EDI / Cluster-II

User Manual

25 Oct, 2004
Issue 3 Rev 5

CONTENTS

Documentation Change Record

Issue	Rev.	Date	Section	Changes
3	0	Mar 1, 1999	Many	Numerous changes resulting from larger EEPROMs, added telecommands, modified Science-TM formats, other developments.
3	1	Sep. 2, 1999	Many	Numerous changes resulting from error fixes, clarifications and new developments, in particular: Chapter 0: added Chapter 2: HK43 and Diagnostic FGM (Mode11) Chapter 3: PGA configuration (3.1.2) TC54, TC 58 (3.2.4) Chapter 7: Building blocks #50, #83, #90, #190, in 7.4; 7.5.1 7.6 Chapter 9 completely rewritten Appendix D. completely rewritten
3	2	Feb. 21, 2000	Many	Numerous changes resulting from error fixes, addition of command sequence building blocks, in particular: all chapters : removed reference to old software status Chapter 2 : defined validity conditions for HK parameters in HK words 43,44 Chapter 3 : added mnemonics for 'reserved' telecommands Chapter 7 : corrected existing command sequences and added/revived some sequences, updated EEPROM and RAM memory map Appendix A: corrected errors and added 'reserved' TCs Appendix D: updated upload sequence Appendix E: updated for Cluster-II
3	3	July 18, 2000	Many	Numerous changes resulting from error fixes, addition of telecommands and command sequence building blocks.
3	4	May 30, 2001	2.2.2 2.3.2 2.3.3 3.2.4 7.2.2 7.2.5 7.4.1	changes in HK TM words 43 and 44 Mode8 2nd header PACM1/5 DATA14/15 length, maxchannel location, time tags, and other small things, Packing mode 4 new telecommands BCM1S, BCM2S ($59, $5A) deleted telecommands $12, $13 changes to TCs PCKMS, SOBBS, TC54, TC58 TC $53 allows jump to quiescent with SRAM on Added comment to TC $54 (automatic startup) Packing mode 4 Init tables Added parameter for first PCKMS of sequences #60 and #61 Added command sequence building block #111 Changed command sequence building block #200 Added comment to sequence #180 Corrected NOOP delay in sequence #190 Corrected address in sequence #210

			7.6.4 9.3.3 several C.4	RAM addresses Limits for CUR5V depend on PGA configuration state References to values $a8 and $b8 for HK parameter EECHK changed to $a and $b, respectively CMD 17, CMD19
3	5	Oct 25, 2004	2.2.2 2.3.x 2.3.6 3.2.4 7.2.x 7.4.1 7.4.2 7.4.3 7.6.4 8.2.1	Word 25-40: add bit/GDSET/GDSEL info Word 42: add bit scheme, programming info Recreate GDU HK parameter tables Reorder/rearrange/add new telemetry descriptions Section "Solution": corrected the listed TM modes for negative and positive deltas TC 09: new use; TC46,48,49,4A: special processing/options for "one gun" operation; Comments before DMP TCs for TCs 53,54,57,58. Original Ambient now "UCSD Ambient" and labeled "obsolete. Ambient mode now refers to a new mode, number $15 or 21. TC 4F: added example LB0 values for selection of TM channels 0-4 Added command sequences #062, #073, #141 (SC2 only) Added command sequence #341. Corrected TC count for various command sequences New section: Building Blocks in Routine Operations Memory Map changed to include references to use of RAM on SC2 Changes due to the absence of the analog-to-digital converter Appendix D: Sections D.4 to D.4.6 are not applicable to Cluster-II New Sections D.7 and D.8 describe Cluster-II RAM upload practices

0. Important Operations Constraints

Power On

- send NOOP TC within 10 to 30s to lock on EDI main interfaces
- wait more than 45s with NOOP-TC to switch to redundant
- a ROM2 checksum failure puts EDI in ROBUST1.
- various ROM/RAM errors can cause jump to ROBUST2
- upon checksum failure on EEPROMS $4000 through $68000, EEPROMs are dumped in TM. Dump can be stopped by jumping to Mode0, using TC's listed in 9.2.1
- checksum failure of the remaining EEPROMs causes jump to Mode0; this case is identified by $000B in memory location $D3F8.
- for other failure conditions at poweron see section 9.4
- if all tests nominal, controller jumps to Mode8 automatically

ROBUST1

- ROBUST1 software is contained in ROM1
- the only way to enter ROBUST1 is by ROM2 checksum failure at poweron
- uniquely identified by $F8F8 in SCI-TM
- identified (not uniquely!) by $FFFF in HK-TM
- can use entire set of PROM TCs
- no main/redundant cycling

ROBUST2

- ROBUST2 software is contained in ROM2
- uniquely identified by $A5A5 in HK and SCI-TM
- Main/Redundant switching every ~20 seconds, recognized by $A5A5 / $FFFF switching.
- to stop switching send NOOP commands until TM fixed ($A5A5)
- when returning to Mode0, notice that CRCNT=2 and CVCNT=1, but only if ROBUST2 was entered at poweron.
- when dumping to TM, note that data are not synched to Telemetry Reset (TMR). Dumps can be found by looking for the header $D1D1 in SCI-TM or $D2D2 in HK-TM
- can use only limited set of TCs (see section 3.)

PGA Configuration

- NM-TM required for EDI code prior to August 1999.
- Configuration in BM-TM requires new files that replace FEDION, FPGA1 and FPGA2A.
- PGAi and PGA1 can be configured in Mode0 and Mode8; PGA2 can only be configured in Mode8
- Sequence must be PGAi, PGA1 and PGA2
- Temporary loss of TM during PGA1 and PGA2 configuration.
- PGA2 configuration is optional, but required for standard science modes
- If configuration not successful, turn power off and start again (or send PGA Reset TC ZEERPGAF)
- Never repeat configuration for PGAi or PGA1
- Minimize operation times with PGA1 unconfigured

Power off

- set safe values (GSAFE)
- wait 6s (to force sensor commanding)
- jump to Mode0
- wait 11s
- turn EEPROM power off
- switch S/C command interfaces and repeat above steps
- wait 10s
- turn EDI power off

Exceptions and Failures During Operation

- temporary loss of TM occurs during Mode switches
- jump to ROBUST2 (see Chapter 9.)
- jump to Mode0 (see Chapter 9.)

Main/Redundant Switching

- at poweron, by waiting < 30s (main) or > 45s (redundant) before sending NOOP-TC
- main-to-redundant switching during ground operations :
  send EESFT_SW_M2R and then switch SC-interfaces
- redundant-to-main switching during ground operations :
  send EESFT_SW_R2M and then switch SC-interfaces
- ROBUST2 cycles between main and redundant

TM-Mode Switching

- preferred sequence: first SC then EDI
- use SUMOS - TC

SCI-Mode Switching

- use SIMOS - TC, but only after PGA1 configuration

IEL

EDI has links with 4 other instruments : FGM, STAFF, PEACE and WHISPER

- from FGM EDI receives BX, BY and BZ (41 bits) approximately 16 times/s. EDI operates safely without FGM data
- from STAFF EDI receives three analog signals which represent the change in BX, BY and BZ
- EDI sets a 5V level when beams return within PEACE aperture. When this condition is no longer fulfilled, the level returns to zero. In ground testing the PEACE blanking pulse can be set by sending EESFT_FPCON (EESFT_FPCONR in redundant). The blanking pulse is turned off by sending EESFT_FPCOF (EESFT_FPCOFR in redundant).
- EDI receives a blanking pulse, whenever WHISPER puts HV on its antenna. In ground testing WHISPER simulates the pulse.

Software Status

- The software status as of the release of this issue of the UM is documented in chapter 7.6.4

1. Instrument Description

Experiment Overview

(see Article in "The Cluster and Phoenix Missions")

Areas of Interest

- All regions reached by Cluster are of interest to EDI.
- There is no firm a-priori relationship between areas and instrument modes.
- Operational modes and/or parameters affecting operational modes will be selected differently in different regions.

On-board Software

- PROM based firmware (Mode 0) provides startup testing, telecommand handling, watchdog and current monitor functions, housekeeping data collection, manual GDU control, and transmission of HK and Science data via telemetry.
- EEPROM based software (Modes 1 and higher) provides for actual science operations and allows additional commanding. Mode 8 is an upgraded EEPROM version of Mode 0.

Physical Characteristics

(see Experiment Interface Document Part B)

2. Telemetry

2.1 Monitoring Philosophy

HK Telemetry
All information needed at power-on and routine checkout is put into the HK telemetry.

Science Telemetry
Science TM data are needed for performance monitoring in the Commissioning Phase, after Critical Software patches, and for some contingency operations.

Built-in Monitoring Routine
The Controller continuously monitors some key currents within EDI and takes appropriate action (HVs off) if overcurrent conditions are detected.

S/C Monitoring
Spacecraft monitoring is no longer required.

2.2 Housekeeping Telemetry

2.2.1 General

- Housekeeping telemetry includes data about the status of the Controller and the GDUs.
- There are 45 words per TMR. Many of the 45 data words are subdivided so that a single word may contain as many as nine distinct pieces of information. Also, many of the words are subcommutated: a data word may contain certain data in one transmission cycle and something else the next n-1 cycles, where the subcommutation cycle can be 2, 4 or 8. For example, housekeeping word 7 can be one of 8 controller secondary currents/voltages.
- Default HK telemetry sequentially provides all internal GDU status and housekeeping information in 8 TMRs. Selection of other options is explained in Appendix B.
- The listed mnemonics are for EDI EGSE and S/C ground testing. These mnemonics are also used as descriptions in the ESOC displays.
- Limits for the important housekeeping parameters are listed in section 9.3.
- All HK data are valid only if SUBMO is NOT 0 and SUBMO is NOT 15.
- All GDU HK data (HK TM words 25-40) and all SENSOR HK data (HK TM words are only valid, in addition, if PGA1 is configured (FPGA1=1; PGACF = 2 or 3)
- In addition, the following HK parameters are only meaningful, if PGA1 is configured:HVON1, HVON2,
  GD121, GD122, GD117, GD221, GD222, GD217
  EVT11, EVT21, EVT12, EVT22,
  MCAD1, MCRR1, MCAD2, MCRR2
  STPS1, STPS2,
  PW221, PW241, PW222, PW242
- Some HK-parameters are valid **only** in mode 8: OLPRM, FGCNT, M8STA, EECHK
- HK-parameter PACMO is not valid in mode 0
- HK parameter BTYPE is valid **only** in himodes

2.2.2 Housekeeping Telemetry Format

WORD ---> **MNEMONIC**

0: GDU Frame Counter at TMR **FRCNT**

Derived from bits 0-11 of the GDU frame counter (cmd word 16) in the low three nibbles and bits 9-12 of the BCI counter in the upper nibble.

1: 28 volt controller primary Current & TM mode

```
 15_14_13_12_11_10__9__8__7__6__5__4__3__2__1__0
|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
  |        |  |________________________________|
  |        |       |--- Controller Primary Current         CONPC
  |________|-- Telemetry Submode ID                        SUBMO
```

2: GDU1 Primary Current

```
 15_14_13_12_11_10__9__8__7__6__5__4__3__2__1__0
|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
  |  |  |  |  |__________________________________|
  |  |  |  |           |-- GDU1 Primary Current            GD1PC
  |  |  |  |
  |  |  |  |-- Primary 28 Volt Over Limit                  28VOL
  |  |  |----- GDU1 Current Over Limit                     GD1OL
  |  |-------- GDU2 Current Over Limit                     GD2OL
  |----------- 5V 2ndary Current Over Limit                5VSOL
```

Note : Bits 15-12 for one TMR only (see Word 43)

3: GDU2 Primary Current

```
 15_14_13_12_11_10__9__8__7__6__5__4__3__2__1__0
|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
  |  |  |  |  |__________________________________|
  |  |  |  |           |--- GDU2 Current                   GD2PC
  |  |  |  |
  |  |  |  |--- Wrong Password Flag                        WRTCP
  |  |  |------ Wrong Science Mode                         WRSCM
  |  |--------- EEPROMs Write Protected (0=false, 1=true)  EEWRP
  |------------ EEproms on/off (0=on, 1=off)               EEPON
```

4: Command Counter(s)

```
 15_14_13_12_11_10__9__8__7__6__5__4__3__2__1__0
|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
  |____________________|  |______________________|
   |                       |
   |--- cmds received      |--- cmds verified
        CRCNT                   CVCNT
```

5: Last command sent to EDI Controller. **LASTC**

6: Mode ID and Digital Status

```
             15_14_13_12_11_10__9__8__7__6__5__4__3__2__1__0
            |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
              |______________|  |  |  |  |  |  |  |  |_____|
               |-Science Mode   |  |  |  |  |  |  |     |
MODID                           |  |  |  |  |  |  |     |-- SubCom Counter   SUCOC
                                   |  |  |  |  |  |  |
HVON1         GDU1 HVON CMD ---|  |  |  |  |  |  |-- Sensor2 Disarm Bit   PW242
            (data 21, bit 13)     |  |  |  |  |- GDU2 data wd 22, bit 1    PW222
                                  |  |  |  |- Sensor1 Disarm Bit           PW241
                                  |  |  |- GDU1 data wd 22, bit 1          PW221
HVON2       GDU2 HVON CMD ---------|  |- HV Disable Connector              HVDIS
            (data 21, bit 13)
```

7: Controller Secondary Currents, Voltages. One word subcommutated 8 times. The data in this word depends upon the subcommutation counter (**SUCOC**) as follows:

SUCOC	Quantity reported in word 7	HK Parameter
0	5V Current	**CUR5V**
1	10V Current	**CU12V**
2	-10V Current	**CN12V**
3	5V Auxiliary Current	**ACU5V**
4	5V Voltage	**VOL5V**
5	10V Voltage	**VO12V**
6	-10V Voltage	**VN12V**
7	5V Auxiliary Voltage	**AVO5V**

8-10: GDU Systems Commands (3 words, subcommutated 2 times)
These words are data words 21, 22, 17. If the subcommutation counter is even, the data words for GDU1 are sent and if the subcommutation counter is odd, the data words for GDU2 are sent.

SUCOC	Systems Commands	
0, 2, 4, 6	GDU1 Data Words 21, 22, 17.	**GD121, GD122, GD117**
1, 3, 5, 7	GDU2 Data Words 21, 22, 17.	**GD221, GD222, GD217**

11-12: EVT1 Rates (2 words) **EVT11, EVT21**
These two words are DATA 29 and 30 for GDU1 (cts/30ms in Modes 0 & 8; counts per BCI in Hi-Modes)

13-14: EVT2 rates (2 words) **EVT12, EVT22**
These two words are DATA 29 and 30 for GDU2.

15-16: Max Correlator Address / Rates (2 words)
These two words are data word 16 GDU1 and data word 16 GDU2.

```
 15_14_13_12_11_10__9__8__7__6__5__4__3__2__1__0
|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
  |________|  |________________________________|
    |                         |
    |-- Max Corr Address.     |-- Rates              MCAD1 / MCRR1
                                                     MCAD2 / MCRR2
```

17: Checksum (8 bits) / PLL-Status (8 bits) **CHKSU, PLLST**

In this word the checksum is in the upper byte and the PLL-status is in the lower byte.

18: B-Magnitude (1 Word) **BMAGN**

In Mode 0 : the raw 12-bit FGM_x data word;
In Mode 8 : bits 15-12 : range
bits 11-00 : magnitude of B calculated according to

```
SQRT( Bx^2 + By^2 + Bz^2 )
```

where Bx, By, Bz are the 12-bit FGM components rotated into the EDI coordinate system.

19-20: HK Options

if **VASEC** is NOT 3 then word 20 is 0 and word 19 is:

```
 15_14_13_12_11_10__9__8__7__6__5__4__3__2__1__0
|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
 |___| |___|  |__|  |  |  |  |  |______________|
   |     |      |   |  |  |  |      |- Sel. GDU Chan. l      GDCHS
   |     |      |   |  |  |  |-- 0
   |     |      |   |  |  |--  GDU (0=GDU1, 1=GDU2)          GDSEL
   |     |      |   |  |
   |     |      |   |  |-- Sensor1 (1=Step, 0=No step)       STPS1
   |     |      |   |
   |     |      |   |-- Sensor2 (1=Step, 0=No step)          STPS2
   |     |      |
   |     |      |--- Variable Section ID                     VASEC
   |     |
   |     |---- GDU subcom counter                            GDSET
   |
   |--PGA flags (0=none,1=PGAi,2=PGAi,PGA1, 3= all PGAs)     PGACF
```

else if **VASEC** is 3 (RAM SELECTED) and EVT options are NOT selected then

Word 19: bits 7-0 = high byte of RAM address (**RAMAD)**
bits 15-8 = same as above
Word 20: low word of RAM address (**RAMAD)**
} **RAMAD**

else if EVT options (*) are selected then (for Mode 8):

Word 19-20 : hh0000xx

hh	=	word 19, bits 15-8	: same as above
0000	=	word 19, bits 7-0,	
		word 20, bits 15-8	: zero
xx	=	word 20, bits 7-0	: $02 = EVT word 1 selected (data29, GUN 1)
			$04 = EVT word 2 selected (data30, GUN 1)
			$08 = EVT word 3 selected (data29, GUN 2)
			$10 = EVT word 4 selected (data30, GUN 2)

(*) Note : the selected EVT option cannot be identified in telemetry. The command history has to be used.

21
(or 23): Analog status for Sensor 1 (or Sensor 2 for word 23)

EDI consists of two Gun Detector Units (GDUs). For every GDU two measurements are made. Together there are four measurements.

So word 21 is the measurement for GDU1
high byte - measurement 1 - MUX setting 1 (**S1MX1**)
low byte - measurement 2 - MUX setting 2 (**S1MX2**)

word 23 is the measurement for GDU2
high byte - measurement 1 - MUX setting 1 (**S2MX1**)
low byte - measurement 2 - MUX setting 2 (**S2MX2**)

```
 15_14_13_12_11_10__9__8__7__6__5__4__3__2__1__0
|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
  |____________________|  |____________________|
    |                       |
    |- Analog Status #1     |- Analog Status #2
       for MUX setting #1      for MUX setting #2
```

Analog Status	**S1MX1**	HK Par.	**S1MX2**	HK Par.	**S2MX1**	HK Par.	**S2MX2**	HK Par.
2.5V Ref	0	**2.5V1**	0	**2.5VA**	0	**2.5V2**	0	**2.5VB**
HV PS Current	1	**HVCR1**	1	**HVCRA**	1	**HVCR2**	1	**HVCRB**
HV PS Error	2	**HVER1**	2	**HVERA**	2	**HVER2**	2	**HVERB**
HV PS Ref	3	**HVRF1**	3	**HVRFA**	3	**HVRF2**	3	**HVRFB**
Preamp Gain	4	**PRGN1**	4	**PRGNA**	4	**PRGN2**	4	**PRGNB**
-5V LV PS	5	**N_5V1**	5	**N_5VA**	5	**N_5V2**	5	**N_5VB**
5V LV PS	6	**P_5V1**	6	**P_5VA**	6	**P_5V2**	6	**P_5VB**
Temperature	7	**STMP1**	7	**STMPA**	7	**STMP2**	7	**STMPB**

22
(or 24): Digital status for Sensor 1 (or Sensor 2 for word 24)

```
  15_14_13_12_11_10__9__8__7__6__5__4__3__2__1__0
 |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
   |_____|  |_____|  |  |  |___________________|
   |         |      |  |       |
   |         |      |  |       |- Subcomm. Value (see table below)
   |         |      |  |
   |         |      |  |- DISARM BIT (bit 8 of GDUx word 24
   |         |      |     from the second reading)              DISA1, DISA2
   |         |      |
   |         |      |- OVERFLOW BIT (bit 9 of GDUx word 24;
   |         |         logical AND of the overflow bit from two
   |         |         readings; 0=overflow, 1=no overflow)       OVRF1, OVRF2
   |         |
   |         |-------- MUX #2                                     S1MX2, S2MX2
   |
   |------------------- MUX #1                                    S1MX1, S2MX1
```

- Note: If **STMP1**, **STMP2** are $FF, AND the MUX values are 7, no valid Sensor Status has been obtained in the present TMR

SUCOC	Source		Contents (bits 7-0 of word 22 or 24)	Bits	HK Parameter (GDU1, GDU2)
0 or 4	DATA 27,	bits 7-0	Base Address	7-0	**BASA1, BASA2**
1 or 5	DATA 26,	bits 3-0	Accumulator Pointer Field	7-4	**ACPO1, ACPO2**
	DATA 27,	bits 11-8		3-0	
2 or 6	DATA 25,	bits 7-0	Correlator Pointer Field	7-0	**COPO1, COPO2**
3 or 7	DATA 24,	bit 7	Power Strobing	7	**PWST1, PWST2**
		bits 6-4	Dead Time Setting	6-4	**DTIM1, DTIM2**
				3	unused
	DATA 26,	bit 6	Execute Immediately	2	**EXIM1, EXIM2**
		bit 5	Swap Channels	1	**SWAP1, SWAP2**
		bit 4	Test Pulser Enable	0	**TPLS1, TPLS2**

- The analog status words are sent every TMR.
- The digital status (bits 7-0 of words 22, 24) is subcommutated as indicated above.

This group of housekeeping values (words 21-24) is subcommutated. It takes 8 telemetry cycles (TMRs) to get a full set of values for word 21 and 23, and 4 TMRs to get a full set of values for word 22 and 24.

25-40: Variable Section (words 0 to 19 within variable section)

Options selected with TC $1B (ZEEBDHKS) and identified by **VASEC**

VASEC	GDSEL	GDSET	GDCHS	RAMAD
0 - DEFAULT	0-1	0-3	N/A	N/A
1 - GDU1	N/A	N/A	0-63	N/A
2 - GDU2	N/A	N/A	0-63	N/A
3 - RAM/EVT	N/A	N/A	N/A	24-bit address

In the DEFAULT mode (**VASEC** = 0), the 16-word variable section contains two groups of GDU HK data words. There are 8 groups for each GDU. After the 8 groups for GDU1 the telemetry switches to GDU2. The GDU is identified by **GDSEL**. The groups are identified by **GDSET** as shown below. A listing of the GDU HK parameters follows at the end of this section.

GDSET wd19: b13-12	GDSEL wd19: b7	GDU	GROUP (GR0, GR1, ...)
0	0	1	0 + 1
1	0	1	2 + 3
2	0	1	4 + 5
3	0	1	6 + 7
0	1	2	0 + 1
1	1	2	2 + 3
2	1	2	4 + 5
3	1	2	6 + 7

For **VASEC** = 1 (2), a single GDU1 (GDU2) HK channel is sampled 16 times. The channel (from 0 to 63) is identified by **GDCHS**.

For **VASEC** = 3 the variable sections contains

- either a single RAM location (identified by **RAMAD**) 16 times
- or that RAM location and the 15 words following it
- or it contains one of the four EVT channels 16 times. These options cannot be uniquely distinguished. However, if **RAMAD** is hh0000xx (xx is 02, 04, 08, 10) it is highly likely that the words are one of the four EVT words.

Notes:

- For special tests, the variable section can also be used to transmit correlator counts (see Appendix B, Item 18).
- It is also possible to transmit user-selected non-contiguous 16 words in the variable section (see Appendix B, Item 19).

41: *Previously: Test Mode Use only*
Now: cone angle (signed)

42: *Previously: Unused* Now (letd tooo r888 8888)

bit 15	code type (0=short, 1=long; onboard this is bit7 in pcktc_bits
bit 14	energy (0=1keV, 1=500eV)
bit 13	TC $5A BCM2S state (0=active)
bit 12	despin bit (0=pure despin, 1=despin+STAFF; onboard this is bit0 in pcktc_bits)
bit 11	TC $59 BCM1S state (0=active)

bit 10-8 optics state (bit 8 was the despin bit for some time)
bit 7 EEPROM (0) or RAM (1) execution
bit 6-0 Himodes: init table
Mode8: reason for last jump to Mode8

00=poweron jump ($6000)	04= bad B limit exceeded in himodes
01=upload routine jump	05=unused
02=normal jump ($6006)	06=overlimit
03=quiescent	

In addition, if restarts of himodes are enabled, bit 6 is set in the period of time between overlimit detection and himodes restart (nominally 5 minutes).

43: *Previously:*
Bits 8-11 permanent copy of 12-15 of HK-Word 2 ***OLPRM***
Bits 0-7 number of wrong Fudge words following uploads ***FGCNT***

Now: (as of upload sessions 51-54, April 2001)
bit 15-12 permanent copy of bits 15-12 of HK word 2 **OLPRM**
bit 11-0 Controller primary voltage **CONPV**

44: *Previously: bit 15-8 Version number error PGAi or PGA1 EEPROMS ($A)* ***EECHK***

Now (vvvv ffff b888 xppp)
bit 15-12 Version number error PGAi or PGA1 EEPROMS ($A) **EECHK**
bit 11-8 number of wrong fudge words following uploads **FGCNT**

no change:
Bits 0-2 TM "Packing Mode" (Sci.TM Format) **PACMO**
Bits 4-6 Mode8 Status (01=standby1, 02=standby2, 04=quiescent) **M8STA**
Bit 7 Himodes BCI type (0=despin, 1=FGM extrapolation) **BTYPE**

Note: PACMO is not valid in mode 0
M8STA, EECHK, OLPRM and FGCNT are valid only in mode 8
BTYPE is valid in himodes only
CONPV in himodes only after upload sessions 55-58, planned for May 2001

GDU HK Parameters
Format: Mnemonic, Short Description for each Parameter
To distinguish GDU1 and GDU2, Mnemonics have '1' or '2' as 5th character.

GR0 GDSET: x'0x',x'4x'		GR1 GDSET: x'1x',x'5x'	
I_D1	Error Deflector 1	I_AN	Error Anode
I_D2	Error Deflector 2	I_FC	Error Focus
I_D3	Error Deflector 3	I_CA	Error Cathode
I_D4	Error Deflector 4	I_BW	Error Beam Width
I_D5	Error Deflector 5	I_BC	Beam current
I_D6	Error Deflector 6	GNDG	GND Ref
I_D7	Error Deflector 7	I_EU	Error Upper Deflector
I_D8	Error Deflector 8	I_AU	Error Upper Injector
GR2 GDSET: x'2x',x'6x'		GR3 GDSET: x'3x',x'7x'	
28VS	28V Supply/20	GPUX	2Ua -+ 1.4Ux
5VUF	+5V/5 UF-Conv	GNUX	2Ua +- 1.4Ux
P5VC	+5V/5	GPUY	2Ua -+ 1.4Uy
GND0	GND Ref	GNUY	2Ua +- 1.4Uy
N5VC	-5V/5	G_AN	Ua
5VIF	+5V INT/5	G_FC	Uf
5VP1	+5V PG1/5	G_CA	Uc
5VP2	+5VPG2/5	G_BW	Uw
GR4 GDSET: x'8x',x'9x'		GR5 GDSET: x'Cx',x'Dx'	
O_EU	Upper Deflector	O_EL	Lower Deflector
O_AU	Upper Injector	O_AL	Lower Injector
G_BC	Beam Current Ref	O_OA	Outer Analyzer
GTMP	Temperature	O_SR	Sensor Reference
REG1	Regulator 1	O_SP	Suppressor
REG2	Regulator 2	O_IA	Inner Analyzer
N2VR	-2.0V Ref	O_RC	Retainer Cone
I_CS	Cathode Supply current	O_ET	Extractor
GR6 GDSET: x'Ax',x'Bx'		GR7 GDSET: x'Ex',x'Fx'	
I_EL	Error Lower Deflector	CFQ1	Converter Frequency
I_AL	Error Lower Injector	CFQ2	Converter Frequency
I_OA	Error Outer Analyzer	CFQ3	Converter Frequency
I_SR	Error Sensor Reference	CFQ4	Converter Frequency
I_SP	Error Suppressor	CFQ5	Converter Frequency
I_IA	Error Inner Analyzer	CFQ6	Converter Frequency
I_RC	Error Retainer Cone	CFQ7	Converter Frequency
I_ET	Error Extractor	CFQ8	Converter Frequency

2.3 Science Telemetry

2.3.1 Telemetry Submode & Format Designations

The format of science telemetry transmitted by EDI changes when the spacecraft telemetry mode changes. We refer to the telemetry modes as submodes (SUBMO). Note that a change of the spacecraft telemetry mode does not cause an automatic change of the EDI telemetry mode. The EDI telecommand ZEESUMOS has to be sent for this purpose (see chapter 3 for a description of telecommands).

