6	*RTE Error*	
7	*USeq Error*	
8..15	*Link*	|— *LINK*

4.3.1 ***Link* field**. The "*Link*" field is the offset (in bytes) to the first complete science subpacket within that TM packet. In computing the Link, counting starts at zero with the first byte of the Packet ID; thus the Link would have a minimum value of eight (e.g. for the very first TM packet transmitted). Its purpose is to eliminate serial dependency (synchronization can be recovered after loss of data within the previous packet).

4.4 HK Type II

Type II HK ("Low-speed H/K") is a TM-parallel data block and consists of a mix of digital and A/D signals as listed in Table 4.4-1. The "Index" column indicates the offset of the parameter or block within the data segment of the packet. Type II H/K contains a more detailed report on the status of the instrument, and includes all "Low Speed" A/D values ("LS A/D"). This packet is only be transmitted when the Source Sequence Count in TM is an even modulus of 40. Each TM packet containing a Source Sequence Count with an even modulus of 40 therefore contains HK Type II data, and will *not* contain a HK Type I, nor a Link/Subsystem Summary word.

For detailed descriptions of the formulation algorithms for signals, refer to the Software Requirements Document.

Table 4.4-1 — Type II H/K Data

Index	# Bytes	Data
0	1	Commutator Index
1	1	spare
2	2	16-bit Local Time
4	78	A/D Snapshot
82	4	DMUX
86	32	Software Status (see Table 4.4-2)
	118	(total)

The data field size within a TM packet is 118 bytes (126 minus 6 for Header and 2 for CRC). The *Link / Subsystem Summary* and H/K I data are not transmitted with the two H/K II packets (see Figure 2.3-1).

Some signals are also included in the Idle subpacket for thorough diagnostic capabilities during ground testing. Note that the 10-bit AMUX parameters are to be rescaled to 8 bits, and thus only require 40 words.

4.4.1 ***Commutator Index***. (Refer to Software User's Manual and Software Requirements Document.)

4.4.2 ***Local Time***. See §3.2.6.1.

4.4.3 A/D Snapshot. This block contains A/D data as shown below. There is also a reflection of the most recent DDB Time and DDB Altitude words, assembled at the time the HKII subpacket is generated (refer to figure). All A/D data consists of the upper 8 bits from the 10-bit A/D input signals.

Word#	Upper Byte	Lower Byte
1	Anode 1	Anode 2
2	EB4-2	EB4-1
3	Fil I 1	Fil I 2
4	Fil Emis 2	Fil Emis 1
5	Bias A	Bias 1
6	Bias 2	Pressure 1
7	Bias Mon 3	Bias Mon 2
8	Spare Mon	Bias Mon 1
9	Anode 3	Anode 4
10	EB4-4	EB4-3
11	Fil I 3	Fil I 4
12	Fil Emis 4	Fil Emis 3
13	Bias B (-50 dual)	Bias 3 (-70-1)
14	Bias 4 (-70-2)	Pressure 2
15	EM Temp	Bias Temp
16	RF Temp	Ref V
17	Anode 5	Anode 6
18	EB4-6	EB4-5
19	Fil I 5	Fil I 6
20	Fil Emis 6	Fil Emis 5
21	Bias C (-50 dual)	Bias 5 (-70-1)
22	Bias 6 (-70-2)	Shell Press
23	DDB Time Word (Word 4)	
24	DDB Altitude Word (Word 5)	
25	Deck Temp	Transistor Temp
26	Therm Press	Th Ref Press
27	Temp IS3 Int	Temp H2
28	Temp Sample	Temp LVPS 1
29	Temp LVPS 2	Temp LVPS 3
30	+13 Mon	+5R Mon
31	5 Ref	-57 Mon
32	Cal Mon	VH Inhibit
33	Temp GC1	Temp EC1
34	Temp EC2	Temp ACP
35	Temp GC2	Temp GC3
36	Temp Inlet	ACP Pres 1
37	ACP Pres 2	Temp FC
38	+5R Mon	RF Mon
39	EM1 Mon	EM2 Mon

Figure 4.4.3-1 -- HKII A/D Format

4.4.4 DMUX Data. The DMUX Data block consists of two words. It is a collection of the valve position readouts, formatted as follows:

