INTERFACE CONTROL DOCUMENT

D-CIXS/XSM Data Handling ICD

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DISTRIBUTION

Name	Iss/Rev Date	Iss/Rev Date	Iss/Rev Date	Iss/Rev Date	Iss/Rev Date	Iss/Rev Date	Iss/Rev Date
	7 16.08.01	8 30.11.01	9 4.07.02	10 11.7.02	11 18.9.02	12 16.10.02	13 24.02.06
RAL Server	X	x	x	x	x	x	x
ESTEC - PMIS	X	x	x			x	

CHANGE RECORD

Date	Iss/Rev	Section	Comments
30.9.99	1		First Issue
1.10.99	1.1	2	Preliminary command data included
27.1.00	2		Telemetry format redefined
19.6.00	3		Telemetry format redefined – 280 byte packets; commands defined.
24.10.00	4		XSM#2 removed Telemetry rates adjusted following CAN BUS data rate allocation change Commands for EEM model defined in detail
19.12.00	5	2 3	Dummy command included Additional DCIXS spectrum telemetry format 2 APIDs used - one for 'Quick-look'
26.4.01	6	2 3	Command table expanded Header included in telemetry tables for clarity Self-Test Format included DCIXS High count spectrum and Low count spectrum data types swapped
	7	2.4.2 2.4.7 3.2.2 3.3.7,8	Test Mode command included WGA command added RICA error flags included in science TM packets History and Auxiliary formats included
30.11.01	8	2	Command Mode Diagram included
4.7.02	9	2.1.4.7 2	Additional commands Command Mode Diagram updated
11.7	10	2.1.4.5	Enable Latch command data incorrect
18.9.02	11		
16.10.02	12	2.2	Parameter Defaults updated
24.02.06	13	2.1.4.3 2.2.2 2.2.3 3.3.1 3.3.10 3.3.7 3.3.5	New submode added, corrected mode value Threshold values changed Additional parameters and values New HK parameters Corrected number of words (ECR 53) New science data format (ECR 54) Correct figure (ECR 57)

CONTENTS

1. INTRODUCTION

This document forms part of the EID-B.

The DCIXS/XSM command and telemetry data are described.

The data structures for the telemetry and on-board CAN BUS are defined. The different packet sizes and transmission periods which can arise for the different experiment modes/states are listed and cross-referenced with the mission phase.

2. COMMANDS

2.1 Command Definitions

DCIXS is a packetised command user conforming to the SMART 1 ICD-5001and EID-A rev 4.

A DCIXS command packet has the following structure:

Packet Header [Sect 2.1.1]	Command Data Field [sect 2.1.2]					
	Command Type	Qualifier	Register address / Function	Data	Further data as required Max 213 bytes	Packet Error Control CRC [sect 2.1.3]
0…….5	6	7	8	10…….11	12….	2 bytes

2.1.1 Packet Header

Length: 6 bytes

Format:

Packet ID				Packet sequence control		Packet length
Version number 3bits	Type 1 bit	Data Field header Flag 1 bit	Application Process 11bits	Segmentation Flags 2 bits	Source Sequence Count 14bits	16bits
000	1	0	011 1110 1110	11	Variable	Variable

2.1.2 Packet Command Data Field

Length: 6 bytes, or longer for patches and table loads.

See section 2.1.4

Command Byte Number	Size in bytes	Function
6	1	Command type
7	1	Qualifier
8-9	2	Register address / Function
10-11	2	Data
12…	N = Maximum 213	further data if required

2.1.3 Packet Error Control

Byte Number	Size in bytes	Function
12+N,12+N+1	2	A CRC code will be used for error control.