SUBMO / abbr / name	bytes / words per TMR
.1 / NM1 / nominal mode 1	980 /490
.2 / NM2 / nominal mode 2	same as .1
.3 / NM3 / nominal mode 3	same as .1
.5 / BM1 / burst mode 1	6944 / 3472
.6 / BM2 / burst mode 2	992 / 496 (same as .1, +6 words $FFFF)
.7 / BM3 / burst mode 3	23188 / 11594

- NM2 and NM3 use the same structure as NM1.
- BM2 uses the same structure as NM1, with an additional six words ($FFFF) at the end of the structure.
- EDI telemetry mode is sent in bits 0 - 2 of the first word of the science telemetry and in bits 12 - 15 of the second word of housekeeping telemetry (**SUBMO**).
- To distinguish different TM formats for the same telemetry mode, the variable **PACMO** (for Packing Mode) has been defined which is sent in bits 8 - 11 of the third word of the science telemetry header and in bits 0 - 2 of word 44 of housekeeping telemetry.

2.3.2 Headers & Time Tags

All modes use a 4 word *Telemetry Header* in words 0-3. Header Word 0 (the STATUS WORD) is defined as follows:

Bit #	Description
15	memory dump bit
14	if bit is set, PGAi configured
13	if bit is set, PGA1 is configured
12	if bit is set, PGA2 is configured
11-10	vary with science mode and submode **NM1:** 11 if bit is set, channel 0 data are compressed 10 if bit is set, channel 1 data and channel 1a data are accumulated **BM1:** 11 if bit is set, channel 2 data are compressed 10 if bit is set, channel 3 data are compressed
9	**in WW mode,** if bit8 is 1: if bit 9 is 1 all the data are det2/gun1 data, if bit 9 is 0 all the data are det1/gun2 data.
8	in WW mode, if 1 then telemetry is for only one det/gun pair
7-3	science mode (SCIMO, same as MODID in HK telemetry)
2-0	telemetry mode (SUBMO) he 2nd, 3rd and 4th Header Words (Words 1, 2 and

3) are used as follows.Word 1 : bits 15-0 in PROM (and EEPROM delivery code) WHISPER Blanking Pulse count

	bits 15-12	in EEPROM, gun1 PEACE counter (0-15, more than 15 is still 15)
	bits 11-8	gun2 PEACE counter
	bits 7-0	in EEPROM, WHISPER Blanking Pulse count
Word 2 :	bits 15	in himodes indicates BCI routine uses (despin(0) or extrapolation(1));

		n/a in MODE8
	bits 14-12	M8STA (mode8 status)
	bits 11-8	PACMO (telemetry packing mode)
	bits 7-0	high byte of dump address
Word 3 :	low bytes of memory dump start address	

When the controller code is not executing in PROM, there is a SECOND HEADER in words 4 to 19 (16 words). The first 15 words are mode specific. The last word is a "good data" flag. It is $A76F if EDI is executing from EEPROM, $A76E if EDI is executing from RAM.

Science mode/ / word no.	**Mode8**	**ModeC**	**ModeD**
0	time tag at TMR	TM step GDU1	modeD step
1	ranged bmag	TM step GDU2	counts (DATA29,1)
2	count: FGMr !=2-5	GDU1 base gain/hv	counts
3	count: |FGMr-r|>1	data step	counts (DATA29,2)
4	GDU1 CMD 01 (xd)	GDU1 step gain/hv	counts
5	GDU1 CMD 02 (yd)	count (high word)	counts (DATA30,1)
6	GDU1 CMD 03 (beam)	count (low word)	counts
7	GDU1 CMD 04 (anode)	GDU2 base gain/hv	counts (DATA30,2)
8	GDU1 CMD 05 (focus)	data step	counts
9	GDU1 CMD 06 (wehnelt)	GDU2 step gain/hv	n/a
10	count: short FGM2FGM	count (high word)	n/a
11	count: long FGM2FGM	count (low word)	n/a
12	count: long BCIs btw FGMs	n/a	n/a
13	count: “short” BCIs	n/a	n/a
14	count: bsq > sqrtlimit	n/a	n/a
15	good data flag	good data flag	good data flag

Science mode /word no.	Mode1 (GEOS), Mode2 (TV) Mode15 (Ambient)	Mode1 (Diagnostic GEOS, xdyd option)	Mode1 (DiagGEOS, Bx opt)
0	time tag at TMR	time tag at TMR	time tag at TMR
1	init/lim-en-m-opt	init/lim-en-m-opt	init/lim-en-m-opt
2	bcnx1/bcnx2	bcnx1/bcnx2	bcnx1/bcnx2
3	dTdtndx-fract/SOB	dTdtndx-fract/SOB	dTdtndx-fract/SOB
4	PERP	PERP	PERP
5	zero	BCIapart/flag bits	BCIapart/flag bits
6	zero	#steps 1/2	#steps 1/2
7	GDU1 CMD 17	GDU1 CMD 17	GDU1 CMD 17
8	PERPX	PERPX	PERPX
9	PERPY	PERPY	PERPY
10	PERPZ	PERPZ	PERPZ
11	zero	lowbyte x/y offset1	Bx offset
12	zero	lowbyte x/y offset2	Bx step
13	zero	x/y step (1)	n/a
14	zero	x/y step (2)	n/a
15	good data flag	good data flag	good data flag

	Mode5 (Windshield Wiper)	Mode13 (UCSD Ambient, obsolete)
0	time tag at TMR	time tag at TMR
1	init/lim-en-m-opt	init/type
2	bcnx1/bcnx2	#spin/#cone steps
3	dTdtndx-fract/SOB	energy start/end
4	Bxstep-PGA2	energy step/shift
5	abr-dbci/nx1-nx2	energy incr
6	limhi/limlo	optics or energy tbl ID
7	GDU1 CMD 17	time tag
8	EVT21	pseudobx
9	EVT22	pseudoby
10	# bkgd samples (N=1,2)	pseudobz
11	ssN_locntT (N=1,2)	fgmx
12	ssN_hicntT(N=1,2)	fgmy
13	reverseN (N=1,2)	fgmz
14	max beam width (N=1,2)	time tag
15	good data flag	good data flag

- For definitions that include a slash, the left side is the high byte, the right side is the low byte; for definitions (N=1,2), GDU1 data is the high byte and GDU2 in the low byte

- Init/lim-en-m-opt (word 1 in modes 1,2, and 5)
  - 15-8 : init table byte
  - 7 : beam width limit (ss_limwi, "always" 1)
  - 6 : energy (0=1keV, 1=500eV)
  - 5,4 : m (00 is 16, 01 is 8, 10 is 4, 11 is 2)
  - 3-0 : optics state

- dTdtndx-fract/SOB (word 3 in modes 1, 2 and 5)
  - 15-12 : dTdtndx
  - 11-8 : fract
  - 7-0 : SOB-byte

- PERP subcom (word 4 in modes 1 and 2)
  This word is subcommutated as follows:

subcomm 0	$8000 (a flag value)
subcomm 1	PERPx
subcomm 2	PERPy
subcomm 3	PERPz

-
- Bxstep-PGA2 (word 4 in mode 5)

Bxstep	if Bxstep=0, bits 15-8 are 4 two-bit FGM step values (xx,yy,XX,YY) GDU2 in CAPS
	if Bxstep=1, bits 15-8 is the current value of the Bx offset step
PGA2	bit 7 (0=short code option B, 1=long code option C)
despin TC	bit 1 (0=TC0980 has not been sent, 1=TC0980 has been sent). TC $09 use:
	$0980 changes EDI to pure despin at the first TMR after the TC is received.
	$0900 changes to despin+STAFF at next scheduled mode start.
despin	bit 0 (0=pure despin, 1=despin+STAFF)

- BCIapart/flag-bits (word 5 in mode 1 diagnostic GEOS / diagnostic GEOS Bx option)

15-8	:	BCI apart	
7-6		not used	
5	:	Scan Task is requested	
4	:	(diag_snr)	1 = S2B, 0 = maxcounts
3	:	(diag_gun)	if bit2 = 1: 1 = detector1, 0 = detector2
2	:	(diag_pks)	1 = 4 peaks @ one detector, 0 = 2 each
1	:	(diag_flag)	0 = xdyd, 1 = Bx
0	:	(diag_flag) not used	

- abr-dbci/nx1-nx2 (word 5 in mode 5)

15-14	(abr)	:	delta flag
13-8	(dbci)	:	deltabci
7-4	(nx1)	:	Windshield Wiper step index for GDU1
3-0	(nx2)	:	Windshield Wiper step index for GDU2

- words 8 - 14 in mode 5
  Each word contains data from both GDUs, the high byte is from GDU1, the low byte from GDU2. Each byte is a compressed word (see NM1 PACM0 channel 0 for a description of the compression function.)

- init/type (word 1 in mode13)

15-8	:	init table byte
7-0	:	0 = perpendicular ion mode, 1 = parallel ion mode, 2 = pitch angle mode

- optics or energy table ID (word 6 in mode 13)

if bit 15 = 1	:	optics table ID
if bit 15 = 0	:	energy table ID

Many telemetry channels use a TIME TAG to identify data blocks. The TIME TAG is created from the GDU frame counter and selected bits of the BCI counter. The time at which the time tag is taken varies with telemetry mode and channel. A table is given at the end of this section (2.3.6). Together with the GDU frame ctr at TMR

(Word 4 overall, Word 0 in second header) and S/C times in telemetry headers, this information enables absolute determination of data times.

2.3.3 NM1 Telemetry Formats

2.3.3.0 NM1, Packing Mode 0, in memory dump format

Offset hex words bytes	offset dec words bytes	#words	description
0000 0000	00 00	4	header
0004 0008	04 08	16	2nd header
0014 0028	20 40	470	data

		490	total words

2.3.3.1 NM1, Packing Mode 0, plain

This general purpose packing mode has been designed for 2ms BCI (science) modes. If being used with a 4ms BCI science mode, only half of the allocated TM will be used.

Offset hex words bytes	offset dec words bytes	#words	description
0000 0000	00 00	4	header
0004 0008	04 08	16	2nd header
CHANNEL 0 : 5 words every 32 BCI 5 words every 16 BCI for ambient			
0014 0028	20 40	1	ch0 address
0015 002a	21 42	1	ch0 time tag
0016 002c	22 44	1	number of 32-BCI structures (82 or 83 for 2ms-BCI, 41 or 42 for 4ms-BCI). For Ambient modes, 82 or 83 16-BCI structures in 4ms-BCI.
0017 002e	23 46	410	data (5 words each interval)
01b1 0362	433 866	5	data if word at offset 22 is 83 ($53) (in 2 ms-BCI) or 42 ($2a) (in 4ms ambient modes)
CHANNEL 1 : 1 word every 64 BCI 1 word every 32 BCI for ambient			
01b6 036c	438 876	2	ch1 address
01b8 0370	440 880	1	ch1 time tag
01b9 0372	441 882	1	number of 64-BCI structures (41 or 42 in 2ms-BCI, 20 or 21 in 4ms-BCI except for ambient 41 or 42 in 4ms-BCI)
01ba 0374	442 884	41	data
01e3 03c6	483 966	1	data if word at offset 441 is 42 ($2a)(in 2ms BCI) or 21 ($15) (in 4 ms ambient modes)
SPARE			
01e4 03c8	484 968	6	spare

		490	total words

The plain telemetry format contains two data channels.

Channel 0 contains 5 words for every 32 BCI. There are two modes:

- In *non-compressed mode*, a 16-bit sample is collected during each of the first 5 BCIs of every 32BCI. Bit 11 of the first word of the header will be zero in non-compressed mode.

```
+----------+----------+----------+----------+----------+
| sample 1 | sample 2 | sample 3 | sample 4 | sample 5 |
+----------+----------+----------+----------+----------+
```

sample 1 ... sample 5 are the samples collected during the first 5 BCIs at the start of a 32 BCI cycle. In *compressed mode*, a 12-bit average and a 2-bit maximum indicator are stored every 4 BCIs. This is repeated eight times, then the eight 12-bit sums are compressed to eight 8-bit sums in four words and the eight 2-bit maxima are squeezed into a fifth word. Thus, compressed channel 0 telemetry is a repeating 5-word sequence. The source for the compression first has 4 added to it, then is shifted three bits right (one shift for going from 14 to 13 bits, the others for averaging), then ANDed with $3FFF.

Bit 11 of the first word of the header will be set in compressed mode.

```
|15      0|15      0|15      0|15      0|15            0|
+---------+---------+---------+---------+---------------|
|    |    |    |    |    |    |    |    |m m m m m m m m|
| s2 | s1 | s4 | s3 | s6 | s5 | s8 | s7 |1 2 3 4 5 6 7 8|
+---------+---------+---------+---------+---------------|
|         |                             |               |
|<-1word->|                             |<-- 1 word --->|
                                            range bits
```

where: sx = compressed sample (1 byte each, x = 1...8)
mx = maximum indicator (2 bits each, x = 1...8)
00 = 1st sample is the max
01 = 2nd sample is the max
10 = 3rd sample is the max
11 = 4th sample is the max

Compression scheme: 1. pre-processing
a) sum = (term1 AND $3FFF) + (term2 AND $3FFF) + (term3 AND $3FFF) + (term4 AND $3FFF)
b) X = ((sum + 4) / 8) AND $3FFF
Note: the ANDing in step 1a) is to avoid problems when testing with optical cable loopback configuration (CMD looped back as DATA). The divide by 8 both averages the 4 terms in the sum and shifts the result to 13 bits.

2. compression function	raw data X	after compression
0000-003F	X	
0040-007F	((X - 0040) / 02) + 40	
0080-00FF	((X - 0080) / 04) + 60	
0100-01FF	((X - 0100) / 08) + 80	
0200-03FF	((X - 0200) / 10) + A0	
0400-07FF	((X - 0400) / 20) + C0	
0800-0FFF	((X - 0800) / 40) + E0	
1000-3FFF	FF	

Channel 1 contains one 16-bit word for every 64 BCI. There are two modes:

- In *non-accumulated mode*, the sample is simply collected and stored. Bit 10 of the first word of the header will be zero in non-accumulated mode.
- In *accumulated mode*, the sample is the sum over 64 BCIs. Bit 10 of the first word of the header will be set in accumulated mode.

2.3.3.2 Packing Mode0, UCSD Ambient (Mode $13, 4ms BCI)

Channel 0 contains 5 words for every 16 BCI. There is only a compressed mode option (no non-compressed mode)

```
|15      0|15      0|15      0|15      0|15     0|
+---------+---------+---------+---------+--------+
|    |    |    |    |    |    |    |    |        |
| d1 | d2 | d1 | d2 | d1 | d2 | d1 | d2 |s s |s s|
+---------+---------+---------+---------+--------+
|         |
|<-1word->|
```

where: d1 = compressed counts from detector 1, collected within some fraction of the previous 4-BCI period
d2 = compressed counts from detector 2, collected within some fraction of the previous 4-BCI period simultaneously with d1
s = spare

The compression function is the same as for other science modes. The pre-processing is:

$$x = \left[\frac{(data30 \quad AND \quad \$3FFF) + \quad 1}{2} \right] AND \quad \$3FFF$$

Channel 1 contains the following 1-word structure every 16 BCIs :

```
+---+---------------+----------------+
| s | n n n n n n n | m m m m m m m m |
+---+---------------+----------------+
 (1)     (7 bits)        (8 bits)
```

where:

s = 1 if this is the first word in the subcommutation sequence, and 0 otherwise.
nnnnnnn = a 7-bit subcommutated value; the 8 sequence values are as follows, and are all "snapped" AT THE SAME TIME, e.g., in the first BCI of the 16-BCI period to which the ch1 word corresponds :

#	value	Description
0	b000000	where b is the sensor-limit flip flag
1	eeeeeee	energy-step number (per current ch1)
2	ttttttt	bits 6 - 0 of ecnt
3	ttttttt	bits 13 - 7 of ecnt
4	000cccc	pcone counter
5	sssssss	pspin counter
6	0000000	spare
7	0000000	spare

mmmmmmmm = the eight "gz < 0" flags (1 if gz is negative, 0 otherwise) for the 8 pairs of count values in the two 5-word ch0 samples prior to the time of this ch1 value.

In UCSD Ambient mode, EVT reset is not automatic. The reset is sent approximately 2 frames after GDU commands are sent. This ensures that the counts are collected only for the new command values.

2.3.3.3 NM1, Packing Mode 0, Diagnostic FGM (Mode $11)

Diagnostic FGM uses a modified NM1, packing mode 0, creating 5 words every 32 BCI and disregarding the channel boundaries defined for plain telemetry.

Offset hex words bytes	offset dec words bytes	#words	description
0000 0000	00 00	4	header
0004 0008	04 08	16	2nd header
	5 words every 32 BCI		
0014 0028	20 40	1	Data flag: 0=b_z; 1=b_y, 2=b_x 3=selected words
0015 002a	21 42	1	ch0 time tag
0016 002c	22 44	1	number of 32-BCI structures (82 or 83 for 2ms-BCI)
0017 002e	23 46	410	data
01b1 0362	433 866	5	data if word at offset 22 is 83 ($53)
01b6 036c	438 876	2	spare
01b8 0370	440 880	1	FGM range
01b9 0372	441 882	49	spare

		490	total words

The five words are **either** :

word1	:	b_z				
word2	:	one of three possibilities	:	b_z	b_y	b_x
word3	:	same axis as word2	:	acc0sz	acc0sy	acc0sx
words4,5	:	same axis as word2	:	bz_0	by_0	bx_0

b_z, etc : normalized, STAFF-adjusted B-field components as of last BCI
acc0sz,etc : STAFF accumulators since the last FGM interrupt including present BCI
bz_0, etc : FGM data * 2^14 in spacecraft coordinate at last FGM interrupt

or:

five user-selected words. The words to be selected have to be specified by writing their addresses to RAM area $00D4C0 - $00D4D3.

The FGM range bits mean:

bits 3-0	nT per bit	Range
000	---	0 : no valid data
001	---	1 : not used
010	0.03125	2 : -64 to + 64 nT
011	0.0125	3 : -256 to + 256 nT
100	0.5	4 : -1024 to + 1024 nT
101	2.0	5 : -4096 to + 4096 nT
110	---	6 : not calibrated

111	32	7 : -65536 to + 65504 nT

2.3.3.4 NM1, Packing Mode 0, Ambient (Mode $15)

Ambient uses a modified NM1, packing mode 0, creating 5 words every 32 BCI and disregarding the channel boundaries as defined for plain telemetry.

Offset hex words bytes	offset dec words bytes	#words	description
0000 0000	00 00	4	header
0004 0008	04 08	16	2nd header
	5 words every 32 BCI		
0014 0028	20 40	1	spare
0015 002a	21 42	1	timetag
0016 002c	22 44	1	number of 32-BCI structures (82 or 83 for 2ms-BCI)
0017 002e	23 46	410	data
01b1 0362	433 866	5	data if word at offset 22 is 83 ($53)
01b6 036c	438 876	12	spare
01c2 0384	450 900	4	RAM INIT words
01c6 038c	454 908	16	Addresses of data words
01d6 03ac	466 932	1	number of NM1 resynchs
01d7 03ae	467 934	1	number of BM1 resynchs
01d8 03b0	468...936	18	spare

		490	total words

The five data words are**:**

word0—hibyte / lobyte: theta (LSB is 0.703125 degrees) / phi (phi LSB is 2.8125)
word1—hibyte / lobyte: energy / type of run:
Pitch Angle 180: bit0 = 1 (g1z sign=Bz sign)
bit1 = n/a
0: bit0 = 0 (g1z sign not equal Bz sign)
bit1 = n/a
90: bit0 = n/a
bit1 = 1 (BxPERP**)
word2—hi / lo: hibyte of Z-perp / hibyte of Y-perp
word3: GDU1, DATA30, frame7 accumulated over BCIs 12-19 in the telemetry interval
word4: GDU2, DATA30, frame7 accumulated over BCIs 12-19 in the telemetry interval

** bit1 is available after upload Sessions 82-84

The addresses of the data that become the five-word Ambient data words are give starting at word 454 for 10 words. Following the addresses are two counters. The counters are error counts for the number of times the onboard code had to resync the Ambient data interval with the telemetry data interval. The first word is the NM1 error counter and the second is the BM1 error counter.

2.3.3.5 NM1, Packing Mode 1

This Packing Mode is only applicable to 4ms-BCI Modes.

Offset hex words bytes	offset decimal words bytes	#words	description
0000 0000	00 00	4	header
0004 0008	04 08	16	2nd header
NM1, PACMO1 : 1 structure (5 words) every 16 BCIs			
0014 0028	20 40	1	time tag
0015 002a	21 42	1	number of 5-word data structures
0016 002c	22 44	405	data (always 81 structures)
01ab 0356	427 854	41	words with 4 low index bits
01d4 03a8	468 936	21	words with 2 high index bits
SPARE			
01e9 03d2	489 978	1	unused

		490	

Each 16 BCI up to 81 times a TMR 5 words of data are collected and stored (81*5 = 405) data words (one or two 16 BCI samples are not stored for telemetry). The format of the 5 words is:

```
+-----------+-----------+-----------+-----------+-----------+
| c | T1    | b |   vx  | a |   vy  | en|   VX  | qQ|   VY  |
+-----------+-- --------+-----------+-----------+-----------+
```

The formats of the words with index bits beginning at 427 (low bits) and 468 (high bits) are:

```
| < --  two BCIs of data   -- > |
| < --  one word  of data  -- > |
+-------|-------+-------|-------+
|   IIa | iia   | IIb   |  iib  |
+-------|-------+-------|-------+
| wd 427 lobyte | wd 427 hibyte |
|  bits | bits  | bits  | bits  |
|  0-3  | 4-7   | 8-11  | 12-15 |
|  det2 | det1  |  det2 |  det1 |
```

low 4 bits of each index are stored starting at word 427. Each BCI a byte is written. The byte contains 4 bits of index information for each detector. Word 427 is earliest data, word 428 is next, and so on.

```
| < --     4 BCIs of data  -- > |
| < --   one word of data  -- > |
+---|---|---|---+---|---|---|---+
| IF|if | IF|if | IF|if | IF|if |
+   b   |   a   |   d   |   c   +
|             word 468          |
|  low byte  |  high  byte      |
| bits  | bits  | bits  | bits  |
|0-1|2-3|4-5|6-7|8-9|a-b|c-d|e-f|
| d2| d1| d2| d1| d2| d1| d2| d1|
```

high 2 bits of each index are stored starting at word 468. Each BCI a byte is written. On even BCIs the byte contains only 4 bits of data in the low order 4 bits. On odd BCIs the high 4 bits of the byte contain the oldest index data and the low 4 bits contain the newest index data. (internal to EDI, the byte is read, shifted and rewritten). Thus the location of index bits in the final word of data depends on the count in word 21. In each pair of bits, the frame bit is in the bit location with the higher number.

det1, d1 = detector of GDU1; det2, d2 = detector of GDU2

The packing mode 1 data items are defined:

iia,IIa,iib, ..	Low 4 bits of index data for detector1 (ii) and detector2 (II) for BCIs a,b,c
fib,FIB,fia, ..	High 2 bits of index data for detector1 (fi) and detector2 (FI) for BCIs a,b,c
T1	TOF1 for gun1 (12 bits), saturated to FFF. See next item for resolution/units.
a,b,c	TOF1-TOF2 (9 bits split plus a sign bit split into two 4-bit nibbles plus 2 bits), saturated to +511 ($1FF) and –512 ($200). a is bits 0-3 ; b is bits 4-7, c is bits 8-9 plus correlator bits **m** in high bits. The resolution of TOF1 and TOF1-TOF2 is that of the correlator. Units are seconds or microseconds depending on the value of **n.** Values for TOF LSB are listed with **n** below.
v(x,y)	va(x,y) +$3200 divided by 8 to fit in 12 bits. v(x,y) for gun1, V(X,Y) for GUN2.
e	Energy in high bit (0 = 1 keV, 1 = 500 eV)
n	nnn is correlator parameter n (CMD17, bits 11-9): — TOF LSB in ns 000 is n=1 — 59.6093 001 is n=2 — 119 010 is n=4 — 238 011 and 100 are n=8 — 476 101 is n=16 — 954 110 is n=32 — 1907 111 is n=64 — 3815
m	m is correlator parameter m (CMD17, bits3-2)
qQ	q is q1, quality at detector1; Q is Q2, quality at detector2; quality bits: 0 = no angle track; 1 = angle track, no time track; 2 = angle and time track; 3 = angle and time track, counts > limhi

	additional/replacement items in PACM5,NM1 and PACM1,BM1 data structures
ii	Index for detector1
II	Index for detector2
***(x/X)a* | *(d/D)*14**	bits 3,2 of max channel number of detector in bits 15,14, DATA word 14 of detector saturated to 3FFF, in bits 13 – 0. x,d for detector1; X,D for detector2.
***(x/X)*b | *(d/D)*15**	bits 1,0 of max channel number of detector in bits 15,14, DATA word 15 of detector in bits 13-0. x,d for detector1; X,D for detector2.

Notes:

- ToF1 is the Time of Flight for the gun2→detector1 path;
  ToF2 is the Time of Flight for the gun1→detector2 path
- the resolution of the index is:

  NM1,PACM1 : the index for this 16-BCI structure has 5 bits for index and anti-aliasing and 1 bit for frame resolution. The low 4 bits of the index/anti-alias information are the 4 bits iia,IIa,iib,IIb, etc. The high bit of the index/anti-alias is the i-bit (low bit) of the fia,FIa,fib,FIb, etc. combination. The one bit of frame information is the f-bit (high bit) of the fia,FIa,fib,FIb, etc. combination. When the f-bit is set, it means that the maximum occurred in frame 15 in two sample operation or in frame 11 or 15 in four sample

operation. There is full resolution in two sample operation; an additional bit would be required for full resolution in four sample operation, but there is no space in telemetry for this bit.
NM1,PACM5: the index for this 32-BCI structure contains 6 bits for index and anti-aliasing and two bits for complete frame resolution. The frame resolution bits are bits 7 and 6 of the ii,II byte. The meaning of these bits is:

• bits7,6:	00	01	10	11
frame:	3	7	b	f

BM1,PACM1: the index for this 4-BCI structure contains 3 bits for index and anti-aliasing and two bits for complete frame resolution. The frame resolution bits are bits 7 and 6 of the ii,II byte. The meaning of these bits is the same as for NM1, PACM5.

2.3.3.6 NM1, Packing Mode 2

Telemetry for diagnostic modes will be created in two steps. In the first step, 16 words are written to scratch RAM every BCI . There are two sets of 16 words, depending on whether peaks are to be searched in S^2/B or in data30. A set is selected by specifying an init table. The set may be changed by the RAMW TC (TC $46). All of the setup for Diagnostic GEOS is done at mode initialization, but the TM process does not begin until PCKM TC (TC $4a02) is sent. Some variables may be changed by telecommand in the in between times (how many peaks, which detector, what type of peak but NOT the steps or the step size).

If **peaks in S^2/B** are to be found, then the 16 words written to scratch RAM are :

0	bx	8	bx
1	by	9	by
2	bz	10	bz
3	data14 gdu2 (+/-SMAX)	11	data14 gdu1 (+/-SMAX)
4	data15 gdu2 (ALL,unsigned)	12	data15 gdu1 (ALL,unsigned)
5	vax1	13	vax2
6	vay1	14	vay2
7	dummy (used later by tm task)	15	dummy (used later by tm task)

If **peaks in data30** are to be found (this is the default), then the 16 words written to scratch RAM are:

0	bx	8	bx
1	by	9	by
2	bz	10	bz
3	data30 frame7 detector	11	data30 frame7 detector
4	data14 gdu2 (+/-SMAX)	12	data14 gdu1 (+/-SMAX)
5	vax1	13	vax2
6	vay1	14	vay2
7	dummy (used later by tm task)	15	dummy (used later by tm task)

The second step of PACM2 tm is execution of a task to scan the words in scratch RAM and find the two peaks for each GDU each TMR (optionally four peaks for one GDU). When a peak is found, 7 words from that BCI, the 7 preceding and 8 following BCIs are written to the telemetry buffer for transmission in the next TMR (this means the data are two TMRs delayed). The 7 words are 0-6 and 8-14 from the list above. The task also writes a number of timing words to the buffer, including a time tag and the BCI offset of the four peaks. The BCI offset is an indicator of the relative time of the four peaks.