Table 4.4.4-1 — DMUX TM Format

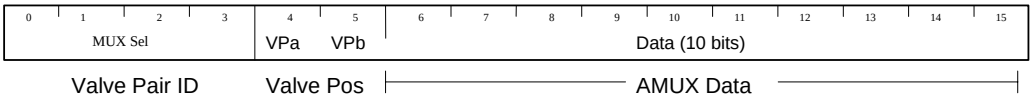
Word 1

Vlv a/b	VPb	VPa	VPb	VPa	VPb	VPa	VPb	VPa	VPb	VPa	VPb	VPa	VPb	VPa	VPb	VPa
Vlv Group	vg0	vg0	vg1	vg1	vg2	vg2	vg3	vg3	vg4	vg4	vg5	vg5	vg6	vg6	vg7	vg7
Vlv ID	IV	IVA	VS6	VAA	VD1	VL1	sp	sp	VS1	VL3	VD2	VS7	VS2	VE	VS3	VC3

Word 2

Vlv a/b	VPb	VPa	VPb	VPa	VPb	VPa	VPb	VPa	VPb	VPa	VPb	VPa	VPb	VPa	VPb	VPa
Vlv Group	vg8	vg8	vg9	vg9	vgA	vgA	vgB	vgB	vgC	vgC	vgD	vgD	vgE	vgE	vgF	vgF
Vlv ID	VS5	VL4	VD3	VZ	VD4	VL2	VG3	VAB	VG2	VV	VG1	VC2	VD6	VC1	sp	VG

4.4.4.1 Correlation to hardware polling formats. The DMUX Data word input to the flight computer consists of both DMUX and AMUX data in the following format:



The *MUX Sel* field indicates which two valves are represented in the *Valve Pos* field. The *MUX Sel* field is represented in Table 4.4.4-1 by the "Vlv Group" row (groups #$vg0_{16}$..vgF_{16}). The *VPa* and *VPb* signals indicate Open or Closed valve status, and are indicated in Table 4.4.4-1 by the "Vlv a/b" row. Finally, the actual Valve ID associated with each Valve Pair is given in the "Vlv ID" row.

4.4.5 Software Status. The formats and descriptions for all signals in the Software Status block are given below.

Table 4.4-2 -- Software Status and Digital Data

Word#	Parameter	#Bytes	Description	In Idle Data
0, 1	*Valve Enable MSW*	4	Valve Enable/Disable Statuses	
2	*Heater MSW*	1	Internally-kept positions (on/off)	Y
2	*Filament/IPS/Htr MSW*	1	On/Off status of Fil 1..6 and IPS A..B	Y
3	*General_Status*	2	All Systems Go, other flags	
4	*General_Error_Status*	2	Software diagnostic flags/pointers	
5	*Latched Submodes*	1	Wait for Go; Latched & Cmded: <t0 and Alt Valid	Y
5	*Absolute Time MSBs*	1	Internal 24-bit Time	
6	*Absolute Time LSBs*	2	Internal Time LSBs: same format as Local Time	
7	*Useq Mode Byte*	1	Sweep Statuses: Frac, Short, Low Power, Sci Quiet, ISS	
7	*BA Emis Status*	1	4-bit BA Filament Emission Ctrl (D/A). 4 spare bits	
8	*RF Freq* Mon_{avg}	2	Counter3 (Digital Freq Sel Mon) Averaged	
9	*USeq MSW*	2	USeq input & output comm. statuses/errors	
10	*DDBs Received*	2	DDB Seq. Counts 0-255. Upper Byte=CDMU A. *	
11	*Scan Counter mod(64k)*	2	Scan Sequence Counter *	
12	*TM Buffer Levels*	2	# Pkts in IORAM(a,b) -- Upper Byte =CDMU A	
13	*Mission Phase*	1	Mission Phase as commanded in DDB	Y
13	*Mission Phase Latched*	1	Mission Phase Latched (internal)	Y
14	*ESW*	2	Experiment Status Word CDMU A & B	Y
15	*Heater/Fil Enable MSW*	2	Enable/Disable for 8 Heaters & 6 Filaments	

* - 16-bit sequence counters reset after 65,535. 8-bit sequence counters reset after 255.

Bit layouts for the fields are given on the pages that follow.

a. *Valve MSW*. This field reflects the valve enable/disable status (32 valves including spares).

b. *Heater MSW*. This field reflects the internally-kept heater statuses (on/off).

c. *Filament/IPS/Heater MSW*. This field reflects the internally-kept Filament and IPS statuses (on/off):

Bit	Signal
0	Filament 1 On
1	Filament 2 On
2	Filament 3 On
3	Filament 4 On
4	Filament 5 On
5	Filament 6 On
6	IPS 123 On
7	IPS 456 On

Bit	Signal
8	Heater 1 On
9	Heater 2 On
10	Heater 3 On
11	Heater 4 On
12	Heater 5 On
13	Heater 6 On
14	Heater 7 On
15	Heater 8 On

d. *General_Status*. Refer to §4.1(f).

e. *General_Error_Status*. Refer to §4.1(g).