2.1.3.1 CRC 'C' Routine

```
/*
crc.c - routine to perform CRC check on a block of data. The CRC is the one
        commonly used in space systems and processed the most significant
        bit first

Calling sequence: crc(buf,len,ocrc)  where:

  buf    is the name of the array holding the data to check
  len    is the length of the data in 16 bit words
  oldcrc is the running total if multiple calls are used
*/
crc(buf,len,oldcrc)
  int buf[],len,oldcrc;
  {
  unsigned i,ax,bx,cx,dx;

  bx=oldcrc;
  for(i=0;i<len;i++)           /* do for each word in buffer */
    {
    dx=buf[i];                 /* fetch word from buffer */
    cx=16;                     /* count of bits */
    do{
      ax=bx^dx;
      dx<<= 1;
      bx<<= 1;
      if(ax>0x7fff)bx^= 4129;
      }while(--cx>0);
    }
    return(bx);
  }
```

2.1.4 Command Formats

2.1.4.1 System Diagnostics and repair

Name/ Database ID	**Command Type (decimal)**	**Qualifier**	**Address /Function**	**Data**	**Further Data**	**Instrument Mode Validity**	**Description/ Verification**
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
DUMMY X001C	1	Fixed 00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	Dummy command which only causes increment of command counter VERIFICATION: HK Packet TC Accepted - Byte 16 incremented
PATCH X100C 8bytes X101C 16bytes X102C 32bytes X103C 64bytes X104C 128bytes X105C 196bytes	2	Page Number 0 – 15	Patch Address	Actual Patch Length	Patch Data	Emergency Mode STANDBY OPERATING	Patch of processor RAM or EEPROM Use fixed length command X100C…..X105C of appropriate size and fill with zeroes as required. The on-board software 'actual patch length' only to determine how much data is to be loaded. VERIFICATION: DUMP from same location
DUMP X003C	3	Page Number 0 – 15	Dump Address	Dump Length	Not used	Emergency Mode STANDBY OPERATING	Dump of processor RAM or EEPROM VERIFICATION: Not applicable

Name/ Database ID	**Command Type (decimal)**	**Qualifier**	**Address /Function**	**Data**	**Further Data**	**Instrument Mode Validity**	**Description/ Verification**
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
GOTO X004C	4	Page Number 0 – 15	Dump Address	Fixed 0000h	Not used	Emergency Mode	Run on-board software from specified address VERIFICATION: Not applicable

2.1.4.2 Operating Mode selection

Name/ Database ID	**Command Type (decimal)**	**Qualifier**	**Address/ Function**	**Data**	**Further Data**	**Instrument Mode Validity**	**Description/ Verification**
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
EMODE X005C	5	Fixed 00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	Force transition to emergency mode VERIFICATION: Not applicable
OPERATING X006C	6	Fixed 00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Go to Operating Mode VERIFICATION: HK Packet TC Accepted - Byte 16 incremented HK Bytes 56 - 61 = TC bytes 6 -11 Mode - Byte 25 bit 0-3 =
STANDBY X007C	7	Fixed 00h	Fixed 0000h	Fixed 0000h	Not used	OPERATING	Go to Standby Mode VERIFICATION: HK Packet TC Accepted - Byte 16 incremented HK Bytes 56 - 61 = TC bytes 6 -11 Mode - Byte 25 bit 0-3 =
TEST X008C	8	Fixed 00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Go to Test Mode VERIFICATION: HK Packet TC Accepted - Byte 16 incremented HK Bytes 56 - 61 = TC bytes 6 -11 Mode - Byte 25 bit 0-3 =

2.1.4.3 DCIXS Science Data Processing Mode

Name/ Database ID	**Command Type (decimal)**	**Qualifier**	**Address/ Function**	**Data**	**Further Data**	**Instrument Mode Validity**	**Description**
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
SCI_SUBMODE X009C	9	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	Select DCIXS Science Submode with Fixed Time-Tagged Events VERIFICATION: HK Packet TC Accepted - Byte 16 incremented HK Bytes 56 - 61 = TC bytes 6 -11 Mode - Byte 25 bits 4-7 = 0000
	9	01h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	Select DCIXS Science Submode with Low Count Spectra VERIFICATION: HK Packet TC Accepted - Byte 16 incremented HK Bytes 56 - 61 = TC bytes 6 -11 Mode - Byte 25 bits 4-7 = 0001
	9	02h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	Select DCIXS Science Submode with High Count Spectra VERIFICATION: HK Packet TC Accepted - Byte 16 incremented HK Bytes 56 - 61 = TC bytes 6 -11 Mode - Byte 25 bits 4-7 = 0010