If two peaks with the same value are found, the first one found will be the high peak. If all data words are the same, BCI offset 1 will be the highest peak and all other peak numbers (one or three others) will be 0000.

NM1, Packing Mode 2 Data description :

Offset hex words bytes	offset decimal words bytes	#words	description
0000 0000	00 00	4	header
0004 0008	04 08	16	2nd header
0014 0028	20 40	1	time tag of first BCI after TMR
0015 002a	21 42	4	offsets of peaks 1-4
PEAK OFFSETS : if 2 peaks for two GDUs, peaks are 1. detector2,gun1 low 2. detector2,gun1 high 3. detector1,gun2 low 4. detector1,gun2 high if 4 peaks for one GDU, peaks are lowest, next, next, highest			
0019 0032	25 50	112	peak 1 : 7 words * 16 BCIs
0089 0112	137 274	112	peak 2 : 7 words * 16 BCIs
00f9 01f2	249 498	112	peak 3 : 7 words * 16 BCIs
0169 02d2	361 722	112	peak 4 : 7 words * 16 BCIs
STEPPING OFFSETS			
01d9 03b2	473 946	1	xd1 offset or Bx offset
01da 03b4	474 948	1	yd1 offset
01db 03b6	475 950	1	xd2 offset or N/A
01dc 03b8	476 952	1	yd2 offset or N/A
01dd 03ba	477 954	1	xd1 step or Bx step
01de 03bc	478 956	1	yd1 step or N/A
01df 03be	479 958	1	xd2 step or N/A
01e0 03c0	480 960	1	yd2 step or N/A
01e1 03c2	481 962	1	timetag
01e2 03c4	482 964	1	# BCIs in RAM to scan
LEFTOVERS			
01e3 03c6	483 966	7	leftovers

		490	

2.3.3.7 NM1, Packing Mode 4

Packing Mode4 no longer exists.

Packing Mode 4 is a diagnostic TM mode. In this mode, selected HK data are written directly to the SCI TM FIFO. This mode may be set as the default at Poweron by spacecraft-specific PACM4 control byte at $87700 on EEPROM 84000. If this byte=1, then PACM4 is the Poweron default. It may also be selected via TC PCKMS. Packing Mode 4 is not double-buffered. In order to ensure that there are data in the FIFO when the spacecraft reads it, the controller writes 44 bytes of $3c3c at TMR. The rest of packing mode 4 telemetry consists of the four words CONPC, GD1PC, GD2PC, CONPV repeatedly over until 490 words have been written. There is no second header and there are no data channels in packing mode 4.

Offset hex words bytes		offset dec words bytes		#words	description
0000	0000	00	00	4	header
0004	0008	04	08	44	$3c3c words written for controller/SC timing
005c	002e	48	96	442	CONPC, GD1PC, GD2PC, CONPV

				490	total words

2.3.3.8 NM1, Packing Mode 5

This packing mode uses the same data structures as BM1, PACM1 thus it provides the same level of data information, but at reduced resolution (32 BCIs vs. 4 BCIs).
This TM format did not exist for CLUSTER-I, but was added based on EQS experience.

offset hex words bytes		offset decimal words bytes		#words	description
0000	0000	00	00	4	header
0004	0008	04	08	16	2nd header
NM1, PACM5 : 1 structure every 32 BCI					
0014	0028	20	40	1	time tag
0015	002a	21	42	1	number of 10-word structures;
0016	002c	22	44	410	data
SPARE					
01b0	0360	432	864	58	spare

				490	

Each 32 BCI 10 words of data are collected and stored in the NM1 data words. In normal processing the 10 data words contain information from both gun/dectector pair. An option was added in May 2002 to fill both slots with data from just one gun/detector pair. In the TM options below, detector1/gun2 data are labelled in lower case; detector2/gun1 data are labelled in CAPS.

Normal: data from both gun/detector pairs. detector2/gun1 lower case; DETECTOR1/GUN2 in CAPS.
Items in the data structure are defined in **NM1, PACM1**.

```
+---------------+---------------+---------------+---------------+------------+
| c  |    T1    | b  |    vx    | a  |    vy    | en |    VX    | qQ |  VY  |
+---------------+---------------+---------------+---------------+------------+
| Xa  |  D14    |  Xb |  D15    |  xa |  d14    |  xb  |  d15   |   ii | II  |
+---------------+---------------+---------------+---------------+------------+
```

Special: data from detector1/gun2.

```
+---------------+---------------+---------------+---------------+------------+
| n-c | T1ast   | n-b | n-VX    | n-a |  n-VY   | en |    VX    | *qQ |  VY  |
+---------------+---------------+---------------+---------------+------------+
| Xa |   D14    |  Xb |   D15   | n-Xa |  n-D14 | n-Xb | n-D15  |  ii | n-ii |
+---------------+---------------+---------------+---------------+------------+
```

Special: data from detector2/gun1.

```
+---------------+---------------+---------------+---------------+-------------+
| n-c | T1ast   | n-b |  vx     | n-a |  vy     | en |  n-vx    | *qQ | n-vy  |
+---------------+---------------+---------------+---------------+-------------+
| n-xa  | n-d14 | n-xb |  n-d15 | xa |     d14  | xb |    d15   | n-II | II   |
+---------------+---------------+---------------+---------------+------------ +
```

In special telemetry, the data in the 10-word structure for the *selected* detector/gun pair are the same as for the normal case. They are data from the last observed peak in the data interval. The data in the 10-word structure for the *unselected* pair are replaced by data for the next-to-last peak in the data interval for the selected pair. In the diagrams above, "n-" designates data from the next-to-last peak. In special telemetry, the time fields in the first three words represent the time of the last peak in the data interval (Tlast) and the difference between the time of this peak and the time of the next-to-last peak in the data interval (n-c, n-b, n-a). The quality bits for the last peak for the selected detector are in their usual locations. The quality bits for the next-to-last peak are in the bits usually occupied by the unselected detector (if detector1/gun2 is selected, the next-to-last peak quality bits are bits1-0; if detector2 is selected, the next-to-last quality bits are bits3-2). The logic is similar for the index bits (last peak index in normal location, next-to-last peak in other detector location).

2.3.3.9 NM1 Generic/Composite Telemetry

Addresses for NM1 send/store buffers are E010 and E410. E010 is used in this sample. PACM4 not included. For comparison with other telemetry charts, divide "hex TM byte offset" column by two. This is the same as "offset hex words".

Hex buffer byte address/offset	hex TM byte offset	#words/bytes dec. / hex	Pacm0	Pacm1	Pacm2	Pacm5	Diagnostic FGM D or Ambient A
n/a	0	4 8	header	header	header	header	header
DFF0 -20	8	16 20	header	header	header	header	header
E010 0	28	1 2	address	timetag	timetag	timetag	flag/spare D/A
E012 2	2A	1 2	timetag	number		number	timetag
E012 2	2A	4 8			offsets		
E014 4	2C	1 2	number				number
E014 4	2C	405 32A		data			
E014 4	2C	410 334				data	
E016 6	2E	410 334	data				data
E01A A	32	448 380			data		
E33E 32E	356	41 52		data			
E348 338	360	58 74				spare	
E34A 33A	362	5 A	data				data
E354 344	36C	2 4	address				
E354 344	36C	52 68					spare
E358 348	370	1 2	timetag				
E358 348	370	1 1					range/spare D/A
E359 349	371	1 1					spare A
E35A 34A	372	1 2	number				
E35A 34A	372	4 8					inits A
E35C 34C	374	41 52	data				
E352 364	38C	16 20					addresses A
E390 380	3A8	21 2A		data			
E39A 38A	3B2	8 10			offsets		
E3AA 39A	3C2	1 2			timetag		
E3AA 39A	3C2	29 3A					spare A
E3AC 39C	3C4	1 2			number		
E3AE 39E	3C6	7 E			spare		
E3AE 39E	3C6	1 2	data				
E3B0 3A0	3C8	6 C	spare				
E3BA 3AA	3D2	1 2		spare			
E3BC	3D4	490 3D4	total				

2.3.4 BM1 Telemetry Formats

2.3.4.0 BM1, Packing Mode 0, in memory dump format

Offset hex words bytes	offset dec words bytes	#words	description
0000 0000	00 00	4	header
0004 0008	04 08	16	2nd header
0014 0028	20 40	3452	data

		3472	total words

2.3.4.1 BM1, Packing Mode 0, plain

offset hex words bytes	offset decimal words bytes	#words (decimal)	description
0000 0000	00 00	4	header
0004 0008	04 08	16	2nd header
0014 0028	20 40	143	memory dump
CHANNELS 2 / 3 : 1 byte each every BCI			
00a3 0146	163 326	2	channel 2 address
00a5 014a	165 330	2	channel 3 address
00a7 014e	167 334	1	time tag
00a8 0150	168 336	1	number of data words (ch2 / ch3) (~$a4e for 2ms-BCI, ~$527 for 4ms-BCI)
00a9 0152	169 338	2637	ch2/3 data
CHANNEL 4 : 1 word every fourth BCI (every other BCI for ambient)			
0af6 15ec 0af7 15ee	2806 5612 2807 5614	1 1	data if word 168 = $a4e data if word 168 = $a4f
0af8 15f0	2808 5616	2	channel 4 address
0afa 15f4	2810 5620	1	time tag
0afb 15f6	2811 5622	1	number of data words (~$293 for 2ms-BCI, ~$149 for 4ms-BCI except ~$293 for ambient 4ms-BCI)
0afc 15f8	2812 5624	659	ch4 data
0d8f 1b1e	3471 6942	1	data if word 2810 = $294

		3472	

The box above is correct for 2ms modes and for ambient modes. For non-ambient 4ms modes, offsets and control word counts are as shown, but the data word counts are half those listed.

BM1 PACM0 contains three data channels :

Channels 2 and 3 contain one byte each, collected every BCI. The source for channels 2 and 3 can either be

- a byte each or
- a word each, which is compressed to a byte. For the compression, the same compression function is used as for channel 0 in NM1 PACM0, only the pre-processing is slightly different:

$$x = \left[\frac{(dataword \quad AND \quad \$3FFF) + 1}{2} \right] AND \quad \$3FFF$$

- Channel 2 is the high byte of the ch2/ch3 word.

Channel 4 contains 1 word collected every other BCI. Channel 4 does not have a compression or accumulation option.

2.3.4.2 BM1, Packing Mode 0, UCSD Ambient (Mode $13)

The telemetry structure for ambient mode in BM1 is the same as for BM1 Packing Mode 0. The channel 2/3 data structures are the compressed data30 values from the two GDUs sampled simultaneously (GDU1 → channel2, GDU2 → channel3). The compression function and pre-processing is the same as for BM1 PACM0 channels 2 and 3.

The upper byte of channel 4 will contain the same subcommutation sequence that was described for NM1, ambient mode, channel 1. The lower byte will contain gz < gzero flip flags. Since values in channel 4 are collected every BCI and steps occur every BCI, only the lowest bit of the channel 4 word is needed to send the flip flags. The remaining 6 bits are zero.

2.3.4.3 BM1, Packing Mode 0, Diagnostic FGM (Mode $11)

Diagnostic FGM uses a modified BM1, packing mode 0, creating 5 words every 4 BCI and disregarding the channel boundaries as usually defined.

offset hex words bytes	offset decimal words bytes	#words	description
0000 0000	00 00	4	header
0004 0008	04 08	16	2nd header
0014 0028	20 40	143	If dataflag < 3, n/a; else first 10 words are addresses of 5 selected words.
	5 words every 4 BCI		
00a3 0146	163 326	1	Data flag: 0=b_z; 1=b_y, 3=b_x 3=selected words
00a4 0148	164 328	1	FGM range
00a5 014a	165 330	2	Not used
00a7 014e	167 334	1	Time tag
00a8 0150	168 336	1	Number of 4-BCI 5 word Structures ($20f or $210)
00a9 0152	169 338	3295	B-field data, 5 words each 4-BCI
0d88 1b10	3464 6928	5	Data if word 2810 = $210
0d8d 1b1a	3469 6938	3	Spare

		3472	

The five words are the same as for Diagnostic FGM for NM1 telemetry mode.

2.3.4.4 BM1, Packing Mode 0, Ambient (Mode $15)

Ambient uses a modified BM1, packing mode 0, creating 5 words every 4 BCI and disregarding the channel boundaries as usually defined.

offset hex words bytes	offset decimal words bytes	#words	description
0000 0000	00 00	4	header
0004 0008	04 08	16	2nd header
0014 0028	20 40	143	First 4 words are RAM INITs, next 16 words are RAM words addresses, next 2 words are synch error counts (NM1, BM1)
00a3 0146	163 326	4	spare
00a7 014e	167 334	1	Time tag
5 words every 4 BCI			
00a8 0150	168 336	1	Number of 4-BCI 5 word structures ($293 or $294)
00a9 0152	169 338	3295	Ambient GEOS data, 5 words each 4-BCI
0d88 1b10	3464 6928	5	Data if word 2810 = $294
0d8d 1b1a	3469 6938	3	Spare

		3472	

The five words are the same as for NM1 Ambient telemetry.

2.3.4.5 BM1, Packing Mode 1

offset hex words bytes	offset decimal words bytes	#words	Description
0000 0000	00 00	4	Header
0004 0008	04 08	16	2nd header
BM1, PACM1 : 1 structure every 4 BCI			
0014 0028	20 40	1	Time tag
0015 002a	21 42	1	Number of 10-word structures; 329 nominally
0016 002c	22 44	3290	Data
0cdc 19e0	3312 6624	10	Data if word 21 > $149
SPARE			
0ce6 19f4	3322 6644	150	Spare

		3472	

Each 4 BCI 10 words of data are collected and stored.

The format of the 10 words the same as NM1, PACM5. Items in the data structure are defined in NM1,PACM1 above.

2.3.4.6 BM1 Generic/Composite Telemetry

Addresses for BM1 send/store buffers are 10030 and 12030. 12030 is used in this sample.
For comparison with other telemetry charts, divide "hex TM byte offset" column by two. This is the same as "offset hex words".

hex buffer byte address/offset	hex TM byte offset	#words/bytes dec. hex	Pacm0	Pacm1	Diagnostic FGM / Ambient GEOS
n/a	0	4 8	header	header	header
12010 -20	8	16 20	header	header	header
12030 0	28	143 11E	memory dump		addrs/memdump D
12030 0	28	4 8			inits A
12030 0	28	1 2		timetag	
12032 2	2A	1 2		number	
12034 4	2C	3290 19B4		data	
12038 8	30	139 116			addrs/memdump A
1214E 11E	146	2 4	address		
1214E 11E	146	1 2			flag D
12150 120	148	3 6			range D
12152 122	14A	2 4	address		
12156 126	14E	1 2	timetag		timetag
12158 128	150	1 2	number		number
1215A 12A	152	2637 149A	data		
1215A 12A	152	3295 19Be			data
135F4 15C4	15EC	2 4	data		
135F8 15C8	15F0	2 4	address		
135FC 15CC	15F4	1 2	timetag		
135FE 15CE	15F6	1 2	number		
13600 15D0	15F8	659 526	data		
139E8 19B8	19E0	10 14		data	
139F2 19C2	19F4	150 12c		spare	
13B26 1AF6	1B1E	1 2	data		
13B28 1B18	1B20	3472 1B20	total		

2.3.5 BM3 Telemetry Formats

BM3 data are generated by the GDMP TC which causes data to be written to scratch RAM every BCI. The GDMP TC has five options which control the type of data written to scratch RAM. BM3 telemetry is a sequential dump of the data previously stored in scratch RAM.

offset hex words bytes	offset decimal words bytes	#words	description
0000 0000	00 00	4	header
0004 0008	04 08	32	2nd header
DATA WORDS			
0024 0048	36 72	11258	data words
LEFTOVERS			
0ff4 1fe8	4084 8168	300	leftovers

		11594	total words

The secondary header contains 32 words which are the addresses of the words written to scratch RAM. These identifying data are unpredictable if GDMP options less than $40 were used to create the dump words.
The high nibbles of words 1, 3, 5 (counting from 0) of the second header contain dump data identification. The high nibble of word 1 contains the option byte of the TC ZEEGDMPS (GDMP); the high nibble of word 3 contains the RAM WDS table number; the high nibble of word 5 contains a flag to indicate 2ms or 4ms processing (0=2ms, 1=4ms).

GDMP options and data written to scratch RAM:

0x --- where x is a selected frame:
  GDU commands, data and xd, yd increments for both GDUs
yx --- where x is a selected frame, y = 1 means GDU1, y = 2 means GDU2:
  commands and data for GDUN (N=1,2) and xd, yd increments for both GDUs
40 --- a user selected 16 words
51 --- beam profile data at detector1 (frame resolution)
52 --- beam profile data at detector2 (frame resolution)

If GDMP $40, $51 or $52 was used to fill scratch RAM, the data are transmitted in telemetry in the same order that the addresses appear in the header. For other GDMP options the order of data transmission in telemetry is :

```
GDMP 1x or 2x    data words : 00-31
                 increments : xd1, yd1, xd2, yd2
                 commands   : 00-30
GDMP 0x          data words : 00 (GDU1, GDU2)
                              01 (GDU1, GDU2)
                              02 (GDU1, GDU2)
                              :
                              31 (GDU1,GDU2)
                 increments : xd1, yd1, xd2, yd2
                 commands   : 00 (GDU1, GDU2)
                              01 (GDU1, GDU2)
                              02(GDU1, GDU2)
                              :
                              30 (GDU1,GDU2)
```

2.3.6 Time Tags

How the time tags are built

The science data time tags (short: time tags) and the TMR time tag (also called frame counter at TMR) are built by merging two counters: the 12-bit h/w frame counter CMD16 and the 16-bit software bci counter bci_cnt. The routine which merges them takes bits 10-0 from CMD16 and bits 11-7 (12-8) from bci_cnt in case of a 4ms (2ms) bci.

Example of merging for a 4ms bci (16 GDU-frames per bci):

```
CMD16                           f f f f f f f f f f f    11 bits used
                                  ^ ^ ^ ^ ^ ^ ^ ^ ^ ^ ^
bci_cnt       b b b b b b b b b b b b b b b b              5 bits used
                      ^ ^ ^ ^ ^
                      -------------------------------
merged number         b b b b b f f f f f f f f f f f    16 bits
```

Example of merging for a 2ms bci (16 GDU-frames per bci):

```
CMD16                           f f f f f f f f f f f    11 bits used
                                  ^ ^ ^ ^ ^ ^ ^ ^ ^ ^ ^
bci_cnt         b b b b b b b b b b b b b b b b            5 bits used
                      ^ ^ ^ ^ ^
                      -------------------------------
merged number         b b b b b f f f f f f f f f f f    16 bits
```

The aliasing problem

This merged counter produces, at times, strange results. There are two reasons:

a) the overlapping bits of CMD16 and bci_cnt (i.e. bits 7-0 of bci_cnt and bits 11-4 of CMD16 in case of a 4ms-bci) do generally not have the same contents.
(this could and would have to be changed in the EDI Controller code, if necessary)

b) the two counters are not changing their states synchronously: while the h/w counter CMD16 changes on defined equidistant intervals, bci_cnt does not due to the latency in the start of interrupt service routines.

There are three types of undesired effects. An 11-bit roll-over in CMD16, unsynched incomplete roll-over in bci_cnt and unsynched full roll-over in bci_cnt.

A) 11-bit roll-over in CMD16

If bits 10-0 of CMD16 are all set, they will change to all zeroes one GDU-frame later. In an ordinary counter this causes the next higher part (bits 15-11) of the counter to increment. Not so for the merged counter, mainly due to reason a). The problem remains until bci_cnt reaches a state where the 5 used bits are incremented.

In case the TMR time tag has been built prior to the 11-bit roll-over in CMD16 and the science data time tag is built before the appropriate change in bci_cnt finally corrects the problem, the resulting science data time tag will be too small by an amount of 2^11 (=2048), seen relative to the TMR time tag.

Example (4ms-bci, | marks where CMD16 and bci_cnt are merged) :

```
                         hex                binary
                        -----       -------------------------
CMD16                   $0f37            0000 1|111 0011 0111
bci_cnt                 $0006       0000 0000 0|000 0110
TMR time tag            $0737            0000 0|111 0011 0111

CMD16                   $0837            0000 0|000 0110 0001
bci_cnt                             0000 0000 0|001 0101
science time tag        $0061            0000 0|000 0110 0001

apparent difference  : $0061 - $0737 = $fffff92a (-1750)
corrected difference : $0861 - $0737 = $0000012a
```

B) Unsynched incomplete roll-over in bci_cnt

This is the inverse of A): if the unused bits of bci_cnt below the 5 used bits (i.e. bits 6-0 in case of a 4ms bci) are all set they will change to all zeroes the next time bci_cnt is incremented, causing the used part of bci_cnt to increment. If at the same time the bits 10-0 of CMD16 do not change to all zeroes, a time tag created after the low-order bit roll-over in bci_cnt, but prior to the correcting 11-bit roll-over in CMD16, will be too high by an amount of 2^11.

Example (4ms-bci) :

```
                         hex                binary
                        -----       -------------------------
CMD16                   $0637            0000 1|110 0011 0111
bci_cnt                 $0076       0000 0000 0|111 0110
TMR time tag            $0637            0000 0|110 0011 0111

CMD16                   $07a9            0000 0|111 1010 1001
bci_cnt                 $0085       0000 0000 1|000 0101
science time tag        $0fa9            0000 1|111 1010 1001

apparent difference  : $0fa9 - $0637 = $00000972
corrected difference : $07a9 - $0637 = $00000172
```

C) Unsynched full roll-over in bci_cnt

If all 16 bits are set in bci_cnt they will change to all zeroes the next time bci_cnt is incremented. In this case there is a general 16-bit roll-over (unavoidable). If at the same time the bits 10-0 of CMD16 do not change to all zeroes, a time tag created after the roll-over in bci_cnt, but prior to the correcting 11-bit roll-over in CMD16, will be too small by an amount 2^16 - 2^12 (65536 - 2048).

Example (4ms-bci):

```
                          hex                binary
                         -----       -------------------------
CMD16                    $0075            0000 0|000 0111 0101
bci_cnt                  $fff6       1111 1111 1|111 0110
TMR time tag             $f875            1111 1|000 0111 0101

CMD16                    $01a9            0000 0|001 1010 1001
bci_cnt                  $0003       0000 0000 0|000 0011
science time tag         $01a9            0000 0|001 1010 1001

apparent difference  : $01a9 - $f875 = $ffff0934 (-63180)
corrected difference : $f9a9 - $f875 = $00000134
```

In addition to these three effects there is the simple, regular 16-bit roll-over to be considered by the data analysis software.

Telemetry Timing

Abbreviation: Delta = science data time tag - TMR time tag

For telemetry/packing modes where the science data time tag is built prior to the TMR time tag the nominal Delta will be a negative number.

For telemetry/packing modes where the science data time tag is built after the TMR time tag the nominal Delta will be a positive number.

Thus, distinction has to be made between modes where the science data time tag is built prior to the TMR time tag and modes where it is vice versa.

Negative nominal Delta:

TM mode	Packing Mode	Science Mode	timetag created
NMx/BM2	0	all except mode11	ch0: start of last 32-BCI block before TMR ch1: start of last 64-BCI block before TMR
	0	mode11	ch0: first BCI after last FGM interrupt before TMR ch1: same time as ch0 OR first BCI after next to last FGM interrupt before TMR

NOTE: Packing Mode 4 produces no timetag.

The largest structure having time tags that are built prior to the TMR time tag is a 64bci structure (nm1, pacm0, channel1). In a 4ms bci this corresponds to 64*16 = 1024 GDU frames.

Positive nominal Delta:

TM mode	Packing mode	science mode	timetag created
NMx/BM2	1	all(*)	first BCI after TMR
	2	all	first BCI after TMR (all science data in TM,including the science data time tag, are two TMRs older in time than the data in the accompanying HK TM packet)
	5	all (*)	first BCI after TMR
BM1	0	all	ch2,3 : first BCI after TMR ch4 : first 4-BCI boundary after TMR
BM1	1	all(*)	first BCI after TMR

(*) Packing modes 1 and 5 run with 4ms BCI science modes only

The largest structure having time tags that are built after the TMR time tag is a 4-BCI structure (nm1-pacm2, bm1-pacm0-ch4,). In a 4ms BCI this corresponds to 4*16 = 64 GDU frames.

Solution

The nominal ranges for Delta are:

```
[-1024 ;    -1 ]     for negative Delta (NMx/BM2 packm 0)
[    1 ;    64 ]     for positive Delta (NMx/BM2 packm 1,2,5;  BM1 packm 0,1)
```

To allow for some latency the ranges are extended by one 4ms bci (16 GDU frames). The allowed range for Delta is therefore:

```
[-1040 ;    -1 ]     for negative Delta
[    1 ;    80 ]     for positive Delta
```

If one of the three undesired effects or the regular 16bit roll-over occurs, Delta will have a value outside the allowed range and has to be corrected (the correction is listed under the ranges):

Effect	negative Delta	positive Delta
None	[-1040 ; -1] no correction required	[1 ; 80] no correction required
11-bit rollover in CMD16 : A	[1008 ; 2047] subtract 2048	[-2047 ; -1968] add 2048
unsynched incomplete rollover in bci_cnt : B	[-3088 ; -2049] add 2048	[2049 ; 2128] subtract 2048
unsynched full rollover in bci_cnt : C	[62448 ; 63487] subtract 63488	[-63487 ; -63408] add 63488
regular 16bit rollover	[64496 ; 65535] subtract 65536	[-65535 ; -65456] add 65536

An example from Windshield Wiper TM, NM1, PACM1 (16bci structure):

framecounter @TMR in HK TM	TMR time tag in SCI TM	PACM1 science date time tag	Delta (dec.)	corrected Delta (dec.)
3b6e	e0fe	e091	-109	
8dde	3b6e	3a91	-221	
d84e	8dde	8d91	-77	
32be	d84e	df91	1859 !!!	-189
852e	32be	3291	-45	
d79e	852e	8491	-157	
2a0e	d79e	d791	-13	
7c7e	2a0e	2191	-2173 !!!	-125
ceee	7c7e	7b91	-237	
195e	ceee	ce91	-93	

3. Control

3.1 Control Philosophy

3.1.1 Poweron and Startup Checks

The poweron firmware sequence is entered when power is turned on to the system or if a system reset occurs. In addition to performing the system bootstrap, the POWERON sequence performs a series of firmware, hardware and software tests. Detailed information on system startup tests and failures is given in Chapter 9.

If the POWERON routine finds no errors in system hardware or firmware, it executes one of two system mode initialization routines. If POWERON tests of EEPROM $4000 pass, the software jumps to a checksum routine on this EEPROM and if all checksums are good, control passes to the Mode 8 initialization routine on EEPROM $4000. Operation on EEPROM $4000 can be verified by a change in the mode bits in HSK TM word 6. If POWERON finds errors on EEPROM $4000 or if the checksum routine on this EEPROM finds an error, the Mode 0 initialization routine in PROM executes.

The final action in the POWERON sequence is the confirmation of Spacecraft main/redundant communication channel. In either Mode 0 or Mode 8, the software waits 30 seconds for the receipt of a telecommand. Receipt of a telecommand is confirmation that communication is taking place on the main channel. Normal interrupt-driven operations begin; the system waits for more telecommands. If no telecommand is received within 30 seconds, the routine assumes a circuitry failure has occurred and switches all OBDH communication lines from main to redundant

Mode 0 system initialization on PROM can also be entered after EEPROM uploads or on a current overlimit condition. When Mode 0 is entered in this way, the 30 second wait is not executed and the routine sits immediately in the telecommand wait loop.
If error conditions at Poweron cause Mode0 initialization instead of Mode8, special care must be taken to initialize EDI correctly in Mode8 after the errors have been resolved. The jump to Mode8 should use these telecommands:

LDEPM	00
DATAM	6000
JDEPM	60

rather than the standard set address to $6006 and TC SIMO 08.