f. *Latched Submodes*. These signals indicate the internal "latched" (filtered) statuses that are used by the flight software, for like-named "raw" signals. The software formulates the signals at the time that this HK message is generated in the format shown below:

The signals in the *Latched Submodes* field will be set as follows:

Bit	Signal	Latched
0	*Commanded After T0*	N
1	*After T0 Latch*	Y
2	*Measured Alt*	N
3	*Measured Alt Latch*	Y
4	*Waiting for GO TC*	Y

g. *Absolute Time*. Refer to §3.2.6.1.

h. *Useq Mode Byte*. This field will contain status signals formulated as follows:

Bit	Signal
0	*Science Quiet*
1	*Low Power*
2	*Fractional*
3	*Short Sweep*
4	*spare*
5	*ISS*
6	
5	

i. *BA Emis Status*. Since this signal is a reflection of the status of the *BA Emission* value generated during the Pressure Security Sequence, it is also dependent upon the *Experiment Phase* signal (see Software Requirements Document, §7.5.1.1). During operation of the Pressure Security Sequence, this field will contain the most recently commanded *BA Emission* (DAC) value. During other phases (viz., Descent, and during such times that the Pressure Security Sequence is not operating), it is undefined.

j. *RF Freq Mon*$_{avg}$. The "raw" digital *RF Freq Mon* parameter will be averaged over 50 integrations to be usable for frequency drift correction. The RF Freq integration will be performed only in the low frequency mode, whenever the quadrupole is tuned between masses 25 and 75. The averaged value, *RF Freq Mon*$_{avg}$. which is used to adjust for frequency drifts (see DN-024), is included in this HK TM block.

k. *Useq MSW*.

l. *DDBs Received*. This field will contain 8-bit sequence counts of the number of DDBs received on each CDMU, modulus 256.

m. *Scan Counter*. This field will contain a 16-bit sequence count of the number of scans performed, modulus 2^16.

n. *TM Buffer Levels*.

o. *Mission Phase*. This field will be set to the Mission Phase as commanded in DDB.

p. *Mission Phase Latched*. See Software Requirements Document, §7.5.1.1.

q. *ESW*. Set to the current ESW value.

4.5 Sampling of High-speed H/K Data.

High-Speed data is assembled into TM as serial subpackets, and consists only of A/D values as indicated in DN-028, §4.9.1. The essential concepts are:

(a) Four signals need to be monitored at ~1 Hz (I Mon 1, I Mon 2, & the two Multanas[3]).
(b) Two Valve capacitor voltages need to be monitored at a higher rate.
(c) The scan start time and Commutator Index must be included in TM to properly interpret the data.
(d) The data is to be telemetered approximately every 10 seconds.

The High-Speed H/K Data is telemetered alternately to the CDMUs.

The Software Requirements Specification, §6.8.4, describes the data collection process and the marching commutator. Refer also to the Software Users Manual, §5.1.

The format of the entire subpacket including header is shown below. Note that A/D data is shifted from 10 to 8 bits for packing. (This data is transmitted during all Mission Phases.)

There is a *Local Time* indication for correlation to scan data. The Commutator Index corresponds to the first mass scan in the subpacket. Obviously, the Commutator Index for subsequent scans can be extrapolated from it.