Name/ Database ID	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
	9	03h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	Select DCIXS Science Submode with Autoformat VERIFICATION: HK Packet TC Accepted - Byte 16 incremented HK Bytes 56 - 61 = TC bytes 6 -11 Mode - Byte 25 bits 4-7 = 00011
	9	04h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	Select DCIXS Science Submode with Compressed low count spectra VERIFICATION: HK Packet TC Accepted - Byte 16 incremented HK Bytes 56 - 61 = TC bytes 6 -11 Mode - Byte 25 bits 4-7 = 0100

2.1.4.4 Instrument On/Off Commands

These commands enable the XSM and DCIXS instruments to be operated independently

Name/ Database ID	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		

Name/ Database ID	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
DCIXS_ON X010C	10	00h	Fixed 0000h	Fixed 0000h	Not used	OPERATING	Turns on DCIXS instrument SCD FPGA power and Science TM VERIFICATION: HK Packet TC Accepted - Byte 16 incremented HK Bytes 56 – 61 = TC bytes 6 -11
DCIXS_OFF X011C	11	00h	Fixed 0000h	Fixed 0000h	Not used	OPERATING	Turns off DCIXS instrument SCD FPGA power and Science TM VERIFICATION: HK Packet TC Accepted - Byte 16 incremented HK Bytes 56 – 61 = TC bytes 6 -11
DELETED X012C							
XSM_OFF X013C	13	00h	Fixed 0000h	Fixed 0000h	Not used	OPERATING	Turns off XSM instrument 12V, 5V and TM VERIFICATION: HK Packet TC Accepted - Byte 16 incremented HK Bytes 56 – 61 = TC bytes 6 -11

2.1.4.5 Processor Commands

Name/ Database ID	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
RAM_TABLE X110C 8bytes X111C 16bytes X112C 32bytes X113C 64bytes X114C 128bytes X115C 196bytes	14	Table ID 00h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 00h Load WGA Length Table Fill with zeroes to fixed length as required
	14	Table ID 01h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 01h Load WGA Vector Table Fill with zeroes to fixed length as required
	14	Table ID 02h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 02h Load WGA tables Table Fill with zeroes to fixed length as required
	14	Table ID 03h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 03h Load WGA Registers Table Fill with zeroes to fixed length as required
	14	Table ID 04h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 04h Load BB registers Table Fill with zeroes to fixed length as required
	14	Table ID 05h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 05h Load FPGA Table Fill with zeroes to fixed length as required
	14	Table ID 06h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 06h Load Software Parameter Table Fill with zeroes to fixed length as required

Name/ Database ID	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
MAX EVENT RATE X014C	14	Table ID 06h	0008	0001	FFFFh	STANDBY OPERATING	Specific software parameter load to set the allowable DCIXS detector maximum event rate to maximum to prevent detector being disabled when operating room temperature

Name/ Database ID	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
EEP_TABLE X110C 8bytes X111C 16bytes X112C 32bytes X113C 64bytes X114C 128bytes X115C 196bytes	15	Table ID 00h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 00h Load WGA Length Table Fill with zeroes to fixed length as required
	15	Table ID 01h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 01h Load WGA Vector Table Fill with zeroes to fixed length as required
	15	Table ID 02h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 02h Load WGA tables Table Fill with zeroes to fixed length as required
	15	Table ID 03h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 03h Load WGA Registers Table Fill with zeroes to fixed length as required
	15	Table ID 04h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 04h Load BB registers Table [Section 2.2.1] Fill with zeroes to fixed length as required
	15	Table ID 05h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 05h Load FPGA Table [Section 2.2.2] Fill with zeroes to fixed length as required
	15	Table ID 06h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 06h Load Software Parameter Table [Section 2.2.3] Fill with zeroes to fixed length as required
	15	Table ID 07h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 07h Load Analogue HK limits Table [Section 2.2.4] Fill with zeroes to fixed length as required