3.1.2 Configuring the FPGAs

Function

EDI contains three field-programmable gate arrays of the XILINX type:

- One, denoted PGAi, is in the CONTROLLER and handles the serial interface with the GDUs.
- PGA1, located in the GDE, handles the GDU side of the serial interface.
- PGA2, also in the GDE, implements the correlator functions, needed to determine the time-of-flight of the beam electrons. Two configuration files for PGA2 (Options A and B) fit within the allocated space in EEPROM.

PGAi and PGA1 are implemented in XILINX 3090s. PGA2 is implemented in a XILINX 4013.

Configuration Procedure

The configuration files for PGAi and PGA1 are 8 kB each, but as they are stored in odd-byte only EEPROMs, they effectively occupy one 16kB EEPROM each. The configuration file for PGA2 is stored in two 16 kB EEPROMs. Each EEPROM is identified by a version number and a generation date. (For historical reasons, the launch code in controllers 6 and 7 stores some miscellaneous data tables in the odd-byte only EEPROM beginning at address $3C000).

- The PGAs have to be newly configured each time power to EDI is turned on.
- The PGAs have to be configured in the sequence PGAi, PGA1, (PGA2). It is not mandatory to configure PGA2.
- If the command sequences listed below are used, PGAs can be configured in NM and BM TM, regardless of the software version loaded into the Controller.

To configure a PGAi or PGA1 one first loads the configuration file into RAM at address $02c000, using three telecommands.

Configuration is then initiated by the following CMDs

PGAi		PGA1	
ZEELDEPM	02	ZEELDEPM	02
ZEEDATAM	c000	ZEEDATAM	c000
ZEEGDCOS	03	ZEEGDCOS	00
ZEERGIFE		ZEERGINE	01

In Cluster-I when PGA2 was also a 3090 XILINX, one could configure PGA2 using telecommands GDCOS and RGIN options. These options have been disabled for Cluster2.

Cluster-II PGA2 cannot be configured from PROM (Mode0), but only from EEPROM (Mode8)!
To configure PGA2, one first copies the configuration file to RAM using the following telecommands:

```
ZEELDEPM          00
ZEEDATAM          D31C      set gdu_ram address  to $2c000
ZEELDWDS          02
ZEEDATAM          C000
ZEEDATAM          0002      copy from XILINX config EEPROM to gdu_ram

ZEELSOPM          xx
ZEEDATAM          4004
ZEELDEPM          02
ZEEDATAM          C000
ZEELBYCM          00
ZEEDATAM          7FFC
ZEECOPLS          00

ZEEDATAM          0F01      configure PGA2
```

xx = 0a for the configuration file stored on EEPROMs 0a4000, 0a8000 (Test)
= 0c for the configuration file stored on EEPROMs 0c4000, 0c8000 (Corr. B)
= 0e for the configuration file stored on EEPROMs 0e4000, 0e8000 (Spare)

For software before August 1999 (FM6 and FM7 at delivery) xx = 16, 14 for Test or Corr. B respectively.

File ID

PGA1 and PGA2 files are identified by a 4-Byte identifier vv mm dd yy, where vv is the version, mm the month, dd the day, and yy the year of its generation. For PGAi the sequence is vvddmmyy (see also appendix D.1).

The ID is located in EEPROM at the following locations:

old format	PGA1	tables	PGAi	PGA2, part1	PGA2, part2	new format
vv	01 C001	03 C001	07 C001	xx 4000	xx bffa	ee
mm	3	3	5	xx 4001	xx bffb	im
dd	5	5	3	xx 4002	xx bffc	dd
yy	7	7	7	xx 4003	xx bffd	vy

Notes: For Cluster-I files, numbers are stored in hex so that they read correctly in decimal (e.g. yy in PGAi is $94).

For Cluster-II files, numbers are stored in hex and the format of the ID is changed to ee im dd vy where

ee is the high byte of the EEPROM start address;
i identifies the type of file: 1=Uwe Pagel test file, 2=flight, 3=TS, 4=test;
m is the month in hex;
dd is the date in hex;
v is version;
y is the year in hex computed as yyyy-1996 AND $000f.

For Cluster-I files: vv (upper nibble) identifies which PGA the file is intended for:

0001 PGA1
0010 tables
0100 PGAi

vv (lower nibble) of PGA files must be 0010, i.e., $2.

(If the lower nibble is b'0001', the file is intended for use with the Controller Emulator, or if the lower nibble is b'0011' the file is intended for use with the Tracking Simulator, 0011). If vv is incorrect (upper nibble inconsistent with the PGA one is trying to configure, lower nibble not $2), or if the date is incorrect (not as specified in the test procedure), DO NOT CONFIGURE, because the hardware could be damaged!

Confirmation

Successful configuration of PGAs is indicated in the first Header Word of Science telemetry and also in bits 15 - 14 of Word 19 in HK telemetry.
The PGA flags are generated in the Controller rather than read from the PGAs. Improper operator interaction (writing to PGA hardware locations) could cause the PGA flags not to reflect the true PGA status.

Read-back

The readback feature has not been implemented.

Re-Configuration

If a problem occurs which requires re-configuration of a PGA, this can be achieved in one of these ways:

- turn power off: this clears all PGAs
- send *PROCESSOR RESET TC*: this also clears all PGAs;
- just repeat configuration procedure (works for PGA2 only);
- turn off clock and configure (works for PGA1 only)
- send PGA reset TC (ZEERPGAF)

The first two methods require a complete new start.

As indicated in the list above, PGA1 can be reconfigured without turning power off or sending a PROCESSOR RESET. It requires turning the clock on the optical link off. This is done by writing a zero into bit 7 of address location $900800. Configuration then proceeds the same way as after power up.

3.1.3 High-voltage Commanding & Protection

The Elements

There are three elements in the HV commanding scheme employed for EDI:

1. a HV Disable Connector/Switch
2. the HVON TC
3. the PASSWORD TCs

Disable Connector/Switch

A sense line is run from the CONTROLLER to the HV Disable Connector at an accessible location on the spacecraft. When the Disable Connector is inserted, the Controller senses its presence and acts accordingly (see below).

When operating with the S/C simulator, there is a HV Disable Switch on the GDU Load box.

HVON

HVON turns the HV cascades for the GUN and OPTICS voltages on. In order that previously set, potentially unsafe, reference values for the HVs are not executed, the Controller first executes GDUSETSF (see Section 3.4), before turning the HVON bit in the GDUs on.

PASSWORD

The password TCs specify a byte ($AF) which is half of the password. The entire password bit pattern is known to the GDE hardware but not to the CONTROLLER.

If the GDE receives no valid password, the hardware restricts the HV references to only the lower 8 bits, thus restricting the GUN and OPTICS voltages to safe values (typically <100V). Power to the cathode is restricted approximately to values corresponding to $2d0. (For bi-polar OPTICS voltages, the hardware inserts proper combinations of the upper 4 bits to effectively produce the same restriction). Without a valid Password, the MCP HV in the SENSOR is inhibited.

If a valid password is received by the GDE, all 12 command bits are considered and the HVs and cathode power can be commanded to their full values. Receipt of a valid password also removes the inhibit in the SENSOR, allowing the MCP to be turned on.

When a valid password is received, the CONTROLLER first tests for the presence of the Disable Connector. If present, no action is taken (CRCNT is incremented, but CVCNT is not). If the Disable Connector is NOT present, the CONTROLLER executes GDUSETSF (in order to have well-defined safe values), then sends the Password, then HVON to both GDUs. If the password was the valid pattern, then the GDE hardware acts accordingly.

Note that the CONTROLLER cannot distinguish a valid from an invalid Password. It will therefore pass on to the GDE also an invalid password (and execute the other actions associated with a valid Password), PROVIDED the Disable Connector is absent. Thus HVON is set by sending a password TC with an invalid password.

There are three different password TCs: ZEEPASSE which operates on both GDUs simultaneously. When running out of EEPROM, separate passwords (ZEEPSWxE, x=1,2) can be sent to GDIU1 and GDU2 so that one unit may be enabled at a time. Note that ZEEPSWxE destroys previous settings for both units, because both GDUs are set into a safe state. Thus ZEEPASSE must be used to bring up both units together.

GSAFE

The telecommand GSAFE causes execution of GDUSETSF directly. This command thus constitutes the HV emergency turn-off.

Accessible States

The figure lists the HV states as a function of the HVON and PASSWORD received by the GDE. Note that "HEAT" refers to the cathode heater power in the GUN.

Note that the lower left corner is accessible only if HVON is set to 0 after a valid PASSWORD has been sent, because HVON is set to 1 upon receipt of a password. That state has no practical importance though.

Receipt (by the GDE) of a valid PASSWORD, puts the GDU into the lower right-hand corner, regardless of the previous state.

		HVON	
		0	**1**
PASSW0RD	NO	LOW HEAT NO MCP	LOW HEAT NO MCP
	YES	NO HVs FULL HEAT FULL MCP	FULL HVs FULL HEAT FULL MCP

3.2 Telecommands

3.2.1 LP Commands

The first LP telecommand, labeled ZEDILP1A (main) or ZEDILP1B (redundant) causes a processor RESET.

The second LP telecommand, labeled ZEDILP2A (main) or ZEDILP2B (redundant) toggles the EEPROM write enable status. The data parameter is “don’t care”.

3.2.2 ML Commands

Memory load commands are labeled by 4-letter mnemonics which are preceded by ZEE which identifies Cluster and EDI and followed by S, E, M (to identify the nature of the TC).

ML commands are 16 bits. Most commands require some parameter data be entered, sometimes a single byte (one word telecommands), sometimes a byte plus a word (two word telecommands), and there is one multi-word telecommand (06_LDWDS).

The high byte of the first telecommand word is the op-code. For one-word telecommands, the low byte of the telecommand word is the data parameter, designated LB0 in the telecommand format descriptions that follow. For two-word telecommands, the low byte of the first telecommand word is the high byte of the data parameter and the next word is the remaining two parameter bytes. These fields are designated HB1 and WD1 respectively.

In byte pictures, the telecommand formats are:

```
       1 word               2 word              LDWD
    telecommands         telecommands        telecommand
  ________________      ______________      ______________
 |  OP     |      |    |  OP   |      |    |  OP   |      |
 | CODE    | LB0  |    | CODE  | HB1  |    | CODE  | HB1  |
 |_________|______|    |_______|______|    |_______|______|
                       |              |    |              |
                       |     WD1      |    |     WD1      |
                       |______________|    |______________|
                                                  .
                                                  .
                                            _______________
                                           |              |
                                           |     WD1      |
                                           |______________|
```

ML Command Caution

The LDWD telecommand should be treated with caution because the consequences of entering it incorrectly are not obvious as they are with other telecommands.

For instance, if LDWD $10 is entered, the system writes the next 16 telecommand words to 16 sequential memory locations. If the $10 is the wrong number, or if commands are missing, this can cause unpredictable failures. Other than a EDI reset, there is no "break out" from this telecommand. Once LDWD n is entered, the next n telecommands are fodder for LDWD.
Sending 256 NOOP TCs will clear the condition of entering wrong LDWD LB0s.

3.2.3 Telecommand List

	ID	OPCODE_MNEMONIC	-	FUNCTION
	00	00_DATAM	-	WD1 for 2-word commands
	01	01_NOOPD	-	no operation
	02	02_LSOPM	-	load source ptr
#	03	03_LDEPM	-	load destination ptr
#	04	04_JDEPS	-	jump to dest. ptr
#	05	05_LDBYS	-	load byte @ dest ptr
	06	06_LDWDS	-	load words @ dest ptr
	07	07_LBYCM	-	load byte count
	08	08_RBT2S	-	jump to ROBUST2
	09	09_FGSFS	-	set despin options
	10	0A_BKGDS	-	set background task
	11	0B_IMSKS	-	set interrupt mask
	12	0C_RGIFE	-	initialize PGAi
	13	0D_RGINE	-	initialize PGA1/2
	14	0E_GSAFE	-	send GDU safe values
	15	reserved	-	$0F: configures PGA2
	16	deleted		
	17	deleted		
	18	deleted		
	19	deleted		
	20	14_HVONN	-	high voltage to GUN1/2
	21	15_TOGLS	-	toggle bit GDU1/2
	22	16_PASSE	-	send password byte
	23	17_MCP1S	-	set GUN1 MCP level
	24	18_MCP2S	-	set GUN2 MCP level
	25	19_GDCOS	-	copy PGA configuration (for PGAi and PGA1)
	26	1A_LDWIS	-	load word with increments
	27	1B_BDHKS	-	select variable HK
	28	1C_SNHKS	-	select sensor MUX
	29	1D_GDMPS	-	select GDU dump
	30	1E_SUMOS	-	select telemetry submode
	31	1F_SIMOS	-	select science mode
	32	20_COPYS	-	copy words(max 256 words)
	33	21_CSUMS	-	compute checksum
	34	22_COPLS	-	long copy
	35	23_CP2RS	-	copy PGA eeprom file to RAM
	64	40_PSW1E	-	GDU1 password
	65	41_PSW2E	-	GDU2 password
	66	42_RPGAF	-	reset all PGAs
	67	43_MST1S	-	step MCP1 voltage to operating level
	68	44_MST2S	-	step MCP2 voltage to operating level
	69	45_OPTSS	-	set optics to "shutoff"
	70	46_GUNSS	-	set nominal GUN voltages, step up beam
	71	47_SENSS	-	set sensor parameters
	72	48_CAT1S	-	Step cathode power GUN1
	73	49_CAT2S	-	Step cathode power GUN2
	74	4A_PCKMS	-	set packing mode
	75	4B_STBQS	-	Set Mode8 status
	76	deleted		
	77	4D_XCRSS	-	Reset extended command queue
	78	4E_RAMWS	-	Select data words for PACM2 or GDMPS

```
     79   4F_TMCSS          - Select source for PACM0 TM channels
     80   50_MMDPS          - Toggle memory dump option
     81   51_INITS          - Set initialization table (tc_init byte)
     82   52_SOBBS          - Set SOB-byte
     83   53_STBYS          - set EDI into standby
     84   54_WWMDS          - automatic himod start
     85   55_RSSRS          - scratch RAM reset
     86   56_SBXOS          - turn Bx stepping off
     87   57_PG2BS          - automatic configure PGA2
     88   58_PGALS          - automatic startup from Mode8
     89   59_BCM1S          - set and activate gun1 beam current clipping
     90   5A_BCM2S          - set and activate gun2 beam current clipping

#   209  D1_DMPSS          - dump science
#   210  D2_DMPHS          - dump housekeeping
```

reserved means that the telecommands are specified using the ZEEDATAM telecommand where the high byte is the opcode (e.g. 0f for PGA2 configuration) and the low byte is the option.

- TCs marked with # are available in ROBUST2
- TCs 08, 09, 15, 34-78, 81-87 are NOT available in PROM
- if one of the TCs identified as deleted are executed, the system will count them as both received and verified but no action will result. That is, these TCs are handled like the NOOP TC (01_NOOPD)
- the execution of TCs $53 and $57 takes about two minutes. The execution of TC $54 takes about one minute. If during this time other telecommands are sent, they will not be executed. They will be counted as "received but not as verified."

3.2.4 Telecommand Description

ID	opcode	mnemonic	wds	description
00	00	DATAM	1	WD1 for two and multi word telecommands.
01	01	NOOPD	1	No operation. LB0 - don't care.
02	02	LSOPM	2	Load Source Pointer (SP). Set souce pointer to 24 bit address specified in HB1-WD1 (high byte, low word)
03	03	LDEPM	2	Load Destination Pointer (DP). Set destination pointer to 24 bit address specified in HB1-WD1 (high byte, low word)
04	04	JDEPS	1	Jump to address stored in DP if checksum in LB0 matches address checksum. No jump if checksum fails.
05	05	LDBYS	1	Load Byte at DP. Write LB0 to DP address. DP is incremented by one byte.
06	06	LDWDS	1	Load LB0 # words beginning at DP address. DP is incremented by one word as each word following this command is entered. LB0 : 00 to FF (00=256 words)
07	07	LBYCM	2	Load Byte Count (BC). Set byte count to 24 bit value specified in HB1-WD1 (high byte, low word)
08	08	RBT2S	1	Jump to ROBUST2. LB0 don't care
09	09	FGSFS	1	Set despin/STAFF processing options (Upload Session 097) LB0 : n000 0000 n = 1 for pure despin 0 for despin + STAFF Note: STAFF requires a functioning a-to-d. EDI no longer has a functioning a-to-d on any satellite so this command is no longer meaningful.
10	0A	BKGDS	1	Set Background Task to routine at address in DP. LB0 is checksum of DP address. If checksum fails, background task is unchanged.
11	0B	IMSKS	1	Set Interrupt Mask to LB0 value.
12	0C	RGIFE	1	Configure PGAi. LB0: don't care.
13	0D	RGINE	1	Configure PGAs. LB0 : 01 - Configure PGA 1 02 - Configure PGA 2.
14	0E	GSAFE	1	Set GDUs to SAFE conditions. LB0: don't care.
15	0F	reserved	1	Configure PGA2. LB0 : 01 - for normal operation PGA 4013 with 32k Image 08 - **! only lab with TS !** PGA 3090 with 8k Image

16-19 deleted

ID	opcode	mnemonic	wds	description
20	14	HVONN	1	Enable High Voltage GUN1 and GUN2

LB0 :
```
                     _7 _6 _5 _4 _3 _2 _1 _0
                    |__|__|__|__|__|__|__|__|
                      |              |  |  |
         Unused ---|______________|  |  |
                                        |  |
              0/1  GUN2 HV off/on -|  |
                                           |
              0/1  GUN1 HV off/on  ---|
```

- Note: This TC acts upon both GDUs. HVONN 03 turns both HVs on; 01 or 02 will turn HV on one GDU, but turn it off on the other.

ID	opcode	mnemonic	wds	description
21	15	TOGLS	1	Toggle CMD 23 BIT 12 ("toggle bit") for GDU1 and/or GDU2.

LB0 :
```
                     _7__6__5__4__3__2__1__0
                    |__|__|__|__|__|__|__|__|
                     |               |  |  |
        Unused ----|_______________|  |  |
                                        |  |
              0 - GDU2 unchanged  ---|  |
              1 - GDU2 toggle.          |
                                           |
              0 - GDU1 unchanged  ------|
              1 - GDU1 toggle.
```

ID	opcode	mnemonic	wds	description
22	16	PASSE	1	Set low byte of password to LB0
23	17	MCP1S	1	Set Preamp Gain & MCP level on GDU1. LB0 : bits 0-3 MCP Level, bits 4-7 Gain; max. value 7 for both
24	18	MCP2S	1	Set Preamp Gain & MCP level on GDU2
25	19	GDCOS	1	Copy Xilinx program from EEPROM to RAM at DP address.

LB0:
```
                     _7__6__5__4__3__2__1__0
                    |__|__|__|__|__|__|__|__|
        Unused ----|_______________| |___|
                                          |
        00 - Set 1C001, PGA1          --|
        11 - Set 7C001, PGAi          --|
```

ID	opcode	mnemonic	wds	description
26	1A	LDWIS	1	Load one word at DP, then increment/decrement DP by LB0 bytes. LB0 is signed offset to DP (example: 80 is -128; ff is -1; 7f is 127).

ID	opcode	mnemonic	wds	description
27	1B	BDHKS	1	Select source for 16 word variable section in HK: memory/EVT, GDU select or default.

LB0:

```
                         _7__6__5__4__3__2__1__0
                        |__|__|__|__|__|__|__|__|
                         |___| |______|  |_____|
        ID: 00 Default --- |       |         |
            01 GDU1                |         |
            10 GDU2               HG        HK
            11 memory/EVT    GDU group   GDU channel
```

In Default Mode, HK data cycles through all GDU channels, two groups at a time, first for GDU1 and then for GDU2.

For ID = 11 (memory/EVT):

bit 0 = 0: 16 consecutive locations starting at SP
bit 0 = 1: SP location 16 times
bits 1,2,3,4 = 1: EVT
(GDU1,wd29; GDU1,wd30; GDU2,wd29; GDU2,wd30)
(only 1 of bits 1-4 may be set at a time)

Explicitly, the options for LB0 are:

00	Default
40 - 7F	GDU1 Channel 0 through 63
80 - BF	GDU2 Channel 0 through 63
C0	memory (16 consecutive locations starting at SP)
C1	memory (location defined by SP 16 times)
C2	EVT11 16 times
C4	EVT21 16 times
C8	EVT12 16 times
D0	EVT22 16 times

ID	opcode	mnemonic	wds	description
28	1C	SNHKS	1	Sensor sensor housekeeping MUX select.

LB0:

```
                          _7__6__5__4__3__2__1__0
                         |__|__|__|__|__|__|__|__|
                          |___|  |  |  |  |_____|
                Unused --|       |  |  |  |_____|
                                 |  |  |     |
        0/1-sensor1/2 ----|  |  |     |
                                    |  |   MUX value
        0/1-no step/step ----|  |
                                       |
        0/1-no update/update ---|
```

- NOTE: In step mode, HK data cycles through all 8 sensor MUX channels. In no step mode, sensor HK data for a particular sensor reflects the selected MUX channel. Unlike GDU channel selections, selecting a MUX channel for a sensor affects only that sensor's data words.

ID	opcode	mnemonic	wds	description
29	1D	GDMPS	1	Dump LB0 selected data to Scratch RAM beginning at the next TMR boundary.

LB0 : 00 to 0f selected GDU frame dumped;
10 dump GDU1 data (himodes only)
20 dump GDU2 data (himodes only)
40 dump 16 selected words
51 beam profile at detector1
52 beam profile at detector2
ff stop dump

ID	opcode	mnemonic	wds	description
30	1E	SUMOS	1	Change telemetry mode at next TMR. to be sent AFTER S/C TM switch LB0: 1, 2, 3, 5, 6, 7 = telemetry mode NM1-NM3,BM1-BM3); 0,4 = invalid SUMOS
31	1F	SIMOS	1	Change Science Mode at next TMR. LB0: new science mode. Before branching to new science mode location, the byte at DP minus 1 is tested to see if it matches LB0. If it does not match, no mode change takes place. Has no effect unless PGA1 configured
32	20	COPYS	1	Copy LB0 words from SP to DP. SP and DP are auto-incremented. LB0: 00 to FF (00=256 words)
33	21	CSUMS	1	Perform checksum on BC bytes beginning at SP, compare Sum to LB0 value.
34	22	COPLS	1	Copy LBYC words from SP to DP. SP and DP are auto-incremented. LB0 don't care.
35	23	CP2RS	1	Copy PGA program from EEPROM to RAM at destination $02C000 and null (set to $FF) locations $2E000 to $2FFFF. LB0: 01 --- PGAi 02 --- PGA1
64	40	PSW1E	1	Set password for GDU1. LB0: low byte of password.
65	41	PSW2E	1	Set password for GDU2. LB0: low byte of password.
66	42	RPGAF	1	Reset all PGAs. LB0 don’t care.
67	43	MST1S	1	For GDU1, step MCP to operating voltages. LB0: bits 7-4, pre-amp gain bits 3-0, HV Set pre-amp gain to bits 7-4, step HV from current level to bits 3-0 level, incrementing once per TMR, or if lower set lower immediately
68	44	MST2S	1	Same as for MST1, but for GDU2.
69	45	OPTSS	1	Set optics voltages to shutoff. CMDs 0, 7, 8, 9, 10, 11, 12, 13, 14, 15 set to $118,92,bb8,fc,477,4db,3f6,0,31e,bd3. LB0: bit0, GDU1; bit1 GDU2.
70	46	GUNSS	1	Set GUN voltages for 1 keV, CMDs 4, 6, 5, 1, 2 set (in this order) to $d48, tabulated, tab., $6a4, $6a4. LB0: bit0, GDU1; bit1, GDU2. If a gun is not working (variable gstroutN at address $eda6/7 set to 1 at poweron), then set CMDs 4,6,5,1,2 to 000.

ID	opcode	mnemonic	wds	description
71	47	SENSS	1	Set BA to 0, apf to $18, cpf to $FF, pwst=0 (disabled); EXE IMM on, routing (CMD 22) SOU2=0, SOU1=1. LB0: bit0, sensor1; bit1, sensor2.
72	48	CAT1S	1	Step cathode GUN1 to LB0*$10 in steps of $10 every 250 ms (ATI-4); if lower, set lower immediately. If gun is not working (variable gstrout1 at address $eda6 set to 1 at poweron), then set CMDs 3 to 000.
73	49	CAT2S	1	Step cathode GUN2 (variable is gstrout2 at $eda7).
74	4A	PCKMS	1	Set telemetry packing mode for 4ms BCI modes and set correlator code length. LB0: bits 2-0 : packing mode (no action in a 2ms BCI) bit 3 : one GDU telemetry: 0 = standard telemetry for two gun/detector pairs 1 = one gun is broken, send TM only for working pair bit 4 : STAFF selection: 0 = no STAFF, 1 = include STAFF bit 5 : 0 = ignore bit 4 1 = process bit 4 bit 6 : code length selection: 0 = short code, 1 = long code bit 7 : 0 = ignore bit 6 1 = process bit 6
75	4B	STBQS	1	Set M8STA to LB0. LB0 : 1 = Standby1. 2 = Standby2. 4= Quiescent
76	deleted			
77	4D	XCRSS	1	resets extended command queue pointer (for use with long commands, such as COPY, CP2R, COPL, CSUM). LB0 don’t care.
78	4E	RAMWS	1	Select a set of data words for PACM2 or debugging that may be used the next time TC GDMPS is sent. LB0: xx; where xx selects a particular address table

ID	opcode	mnemonic	wds	description

79	4F	TMCSS
		
		`ch4: LB0=$80`
		`ch3: LB0=$40`
		`ch2: LB0=$20`
		`ch1: LB0=$08`
		`ch0: LB0=$04`
			1	Set LDEP into selected TM channel
				LB0: abcdefxy
				where a selects channel 4
				b selects channel 3
				c selects channel 2
				d causes the Diagnostic FGM selection to change
				e selects channel 1
				f selects channel 0
				x if e bit is set : sets accumulation for channel 1
				y if b, c, f is set : sets compression for channel 3, 2, 0
				xy if d bit set : select Diagnostic FGM axis
				(0 = Z; 1 = Y; 2 = X; 3=five user selected words)

80	50	MMDPS	1	toggle memory dump option for dump of scratch RAM to telemetry in telemetry modes other than BM3 LB0 : don't care
81	51	INITS	1	set initialization table byte LB0 : initialization table number
82	52	SOBBS	1	set sob-byte LB0: sob-byte bit 7 : SW bit bit 6 : energy change bit 5 : nextn bit 4 : nzero bit 3 : autostart GDMP with himode bit 2 : GDMP words set, do not reset using RAMW parameter bit 1 : overflow. This bit is set to 1 in initialization for 4-sample WW and results in CMD19 = $xbxx (2-sample CMD19 = $xcxx). bit 0 : nextm
83	53	STBYS	1	LB0 = 0: set EDI into standby; this command takes about 2 minutes to execute the following sequence of telecommands internally.

```
Sci.Mode 8                  0:00   03   LDEPM   00
                                   00   DATAM   6006
                                   31   SIMOS   08
Sensor Setup                0:01   71   SENSS   03
Optics Shutdwn              0:02   69   OPTSS   03
MCP1 level1                 0:06   23   MCP1S   41
MCP2 level1                 0:07   24   MCP2S   41
Turn off Start-circuit      0:08   03   LDEPM   A0
and turn on Scratch RAM            00   DATAM   0000
                                   05   LDBYS   81
Gun HVs                     0:09   70   GUNSS   03
Beam 1                      0:14   72   CAT1S   A0
Beam 2                      0:15   73   CAT2S   A0
Set Standby 1               0:25   75   STBQS   01
Beam 1                      1:25   72   CAT1S   87
Beam 2                             73   CAT2S   87
Shut off beams                     03   LDEPM   80
                                   00   DATAM   0832
                                   06   LDWDS   03
                                   00   DATAM   0FFF
                                   00   DATAM   0000
                                   00   DATAM   0FFF
Set Standby 2               1:35   75   STBQS   02
```

```
Notes:
a. Standby 1 is created to allow reading of cathode current
   HK value at fixed reference ($A00)
b. Standby 2 is the true standby state where the beams are
   set to reference $870
c. The 1 min. wait after Standby 1 is to allow time for the
   HK subcommutation to reach the cathode currents.
d. At the end the beams are shut off by setting the Wehnelt
    negative even though the cathodes may still be powered.
```

LB0 = 1: set EDI into quiescent, but leave Scratch RAM on; this commands executes instantaneously. A delay of 1 second before sending the next TC should always be used, though.