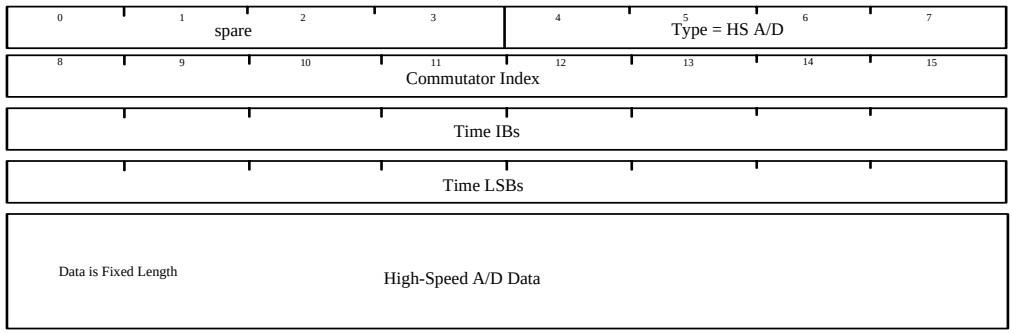


Figure 4.5-1 — High-Speed A/D H/K Subpacket Format

[3] Multana 2 is not strictly required

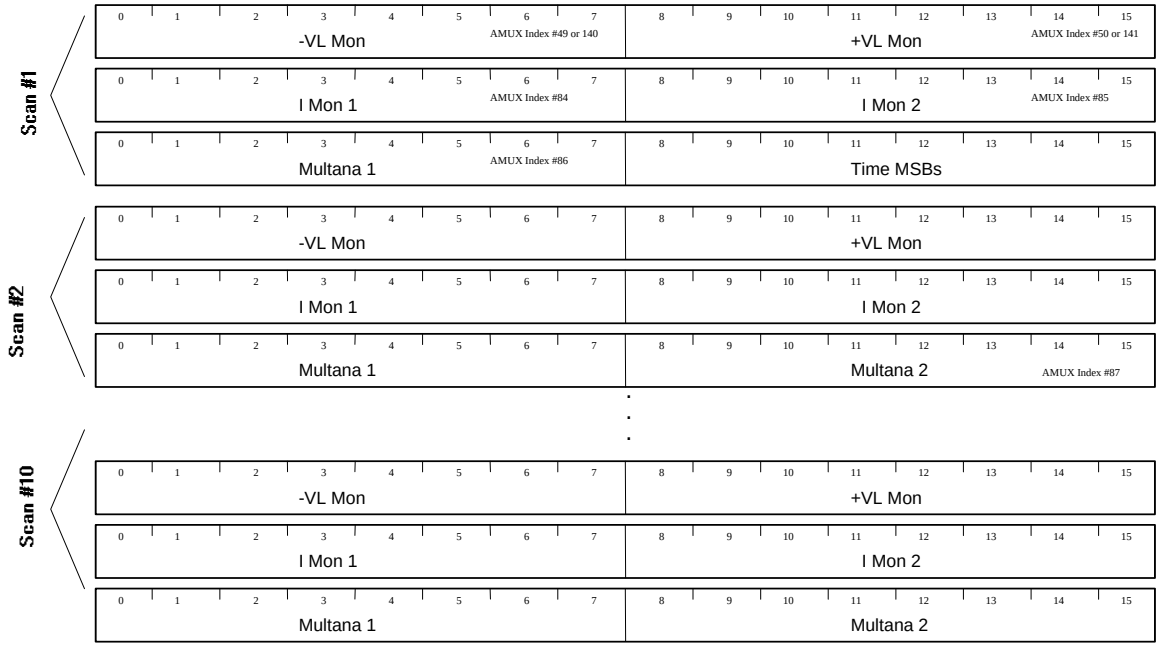


Figure 4.5-2 — High-Speed A/D Data

4.6 Sampling of Mid-speed H/K.

Mid-Speed data is assembled into TM as serial subpackets, and consists of both A/D values and special "counts."

The A/D values to be sampled are:

A/D #	Signal Name
51	*IP Mon 6*
52	*IP Mon 5*
53	*IP Mon 2*
54	*IP Mon 1*
55	*IP Mon 3*
56	*IP Mon 4*
57	*BA Mon*

The special counts to be sampled are:

IPx Hi Sens Count ‡
IPx Lo Sens Count
IPy Hi Sens Count ‡
IPy Lo Sens Count
Best Overlap Hi Sens Count‡
Best Overlap Lo Sens Count
Best Overlap IP#
Best Overlap Scan#

‡- Hi Sens counts are square-rooted

All A/D data will consist of the upper 8 bits of the 10-bit input signals, except for *Temp GC3*, which is the lower 8 bits (the 2 MSBs are discarded.)

After every 10th scan, the MS H/K data is collected (sampled from the most recent scan), and the subpacket is assembled and transmitted. To reduce data generation by 50%, MS H/K is sent alternately to the CDMUs.

The IPx samples are counts taken on the same IP# every sweep (refer to Software Requirements Document). Likewise the IPy.

"Best Overlap" criteria is simply the highest number in the high-sens counter for the 10-sweep period. Both counters, and the Scan # and IP# where the highest value was found, are included.

Like High-Speed data, Mid-Speed A/D values will not be collected simply in "order of arrival" (see above). The Mid-Speed A/D values therefore are collected in a manner similar to High-Speed -- that is, extracted from the 187-word A/D table only at the end of a scan -- except that this is done only once every 10 scans.

The format of the entire subpacket including header is shown below. Note that A/D data is shifted from 10 to 8 bits for packing. This data is transmitted during Descent mode.

There is a *Local Time* indication for correlation to scan data.