Name/ Database ID	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	15	Table ID 08h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 08h Load Offset/ADC Transfer Function Table [Section 2.2.5] Fill with zeroes to fixed length as required
	15	Table ID 09h	Address Offset	Actual No. of words	Table data	STANDBY OPERATING	Qualifier = Table ID = 09h Load Offset Nulling Reference Table [Section 2.2.6] Fill with zeroes to fixed length as required

Name/ Database ID	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
CPY_TABLE X016C	16	Table ID	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Copy a parameter table from EEPROM to RAM Qualifier Byte 7 identifies Table
	16	FFh	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Table ID = FFh Copies ALL tables

2.1.4.6 Radiation Shield Actuator Commands

Name/ Database ID	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
DCIXS_DOOR X017	17	00h	Maximum Steps	Step Size	Not used	STANDBY OPERATING	Full Steps – Ignore Switches – Close
	17	20h	Maximum Steps	Step Size	Not used	STANDBY OPERATING	Full Steps – Ignore Switches – Open
	17	40h	Maximum Steps	Step Size	Not used	STANDBY OPERATING	Full Steps – Observe Switches – Close
	17	60h	Maximum Steps	Step Size	Not used	STANDBY OPERATING	Full Steps – Observe Switches – Open
	17	80h	Maximum Steps	Step Size	Not used	STANDBY OPERATING	Half Steps – Ignore Switches – Close
	17	A0h	Maximum Steps	Step Size	Not used	STANDBY OPERATING	Half Steps – Ignore Switches – Open

Name/ Database ID	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	17	C0h	Maximum Steps	Step Size	Not used	STANDBY OPERATING	Half Steps – Observe Switches – Close
	17	E0h	Maximum Steps	Step Size	Not used	STANDBY OPERATING	Half Steps – Observe Switches – Open
XSM_SHUTR X018C	18	Fixed 00h	Fixed 0000h	Fixed 0000h	Not used	OPERATING	Close XSM Shutter
	18	Fixed 01h	Fixed 0000h	Fixed 0000h	Not used	OPERATING	Open XSM Shutter
OPEN_LATCH X019C	19	Fixed 00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Open DCIXS Radiation Pin-Puller Latch
ENBL_LATCH X020C	20	Fixed D6h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Enable DCIXS Radiation Pin-Puller Latch Circuit
	20	Fixed 00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Disable DCIXS Radiation Pin-Puller Latch Circuit

2.1.4.7 Direct Commands

**********THESE COMMANDS ARE FOR EMERGENCY DIAGNOSTIC USE ONLY********

Name	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
XSM_DATA X021C	21	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	STOP acquisition of XSM data
	21	01h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	START acquisition of XSM data
SET_PELTIER X022C	22	00h	Fixed 0000h	data	Not used	STANDBY OPERATING	Set target temperature for Peltier cooler
ENBL_BIAS X023C	23	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	Disable the XSM HV bias
	23	01h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	Enable the XSM HV bias
PELTIER_PWR X024C	24	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	Switch Peltier cooler OFF
	24	01h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	Switch Peltier cooler ON
BIAS_OVERRIDE X025C	25	00h	Fixed 0000h	data	Not used	STANDBY OPERATING	Load pattern in XSM bias override register
XSM_THRES X026C	26	00h	Fixed 0000h	data	Not used	STANDBY OPERATING	Set threshold for XSM photon events
XSM_12V X027C	27	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	XSM 12V power OFF

Name	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
	27	01h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	XSM 12V power ON
SCD_BANK1 X028C	28	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	DCIXS SCD Bank 1 OFF
	28	01h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	DCIXS SCD Bank 1 ON
SCD_BANK2 X029C	29	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	DCIXS SCD Bank 2 OFF
	29	01h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	DCIXS SCD Bank 2 ON
WGA_COMMAND X030C	30	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	STOP SCD Readout Waveform Generator
	30	01h	Fixed 0000h	Fixed 0000h	Not used	STANDBY OPERATING	START SCD Readout Waveform Generator
LOAD_FPGA X031C	31	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Load SCD FPGA device from table
LOAD_3D+ X032C	32	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Load SCD 3D+ device from table
LOAD_WGA X033C	33	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Load SCD WGA device from table and start it running
CKSUM X034C	34	Page 00-0Fh	Address	Length in words	Not used	STANDBY	Calculate checksum over memory area given
EEP_PROT X035C	35	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Disable EEPROM writing