84	54	WWMDS	1	restart EDI in WW after overlimit detection and a delay (nominally 5 minutes). Restarting WW begins in Mode8, quiescent with scratch RAM on. Takes about 2 minutes to execute the following sequence internally: LB0 don't care.

```
HV Password                   0:00   16    PASSE    xx
MCP warmup                    0:01   23    MCP1S    41
MCP warmup                    0:02   24    MCP2S    42
Sensor Setup                  0:03   71    SENSS    03
Optics Setup                  0:04   69    OPTSS    03
Gun HVs                       0:09   70    GUNSS    03
Beam 1                        0:19   72    CAT1S    nn
Beam 2                        0:20   73    CAT2S    mm
MCP 1                         0:30   67    MST1S    42
MCP 2                         0:31   68    MST2S    42
Packing mode (STAFF option) 0:46   74    PCKMS    30
init table                           51    reserved 2E
SOB byte                             52    reserved 00
science mode address                 03    LDEPM    02
science mode address                 00    DATAM    45e1
science mode                  0:51   31    SCIMO    05
telemetry mode                0:55   30    SUBMO    0x
packing mode                  0:61   74    PCKMO    8s
```

```
Notes:
This is effectively what happens when TC54 executes.  It is
not what really happens internally.  CAT1S and CAT2S send
the cathode which was set the last time these telecommands
were executed.  The telemetry submode is selected to match
the current state of the spacecraft (NMx or BM1).  The
packing mode is set to match the submode (5 if NM1, 1 if
BM1).
```

85	55	RSSRS	1	reset scratch RAM. LB0 don't care
86	56	SBXOS	1	Bx stepping off. LB0 don't care
87	57	PG2BS	1	Configures PGA2 using a single TC, for code after August 1999

ID	opcode	mnemonic	wds	description
88	58	PGALS	1	Automatic startup from Mode8, starting from no PGAs configured through PGA2B configured. Can be used in BM-TM for code after August 1999. (Option to override $B checksum error in Tracking Simulator operation).

```
SRAM on                    0:00
destptr                    0:01   03   LDEPM    02/C000
PGAi config copy           0:02   25   GDCOS    03
config PGAi                0:03   12   RGIFE
destptr                    0:08   03   LDEPM    02/C000
PGA1 config copy           0:09   25   GDCOS    01
config PGA1                0:10   13   RGINE    01
destptr                    0:20   03   LDEPM    02/C000
copy count                 0:21   07   LBYCM    7ffc
PGA2 config copy           0:22   34   COPLS
config PGA2                0:23   15   reserved
done                       0:43
```

ID	opcode	mnemonic	wds	description
89	59	BCM1S	1	set and activate gun1 beam current clipping value bit 7 of LB0 : 0=activate clipping, 1 = deactivate clipping bits 5-0 : specify clipping value (0 means deactivate clipping, even if bit 7 is zero)
90	5A	BCM2S	1	set and activate gun2 beam current clipping value LB0 : see BCM1S

TCs 53,54,57,58 are "automatic" TCs in that they cause an onboard task to run which automatically executes a series of TCs that would otherwise have to be sent one by one. The controlling bytes for the task are:

stbybyte	0,1,2	0=autotask not in operation, 1=start standby, 2 autotask in opeartion
stbycnt	0,N	0=autotask not in operation, N=autotask step counter
stbydlay	0,N	0=no delay between TCs, N=number of TMRs to delay between TCs
storsu	1,2,3,4	TC53 standby, TC38 autostart, TC54 himod, TC57 pga2

The following commands are valid only for ROBUST2

A Header is sent to recognize the dump data in the TM (8 words $D1D1 for TC DMPSS, 8 words $D2D2 for TC DMPHS). The start of the dump is not synchronized to TMR.

ID	opcode	mnemonic	wds	description
209	D1	DMPSS	1	Dump LB0 words beginning at DP (destination pointer) into the SCIENCE TM. Not synchronized to TMR.
210	D2	DMPHS	1	Dump LB0 words beginning at DP (destination pointer) into the HK TM stream. Not synchronized to TMR. Since there are 64 HK words allocated for EDI in telemetry but EDI uses only 45 of them and since the dump is not synchronized to TMR, the dumped words may be partially or completely (depending on the amount of the words dumped) located outside the 45 words, that is, in words 45-63.

3.3 Reflection of TCs on TM

The effects of the telecommands on the telemetry data are tabulated in Appendix A.

3.4 Internal Control and Commands

3.4.1 Brief Description

Communication between CONTROLLER and GDUs is via a serial interface implemented with 3 optical links (Command, Clock, Data). The clock rate is approximately 8 MHz.

Each CMD and DATA frame consists of 32 16-bit words. Frame duration is 244 micro-s. The bitrate is approximately 2 MHz.

Technically, the CMDs are set up in a special section of RAM ("GDU RAM"), and then are fetched by hardware implemented in PGAi where they are formatted for transmission to the GDUs. There the CMDs are received and processed by PGA1.

To send a CMD to a GDU, one writes to the appropriate GDU-RAM location.

For a listing of the GDU CMDs and DATA words, and their location in RAM, see Appendix C.

- CMDs 0 - 15 are "analog" CMDs, setting references for the GUN & OPTICS.
- CMD 16 is a frame counter, and CMDs 17 - 31 are digital CMDs.
- All CMDs except CMD 31 must have bit 15 high. This is done by hardware (PGAi).

For frame synch purposes, CMD 30 must have the last bit high (achieved by software), as well as the first bit (hardware); CMD 31 must have all bits low.

CMD 30 also serves as a PASSWORD (see below).

The CONTROLLER s/w sets new GDU CMDs no more often than once per "Basis Cycle" (BC), which is either 8 or 16 frames long, depending on the science mode (SCIMO in science tm, MODID in HK tm). To be able to increment CMDs more often, there is a hardware increment feature in PGAi. From increments written to the proper locations in GDU RAM, PGAi auto-increments the GDU CMDs every frame. This feature has no effect if increments are set to 0.

3.4.2 Initialization

Right after configuration of PGA1, a routine called GDUSETSF writes an initial set of CMDs to the GDU RAM. This set puts the GDUs into a safe operating mode, including setting the HVON bit to 0. GDUSETSF also causes an invalid Password to be sent. (The TC GSAFE runs GDUSETSF)

The CMDs are (in hex, and ignoring the "hardwired" bit 15):

CMDs 0 - 15 ("Analog" CMDs):
0, 0, 0, 0, 0, 0, 0, 0, 3E8, 7D0, 3E8, 7D0, 7D0, 3E8, 0, 0, 0;

CMDS 17 - 29 ("Digital" CMDs)
0, 0, 0, 0, D0E, 0, 640, 0, 00A, 0, 0, 0, 0

Note that the set of analog CMDs produced by GDUSETSF produces HVs which are safe even when a valid Password has been received by the GDE, also for the bi-polar OPTICS voltages (for which sending a 0 reference value would cause large negative voltages)

CMD 16 is a frame counter, generated by the Controller, and thus is not used.

For the digital CMDs, GDUSETSF is designed such that it does not depend on whether or not PGA2 is already configured. That requires that it leaves bit 8 in CMD 21 and bit 9 in CMD 22 unchanged:

CMD 21: Get current CMD 21
AND $0100
OR $0C0E
Replace CMD 21 with modified CMD 21

CMD 22: Get current CMD 22
AND $0200
Replace CMD 22 with modified CMD 22

Note that GDUSETSF turns the GDE start supply off (bit 11 in CMD21 = 1).

The choice of CMD22 has SOU2=SOU1=0, i.e. DATA29 connected to Sensor Corr.output, while DATA30 is NOT connected. Standard configuration (i.e., by the SENS TC) is SOU2=0, SOU1=1.

The Sensor CMDs set pointer fields apf, cpf both to 0, and enable power strobing, implying that amplifiers are NOT powered.

4. Environment

4.1 Thermal

Monitoring

- GUN temperatures monitored via S/C-powered thermistors
- Sensor & GDE temperatures monitored via instrument-powered thermistors.

Controller

No temperature monitoring

Heater

GUNs have external heaters to be used in long eclipses.

Operational constraints

- GUN temperature must be within operational range before EDI can be turned on.
- Operating range is -10/+40 C. (Preferred range is -10/+30C)

4.2 Power

Power consumption varies with following settings:

- Scratch-RAM ON/OFF
- FPGAs configured/not configured
- HVs ON/OFF
- Sensor amplifiers ON/OFF
- MCP Supply ON/OFF , level
- Cathode Heater Power ON/OFF, level
- Correlator Code-clock frequency setting

Power consumption will also vary with SENSOR count rates from ambient and/or beam electrons.
Below are listed power consumptions for the main operating modes:

Mode	Quiescent	Standby	Nominal	High Power
Power (W)	5.0	8.6	9.5 (Baseline (9.5)	9.9

4.3 Inter Experiment Links

- The magnetometer must be operational and transmitting data (41 bits per sample) for EDI to perform science functions. EDI does, however, operate safely without magnetometer data.
- During normal operation the PEACE BLANKING PULSE is set every time the beam possibly affects PEACE operation. During tests this pulse may be set by the controller by sending an appropriate CF-file.
- WHISPER PULSE is generated in the WHISPER experiment. During normal operation, the pulse is set whenever WHISPER puts a high voltage on its antenna. During tests WHISPER simulates this pulse.
- STAFF has an analog interface to EDI over which EDI receives the change in BX, BY and BZ.

4.4 Other Instruments

It is desirable that Potential Control Device (ASPOC) be operational when EDI is operated. This is because the EDI electron beams, when operated without Potential Control Device, might adversely affect the spacecraft potential.

5. Ground Operations

5.1 Approach

We have created separate Control Files (CFs) for each function or test-step, from which appropriate test sequences can be constructed. Many CFs contain only a few or even only a single command.

For unit-level AIV, using the S/C simulator or EGSE, control files are in a special format, identified by the .icf extension.

For S/C AIV, CFs have been converted to the ELISA format.

For flight ops, ESOC has converted the relevant ICF-files, identified to be needed, into their specific format.

5.2 Control Files in ICF Format

All ICF-Files are kept in MPECL4::DKA400:[CLUSTER.MODULES].

The function of each file is discribed in the comment section at the beginning of the file.

5.3 Control Files in ELISA Format

The following Master Control Files are applicable:

EESFT_INIMST	Initialization	unchanged from Cluster-I
EESFT_ISTMST	IST-internal master	unchanged from Cluster-I
EEIST_MASTER	In-air IST	unchanged from Cluster-I
EEIST_RFBMAS	In-Air IST, but no IEL	unchanged from Cluster-I (post-refurbishment)
EETVT_MASTER	T/V IST	modified for Cluster-II (reduced MCP setting)
EESFT_MASTER	In-Air NOMOP	unchanged from Cluster-I
EETVM_MASTER	T/V NOMOP	modified for Cluster-II (Gun & MCP not turned on)
EEAFT_MASTER	Abreviated Functional	modified for Cluster-II (Pulser test added)
EEIEL_MASTER	IEL Test	unchanged from Cluster-I

The following Master Control Files are no longer applicable:
EETVT_ISTMST
EESSPT_MASTER

The following CFs were modified or added for Cluster-II:

EESFT_FPGA2A	Configure PGA2	new addresses, new PGA2 TCs
EESFT_DSPFGM	Display FGM	FGM data moved from Science- to HK-TM
EESFT_FJM1	Jump Mode 1	beam current activation removed
EEMOD_POWROF	Power off	Mode0 and EEPROM off added
EESFT_HVVAC	Set HVs	changed to generic Gun-HV settings
EESFT_FBEAM	Turn on beams	reduced beam currents
EESFT_FM404	MCP set-up	reduced MCP level, 2 FBASTs deleted

5.4 Test Procedures

Procedures for unit-level AIV are described in a separate document, named EDI Acceptance Test Manual.

For S/C AIV, the following procedures are applicable:

EDI_IST_1_RFB..PROC	In-Air IST, Part 1
EDI_IST_2_RFB.PROC	In-Air IST, Part 2
EDI_IST_3.PROC	Vacuum-Functional (follows Parts 1 and 2)
EDI_NOMOP.PROC	IN-Air NOMOP/MST
EDI_IEL.PROC	IEL-Test
EDI_MST.PROC	Vacuum-NOMOP/MST

5.5 HV Operation in Air

In air,

- the MCP must not be turned on at any time;
- the cathode heater power must be restricted to small values so that the wire does not burn out.
- the GUN and OPTICS HVs must be kept at small enough values to avoid breakdown.

These restrictions are automatically obeyed by the hardware, if no valid PASSWORD is received by the GDE.

To avoid that a password can be sent to the GDE, the DISABLE CONNECTOR must be inserted at all times when operating in air.

The following is a standard setting for operation in air:

GDU-CMDs 0 - 15
64, 32, 32, 0, 64, 0, 0, 8C, 64, 8C, 64, 64, 8C, 64, 64, 64

GDU-CMDS 17 - 29
0, 0, 0, 0, D0E, 600, 14F, F00, FFA, 500, 0, 0, 0

In order to be able to check the integrity of the cathode in air, some small power can be applied. Current flow is established from the cathode current HK value (I_CSx, x=1,2).

5.6 HV Operation in Vacuum

For ambient pressures under 10^{-5} hPa, the MCP, the GUN, and the GUN and Optics voltages can be run up to normal operating levels.

For operations in vacuum, the Disable Connector must be removed to allow full HV operation.

A typical operation (T/V chamber) would set the GUN and OPTICS for 1keV, turn the MCP up slowly (a few minutes) to operating level, and optionally also generate a 1 keV electron beam at low beam current (a few nA).

6. EDI Commissioning

The Commissioning Plan & Procedures are dealt with in a separate document, except for the CPT that is provided in Appendix E for illustration.

7. Nominal Operations

7.1 Power Modes

OFF

- Configuration : EDI primary power off
- Application : Option for times when no science data are collected (for radiation damage reasons)
- Power : -

ECLIPSE

- Application : Long Eclipses
- Configuration : Primary Power off, external heater power on
- Power : Heater Power only

STANDBY & QUIESCENT

- Application : "Standby" - Normal mode for times when no data are being collected;
  "Quiescent" - Normal mode during software uploads

- Configuration :

	Standby	Quiescent
HV Cascades	on	off
Optics HVs	Shut-down	off
Gun HVs	1kev/0deg	off
Cath. power	$870	off
Beam Current	off	off
MCP Gain/HV	4/1	off
Sensor BA	00	00
Sensor Pointer Fields	$18/$ff	00
Preamps	on	off
PGAs configured	configured *	
Sci. Mode	8	8
Scratch RAM	off	off
EEPROMs	on	on

* Power-on, PGA1 not configured is not a safe state (GDU currents)

- Power : "Standby" - 8.8 W
  "Quiescent" - 5.0 W

NOMINAL MODE

- Application : Science Operations
- Configuration : Full operation in one of the various Science Modes (see below); some restriction on cathode power and code-clock frequency
- Power : 9.5 W (Baseline 9.5 W)

HIGH POWER

- Application : Commissioning and other special situations
- Configuration : As in NOMINAL, but no restrictions on power
- Power : 9.9 W

IN-FLIGHT PULSER TEST (Science Mode D)

- Application : Commissioning, periodic in-flight tests
- Configuration : as in QUIESCENT, but internal pulse generator running to test counters and amplifiers
- Power : As in Quiescent

IN-FLIGHT MCP GAIN TEST (Science Mode C)

- Application : Commissioning, periodic in-flight tests
- Configuration : as in NOMINAL but preamp gain and MCP HV level cycled to establish MCP gain
- Power : Nominal

7.2 Science Modes

7.2.1 Science Mode Designation

The following mode designations exist.

The addresses are the mode jump addresses which must be specified as destination pointer (ZEELDEPM xx, ZEEDATAM xxxx) prior to the science mode change telecommand (ZEESIMOS). EEPROM addresses are used on SC1 and SC3; RAM addresses are used on SC2.

```
          EEPROM    RAM
MODID     ADDRESS   ADDRESS   FUNCTION

mode0     0002F0         PROM manual mode
mode1     02455D    4c010     geos
mode2     024581    n/a       TV
mode5     0245E1    4c050     windshield wiper (WW)
mode8     006006    6d388     ["poweron" start address: not active]
mode8     006006    6D38E     Manual mode
modec     024681    4c030     in-flight MCP gain calibration
moded     0246A1    n/a       in-flight pulser test
mode11    024661    n/a       diagnostic FGM
mode13    0246E1         [UCSD ambient electrons & ions, obsolete]
mode4     0245C1         spare
mode15    024601    4c070     Ambient
modeb     024621    n/a       spare
modef     024641    n/a       spare
mode3     0245A1    n/a       spare
```

7.2.2 Science Modes & Telemetry Modes

The HK parameter MODID identifies the Science Mode ($0 through $1f; hi bit in MODID not used).
Manual operation is via the PROM based firmware (Mode 0) or its upgraded EEPROM equivalent (Mode 8).
The actual science operation is through "high" modes.
TM modes are selected via TC SUMOS xx, where x = 01, 05, 07 for NM1, BM1, BM3. The TM Mode EDI is running in is reported in the HK parameter SUBMO.
Some science modes can be run with any TM mode, others cannot.
For some TM modes EDI will have different TM formats (called Packing Modes), as indicated by the HK parameter PACMO, differing in what information is transmitted and at what sampling rate.

Valid Science Mode – Telemetry Mode – Packing Mode Combinations :

MODID	SUBMO.PACMO	SUBMO.PACMO	SUBMO.PACMO
0	1.0	5.0	7.0
8	1.0, [1.4 obsolete]	5.0	7.0
1	1.0, 1.2	5.0	7.0
2	1.0	5.0	7.0
5	1.0, 1.1, 1.5	5.0, 5.1	7.0
C,D	1.0	5.0	
11,13,15	1.0	5.0	7.0

7.2.3 Science Mode Descriptions

For EDI internal use there is a separate manual describing the science modes and their implementation in detail (EDI Himodes Description Manual).

GEOS Mode (Science Mode 1)
In GEOS mode, the beams are fired in a predefined scan-plane with arbitrary orientation. The firing direction within the scan-plane is calculated from the magnetometer data to be always perpendicular to the magnetic field. GEOS can also be run to gather diagnostic data using PACM2 telemetry.

TV Mode (Science Mode 2)
In TV mode, the algorithm uses predefined maximum and minimum analytical voltages and a variable step size to step through gun deflection voltage space. The mode can also step through sensor base addresses and optics look angles, but there is no automatic connection between the gun direction and sensor/optics directions as there is in other science modes.

Windshield-Wiper (WW) Mode (Science Mode 5)
This Science Mode performs beam angle and time tracking.

Diagnostic FGM Mode (Science Mode 11)
This mode executes GEOS code, but FGM data words are sent instead of the usual telemetry.

[UCSD Ambient Particle Modes (Science Mode 13) — obsolete]
These modes perform analysis of ambient electron and ion populations.

Ambient Particle Mode (Science Mode 15)
This mode gathers information about ambient electron populations.

In-flight Test Modes (Science Modes C and D)
There are two separate Science Modes for special in-flight tests (see below).

7.2.4 Hi-Mode Initialization

All non-manual modes (not Mode 0 or Mode 8) go through a common initialization routine. The initialization routine uses predefined initialization tables (see below) to prepare the controller and the hardware for the mode to be executed.

In general, parameter values in the initialization tables are used directly to set RAM variables. However, there are several values which serve as flags:

- In all modes operating as of October 2004:
  init table flag variable 1cmd17 values:
  N = reset CMD17,19 to init table values
  -1 = do not reset the RAM variable values
  -2 = reset RAM variables with SOB calculated values (not applicable to CSSTEP)

[Obsolete: In ambient modes :
Some ambient mode parameters are signed quantities; special processing on minus numbers does not apply to these parameters.
$ff (-1) is a valid setting for CPF. A value of 00 for CPF means do not reset the RAM variable for CPF.]

Other common initialization table parameters:

- dispatch table -- identifies addresses of interrupt service routines
- task byte -- identifies what tasks can be activated in this mode. The maximum number of tasks that EDI can identify is 32. As a practical matter, no more than 15 should be active in a mode. The following tasks are identified:
  - mode8 HSK and in NM1 science telemetry also
  - himodes HSK and in NM1 science telemetry also
  - checksum
  - current monitor
  - extended TC handler
  - cathode power stepping (steps $10 every 10ms)
  - SOB task
  - BVAR task
  - PACM2 science telemetry
  - telemetry headers and reset (TISC)
  - autotask for TCs $53, $54, $57, $58
- 2ms or 4ms BCI
- PERP vector components
- correlator selection and setup
- EVT reset delay
- optics state
- tm defaults

7.2.5 Initialization Table Number Assignments

INIT table numbers are commonly given in hex. The most frequently used INIT tables:

	1000eV	**500eV**	
4 sample	2a/5a	2c/5c	numbers left of the slash are despin / despin+STAFF tables
2 sample	2e/5e	30	numbers right of the slash are extrapolation tables

The original $40 INIT tables were duplicated, split into various groups and reassigned when B processing changed from STAFF only to extrapolation and despin (with and without STAFF). The groupings and assignments are:

EDI despin	00-3f	original
EDI extpol	40-59	copies of the original 00-19 +$40
EDI extpol	5a-63	copies of the original 2a-33 +$30
UCSD Ambient despin	75-88	copies of the original 15-28
UCSD Ambient extpol	a5-b8	copies of 75-88 +$30

Experience showed that despin is better than extrapolation. STAFF is no longer available because the a-to-d's are no longer working. Therefore as a practical matter, in 2004 and beyond only the Despin column tables are used.

Despin	Extrapolation	Description	Notes
0	40	GEOS, Ambient, no beam	
1,2	41,42	GEOS, Ambient	
3	43	ModeC, ModeD	
4	44	GEOS, Ambient	
5	45	Mode11	
6	46	GEOS, Ambient	
7,8	47,48	Test	7 is mode11, 8 is WW
9	49	Mode11	STAFF gains = 000
A	4A	Test	[UCSD Ambient, obsolete]
B-14	4B-54	Diagnostic GEOS	
15-28	55-58	Unused	
29	59	WW	Test
2A,2B	5A,5B	WW	4-sample, 1keV
2C,2D	5C,5D	WW	4-sample, 500eV
2E,2F	5E,5F	WW	2-sample, 1keV
30,31	60,61	WW	2-sample, 500eV
32,33	62,63	WW	Bx step, otherwise like 2A,2E
34-39		WW	Unused
3A-3C		Interference campaign	
3D		Service mode	
3E		Interference campaign	
3F		Service mode	
75	A5	[UCSD Ambient, obsolete]	Parallel ion
76	A6	[UCSD Ambient, obsolete]	PASIF
77	A7	[UCSD Ambient, obsolete]	Perpendicular ion
78-7F	A8-AF	[UCSD Ambient, obsolete]	Parallel ion
80-81	B0-B1	[UCSD Ambient, obsolete]	Perpendicular ion
82-85	B2-B5	[UCSD Ambient, obsolete]	PASIF
86-88	B6-B8	[UCSD Ambient, obsolete]	Parallel ion

7.3 In-flight Tests

Two types of in-flight tests are foreseen: a test of the amplifier-to-counter chain, using the built-in test pulser; and a determination of the MCP gain, using a programmed sequence of amplifier gain steps and MCP voltage levels.

7.3.1 Test Pulser Function

The GDE contains two test pulsers which can be used to stimulate the electronics in a number of different ways. Routing of the pulses can be either into the SENSOR anodes, or directly into the Accumulators in PGA1, and potentially into the Correlator channels in PGA2. The pulses can be either equidistant or pseudonoise (PN) coded. Frequency is selectable. Fig.1 illustrates the pulser functions.

The two pulsers can be used to simulate signal and background. They are thus referred to as Signal and Background Pulsers, respectively. The signal pulser is modulated with the PN code and thus its rates are reduced to 50%.

Many options exist for the operation of the pulsers. They are set by these bits in GDU commands 22, 23, 17:

```
GDU CMD 22: bit  6 : FON (1 = Pulser Powered),
            bit 13 : TON (1 = Routed to Sensor)
            bit 12 : TPN (1 = PN coded)
GDU CMD 23: bit  4 : ENA (1 = Sensor Pulser enabled)
GDU CMD 17: bit  5 : NOC (1 = No Code)
```

Routing of the Sensor output channels (called ACCUmulator and CORRelator) to the GDE counters ACCU1 and ACCU2 which are transmitted in GDU Data Channels 29 and 30, respectively, is controled by the SWAP bit in GDU CMD 23 (bit 5) and the SOU bits in CMD 22 (bits 11,10).

SWAP	SOU2	SOU1	DATA29	DATA30
0	0	0	CORR	-
0	0	1	ACCU	CORR
0	1	0	CORR	ACCU
0	1	1	ACCU	PULSER DIRECTLY
1	0	0	ACCU	-
1	0	1	CORR	ACCU
1	1	0	ACCU	CORR
1	1	1	CORR	PULSER DIRECTLY

For SOU2=SOU1=1, test pulses appear directly in DATA30.

Note that the HK routine in Mode8 counts DATA29 & DATA30 for 30 ms, referred to as EVT1x and EVT2x, respectively (x=GDU number, 1 or 2).

Standard configurations for GDE testing:

```
CMD 22: 0E40 (directly into DATA30, not coded), 1E40 (PN coded)
CMD 17: 0020 (NOC=1)
```

Standard configurations for SENSOR testing:

SOU=01, Sensor Pulser enabled, Pointer Fields either FF (all amplifiers tied together) or 01 (single preamp, in parentheses):

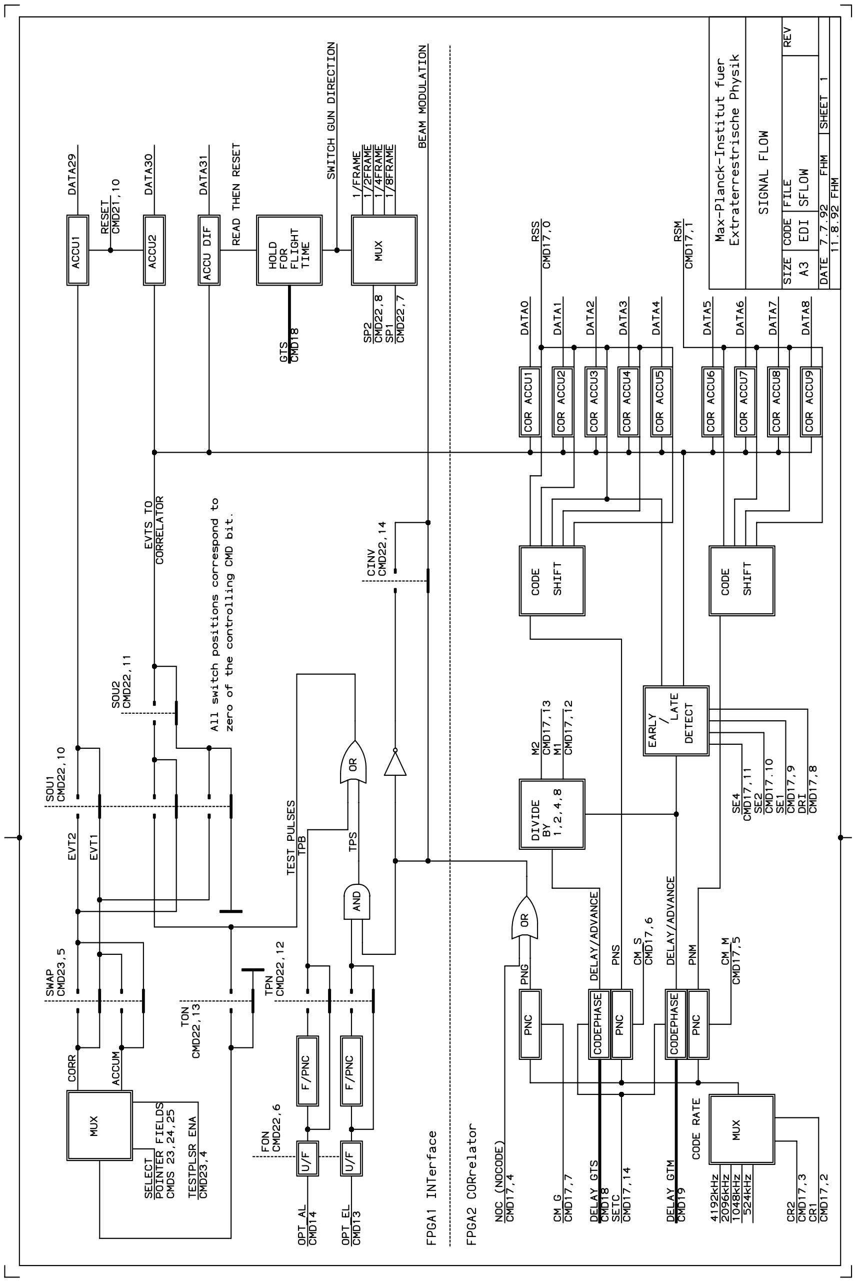
```
CMD22: 2640
CMD23: 065F (0651)
CMD24: 0F00 (0100)
CMD25: 0FFA (001A)

To turn the pulser off:
CMD22: 0200
```

Frequency Selection

CMD13 selects the Signal Pulser frequency, CMD14 the Background Pulser frequency.