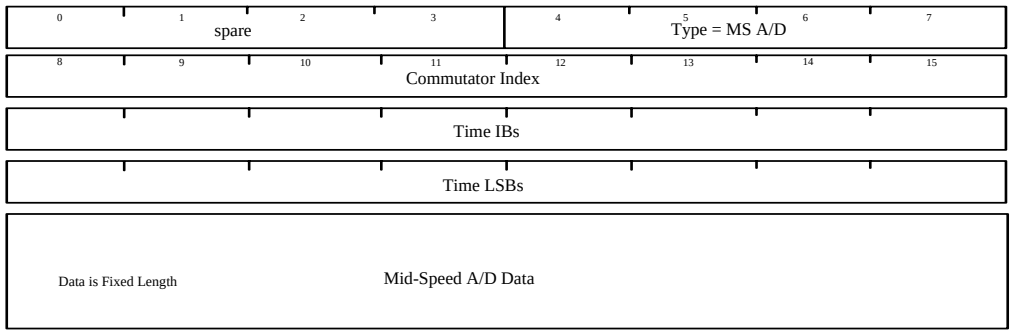


Figure 4.6-1 — Mid-Speed H/K Subpacket Format

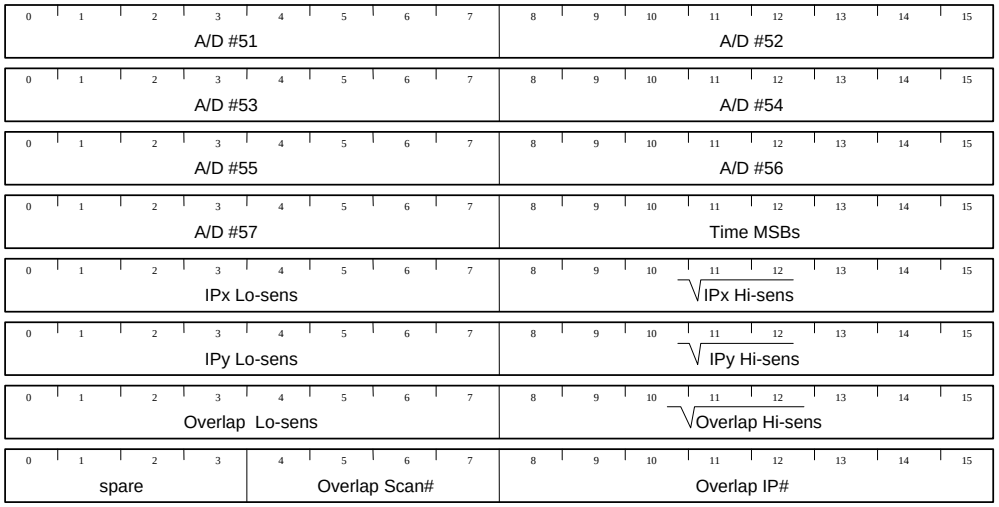


Figure 4.6-2 — Mid-Speed Data

4.7 Acknowledge TM Subpackets.

The occurrence of instrument external interrupts, and receipt of any non-DDB telecommand, will result in "ack" TM serial subpackets being transmitted by the FC. Bits 1-3, *Ack Type*, are used to identify the type of the ack subpacket:

Code			Ack Type
0	0	0	ACP EI Ack
0	0	1	PS Over Current EI Ack
0	1	0	Over Pressure EI Ack
0	1	1	TC Ack -- for EEPROM TCs: TAP, CMP or ICCU
1	0	0	TC Ack -- for RAM TCs: GIC or GIQ
1	0	1	DDB Ack
1	1	0	not used
1	1	1	not used

4.7.1 External Interrupt Acknowledge. External Interrupts are simply temporal events with no associated input data; hence, External Interrupt (EI) Ack subpackets have no amplifying data except the *Local Time* that the interrupt was received. The format of EI Ack subpackets is shown in figure 4.7-1.

4.7.2 Telecommand Acknowledge. The TC Ack subpackets (see figure 4.7-2) contain a *Sequence Count Repeatback* word, and a *Nack* (No Acknowledge) flag. The *Sequence Count Repeatback* word will be set to the *Source Sequence Count* of the TC that is being acknowledged. The *Nack* flag will be set when a data error is detected (e.g. CRC or data length is bad), and clear otherwise. When *Nack* is set, then by definition neither the type of TC nor the *Source Sequence Count* are trustworthy; thus, *Ack Type* will be set to 3, and *Sequence Count Repeatback* will be set to zero.

The *Serial Number Repeatback* field is also "echoed" back through TM — copied from the TC and placed in the Ack subpacket.

4.7.2.1 DDB Acknowledge. During ground checkout it may be useful to observe the DDB activity. This capability is provided with the DDB Ack option. Two telecommands provide the ability to turn DDB Acks on and off. The format for DDB Ack subpackets is illustrated in figure 4.7-3. DDB Ack subpackets always contain nine words: header word, local time, and seven words "echoing" the DDB data in full.

4.7.2.1 Ack Subpacket Limits. Malfunctional electronics could cause instrument EIs to occur sporadically and with high frequency. Similarly, garbled DDBs could be received regularly. To inhibit the possibility of saturating the TM bandwidth with Ack (or Nack) subpackets due to extraneous EIs or TCs, the limits shown in Table 4.7.2-1 will be used. These limits vary depending upon the Mission Phase field in the most recently received valid DDB. Once the limit is reached, the software will suppress Ack subpackets (of that type).

Table 4.7.2-1 — Ack Subpacket Limits

	Limit value:		
Name	**Ground**	**Cruise**	**Descent**
EI_Ack_Limit	65,535	40	75
TC_Nack_Limit	65,535	100	75

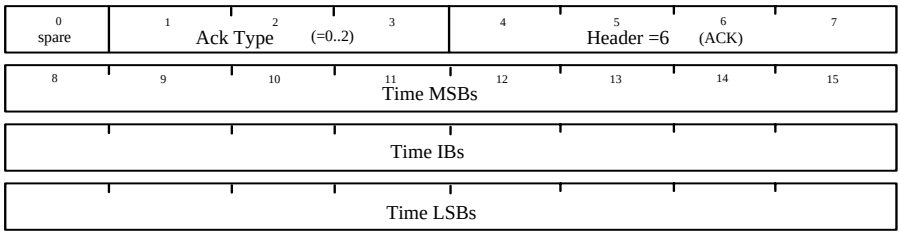


Figure 4.7-1 EI Acknowledge Subpacket

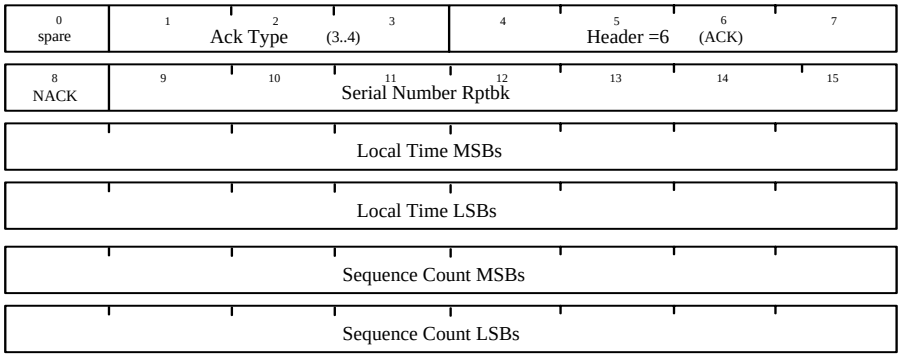


Figure 4.7-2 TC Acknowledge Subpacket

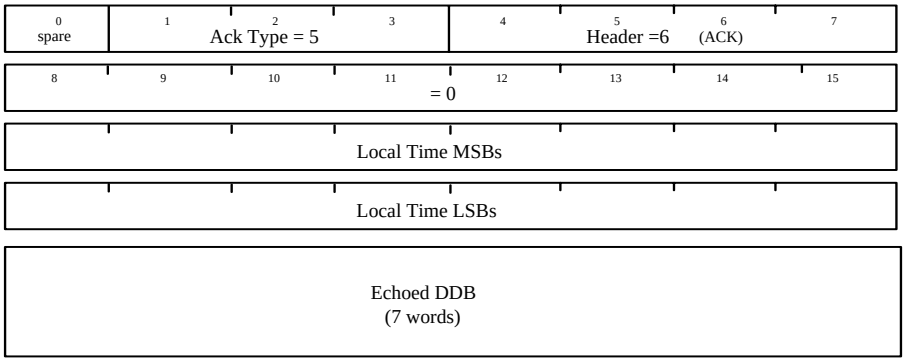


Figure 4.7-3 DDB Acknowledge Subpacket

4.8 Idle Subpacket.

Each time the CDMS transmits a BCP, the software checks the TM FIFO status word. If the status word indicates that the TM FIFO is empty, and no complete packet is ready within the Flight Computer memory buffers, an "Idle Subpacket" is packetized and placed serially in the output TM queue, with the following caveat:

> Since no great information is gained by sending TM at the maximum polling rate, GCMS software limits generation of Idle packets to ~1/2 of the requested rate.

An Idle Subpacket consists of the Descriptor as shown in Figure 4.8-1, and 61 "Health" status words as shown in Table 4.8-1.

a) The A/D data starts with A/D Ref #1 in the most significant byte (see DN-013 Table 3.4.4-1). All data in this block contain values polled on the first 91 IPs of the scan.

b) The "Supplementary" pressure data are from the second A/D polling sequence (so-called "super-commutator" indices, viz., higher than IP #91) of the scan. See DN-032, §5.1.1.4.

c) The Filament/IPS/Htr MSW indicates the ON/OFF status of those devices.

d) The DAC data provides diagnostic information important during ground tests, especially for analysis of the Pressure Security sequence. Refer to Table 1.1.1-1 in EID-B Annex 2, Section "TC" for a DAC Signal/Index Correlation.