Normally, when the pulser is off, CMDs 13 and 14 determine the OPTICS voltages OPT_EL and OPT_AL, respectively. If no PASSWORD has been received (i.e., for operation in air), only the lower 8 bits of CMDs 13 and 14 are being used. This way the maximum frequency of the pulsers is reduced to about 12 kHz when operating in air. In vacuum, the maximum frequency is 8 times as large.



7.3.2 Test Pulser Operation

For ground testing and commissioning, two Control Files, FGDPLS and FSNPLS, are used within EDI CPTs (Commissioning Step 1) for GDE and Sensor testing, respectively.
During routine in-orbit operations, a pulser test will be run as a special Science Mode (Mode D). It will collect count rates induced by the pulser in each (of 8) preamps and also when input directly into the accumulators. Test duration is ca. 90s. Note that the CMDs refer to the internal commands to the GDUs. In steps 1 and 2, the test pulses are routed directly to the accumulators. In steps 3-14, they are routed through the Sensor. Steps 3-10 exercise single sensor preamps, steps 11-14 test the swapping options of the event pulse routing. After completion of all steps, the GDUs are commanded into a safe state (GSAFE). The data for each step are recorded in the second header of the science telemetry (see section 2.3.2).

The following table lists in detail the CMD settings for each step.
Abbreviations: apf = accumulator pointer field, cpf = correlator pointer field

Steps	CMDs	Description	Counts in TM second header
1	CMD22=0e40 CMD14=01ff	test pulser power on; pulses are routed directly into accumulators; background pulser reference to 01ff	DATA29 not counting DATA30 counting
2	CMD13=01fe	signal pulser reference to 01fe	as in step 1, but higher
3	GSAFE CMD26=0500 CMD22=2640 CMD14=01ff CMD25=0012 CMD24=0100 CMD23=0650	reinitialize for sensor test set sensor preamp gain to 5 test pulser power on; pulses are routed to the sensor background pulser reference to 01ff cpf to 01; power strobing off apf to 01; (preamp E0) test pulser enable in sensor	both DATA29 and 30 counting
4	CMD25=0022 CMD24=0200	cpf and apf to 02 (preamp E1)	as in step 3
5	CMD25=0042 CMD24=0400	cpf and apf to 04 (preamp E2)	as in step 3
6	CMD25=0082 CMD24=0800	cpf and apf to 08 (preamp E3)	as in step 3
7	CMD25=0102 CMD24=0000 CMD23=0651	cpf and apf to 10 (preamp E4)	as in step 3
8	CMD25=0202 CMD23=0652	cpf and apf to 20 (preamp E5)	as in step 3
9	CMD25=0402 CMD23=0654	cpf and apf to 40 (preamp E6)	as in step 3
10	CMD25=0802 CMD23=0658	cpf and apf to 80 (preamp E7)	as in step 3
11	CMD25=0ff2 CMD23=0650	cpf to ff apf to 00	DATA29 not counting DATA30 counting
12	CMD23=0670	swap event channel routing in sensor	DATA29 counting DATA30 not counting
13	CMD22=2a40	swap event channel routing in GDE	DATA29 not counting DATA30 counting
14	CMD23=065f CMD24=0f00 CMD22=2a00	apf to ff test pulser power off	DATA29 not counting DATA30 not counting

7.3.3 MCP Gain Test

Another special science mode (Mode C) will run through a sequence of amplifier gains and MCP voltage settings. The resulting countrates will be collected in synchronism with the stepping and transmitted in HK TM. Test duration ca. 200 s. It is assumed that the Sensor has been properly configured by the SENS TC. The data for each step are recorded in the second header of the science telemetry (see section 2.3.2).

The test will step through the following states. N is the current operational setting for the respective parameter.

S/C Spin	MCP HV Step	Gain Step	Comment
1	N	N	BASELINE
2	N	N+2	
3	N	N+1	
4	N	N-1	
5	N	N-2	
6	N	N-3	
7	N	N-4	
8	N	N	BASELINE
9	N+1	N	
10	N+1	N+2	
11	N+1	N+1	
12	N+1	N-1	
13	N+1	N-2	
14	N+1	N-3	
15	N+1	N-4	
16	N	N	BASELINE
17	N-2	N	
18	N-2	N+2	
19	N-2	N+1	
20	N-2	N-1	
21	N-2	N-2	
22	N-2	N-3	
23	N-2	N-4	
24	N	N	BASELINE
25	N-1	N	
26	N-1	N+2	
27	N-1	N+1	
28	N-1	N-1	
29	N-1	N-2	
30	N-1	N-3	
31	N-1	N-4	
32	N	N	BASELINE

7.4 Command Sequence Building Blocks

Below we list the command blocks from which all routine EDI operations.

NOTES:

- The 4 columns shown give the
  - function
  - time(in min:sec, relative to the preceding command in the block);
  - the TC number (decimal)
  - Command mnemonic and parameter (hex notation), respectively, of the commands listed.
- When command parameters are fixed but not yet defined, this is indicated by TBD.
- If a parameter will not be fixed until the time the command sequence is set up for the next planning period,
  this is indicated by xx or yy.
- To make building blocks context insensitive, NOOP (no-operation) commands have been added at the end
  of blocks when necessary. The NOOP command has been timed such that the action initiated by the previous command has enough time to execute.

7.4.1 Building Blocks for Nominal Operations

These command sequence building blocks are available at ESOC as both, time tagged and real time versions.

#10 - EDI-ON (4 EDI TCs)

```
FUNCTION                               TIME   TC#   MNEM      PARAM
Power-on                               0:00   (S/C Function)
Wake-up                                0:15   01    NOOPD     00
Turn off Start-circuit                 0:00   03    LDEPM     A0
and turn on Scratch RAM                       00    DATAM     0000
                                              05    LDBYS     81
```

Note: Upon completion of the automated power-up self-tests, the Controller turns on the EEPROMs and jumps to Mode8 if a 4-byte checksum at the beginning of the $4000 EEPROM is correct. The correct checksum has been implemented in a software upload in October 1997.

#20 - PGA (22 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Configure PGAi	0:00	03	LDEPM	02
		00	DATAM	c000
		25	GDCOS	03
	0:02	12	RGIFE	00
Configure PGA1	0:02	03	LDEPM	02
		00	DATAM	c000
		25	GDCOS	00
	0:02	13	RGINE	01
Configure PGA2	0:02	03	LDEPM	00
		00	DATAM	D31C
		06	LDWDS	02
		00	DATAM	C000
		00	DATAM	0002
		02	LSOPM	0c
		00	DATAM	4004
		03	LDEPM	02
		00	DATAM	C000
		07	LBYCM	00
		00	DATAM	7FFC
		34	COPLS	00
	0:02	00	DATAM	0F01
	0:10	01	NOOPD	00

#30 - HV (6 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Password (both GDUs)	0:00	22	PASSE	AF
Sensor Setup & Routing	0:00	71	SENSS	03
Optics Shutdwn	0:00	69	OPTSS	03
MCP1 level1	0:00	23	MCP1S	41
MCP2 level1		24	MCP2S	41
No-Op	0:32	01	NOOPD	00

Note: The 32s wait is to allow warm-up of the MCPs in level 1

#40 - GUN (4 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Gun HVs	0:00	70	GUNSS	03
Beam 1	0:02	72	CAT1S	xx (default $A0)
Beam 2		73	CAT2S	yy (default $A0)
No-Op	1:04	01	NOOPD	00

Note: The 1:04 minute wait is to allow stepping of the Guns cathode power

#41 – GUN-HV (1 EDI TC)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Gun HVs	0:00	70	GUNSS	xx (default $03)

#42 – CAT1 (2 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Beam 1	0:00	72	CAT1S	xx (default $A0)
	1:04	01	NOOPD	00

#43 – CAT2 (2 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Beam 2	0:00	73	CAT2S	xx (default $A0)
	1:04	01	NOOPD	00

#50 - MCP (3 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
MCP1 ops level	0:00	67	MST1	xx (default $41)
MCP2 ops level	0:00	68	MST2	yy (default $41)
No-Op	0:40	01	NOOPD	00

Note: The 40 s wait is to allow stepping of the MCP High-voltage; Stepping is every TMR and there are up to 6 steps.

#60 - MODE (6 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Init Table #	0:00	81	INITS	xx	(default 0)
Packing Mode		74	PCKMS	xx	(default 0)
Sci.Mode		03	LDEPM	02	
		00	DATAM	xxxx	(default 0)
		31	SIMOS	XX	(default 0)
Packing Mode	0:08	74	PCKMS	xx	(default 0)

Notes:
- a. The parameter of INITS specifies the Init Table to be used. INITS determines whether BCI in the new mode will update B with despin or extrapolation.
- b. The first PCKMS specifies whether BCIs in the new mode will update B with pure despin or despin+STAFF.
- c. SIMOS specifies the Science Mode #, the DATAM before it the two lower bytes of the jump address of the code;
- d. The second PCKMS specifies the packing mode and, optionally, the correlator code length.

#61 - MODE-SOB (7 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
SOB-byte	0:00	82	SOBBS	xx	(default 0)
Init Table #		81	INITS	xx	(default 0)
Packing Mode		74	PCKMS	xx	(default 0)
Sci.Mode		03	LDEPM	02	
		00	DATAM	xxxx	(default 0)
		31	SIMOS	xx	(default 0)
Packing Mode	0:08	74	PCKMS	xx	(default 0)

Notes:
- a. SOBBS specifies the SOB-byte; other notes see sequence #60

#62 - MODE-GEN (7 EDI TCs, **SC2 only**)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
SOB-byte	0:00	82	SOBBS	xx	(default 0)
Init Table #		81	INITS	xx	(default 0)
Packing Mode		74	PCKMS	xx	(default 0)
Sci.Mode		03	LDEPM	xx	(default 0)
		00	DATAM	xxxx	(default 0)
		31	SIMOS	xx	(default 0)
Packing Mode	0:08	74	PCKMS	xx	(default 0)

#71 - MODE8 (4 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Sci.Mode	0:00	03	LDEPM	00
		00	DATAM	6006
		31	SIMOS	08
	0:08	01	NOOPD	00

#72 - MODE8-INIT (4 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Sci.Mode	0:00	03	LDEPM	00
		00	DATAM	6000
		04	JDEPS	60
	0:02	01	NOOPD	00

#73 – MODE-8-RAM (4 EDI TCs, **SC2 only**)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Sci.Mode	0:00	03	LDEPM	06	
		00	DATAM	D38E	
		31	SIMOS	08	
	0:08	01	NOOPD	00	

#81 - VAR-1 (3 EDI TCs)

VAR-1 will write a single byte:

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Addr, 1st word	0:00	03	LDEPM	xx	(default 0)
		00	DATAM	xxxx	(default 0)
Data byte		05	LDBYS	xx	(default 0)

#82 - VAR-2 (4 EDI TCs)

VAR-2 will write a single word:

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Addr, 1st word	0:00	03	LDEPM	xx	(default 0)
		00	DATAM	xxxx	(default 0)
number of words to load		06	LDWDS	01	
data word		00	DATAM	xxxx	(default $0100)

#83 - VAR-3 (10 EDI TCs)

VAR-3 will set up to 7 adjacent words:

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Addr, 1st word	0:00	03	LDEPM	xx	(default 0)
		00	DATAM	xxxx	(default 0)
		06	LDWDS	xx	(default $01)
Word 1		00	DATAM	xxxx	(default $0100)
Word 2		00	DATAM	xxxx	(default $0100)
Word 3		00	DATAM	xxxx	(default $0100)
Word 4		00	DATAM	xxxx	(default $0100)
Word 5		00	DATAM	xxxx	(default $0100)
Word 6		00	DATAM	xxxx	(default $0100)
Word 7		00	DATAM	xxxx	(default $0100)

Note: If fewer than 7 words are to be set, the extra DATAM's ($0100) will be recognized as NOOPD's by the Controller.

#84 - VAR-4 (6 EDI TCs)

VAR-4 will set up 3 adjacent words:

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Addr, 1st word	0:00	03	LDEPM	xx	(default 0)
		00	DATAM	xxxx	(default 0)
		06	LDWDS	03	
Word 1		00	DATAM	xxxx	(default $0100)
Word 2		00	DATAM	xxxx	(default $0100)
Word 3		00	DATAM	xxxx	(default $0100)

#90 - EDI-OFF (8 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
HVs off	0:00	14	GSAFE	00
Jump to Mode0	0:06	03	LDEPM	00
	0:00	00	DATAM	02F0
	0:00	04	JDEPS	F2
Turn EEPROM power of	0:11	03	LDEPM	01
	0:00	00	DATAM	4001
	0:00	05	LDBYS	0
EDI Power Off	0:10	S/C Function		

#100 - STANDBY (1 EDI TC)

This sequence is now executed with a single telecommand :

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Go to standby	0:00	83	STBYS	00
	2:00	01	NOOPD	00

#110 - QUIESCENT (8 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Sci.Mode 8	0:00	03	LDEPM	00
		00	DATAM	6006
		31	SIMOS	08
HVs & Beams off	0:08	14	GSAFE	00
Turn off Start-circuit		03	LDEPM	A0
& Scratch RAM		00	DATAM	0000
		05	LDBYS	80
Set Quiescent Status		75	STBQS	04

#111 - QUIESCENT-2 (2 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Quiescent, Scratch RAM on	0:00	83	STBYS	01
	0:01	01	NOOPD	00

#120 - PGA-RESET (1 EDI TC)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Reset PGAs	0:00	66	RPGAF	00

Note: This single-command block is only used for start-up from Quiescent state

#130 - PULSER (6 EDI TCs ; explicit sequence #60)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Init Table #	0:00	81	INITS	03
Packing Mode		74	PCKMS	00
Sci.Mode D		03	LDEPM	02
		00	DATAM	46A1
		31	SIMOS	0D
No-Op	2:00	01	NOOPD	00

Notes:
a. This block starts an in-flight test using a test pulser
b. The 2 min. wait accounts for the length of the pulser operation; the code automatically returns to Sci.Mode 8 at the end

#140 - MCP-GAIN (6 EDI TCs ; explicit sequence #60)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Init Table #	0:00	81	INITS	03
Packing Mode		74	PCKMS	00
Sci.Mode C		03	LDEPM	02
		00	DATAM	4681
		31	SIMOS	0C
No-Op	3:20	01	NOOPD	00

Notes:
a. This block starts an in-flight test of the MCP gain
b. The 3 min. 20 sec. wait accounts for the length of the Gain & MCP stepping: the code automatically returns to Sci.Mode 8 at the end

#141 - MCP-GAIN-RAM (6 EDI TCs ; explicit sequence #60, **SC2 only**)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Init Table #	0:00	81	INITS	03
Packing Mode		74	PCKMS	00
Sci.Mode C		03	LDEPM	04
		00	DATAM	C031
		31	SIMOS	0C
No-Op	3:20	01	NOOPD	00

#150 - EDI-DMP (1 EDI TC)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Start dump	0:00	29	GDMPS	xx	(default $40)

Notes:
a. GDMPS 40 dumps 16 words defined in a ram words table (which can be activated with TC ZEERAMWS)
b. GDMPS 51 (52) dumps beam profile data for detector1 (detector2).

#151 - EDI-DMP-OFF (1 EDI TC)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Stop dump	0:00	29	GDMPS	FF

#160 - TM-CHAN (3 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Select channel address	0:00	03	LDEPM	xx	(default 0)
		00	DATAM	xxxx	(default 0)
Select TM channel		79	TMCSS	xx	(default 0)

Notes:
a. LDEPM/DATAM selects the address of the word to be displayed in packing mode 0 telemetry
b. TMCSS selects the telemetry channel, and the compression/accumulation option, where appropriate
c. for Diagnostic FGM, set LDEPM/DATAM to 00/0000, parameter for TMCSS: $10 (Bz), $11 (By), $12 (Bx)

#170 - SRON (3 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Turn off start circuit	0:00	03	LDEPM	A0
and turn on scratch RAM		00	DATAM	0000
		05	LDBYS	81

#171 - SROF (3 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Turn off start circuit	0:00	03	LDEPM	A0
and turn off scratch RAM		00	DATAM	0000
		05	LDBYS	80

#180 - TC 54 (1 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
automatic WW	0:00	84	WWMDS	00
	1:00	01	NOOPD	00

Automatic REstart after an overlimit has been detected. The REstart assumes that values exist for MCP state and beam current and it sets these values. See also the description of TC $54 in section 3.2.4

Notes:
a. Puts EDI in WW mode, INIT table 2E, despin+STAFF, short code, MCP and beam current settings are restored from the parameters of previously executed TCs $48/$49 (CATxS) and
$43/$44 (MSTxS)
b. Assumes that EDI is in mode 8 and the PGAs are configured (QUIESCENT or STANDBY); does not turn Scratch-RAM

#190 - TC 58 (1 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
automatic startup	0:00	88	PGALS	00
	1:00	01	NOOPD	00

#200 – Set Max B_C (4 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Set gun1 beam current clipping	0:00	89	BCM1S	xx	(default $80)
		90	BCM2S	xx	(default $80)

#210 – LIMLO_HI (10 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Set address	0:00	03	LDEPM	00	
		00	DATAM	DDD4	
Set number of words to load		06	LDWDS	04	
LimLo 1keV		00	DATAM	xxxx	(default $0082)
LimHi 1keV		00	DATAM	xxxx	(default $00D7)
LimLo 500eV		00	DATAM	xxxx	(default $0082)
LimHi 500eV		00	DATAM	xxxx	(default $00D7)
~~Set address~~		~~03~~	~~LDEPM~~	~~00~~	
		~~00~~	~~DATAM~~	~~D25A~~	
~~activate manual LimLo/LimHi~~		~~05~~	~~LDBYS~~	~~01~~	

#220 – AUTO_LIMS (3 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Set address	0:00	03	LDEPM	00	
		00	DATAM	D25A	
deactivate manual LimLo/LimHi		05	LDBYS	xx	(default 00)

#230 – B_x Stepping Off (1 EDI TC)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Turn off Bx stepping	0:00	86	SBXOS	00

#240 – Bx Offset (6 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Turn off FGM interrupt	0:00	11	IMSKS	9F	
Set address	0:01	03	LDEPM	00	
		00	DATAM	D282	
Set number of words to load		06	LDWDS	01	
Set Bx offset		00	DATAM	xxxx	(default $0800)
Turn FGM interrupt back on		11	IMSKS	BF	

#250 – RAM Words Table (1 EDI TC)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*	
Specify RAM Words Table	0:00	78	RAMWS	xx	(default 0)

#280 – Pointer Reset (1 EDI TC)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Reset Scratch RAM pointers	0:00	85	RSSRS	00

#290 – MEMDMP (1 EDI TC)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Toggle memory dump option	0:00	80	MMDPS	00

#500 – M2 - STINT (31 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Set address	0:00	03	LDEPM	00
		00	DATAM	D720
Set number of words to load		06	LDWDS	04
gun1 vax start value		00	DATAM	xxxx (default 0)
gun1 vay start value		00	DATAM	xxxx (default 0)
gun2 vax start value		00	DATAM	xxxx (default 0)
gun2 vay start value		00	DATAM	xxxx (default 0)
Set address		03	LDEPM	00
		00	DATAM	D8E4
Set number of words to load		06	LDWDS	04
start gun1 command 5		00	DATAM	xxxx (default 0)
start gun1 command 6		00	DATAM	xxxx (default 0)
start gun2 command 5		00	DATAM	xxxx (default 0)
start gun2 command 6		00	DATAM	xxxx (default 0)
Set address		03	LDEPM	00
		00	DATAM	D83C
Set number of words to load		06	LDWDS	04
gun1 vax stop value		00	DATAM	xxxx (default 0)
gun1 vay stop value		00	DATAM	xxxx (default 0)
gun2 vax stop value		00	DATAM	xxxx (default 0)
gun2 vay stop value		00	DATAM	xxxx (default 0)
Set address		03	LDEPM	00
		00	DATAM	D6E4
Set number of words to load		06	LDWDS	02
gun1 vax increment		00	DATAM	xxxx (default 0)
gun1 vay increment		00	DATAM	xxxx (default 0)
Set address		03	LDEPM	00
		00	DATAM	D848
Set number of words to load		06	LDWDS	02
gun2 vax increment		00	DATAM	xxxx (default 0)
gun2 vay increment		00	DATAM	xxxx (default 0)

#501 – M2 - FLGS (7 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Set address	0:00	03	LDEPM	00
		00	DATAM	D6D7
loop flag		05	LDBYS	xx (default 0)
Set address		03	LDEPM	00
		00	DATAM	D6D8
Set number of words to load		06	LDWDS	01
Set BCI delay		00	DATAM	xxxx (default 0)

Note: possible values for the loop flag are:

- 00 = stop execution of loop
- 01 = execute loop
- 02 = initialize and execute loop

#502 – M2 - OFF (3 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Set address	0:00	03	LDEPM	00
		00	DATAM	D6D7
stop loop		05	LDBYS	00

7.4.2 Building Blocks for Contingency Operations

These Command Sequence Building Blocks are not available as time tagged command sequences.

#300 – NOOPS (256 EDI TCs)

```
FUNCTION                             TIME   TC#   MNEM      PARAM
Clear internal command queue         0:00   01    NOOPD     00  \
                                            ..    ...       ..   |   256
                                            ..    ...       ..    >  NOOPD's
                                            ..    ...       ..   |   total
                                            01    NOOPD     00  /
```

#310 – STBQ (1 EDI TC)

```
FUNCTION                             TIME   TC#   MNEM      PARAM
Set mode8 status                     0:00   75    STBQS     xx (default 0)
```

#320 – VASEC (3 EDI TCs)

```
FUNCTION                             TIME   TC#   MNEM      PARAM
Set HK variable section              0:00   02    LSOPM     xx    (default 0)
                                            00    DATAM     xxxx  (default 0)
                                            27    BDHKS     xx    (default 0)
```

#330 – LOCKIF (3 EDI TCs)

```
FUNCTION                             TIME   TC#   MNEM      PARAM
Lock telemetry interface in Robust2  0:00   01    NOOPD     00
                                     0:15   01    NOOPD     00
                                     0:15   01    NOOPD     00
```

#340 – CKSMS (4 EDI TCs)

```
FUNCTION                             TIME   TC#   MNEM      PARAM
Perform checksum verification        0:00   03    LDEPM     00
                                            00    DATAM     4030
                                            04    JDEPS     70
                                     0:01   01    NOOPD     00
```

#341 – CKSMS-341 (4 EDI TCs)

```
FUNCTION                             TIME   TC#   MNEM      PARAM
Perform checksum verification        0:00   03    LDEPM     00
                                            00    DATAM     01A6
                                            04    JDEPS     A7
                                     0:01   01    NOOPD     00
```

This Sequence calls PROM code to verify the checksums of the EEPROMs 04/08/24/28 Once these EEPROMs are checked the code jumps to address $4030 and checksums the remaining EEPROMs.

#350 – EE-POWER (4 EDI TCs)

```
FUNCTION                             TIME   TC#   MNEM      PARAM
Turn on EEPROM power                 0:00   03    LDEPM     01
                                            00    DATAM     4001
                                            05    LDBYS     01
                                     0:01   01    NOOPD     00
```

#351 – EE-POWER-OFF (4 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Turn off EEPROM power	0:00	03	LDEPM	01
		00	DATAM	4001
		05	LDBYS	00
	0:01	01	NOOPD	00

#360 – RAMTST (17 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
setup HK variable section	0:00	02	LSOPM	00
		00	DATAM	D710
		27	BDHKS	C0
set memory area		03	LDEPM	00
		00	DATAM	D700
		06	LDWDS	04
		00	DATAM	xxxx (default $C000)
		00	DATAM	xxxx (default $0002)
		00	DATAM	xxxx (default $FFFF)
		00	DATAM	xxxx (default $0003)
Initiate data test		03	LDEPM	08
		00	DATAM	4000
		10	BKGDS	48
Initiate address test	0:35	03	LDEPM	08
		00	DATAM	4095
		10	BKGDS	DD
	0:20	01	NOOPD	00

#370 – JM0 (4 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Jump to mode 0	0:00	03	LDEPM	00
		00	DATAM	02F0
		04	JDEPS	F2
	0:02	01	NOOPD	00

#380 – COPY (8 EDI TCs)

FUNCTION	*TIME*	*TC#*	*MNEM*	*PARAM*
Copy memory area	0:00	02	LSOPM	xx (default 0)
		00	DATAM	xxxx (default 0)
		03	LDEPM	xx (default $B0)
		00	DATAM	xxxx (default $0100)
		07	LBYCM	00
		00	DATAM	xxxx (default $4000)
		34	COPLS	00
	0:10	01	NOOPD	00

7.4.3 Building Blocks frequently used in routine operations

#81 - VAR-1 **X'00',X'D766',X'04'**

Set the number of automatic restarts (rehimod) to 4. This variable has meaning only if the analog to digital converter is working.

#83 - VAR-3

```
X'00',X'ED60',X'06',X'0101',X'0001',X'0007',X'4000',X'0040',X'0100'
                       b a     d c     f e     h g     j i      k
```

Initialize Ambient operating parameters:
a: must be 1 for Ambient
b: 0=no switching, 1=switch between PERP_B and along B
c: 0=1keV operation, 1=500eV
d: 1=energy switching (not implemented)
e: optics state, usually 7
f,g,h: PERPx/X'100', PERPy/X'0100', PERPz/X'100'
i,j: internal use
k: number of BCIs between alongB/PERP_B switches

#81 - VAR-1 **X'00',X'D3EE',X'84' or X'00',X'D3EE',X'80'**

In the first case, set correlator m (GDU CMD 17, bits 3-2) to the fixed value in bits 3-2 of the variable at address x'D3EE'. In the second case, allow the onboard code to adjust m.