Since the subpacket is longer than the data segment of a TM packet (it has 122 data bytes and 4 descriptor bytes for a total of 126 bytes), this will always result in assembly of one complete packet, also "flushing" any partial packet that might exist in the FC TM buffer.

Table 4.8-1 — Idle Subpacket Data

Word#	PARAMETER	# BYTES	DESCRIPTION
1..4	Absolute Time	4	32-bit Time Stamp
5 .. 50	A/D Data	91	Complete A/D list
51	Pressure 1 Supplementary	1	Pressure 1 at IP#103 (91+12)
51	Pressure 2 Supplementary	1	Pressure 2 at IP#119 (91+28)
52	Filament/IPS/Htr MSW	1	Refer to 4.4.5(c)
53	Latched Submodes	2	Refer to 4.4.5(f)
54	ESW (A) and (B)	2	ESW for both CDMUs
55	Commutator Index	1	Commutator at time of packetization
56..61	Partial DAC List	12	Selected DAC values (see figure below)
62	Temp GC1 (10-bits)	2	10-bit A/D: GC1 Temperature
63	Temp GC2 (10-bits)	2	10-bit A/D: GC2 Temperature

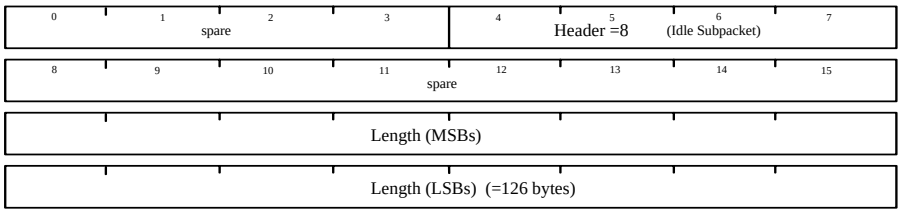


Figure 4.8-1 — Descriptor Format for Idle Subpacket

Word#	Upper Byte	Lower Byte	
1	=08	=00	Subpacket Header
2	=00	=7E	
3	Abs Time MSBs		
4	Abs Time LSBs		
5	A/D #1	A/D #2	
6	A/D #3	A/D #4	Complete
...	. . .	. . .	A/D List #1 .. 91
50	A/D #91	spare	
51	A/D #103	A/D #119	←Supercommutator Pressure Mons
52	Filament MSW		
53	Latched Submodes		
54	GCMS ESW		
55	Commutator Index		
56	D/A #7	D/A #8	
57	D/A #15	D/A #16	
58	D/A #17	D/A #18	Partial
59	D/A #19	D/A #20	D/A List
60	D/A #21	D/A #22	
61	D/A #23	D/A #24	
62	Temp GC1 (10-bit)		
63	Temp GC2 (10-bit)		

Figure 4.8-2 — Idle Subpacket Format

Ref	Signal Name
01	Anode 1
02	Anode 2
03	EB4-2
04	EB4-1
05	Fil I 1
06	Fil I 2
07	Fil Emis 2
08	Fil Emis 1
09	Bias A
10	Bias 1
11	Bias 2
12	Pressure 1
13	Bias Mon 3
14	Bias Mon 2
15	Spare Mon
16	Bias Mon 1
17	Anode 3
18	Anode 4

Ref	Signal Name
31	RF Temp
32	Ref V
34	Anode 6
35	EB4-6
36	EB4-5
37	Fil I 5
38	Fil I 6
39	Fil Emis 6
40	Fil Emis 5
41	Bias C (-50 dual)
42	Bias 5 (-70-1)
43	Bias 6 (-70-2)
44	Shell Press
45	Not Used
46	Not Used
47	Not Used
48	Not Used
49	-30 VL Mon

Ref	Signal Name
62	Temp IS3 Int
63	Temp H2
64	Temp Sample
65	Temp LVPS 1
66	Temp LVPS 2
67	Temp LVPS 3
68	+13 Mon
69	+5R Mon
70	5 Ref
71	-5.7 Mon
72	Cal Mon
73	VH Inhibit
74	Temp GC1
75	Temp EC1
76	Temp EC2
77	Temp ACP
78	Temp GC2
79	Temp GC3

19	EB4-4
20	EB4-3
21	Fil I 3
22	Fil I 4
23	Fil Emis 4
24	Fil Emis 3
25	Bias B (-50 dual)
26	Bias 3 (-70-1)
27	Bias 4 (-70-2)
28	Pressure 2
29	EM Temp
30	Bias Temp

50	+30 VL Mon
51	IP Mon 6
52	IP Mon 5
53	IP Mon 2
54	IP Mon 1
55	IP Mon 3
56	IP Mon 4
57	BA Mon
58	Deck Temp
59	Transistor Temp
60	Therm Press
61	Th Ref Press

80	Temp Inlet
81	ACP Pres 1
82	ACP Pres 2
83	Temp FC
84	I Mon 1
85	I Mon 2
86	Multana 1
87	Multana 2
88	+5R Mon
89	RF Mon
90	EM 1 Mon
91	EM 2 Mon

Figure 4.8-3 — Complete A/D List
(from GCMS SIS Table 3.4.4-1)

4.9 Memory Dumps.

Memory dump subpackets are a type of solicited HK, generated in response to "GIC" (Ground Instrument Query) TCs, and are assembled serially into the TM packet stream. The format for RAM, IORAM and EEPROM dumps is shown in the figures below.

The *type* field indicates which memory type was dumped:

9 = RAM Dump
10= EEPROM Dump
11= IORAM Dump

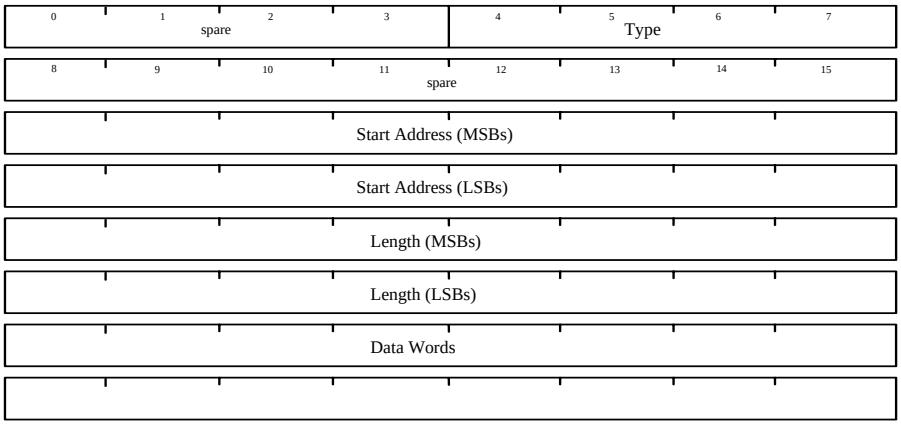


Figure 4.9-1 — Format for Memory Dump Subpackets

Abbreviations and Acronyms

amu	Atomic Mass Unit
ACP	Aerosol Collection Pyrolyzer
ALF	Assisted Load Format
BIT	Built-In Test
BIU	Bus Interface Unit
CDMU	Command and Data Management Unit
CMP	Computer Memory Patch
CW	Control Word
DAC	Digital-to-Analog Converter
DN	Design Note
EEPROM	Electronically Erasable PROM
EI	External Interrupt
EM	Engineering Model
FC	Flight Computer
FS	Fractional Sweeps
GC	Gas Chromatograph
GCMS	Gas Chromatograph Mass Spectrometer
GIC	Ground Instrument Command
GIQ	Ground Instrument Query
GSE	Ground Support Equipment
H/K	Housekeeping
HS	High Sensitivity
IB	Intermediate Bit
ICC	Instrument Command Chain
ICCU	Instrument Command Chain Upload
ID	Input Data, Identification
IDN	INMS Design Note
INMS	Ion and Neutral Mass Spectrometer
IOM	Intra-Office Memorandum
IP	Integration Period
IPS	Ion Pump Select, Ion Pump Supply
IS	Ion Source
ISS	Ion Source Select
LSB	Least Significant Bit
MLC	Memory Load Command
MSB	Most Significant Bit
MSC	Mass Sweep Command
MSW	Monitor/Status Word
QP	Quadrupole
PROM	Programmable Read-Only Memory
RAM	Random Access Memory
ROM	Read-Only Memory
S/C	Spacecraft
SIS	Software Interface Specification
SOM	System Operator's Manual
SPRL	Space Physics Research Laboratory

TAP	Tuning and Adaptation Parameter
TBC	To Be Confirmed
TBD	To Be Determined
TBS	To Be Supplied
TC	Telecommand
TDIC	Time-Driven Instrument Controller
T/H	Threshold
TM	Telemetry
US	Unity Sweeps
USeq	Micro Sequencer
VAC	Volts AC
VDC	Volts DC
uP	Microprocessor

INDEX