#82 - VAR-2

```
X'00',X'ED9A',X'0000'
                 b a
```

Override the value stored at poweron describing the way telemetry will be gathered on this SC. Byte a=1 means that only one gun/detector pair is working,
a=0 means both gun/detector pairs are working
Byte b has meaning only if byte a=1.
b=0 means gather data for gun2/detector1 only (gun1/detector2 not working)
b≠0 means gather data for gun1/detector2 only (gun2/detector1 not working)

#82 - VAR-2

```
X'00',X'D774',X'0200'
                 b a
```

Set the beam current maximum offset. Values are set at Poweron, the bytes here change the Poweron values. **a** changes the beam offset for gun1; **b** changes the beam maximum offset for gun2. Numbers **a** and **b** are added to numbers read from BC MAX tables. The BC MAX tables are indexed by the value of B in 0.25nT.

#81 - VAR-1 **X'00',X'D303',X'01'**

Set the a2d check byte to 1 if the analog-to-digital converter is not working. When this byte is 1, EDI does not make overlimit checks.

#81 - VAR-1 **X'00',X'D25F',X'01'**

Define the status of STAFF. If the option byte is 1, STAFF is ignored onboard.

7.5 Routine Command Sequences

Based on the building blocks defined in the previous section, one can construct all command sequences which are needed for routine operations. Some blocks have been written with dummy NOOP command at the end to account for the execution time of the last command or entire block.

7.5.1 Start-up from Power-off State

Starting EDI from an unpowered state requires sending the following blocks, with the in-flight tests (PULSER and MCP GAIN) as well as the VAR-X sequence optional. The numbers refer to the numbers given the blocks in the previous section.

```
  #10   EDI-ON
  #20   PGA
(#130)  OPTIONAL: PULSER
  #30   HV
* #40   GUN
  #50   MCP
(#140)  OPTIONAL: MCP-GAIN
  #71   MODE8
  #61   MODE-SOB
```

Notes:
a. The * is to indicate that when running ambient particle modes, the GUNS block would not be run.
b. If ambient modes are to be run, the SOB-byte in block #61 can be anything.
c. To reduce the number of commands, Sequence #190 (TC58) can be used instead of sequence #20 to configure the PGAs.
d. If WW is the desired mode, the following sequence, which has much fewer commands, may be used:

```
 #10  EDI-ON
#190  TC58
#180  TC54
#170  SRON
 #50  MCP
```

7.5.2 Startup from Standby State

```
  #50   MCP
(#140)  OPTIONAL: MCP-GAIN
  #61   MODE-SOB
```

7.5.3 Startup from Quiescent State

```
(#120)  OPTIONAL: PGA-RESET
(#190)  OPTIONAL: TC-58
(#130)  OPTIONAL: PULSER
  #30   HV
* #40   GUN
 #170   SRON
  #50   MCP
(#140)  OPTIONAL: MCP-GAIN
  #61   MODE-SOB
```

Notes:
a. The * is to indicate that when running ambient particle modes, the GUN block (#40) would not be needed.
b. If WW is the desired mode, TC54 (#180) is an option for Startup from Quiescent, replacing blocks #30, #40 and #61. Block #140 must not be run in this case. Thus, the sequence is [#120, #190, #130, #180, #170, #50]

The purpose of the first two steps (reset PGAs and re-configure PGAs) is to start operation with newly configured PGAs. Bit errors in the PGA configuration might occur during the long times no data are acquired and the instrument is in the Quiescent state.
In the Quiescent state the PGAs remain configured and must be reset before they can be re-configured again. Thus when starting from Quiescent, the PGA-CONFIG block must be preceded by the PGA-RESET block.

7.5.4 Power Off

Requires a single block : #90 (EDI-OFF)

7.5.5 Put EDI in Standby State

Requires a single block : #100 (STANDBY)

7.5.6 Put EDI in Quiescent State

Requires a single block : #110 (QUIESCENT)

7.5.7 Science Mode Switching

Requires #60 (MODE) or #61 (MODE-SOB)

There are no restrictions on switches from any source to any target Science Mode among those already defined. It is, however, possible that some Science Modes to be designed for ambient particles may require transition through the Standby state in order to avoid unacceptably large jumps in Sensor Reference voltage.

7.5.8 TM Mode Switching

A TM Mode switch requires sending the TC SUMOS x, where x = 1,5,7 for NM1, BM1, BM3. This TC must occur AFTER the spacecraft has been configured for the new TM mode.

7.5.9 Startup from Power-Off to Standby

Requires the sequence

#010 (EDI-ON)
#190 (TC-58)
#030 (HV)
#100 (STANDBY)

7.5.10 Startup from Power-Off to Quiescent

Requires the sequence

#010 (EDI-ON)
#190 (TC-58)
#110 (QUIESCENT)

7.6 Table & Software Upload

7.6.1 Approach

Gun deflection voltage tables, optics deflection voltage tables, science code as well as PGA configuration files may need to be reloaded in EEPROM during flight. Magnetometer calibration constants will have to be adjusted frequently.

There are four 128kB EEPROM chips plus one 32 kB chip in the Controller . We divide each of the large chips into eight 16kB segments and the 32kB chip into four 8kB segments. The 32kB chip holds the PGAi & PGA1 configuration files. We refer to these segments as EEPROMs. They can be identified by the three hex digits of the start address of the EEPROM. The Memory Map (see below) identifies the EEPROMs and their contents.

There is a procedure for creating a file which contains the patch one wishes to upload, "Procedure for Creating Software Patch", see Appendix D.1. This procedure is of importance only to the EDI team. Uploading the patch follows the "Procedure for Uploading Software Patches" (Appendix D.2). The procedure is simplified for FGM/STAFF calibration constants (Appendix B.5)

7.6.2 Upload Steps

To patch a certain EEPROM:

- copy the EEPROM to be patched into RAM
- upload the patch
- do a checksum on the patched file in RAM
- write enable the EEPROMs
- copy from RAM back into EEPROM
- do a checksum in the appropriate EEPROM
- jump to mode 8
- set the status of mode 8
- verify the upload by checking the fudge words against their nominal values.

– For uploads on unit-level, the ICF-files C2Rxxx.ICF, RCK16K.ICF, C2Exxx.ICF, CKxxx.ICF, FJM8.ICF, STBQ04.ICF, and FUDGE.ICF or FCV.ICF could be used to accomplish the same steps but in practice they are not. If FCV.ICF is used to record checksums and version numbers in a .DMP file, program eemdram.exe can be used to
print these data as follows: eemdram /i infile.dmp /o infile.out /flags 8.

For SC-uploads, IPCH-files are used (see Appendix D)

7.6.3 Number of Table/Software Patches

During commissioning, we expect uploads of the Gun deflection tables and software patches about once every orbit. After commissioning, the frequency of such software patches is expected to drop to once a week, and later on to once a month. However, we expect that new magnetometer calibration constants will have to be adjusted regularly every week.

7.6.4 Memory Map

PROM

There are two 8kb PROMs, ROM1 (0000-0fff) and ROM2 (1000-1fff).

EEPROM

There are 32 16kB EEPROMs for EDI and four 8kB, odd-byte EEPROMs of which two are in use. The table below shows the EDI software configuration for all four S/C as of July 18, 2000. EEPROM 04000 (mode8.0) on FM7 has been patched with the Robust2 fix at Baikonur.

EEPROM	Filename	Check-sum	Version at	Version number	Fudge word
004000	mode8.0	$4a	3ffa-3ffe	04 0b 16 03	b7f3
008000	FORTH (spare)	$4a	----	None	90ff
024000	himod.0	$4a	3ffa-3ffe	24 08 19 03	55c9
028000	himdx.0	$4a	3ffa-3ffe	28 08 19 13	0e6a
044000	TS PGA1 * (spare)	$ab	0-3	44 1a 07 32	---
048000	(spare)	$4a	3ffa-3ffe	FM6,FM7,FM8: 48 cc cc cc	0a8e
				FM5 : 48 09 01 03	69cf
064000	(spare)	$4a	3ffa-3ffe	64 cc cc cc	0a72
068000	(spare)	$4a	3ffa-3ffe	68 cc cc cc	0a6e
084000	tests.0	$4a	3ffa-3ffe	84 08 1f 23	63dd
088000	optix.0	$4a	3ffa-3ffe	FM6,FM7: 88 08 19 03	6a77
				FM5,FM8: 88 0c 0e 02	9fba
0a4000	ca050898.0 *	$a7	0-3	a4 48 05 2e	---
0a8000	ca050898.0 * (part2)	$25	3ffa-3ffe	a8 48 05 2e	---
0c4000	corr_40f.mcs *	$4a	0-3	c4 27 1e 03	---
0c8000	corr_40f.mcs * (part2)	$95	3ffa-3ffe	c8 27 1e 03	---
0e4000	reserved: new PGA2	$00	0-3	e4 aa aa aa	---
0e8000	reserved: new PGA2	$00	3ffa-3ffe	e8 aa aa aa	---
104000	gdu*MM*y5.0	$4a	3ffa-3ffe	FM5: 05 5a 06 23	5f8d
				FM6: 05 f8 1f 13	8b9b
				FM7: 05 18 1f 13	a47b
				FM8: 05 38 1f 23	b117
108000	gdu*MM*y5.0 (part2)	$4a	3ffa-3ffe	FM5: 09 5a 06 23	a9c7
				FM6: 09 f8 1f 13	efea
				FM7: 09 18 1f 13	ef70
				FM8: 09 38 1f 23	9177
124000	gdu*MM*x5.0	$4a	3ffa-3ffe	FM5: 25 5a 06 23	0e5f
				FM6: 25 f8 1f 13	1c59
				FM7: 25 18 1f 13	4365
				FM8: 25 38 1f 23	e29d
128000	gdu*MM*x5.0 (part2)	$4a	3ffa-3ffe	FM5: 29 5a 06 23	b765
				FM6: 29 f8 1f 13	d8db
				FM7: 29 18 1f 13	b99a
				FM8: 29 38 1f 23	256e
144000	gdu*NN*y5.0	$4a	3ffa-3ffe	FM5: 45 49 08 13	bdf1
				FM6: 45 e8 1f 23	a3c7
				FM7: 45 08 1f 23	8fe1
				FM8: 45 28 1f 13	649f
148000	gdu*NN*y5.0 (part2)	$4a	3ffa-3ffe	FM5: 49 49 08 13	120c
				FM6: 49 e8 1f 23	b75e
				FM7: 49 08 1f 23	88e2
				FM8: 49 28 1f 13	9a9c

EEPROM	Filename	Check-sum	Version at	Version number	Fudge word
164000	gdu*NN*x5.0	$4a	3ffa-3ffe	FM5: 65 49 08 13	4bdd
				FM6: 65 e8 1f 23	07a1
				FM7: 65 08 1f 23	a627
				FM8: 65 28 1f 13	0bd1
168000	gdu*NN*x5.0 (part2)	$4a	3ffa-3ffe	FM5: 69 49 08 13	d59c
				FM6: 69 e8 1f 23	237c
				FM7: 69 08 1f 23	363d
				FM8: 69 28 1f 13	617c
184000	gdu*MM*y.0	$4a	3ffa-3ffe	FM5: 85 5a 06 23	7792
				FM6: 85 f8 1f 13	ce63
				FM7: 85 18 1f 13	77b7
				FM8: 85 38 1f 23	4b95
188000	gdu*MM*y.0 (part2)	$4a	3ffa-3ffe	FM5: 89 5a 06 23	91aa
				FM6: 89 f8 1f 13	f210
				FM7: 89 18 1f 13	349c
				FM8: 89 38 1f 23	c08c
1a4000	gdu*MM*x.0	$4a	3ffa-3ffe	FM5: a5 5a 06 23	8b69
				FM6: a5 f8 1f 13	9865
				FM7: a5 18 1f 13	a2bd
				FM8: a5 38 1f 23	a23e
1a8000	gdu*MM*x.0 (part2)	$4a	3ffa-3ffe	FM5: a9 5a 06 23	a1dd
				FM6: a9 f8 1f 13	fb20
				FM7: a9 18 1f 13	59cf
				FM8: a9 38 1f 23	4b96
1c4000	gdu*NN*y.0	$4a	3ffa-3ffe	FM5: c5 49 08 13	9e76
				FM6: c5 e8 1f 33	7feb
				FM7: c5 08 1f 23	e35f
				FM8: c5 28 1f 13	3177
1c8000	gdu*NN*y.0 (part2)	$4a	3ffa-3ffe	FM5: c9 49 08 13	1c67
				FM6: c9 e8 1f 33	607c
				FM7: c9 08 1f 23	451a
				FM8: c9 28 1f 13	0da8
1e4000	gdu*NN*x.0	$4a	3ffa-3ffe	FM5: e5 49 08 13	7e46
				FM6: e5 e8 1f 33	a9a6
				FM7: e5 08 1f 23	452c
				FM8: e5 28 1f 13	668c
1e8000	gdu*NN*x.0 (part2)	$4a	3ffa-3ffe	FM5: e9 49 08 13	da9f
				FM6: e9 e8 1f 33	1520
				FM7: e9 08 1f 23	1815
				FM8: e9 28 1f 13	895d
01c000	i071098a.02 *	$0b	1,3,5,7	12 10 07 98	---
03c000	[lnsb.0]	$67	1,3,5,7	21 01 10 98	---
05c000	---	$00	1,3,5,7	aa aa aa aa	---
07c000	fg4ms.mcs	$09	1,3,5,7	42 24 10 94	---

NN : GDU1 number (FM5: *20*, FM6: *14*, FM7: *16*, FM8: *18*)
MM : GDU2 number (FM5: *21*, FM6: *15*, FM7: *17*, FM8: *19*)
*: filename and checksums change when version changes

Deviations from standard EEPROM configuration as documented in above table				
	FM5	FM6	FM7	FM8
SVT dummy upload to $88000 EEPROM (1)	X			X
16kB IPCH test upload to $48000 EEPROM (2)	X			

EEPROM filename changes

044000	non $4a chksum	lnnew.0
048000	non $4a chksum	lnnew.0 (part 2)
064000	$4a chksum	gvztb.0
068000	$4a chksum	gvztb.0 (part 2)
0c4000	$6b chksum	corx2s3.mcs
0c8000	$6e chksum	corxs3.mcs
01c000	$27 chksum	i170100.02

RAM

RAM MEMORY $xc000 - $0y0000 where x=0,2,4,6 -- y=1,3,5,7 -- c means hex c

$c000 - $c000	FORTH
$c210 - $c260	BVAR buffers (rbmag, rbx, rdt, rdb)
$c270 - $c400	correlator counter/modeC,modeD tables (mutually exclusive)
$c400 - $c540	task tables
$c540 - $c560	zeroes
$c560 - $c600	max/min buffers
$c600 - $c800	circular buffers
$c800 - $c900	BVAR buffers
$ce00 and down	FORTH stack
$d100 and down	interrupt stack
$d200	static base origin
$d200 - $d900	static base relative variables
$d900 - $dbb0	buffers
$dbb0 - $dfe0	static base relative variables
$dfe0 - $e38c	nom1 header, buffer1
$e3f0 - $e79c	nom1 header, buffer2
$e800 - $e850	upload fudge words
$e850 - $e8e0	fudge word error count and addresses of EEPROMs in error
$10000 - $11b00	bm1 buffers
$12000 - $13b00	bm1 buffers
$14000 - $1c000	unknown
$nc000 - $m0000	odd byte EEPROMs (n=1,3,5,7; m=2,4,6,8)
$2c000 - $30000	used for PGA configuration
$30000 - $34000	used for PGA configuration
$4c000 - $50000	unused RAM memory on SC1, SC3; EDI code loaded here on SC2
$50000 - $54000	unused RAM memory on SC1, SC3; EDI code loaded here on SC2
$6c000 - $70000	unused RAM memory on SC1, SC3; EDI code loaded here on SC2
$70000 - $74000	unused RAM memory on SC1, SC3; EDI code loaded here on SC2

Ram addresses that contain status information:

d3f6 flag and count of EEPROMs whose checksums were not correct
(EEPROM addresses $44000 and above and all odd-byte EEPROMs)
d3f8 0b if a non-odd-byte EEPROM has a checksum error
0a if an odd-byte EEPROM has a checksum error over $2000 bytes, but is OK if the version number is not included in the checksum
00 if there are no checksum errors
d456 count of fudge words that did not verify
d457 overlimit bits
c270 calculated odd-byte checksums (at POWERON or RESET)
c290 calculated non-odd-byte checksums (at POWERON or RESET)
e850 count of fudge words that did not verify
e854 addresses of the failing fudge words

7.7 Health and Status Checking

7.7.1 Standard Checks

It is expected that during routine in-orbit operations, ESOC operators check the EDI HK data for instrument failures and errors affecting instrument health as soon as the data are available. Chapter 9 describes the failures or errors, and the expected operator response.

7.7.2 Status Consistency Checks

It is also desirable that operators verify that EDI has been running in the proper Science Mode, TM Mode, and TM Format. This requires comparing the corresponding HK parameters MODID, SUBMO, and PACMO, respectively, with the EDI Science Mode#, S/C TM Mode, and EDI TM format which were scheduled for that time. If discrepancies are detected, the EDI representative should be notified immediately.

8. Critical Operations

Critical operations are:

1. MCP high-voltage turn-on and level setting
2. Cathode heater power turn-on and level setting
3. FPGA Configuration

8.1 HV & Cathode Protection

With regard to Items 1 & 2, we have implemented a protection scheme which prevents inadvertent turn on of MCP or Cathode heater (see Section 3.1.3)

- First, a Disable Connector prevents turn-on in air.
- After removal of the disable connector, a Password is needed to activate the critical functions.

All procedures which follow the Password will have to be checked carefully for MCP and Cathode heater settings.

8.2 PGA Configuration

8.2.1 TM-Mode during configuration

PGAs can be configured in any telemetry mode. Science Mode0 or 8 is required. (PGA2 in Mode8 only!))
On SC2 the sequence of events should be: poweron (goes to PROM because of a-to-d failure), configure PGAi, configure PGA1, load RAM with EDI code, jump to mode8 in RAM, configure PGA2.

8.2.2 Wrong Configuration File

Configuring a PGA (Programmable Gate Array) with the wrong configuration file can, in principle, damage the PGA. Configuration files (in EEPROM) are identified by a version number. Before configuring a PGA for the first time the version number is read (as part of the turn-on procedure) and compared with the intended file version. If found incorrect, the procedure must be terminated, and the proper file must be uploaded before the procedure can be resumed.

8.2.3 Configuration Sequence

The correct sequence of configurations must be maintained to assure proper instrument operation:

PGAi, PGA1, PGA2

Furthermore, PGAi (in the Controller) and PGA1 (in the GDU) must always be configured together one after the other. This is to avoid that one inadvertently tries to configure just PGAi, at a time when PGAi and PGA1 are already configured. This action would configure PGAi, but reset PGA1 and thus leave the GDUs non-operational.
PGA2 can be configured multiple times once PGAi and PGA1 have been configured.

8.2.4 Timing Constraint for PGA1 Configuration

To put EDI in a stable power state, it is recommended to configure PGA1 within 40 minutes after poweron.

9. Contingency Operations

9.1 Normal EDI States

Normal operating state

HSK0, FRCNT	:	changing by about $5270 each TMR
HSK5, LASTC	:	value dependent on last TC sent
HSK6, MODID	:	1,(2),5,8,12,(13),17 or 19. Numbers in parentheses are rare.
HSK6, SUCOC	:	changing by 1 each TMR, values 0-7.
HSK19, PGACF	:	3, except during start-up; can be 0,1,2 in Mode 8

Mode 0

HSK0, FRCNT	:	changing by about $5270 each TMR
HSK5, LASTC	:	value dependent on last TC sent
HSK6, MODID	:	0. Mode0 is a normal, transitional state during upload procedures Mode 0 is a normal state after a current limit trip.
HSK6, SUCOC	:	changing by 1 each TMR, values 0-7
HSK19, PGACF	:	3

Temporary FFFF state

HSK0, FRCNT	:	65535 ($ffff)
HSK5, LASTC	:	$ffff
HSK6, MODID	:	63 ($3f)
HSK6, SUCOC	:	7
HSK19, PGACF	:	3

When EDI normal operating states are switched, the data in HSK words 0, 5, 6 and 19 may temporarily show a FFFF state (all bits in all words are set to 1). If the FFFF State continues for more than 45 seconds, it is not a temporary FFFF state, but an indication of an abnormal condition.

9.2 Abnormal EDI States

The pathways to abnormal EDI states are not unique and therefore problem resolution requires some review of events preceding the abnormal state. Operators should identify exactly when the abnormal state began, what state EDI was in before the abnormal state and what telecommands, if any, were sent in the two minutes before the abnormal state.

A. **Robust2 (alternating patterns every 22 seconds)**

HSK0, FRCNT	:	42405 ($a5a5)	alternating with 65535 ($ffff)
HSK5, LASTC	:	$a5a5	alternating with $ffff
HSK6, MODID	:	41 ($29)	alternating with 63 ($3f)
HSK6, SUCOC	:	5	alternating with 7
HSK19, PGACF	:	2	alternating with 3

B. **PGAs configured after a jump from ROBUST2 to Mode 0**

HSK0, FRCNT	:	changing by about $5270 per TMR
HSK5, LASTC	:	reflects last TC sent before entry to Robust2
HSK6, MODID	:	0.
HSK6, SUCOC	:	changing by 1 each TMR, values 0-7
HSK19, PGACF	:	2 or 3

PGAs not configured, Mode 0 or 8.

HSK0, FRCNT	:	changing by about $5270 per TMR
HSK5, LASTC	:	value dependent on last TC send
HSK6, MODID	:	0 or 8
HSK6, SUCOC	:	changing by 1 each TMR, values 0-7
HSK19, PGACF	:	0 or 1

C. FFFF state for more than 45 seconds

HSK0, FRCNT	:	65535 ($ffff)
HSK5, LASTC	:	$ffff
HSK6, MODID	:	63 ($3f)
HSK6, SUCOC	:	7
HSK19, PGACF	:	3

9.2.1 Operator Action for Abnormal States

The EDI representative should be notified of all abnormal states.

A. ROBUST2

Robust2 is an error state which can be entered during Power-up as the result of a hardware test failure or during normal operation as the result of a software failure (divide by zero, illegal instruction or some other type of illogical condition). Operator action depends on which type of error caused entry to Robust2. Review Spacecraft logs and/or playback telemetry to determine type of error.

A subset of EDI telecommands is available in Robust2 (LDEP,LDBY,JDEP,DATA,DMPS,DMPH).

If entry from Power-up

Turn power off to EDI. EDI representatives will require real time contact in order to resolve this problem

If entry during normal operation

Robust2 sends $A5A5 in HK and SCIENCE telemetry. It switches between main and redundant OBDH interfaces periodically. Telecommands can only be received if EDI is listening on the same interface that the S/C is sending the telecommands. A mismatch of interfaces happens periodically in Robust2 due to the interface switching, and is recognized by $FFFF in HK and SCIENCE telemetry. The first telecommand received in Robust2 turns off interface switching and locks EDI on the currently active interface.

In order to lock EDI on the currently active S/C interface and to jump to mode 0 send sequences #330 (LOCKIF) and #370 (JM0)

EDI should change to Mode 0 state (HK parameter MODID=0)
If EDI does change to Mode 0 state and if HK parameter PGACF is 2 or 3, leave EDI in Mode 0 until an EDI representative is available to continue problem resolution.
If EDI does not change to Mode 0 or if HK parameter PGACF is 0 or 1, shut EDI off.

B. PGAs configured after a jump from ROBUST2 (Mode 0)

When EDI jumps to Robust2 as the result of a software error, the state of the EDI hardware may be preserved. A jump to Mode 0 out of Robust2 restores EDI HSK telemetry. If EDI HSK telemetry shows a normal state, Operators should leave EDI in this state until an EDI representative has determined the cause of the jump to Robust2.

C. PGAs not configured, MODE 0 or 8

EDI Operation with PGAs not configured is an abnormal state that has unstable power consumption. Therefore shut off power to EDI when this state is observed:

Mode 0 or 8	(HSK word 6, MODID=0 or 8)
PGAs not configured	(HSK 19, PGACF=0 or 1)

(except, of course, when this state occurs during the EDI power-up procedure before PGA configuration is completed).

Power-up

If this abnormal state occurred during a power-up procedure, the next time real-time contact is possible, start the EDI power-up process again (Sequence #010 EDI-ON). If Mode 0 appears again, check to see if this state is the result of a checksum error on one of the EEPROMs with higher addresses (addresses higher than $28000). This error is indicated by a $000B in RAM location $D3F8. To see the contents of RAM location $D3F8, use sequence #320 (00,D3F8,C0). When HK parameter RAMAD is 00D3F8, look at the first word in the variable section of HSK TM. If this word is 000B, then at least one of the EEPROMs has an invalid checksum. Turn off power to EDI to avoid the dangerous „PGAs not configured“ state. EDI representatives will require real time contact in order to correct a $000B problem.
If EDI enters Mode 8 on power-up after Operators have turned off EDI power because of a „PGAs not configured“ state, it is probably still unsafe to continue with the EDI operation unless an EDI Representative is available to verify that the PGAs have not been damaged. Shut off power to EDI (sequence #090).

Current Overlimit

Another reason for EDI PGAs to show „not configured“ is that the onboard software has reacted to a current overlimit condition by turning off the PGAs and possibly other circuits. Usually telemetry will show the cause of the overlimit condition in the TMR where the problem begins. Overlimit indicators appear in HK-Word 2, but are reset the next TMR. In Mode8 a permanent copy is shown in HK parameter OLPRM. In Mode0, the indicators can be displayed in the HK variable section by sending sequence #320 (00, D457,C0).

If byte $D457 in the first word og the variable section in HK is non-zero, then there was an overlimit trip:

D457 = 01 = 28V circuit overlimit
02 = gdu1 overlimit
04 = gdu2 overlimit
08 = 5V circuit overlimit

If a current overlimit is the cause of the „PGAs not configured“ state, HSK words GD117,GD121, GD122, and sometimes GD217,GD221,GD222 will be corrupted and should be ignored.

To determine what circuit caused the overlimit condition, replay telemetry looking for these changes:

- jump to Mode0
- GDx17,GDx21 or GDx22 change from normal values to garbage values
- HSK telemetry word 28VOL, GD1OL, or GD2OL is 1 (these are ususally zero)

The last three data words are key to the overlimit problem. Report the word that is 1 and the time of the problem to the EDI representative. If none of these words changes to at the time that the PGAs first show „not configured" report that information to the EDI representative.

D.FFFF State

If an EDI power-up sequence was ongoing at the time the FFFF state appears, it may take as long as 12 minutes before EDI changes to a permanent state. During this time, EDI is dumping EEPROMs to SCI telemetry, but HSK telemetry shows only the FFFF state. Turn power off to EDI if there are more than 45 seconds of FFFF state telemetry.
Further problem resolution will require real-time contact and an on site EDI representative.

9.2.2 EDI Team Response for Abnormal States

A. ROBUST2 :

Robust2 is a failure recovery routine, uniquely identified by $A5A5 in the SCI and HSK Data. Upon entry to ROBUST2, all unnecessary power control circuitries are turned off and an error report is written to SCI telemetry. The report is not synchronized to the TMR. Information in the error report is described in detail in later sections.
ROBUST2 is self-contained. That is, it does not rely on ROM1, RAMs, EEPROMs, or the operation of maskable interrupts. It uses only the non-maskable interrupt (generated for each telecommand received), SCI telemetry and/or HSK telemetry channels, ROM2, and its own internal register set. Because of its configuration, ROBUST2 telecommands are restricted to a subset of the normal telecommands including LDEP, LDBY, JDEP, DATA, DMPS and DMPH.
DMPS and DMPH are used to dump blocks of controller memory into either SCI or HSK. When dumping to the science telemetry, an eight word header of $D1D1 will precede the memory dumps; when dumping to housekeeping telemetry, the eight word header is $D2D2. Neither dump is synched to the TMR.
If the entry to ROBUST2 comes during power-up, there is a hardware failure. The ROBUST2 error report should contain sufficient information to determine the precise reason for entry to ROBUST2.
If entry to ROBUST2 comes during normal operation, there is a software failure. Operator action after Robust2 can leave EDI either powered off or powered on. If EDI is on, the EDI team should turn on EEPROMs, jump to Mode 8 and proceed cautiously with normal operations. If EDI is off, the EDI team should first determine if the PGAs have been damaged (turn EDI on, verify checksums, configure PGAs one by one and observe PGA current and voltage readings in HSK TM). If no damage is evident, normal operations may be restarted.
The EDI team should review telemetry and telecommand logs to see what state preceded the jump to ROBUST2 and recreate the environment and see if the problem reoccurs. Test equipment on the ground may be useful in resolving the problem, or it may not.

B. PGAs not configured (MODE 0 or MODE 8)

Operation with PGAs not configured over a long period of time will damage the PGAs. Therefore, Operators will shut off power to EDI when this state is observed.

The first task for EDI representatives is to verify that the PGAs are undamaged (turn EDI on, verify checksums, configure PGAs one by one and observe PGA current and voltage readings in HSK TM). After good status for the PGAs has been verified, EDI Representatives must determine the reason for the abnormal Mode 0 operation. There are a number of possibilities:

Problem : power-up went to Mode 0 with $000B in location $D3F8.
Resolution : power-up EDI and continue $000B problem analysis as described in section 9.4.6.

Problem : power-up went to Mode 0 but location $D3F8 is not $000B
Resolution : the jump address at $4000 is incorrect (but the $4000 checksum is still $4a) or there was a current overlimit condition. The first is extremely unlikely but easy to check. The jump address stored at $4000 is $4030. The next two bytes force the two-byte checksum to $a5. Verify these numbers. If they are good, follow overlimit error discussion.

Problem : power-up was not ongoing when operation „PGAs not configured“ began.
Resolution : Review EDI telemetry and telecommand logs to try to determine the events leading up to this state. Ground testing of EDI software may the best approach to problem resolution.

Problem : current overlimit
EDI includes routines to monitor the system's health. In mode0 and mode8 the RTI interrupt routine (10ms) reads controller voltages and currents and stores the data for the current monitor task. In himodes, the BCI interrupt routine (2ms or 4ms) collects and stores the data for the current monitor task. The current monitor task runs every 250ms.
If an overlimit condition is caused by the 28V or 5V circuits, the controller turns off scratch RAM (turns on start circuit). For all overlimits detected while executing in EEPROM (everything but Mode0 operation), the controller turns off interrupts, executes the SET SAFE routine, stops the GDU clock (writes $00 to the PGA1 status address), clears the software PGA configuration flags, and jumps to Mode0 initialization. If Mode0 sees an overlimit condition (which might happen after an EEPROM-detected overlimit error), the controller turns off power to the EEPROMs, executes SET SAFE, clears the software PGA configuration flags and writes zero to the PGA1 status address. Writing zero to the PGA1 status address causes subsequent reads of GDU DATA Ram to return configuration bytes. This means HSK data words GDx17,GDx21,GDx22 show corrupted values.
To reset EDI hardware and restart normal operations, EDI representative should send the Reset PGA telecommand (TC 66, hex 42) or turn EDI power off/on.
Resolution : Review EDI telemetry and telecommand logs to see if the overlimit state was caused by changing hardware states (e.g. MCP power-up) or Science or telemetry modes or if there is no obvious reason for the overlimit error.
Appropriate action will be decided upon based on determination of the cause of the error.

If the EDI team is pretty sure that EDI is operating properly and that EDI hardware has not been damaged, normal operation may be resumed with an eye to reestablishing the same set of conditions as existed when the error occurred to see if it reoccurs. When real-time contact is available, begin the power-up sequence again and see what happens.

Note : Review logs and telemetry to see if a Robust2 failure or watchdog reset preceded the „PGAs not configured“ state.

C. FFFF State: ROBUST1, EEPROM Dump, Watchdog Trip, Wrong Channel, Undetermined

From the Operator’s point of view (seeing only HSK TM), all of these abnormal states look the same. However, the EDI Representative may find additional information in SCI TM.

Note: Power-up and Watchdog trip cause the same piece of EDI software to be executed although descriptions in this section may refer to only one or the other of these terms.

– **ROBUST1:**
Robust1 is uniquely identified by an eight-word $F8F8 header in the SCI telemetry. Operation in Robust1

means that the ROM2 checksum was not as expected. This is a very serious error and it occurs only on power-up. The next real time contact, turn on EDI and use ROBUST1 telecommands to verify the ROM2 checksum error. Robust1 assumes that RAMs and ROM1 are operative. In this configuration, all of the normal PROM telecommands are available.

- In order to continue the experiment if there is a Robust1 failure, an operational system not including ROM2 will have to be built. (ROM2 code moved to EEPROM, mod tables for higher modes changed to reference non-ROM2 addresses) and power-up procedures changed to document entry to Robust1 each power-up and begin normal operation starting from Robust1. These changes are decidedly non-trivial.

- **EEPROM Dump:**
  During power-up tests, the controller verifies the checksums of the first four EEPROMs (beginning hex addresses 4000,8000,24000,28000). If any checksum is wrong, the controller dumps the contents of the first eight EEPROMs (04,08,24,28,44,48,64,68) to SCI telemetry, unsynchronized to the TMR. This phenomenon can occur only at power-up/reset. There is no easy way to describe what telemetry looks like in this situation. It will be seemingly random and changing every TMR. To dump eight EEPROMs requires approximately 12 minutes. After the dump is complete, EDI goes through its normal power-up test of verifying the communication channel upon receipt of a telecommand. If a telecommand is not received within 30 seconds, EDI assumes there has been a failure in the communication hardware main channels, and swaps to the redundant channels.
  If EDI power-up occurs in non-real-time and this scenario is played out, the final result will likely be a channel mismatch between the Spacecraft and EDI. If EDI power-up occurs during real-time and the EDI representative anticipates an EEPROM Dump situation, he should send telecommands to change the EDI state after the FFFF telemetry appears. The EEPROM dump operates from ROM1 and the complete set of PROM telecommands is available. To get out of the EEPROM dump and start operation in Mode 0, send sequence #370 (JM0) . The EDI representative should then determine which EEPROM is in error and upload code as required.

- **Watchdog Trip:**
  The EDI "watchdog" circuit is a hardware check against infinite loops and other failures. When EDI is functioning properly, the software resets the watchdog hardware address periodically (approximately every 10 ms). If the software does not reset the watchdog at least once in 2 seconds, a system reset is generated. The controller is in the same state as if power were turned on but no command is sent (Mode 0 or Mode 8). If telecommands are interrupted by a watchdog reset, results are unpredictable. The watchdog is disabled when the EEPROMs are write enabled. The EDI team should proceed as cautiously as possible, verifying the PGAs and all software versions before proceeding with normal operation.

- **Wrong Channel:**
  If a reset or Power-up occurs in non-real time and EDI does not receive a telecommand within 30seconds, then the on-board software assumes a communications failure and switches all communications lines from main to redundant. This will appear as the FFFF state to Operations. Follow the same procedures as for undetermined.

- **Undetermined:**
  Sometimes a software error occurs which puts EDI is a completely undefined state with telemetry showing the FFFF state. The EDI team should proceed as cautiously as possible, verifying the PGAs and all software versions before proceeding with normal operation.

9.3 Normal Operating States, Error Indicators

9.3.1 Overview

Error	Indication	Operator Action	EDI action
current limit trip	Mode0	- record: EEPON all currents and voltages (see 9.2.3) 28VOL GDxOL (x=1,2) 5VSOL - record if during power-up; - review log/telecommands to see if current limits have been reset by telecommand since power-up; - notify EDI representative	see 9.2.2
red/yellow limits	HK shows current or voltage in red	see 9.2.3	For out-of-bounds conditions with exceeded ratings 3 as described below, the EDI team will determine the cause of the problem. This will require real time contact.

9.3.2 Current Monitor Task

The a/d converter has failed on all SC so the current monitor task is no longer executed.

The current monitor task checks the values read from the a/d converter against previously set limits:

		lo	hi
28V current	:	0	$3FF
5V current	:	0	$3FF
GDUs	:	0	B - [(A * 28V current) / 2^{10}] where B = $40e and A = $166 set at POWERON, RESET (B = $564 from launch to December 2002)

Any of the limits can be changed after startup. The GDU hi limit is calculated on the basis of the variables A and B. The RAM addresses of the variables are:

28V current	:	$D502	$D500
5V current	:	$D50A	$D508
A	:	$D50C	
B	:	$D50E	

If the current on any of these circuits exceeds the high limit, the current monitor task takes action to cut the current use and put the system in a safe configuration. If it is the 28v or 5v current that exceeds the threshold, the routine turns off power to the EEPROMs and to scratch RAM and turns on the start/run circuit. For all overcurrents, the GDU is commanded to safe voltage levels (GDU SETSAFE routine), both PGA1 and PGA2 are set to their reset state and a jump is made to the system initialization routine in PROM. The controller is then in the same state as if power were turned on and a telecommand sent.

9.3.3 Critical and Semi-critical-HK Data

The EDI housekeeping data telemetry can be grouped into critical, semi-critical and non-critical groups as follows (parameter mnemonics in parentheses):

Critical Group

28V current (CONPC)
GDU1 current (GD1PC)
GDU2 current (GD2PC)
5V current (CUR5V)

HV1 GDU1 (REG11)
HV2 GDU1 (REG21)
HV1 GDU2 (REG12)
HV2 GDU2 (REG22)

MCP GDU1 (HVCR1) sensor 1
MCP GDU2 (HVCR2) sensor 2

Semi-critical Group

+/- 10.6V (VO12V/VN12V)
+/- 10.6V current (CU12V/CN12V)
5V_AUX current (ACU5V)

GDU-Group 0 (all)
GDU-Group 1 (all exc. I_BC, GNDG)
GDU-Group 6 (all)

All other HK parameters are classified as non-critical.

Limits Critical Group

a) Controller HK

HK parameters: CONPC, GD1PC, GD2PC, CUR5V :

	Low / mA		High / mA		condition
	red	yel	yel	red	
CONPC	15	30	100	130	none
CUR5V	150 80	180 120	500 500	550 550	PGACF=2 or 3 PGACF=0 or 1

limits for GD1PC and GD2PC are dependent on the state of the instrument
(x = 1 for GD1PC, x = 2 for GD2PC) :

Condition	Limits			
PGA1=NCFG	40	50	90	100
PGA1=CFG & HVONx=0 & PW22x=0	30	35	80	85
PGA1=CFG & HVONx=1 & PW22x=0	35	40	95	100
PGA1=CFG & PW22x=1	35	40	140	150

limits for the total PC are dependent on the state of the instrument (x = 1 for GD1PC, x = 2 for GD2PC) :

Condition	Limits			
PGA1=NCFG	95	130	280	330
PGA1=CFG & HVONx=0 & PW22x=0	75	100	260	300
PGA1=CFG & HVONx=1 & PW22x=0	85	110	290	330
PGA1=CFG & PW22x=1	85	110	380	430

b) GDU HK (only valid if FPGA1=CFG, i.e. do not check otherwise)

HK parameters: REG11, REG21, REG12, REG22 (x = 1,2, y = 1,2c) :

Parameter	Condition	Limits			
REGxy	HVONy=0	1.9	1.9	2.2	2.2
	HVONy=1	-1.2	-1.0	0.6	0.8

c) SENSOR HK (only valid if FPGA1=CFG, i.e. do not check otherwise)

HK parameters: HVCR1, HCVR2 (x = 1,2) :

Parameter	Limits			
HVCRx	-7	-7	25	30

Limits Semi-critical Group

a) Controller HK

HK parameters: VO12V, VN12V, CU12V, CN12V, ACU5V :

	Low		High	
	red	Yel	yel	red
VO12V / V	7.95	9.00	12.20	13.25
VN12V / V	-13.25	-12.20	-9.00	-7.95
CU12V / mA	-5	0	15	25
CN12V / mA	-23	-13	0	7
ACU5V / mA	-5	0	15	25

b) GDU HK (only valid if FPGA1=CFG, i.e. do not check otherwise)

HK parameters:

GDU HK Group 0: I_Dyx y=1...8, x=1,2

GDU HK Group 1: I_ANx, I_FCx, I_CAx, I_BWx, I_EUx, I_AUx, x=1,2

GDU HK Group 6: I_ELx, I_ALx, I_OAx, I_SRx, I_SPx, I_IAx, I_RC1, I_ET1, x=1,2

Parameter	Limits			
I_Dyx	-1.5	-1.0	4.0	5.0
I_ANx	-1.5	-1.0	3.5	4.0
I_FCx	-3.5	-3.0	1.0	1.5
I_CAx	-3.5	-3.0	1.0	1.5
I_BWx	-3.5	-3.0	1.0	1.5
I_EUx	-1.5	-1.0	4.0	5.0
I_AUx	-1.5	-1.0	4.0	5.0
I_ELx	-1.5	-1.0	4.0	5.0
I_ALx	-1.5	-1.0	4.0	5.0
I_OAx	-3.0	-2.5	3.5	4.5
I_SRx	-3.5	-3.0	3.0	4.0
I_SPx	-3.5	-3.0	3.0	4.0
I_IAx	-3.0	-2.5	3.5	4.5
I_RCx	-3.0	-2.5	3.5	4.5
I_ETx	-3.5	-3.0	3.0	4.0

Notes: For conditions of validity of HK-data see 2.2.1

9.3.4 Operator Response

The following tables assign a rating number to red and yellow out-of-bounds readings for the critical, semi-critical and non-critical groups and describes the action to be taken in each case.

Rating	Operator Action
3	Turn power off at next occasion, contact EDI rep
2	Record out of limits value and notify EDI rep.
1	Log time of event and record out of limits value
0	No action

Monitor	Red Lo ------	Yel Lo	Yel Hi -------	Red Hi
Critical group	3	2	2	3
Semi-critical group	2	1	1	2
Non-critical group	1	0	0	1

9.3.5 EDI Team Response

If a current limit trip is handled by EEPROMs, some circuits are shut off and the code jumps to Mode0. If Mode0 also finds a current overlimit, the status of the EEPROMs can be used to identify which circuit caused the limit trip (on means GDU trip, off means controller trip).
The status is stored at $d457. This byte will remain set until it is resets. So if one finds EDI in Mode0, this byte can be displayed in the HSK variable section by sending sequence #320 (00,D457,C0). Wait until HK parameter RAMAD displays 00D457, then look at the first word in variable section of HK. If the lower byte of this word is non-zero, then there was an overlimit trip:

Byte at $d457	Value	Description
01	28V	circuit overlimit
02	gdu1	overlimit
04	gdu2	overlimit
08	5V	circuit overlimit

Also, in the first TMR after the limit trip is detected, HSK word 2 bits 15-12 (5VSOL, GD2OL, GD1OL, 28VOL) tells which circuit caused the limit trip. HSK-Word 43 (OLPRM) contains a permanent copy of those flags. It must then be determined why the overlimit occurred. This may require real time contact.

9.4 Description of PROM Power-up Tests

This section contains information which may be useful to the EDI team in Power-on error determination.

Upon POWERON the controller undergoes a fairly extensive self-test on several of its key components. These tests include checksums on ROMs and, under some conditions, on EEPROMs, complete data and address testing of the controller's local RAMs, interrupt line test through the use of the A/D converter, 5V current limit checking, as well as a four byte checksum of the address of the desired operating mode located at the start of the EEPROM. If any failure occurs, an error report is written to the science telemetry FIFO. Depending upon controller timing, the error report may or may not be visible in the science telemetry.

9.4.1 Program Base Addresses Tests

The first test that the controller performs is on two processor Program Base (PB) addresses. The first PB test is for the NMI (Non-Maskable Interrupt). If a failure occurs during this test, program execution will pass into ROBUST2 with R7 containing the PB address and all other registers zeroed. The second PB address that is tested is the PB for ILL (Illegal Instruction Trap). If a failure occurs during this test, program execution will pass into ROBUST2 with R6 containing the PB address of ILL and R7 containing the PB address of NMI and other registers zero.

9.4.2 ROM1 Checksum Test

The first major test the controller performs is the calculation of the ROM1 checksum (ROM1 contains the firmware addresses $0000 to $0FFF). The checksum test is a simple test in which the contents of all memory addresses locations are summed and the resulting byte is compared to a predetermined value. For ROM1 the odd bytes and the even bytes each have a checksum of $A5. So for the entire ROM1, the checksum expected would be $4A. If a non-matching checksum is calculated, R4 contains the ID value of $10000 and R5 contains the calculated checksum when program execution passes to ROBUST2.

9.4.3 16k RAM Test

The next tests are RAM data and address tests on the controller's local 16k RAM. In the data test, two patterns ($A5 and $5A) are used to test each RAM byte location. Each pattern is written, read back and compared with the intended pattern. If a non-match occurs, the high word of R4 contains $0002 and the low byte contains the failed pattern, i.e. $200A5, on entry to ROBUST2. R5 contains the failed RAM location, R6 the PB of ILL, and R7 the PB of NMI.
In the address test, the address of each word RAM location is written to that RAM location and then read back and compared to the actual address. If non-match occurs during the address test, R4 contains $30000, R5 the failed RAM location, R6 and R7 remain as before upon entry to ROBUST2.

9.4.4 Summary of ROBUST2 status report for Power-up failures

The following table is a quick summary of the status report table sent in the housekeeping telemetry when an entry into ROBUST2 at POWERON occurs.

Initial entry header: 8 words of $0010
Register dump order in housekeeping telemetry (double words): R7, R6, R5, R4

Conditions	R7	R6	R5	R4
1st PB failure	failed 1st PB	xx	xx	xx
2nd PB failure	1st PB	failed 2nd PB	xx	xx
ROM1 checksum fail	1st PB	2nd PB	checksum	$10000
RAM data test fail	1st PB	2nd PB	RAM location	$200ZZ
RAM addr test fail	1st PB	2nd PB	RAM location	$30000

xx is an unknown quantity; zz is the failing pattern

9.4.5 Other PROM Power-up Tests and Reports

After all POWERON tests which may result in entry to ROBUST2 have completed successfully, the controller tests some secondary components: the ADC and EEPROM checksums. The action of the controller upon a test failure depends on the test being run. During each of these tests, status reports are generated and written (sometimes visible) in the science telemetry. Similar to ROBUST2's reports, each status report is preceded by an 8 word header followed by the dump of the processor's internal registers. The following table is a summary of this status report and resulting controller action.

Conditions	Header	R7	R6	R5	R4	Results
4byte chksm fail	$0001	1stPB	2ndPB	ROM2chksm	4bytechksm	see 1 below
ADC timeout	$0005	1stPB	2ndPB	ROM2chksm	ADC Val/4	see 2 below
5V over current	$0006	1stPB	2ndPB	ROM2chksm	ADC Val/4	see 3 below
ROM2 chksm fail	$0003	1stPB	2ndPB	ROM2chksm	ADC Val/4	see 4 below
Begin E2 chksm	$0002	1stPB	2ndPB	ROM2chksm	ADC Val/4	see 5 below
Dump EEPROMs	$0004	E0even	E0odd	E1even	E1odd	see 6 below
End dump EEPROMs	$0007	xx	E0odd	E1even	E1odd	see 7 below
Pass EEPROM chksm	$0000	E0even	E0odd	E1even	E1odd	see 8 below

1. The checksum of the four byte address pointer located at the start of EEPROM ($4000) does not add up to $A5. The controller turns off power to the EEPROMs, writes the status report and computes the ROM2 checksum. If the ROM2 checksum is good, execution passes to the POWERON entry point of MODE0.1 in PROM, otherwise execution passes to ROBUST1.
2. If the four byte checksum test passes, the controller tests the ADC. It is an error if the ADC does not respond within a predetermined time limit. Failure to respond could indicate an error either in the interrupt circuit or the A/D converter itself. The controller turns off power to the EEPROMs, sends the status report and then it checks the ROM2 checksum previously computed. If the checksum is good, program execution passes to the POWERON entry point of MODE0.1 in PROM, otherwise execution passes to ROBUST1.
3. If controller passes the ADC time out test, the converted 5V current is checked against a predetermined limit. If the value read is outside the limit, the controller turns off EEPROMs, sends the status report, and then checks the ROM2 checksum previously computed. If the checksum is good, program execution passes to the POWERON entry point of MODE0.1 in PROM, otherwise execution passes to ROBUST1.
4. Entry to ROBUST1.
5. After the controller passes all of the above tests, it computes checksums of EEPROMs $4000-$7FFF, $8000-$BFFF, $24000-$27FFF, $28000-$2BFFF. Checksums are performed separately on odd and even bytes. A status report with the eight header words of $0002 indicates only the beginning of this EEPROM checksum calculation and does not mean any type of failure has occurred.
6. For an EEPROM checksum error, registers 4-7 contain checksums as follows:

	hi	lo
r4	$08000-odd	$28000-odd
r5	$08000-even	$28000-even
r6	$04000-odd	$24000-odd
r7	$04000-even	$24000-even

Following the standard status report is a header with eight words of $0E0E. Immediately following a dump of all four EEPROMs. The dumping of the EEPROMs can be interrupted by using telecommands to jump to somewhere else, for example jump to Mode 0. At the conclusion of the dump, the EEPROMs will be turned off, and the ROM2 checksum tested. Program execution passes to the POWERON entry point of MODE0.1 in PROM if ROM2 checksum passes or to ROBUST1 if it fails.

7. This status report is used to indicate the end of the dumping of the EEPROMs. The controller proceeds as described in the previous paragraph.
8. This indicates that all POWERON test sequences have completed and that the EEPROM checksums are valid. Program execution passes to the memory address stored in the first three bytes of EEPROM if the 4-byte checksum at the start address of the $4000 EEPROM is correct. The memory address in the first three bytes of EEPROM will then be the start address of mode8. There a checksum test on all other EEPROMs is performed. Errors are reported as $B in HK parameter EECHK.
9. This indicates that all POWERON test sequences have completed and that the EEPROM checksums are valid. Program execution passes to the memory address stored in the first three bytes of EEPROM if the 4-byte checksum at the start address of the $4000 EEPROM is correct. The memory address in the first three bytes of EEPROM will then be the start address of mode8. There a checksum test on all other EEPROMs is performed. Errors are reported as $B in HK parameter EECHK.

9.4.6 EEPROM Power-up Test

ROM power-up runs a number of tests including checksum tests on the first four EDI EEPROMs. If all these tests are successful, control passes to a checksum routine on the first EEPROM. This checksum routine verifies the checksums of the remaining 32 EDI EEPROMs. If minor errors (safe to continue power-up sequence) are found, EDI remains in Mode 8 and sets a status flag to $A. If major errors (possible damage to hardware may result if power-up sequence continues) are found, EDI jumps to Mode 0 and sets the error flag to $B.

If power-up ends in Mode 0, the power-up process is in an incomplete state. A special jump to Mode 8 is required before normal processing can continue. Configuring PGAs with invalid files can damage EDI hardware, therefore special telecommands must be used to configure PGAs if normal processing is to continue after a power-up that sets the status flag to $B.

If EDI is in Mode 0 after power-up, the EDI team must determine why. There are three possibilities: checksum errors on an EEPROM or an overcurrent condition or a checksum error on the jump address. The third possibility is exceedingly unlikely. Corrective procedures for the second possibility are included earlier in this chapter. Procedures for the first possibility follow. As usual for EDI power-up, PGA configurations must be done in NM1, other parts of this procedure might be done in BM3. NM1 is assumed for this procedure. Variations for BM3 are noted.

To determine the extent of the EEPROM errors, send sequence #320 (00,D3F6,C0). When HK parameter RAMAD is 00D3F6, look at the first two words in the variable section of HSK TM. If the second word of HSK TM is not 000B, then the reason for Mode 0 operation is not an invalid checksum; it is most likely an overcurrent condition. If the second word is 000B, then at least one of the EEPROMs has an invalid checksum. The first word in the HSK variable section is a flag word. The high byte is either FF, indicating an error in the odd byte EEPROMs, or 00, indicating an error in some other EEPROM. The low byte is the total of the number of EEPROMs with checksum errors.

If 000A occurs in second word of HSK variable section, this means that one of the odd-byte PGA EEPROMs has a checksum that is wrong over the entire file but is correct if the version number in the first four bytes is ignored in the checksum calculation. EDI operation can continue from this point. The EDI team may want to correct the version number error with an upload.

If 000B occurs in second word of HSK variable section, to determine which EEPROM is in error:

1. Turn on Scratch RAM
2. Execute ICF file FCVALL. This file records version numbers and checksums of all EEPROMs in Scratch Ram beginning at location $B00100 and $B00190 respectively.
3. Set the memory dump pointer to $B00100 :

```
LDEP    00
DATA    D470
LDWD    02
DATA    0100
DATA    00b0
```

   This will record the version and checksum numbers in NM1 Science Telemetry. (This is the „memory dump“ telemetry option. See the Telemetry sections for more information).

4. Set the HSK variable section to display 20 words of data beginning at address $B00190. The first 16 words will show the EEPROM address in the left (high) byte and the checksum in the right (low) byte for the first 16 EEPROMs. Check these numbers against expected values. Change the HSK variable display address to $B001B0. Information on the next 16 EEPROMs will be displayed. For EEPROM addresses greater than or equal to $10 0000, the high byte EEPROM address is the sum of xx and 1, where xx is the middle bytes of the EEPROM address (thus, for example, $10 4000 shows as $05). Check the second set of numbers, and change the HSK variable display address to $B001D0.
   Check the information on the final four EEPROMs.
5. If the EEPROM in error is not the 4000 EEPROM, jump to Mode 8 using these special telecommands:

```
LDEP    00
DATA    6000
JDEP    60
```

   This series of telecommands will ensure that the power-up process completes correctly.

NOTE: If the EEPROM in error is $4000, then do a full upload to restore Mode8.

6. If the error is not in $4000, one can determine which bytes are in error by dumping the contens of EEPROMs to scratch RAM, transferring the contents fo scratch RAM to telemetry, extracting data from the telemetry dump file and comparing the contents to known EEPROM load files. It is easier to dump scratch RAM if BM3 is an option. BM3 is an option only if PGAi and PGA1 are configured. If the EEPROMs in error are not the PGA configuration files, configure PGAi and PGA1 so that BM3 may be used.
A special sequence of telecommands is required to configure the PGAs when the EEPROM error flag word is 000B. The sequences are:

```
To configure PGAi:
LDEPM   02
DATAM   C000        ; set gdu_ram address
GDCOM   03
DATAM   0C80

To configure PGA1:          To configure PGA2:
LDEPM   00                  LDEPM   00
DATAM   D31C                DATAM   D31C  ;  set gdu_ram address
LDWDS   02                  LDWDS   02
DATAM   0000                DATAM   C000
DATAM   0001                DATAM   0002
```

LDEPM	02	LDEPM	02	
DATAM	C0000	DATAM	C000	; config file „copy to“ to address
LSOPM	01	LSOPM	0A	
DATAM	C004	DATAM	4004	; config file „copy from“ address
LBYCM	00	LBYCM	00	
DATAM	1ffc	DATAM	7ffc	
COPLS	--	COPLS	--	; argument does not matter
RGINE	81	DATAM	0f81	; 7bit is 000B override

7. Copy to scratch RAM the EEPROM(s) whose checksums do not match the expected numbers:

```
LDEP    B0
DATA    0100
LSOP    xx      address of EEPROM,  example 02
DATA    xxxx    address of EEPROM,  example 4000 for EEPROM 24000
LDBY    00
DATA    4000
COPL    --      argument for COPL TC does not matter
```

   If there is more than one questionable EEPROM, repeat this set of TCs for each, increasing the destination pointer address by $4000 each time.

8. If operation is in NM1, set the memory dump end and memory dump begin addresses and turn on the memory dump feature:

```
LDEP    00
DATA    D46C
LDWD    04
DATA    x100    end address:  yx is $4000 * n, where n is the number of EEPROMs in error
DATA    00by
DATA    0100    start address:
DATA    00b0
```

   Turn on the memory dump feature:

```
LDEP    00
DATA    D380
LDBY    01
```

9. If operating in BM3 (possible only if PGAs can be configured), it takes one TMR to dump one EEPROM. If operating in NM1, it takes 16 TMRs to dump one EEPROM. After the requisite number of TMRs have gone by, turn off the memory dump feature should if it was turned on (NM1). The Telecommands to do this are:

```
LDEP    00
DATA    D380
LDBY    00
```

The EDI team will process Science Telemetry files created in this procedure to determine the extent of the EEPROM problem and will prepare an EEPROM upload.