Name	Command Type (decimal)	Qualifier	Address/ Function	Data	Further Data	Instrument Mode Validity	Description
	Byte 6	**Byte 7**	**Bytes 8-9**	**Bytes 10-11**	**Bytes 12 …**		
	35	01h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Enable EEPROM writing
	35	02h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Disable EEPROM completely
	35	03h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	Enable EEPROM
BB_CAL X036C	36	00h	Fixed 0000h	Fixed 0000h	Not used	OPERATING	Burr-Brown (3D+) Offset calibration
XSM_ANL_ON X037C	37	00h	Fixed 0000h	Fixed 0000h	Not used	OPERATING	XSM Annealing ON
XSM_ANL_OFF X038C	38	00h	Fixed 0000h	Fixed 0000h	Not used	OPERATING	XSM Annealing OFF
CIX_ANL_ON X039C	39	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	DCIXS Annealing ON
CIX_ANL_OFF X040C	40	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	DCIXS Annealing OFF
CIX_ANL_ENB X041C	41	01h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	DCIXS Annealing ENABLE
	41	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	DCIXS Annealing DISABLE
XSM_CALIB X042C	42	00h	Fixed 0000h	Fixed 0000h	Not used	STANDBY	XSM Calibration

2.2 Parameter Tables

2.2.1 Table 4 Burr-Brown ADC Parameters

Parameter	Default
00 Bank1 chan A-C configuration	0
01 Bank1 chan A offset	0
02 Bank1 chan B offset	0
03 Bank1 chan C offset	0
04 Bank1 chan A gain	1Eh
05 Bank1 chan B gain	1Eh
06 Bank1 chan C gain	1Eh
07 Bank1 chan D-F configuration	0
08 Bank1 chan D offset	0
09 Bank1 chan E offset	0
0A Bank1 chan F offset	0
0B Bank1 chan D gain	1Eh
0C Bank1 chan E gain	1Eh
0D Bank1 chan F gain	1Eh
0E Bank1 chan G-I configuration	0
0F Bank1 chan G offset	0
10 Bank1 chan H offset	0
11 Bank1 chan I offset	0
12 Bank1 chan G gain	1Eh
13 Bank1 chan H gain	1Eh
14 Bank1 chan I gain	1Eh
15 Bank1 chan J-L configuration	0
16 Bank1 chan J offset	0
17 Bank1 chan K offset	0
18 Bank1 chan L offset	0
19 Bank1 chan J gain	1Eh
1A Bank1 chan K gain	1Eh
1B Bank1 chan L gain	1Eh
1C Bank2 chan A-C configuration	0
1D Bank2 chan A offset	0
1E Bank2 chan B offset	0
1F Bank2 chan C offset	0
20 Bank2 chan A gain	1Eh
21 Bank2 chan B gain	1Eh
22 Bank2 chan C gain	1Eh
23 Bank2 chan D-F configuration	0
24 Bank2 chan D offset	0
25 Bank2 chan E offset	0
26 Bank2 chan F offset	0
27 Bank2 chan D gain	1Eh
28 Bank2 chan E gain	1Eh

Parameter	Default
29 Bank2 chan F gain	1Eh
2A Bank2 chan G-I configuration	0
2B Bank2 chan G offset	0
2C Bank2 chan H offset	0
2D Bank2 chan I offset	0
2E Bank2 chan G gain	1Eh
2F Bank2 chan H gain	1Eh
30 Bank2 chan I gain	1Eh
31 Bank2 chan J-L configuration	0
32 Bank2 chan J offset	0
33 Bank2 chan K offset	0
34 Bank2 chan L offset	0
35 Bank2 chan J gain	1Eh
36 Bank2 chan K gain	1Eh
37 Bank2 chan L gain	1Eh

2.2.2 Table 5 Detector FPGA Parameters

Parameter	Default
00 00 Bank1 channel A threshold	125
01 01 Bank1 channel B threshold	FFFh
02 02 Bank1 channel C threshold	FFFh
03 03 Bank1 channel D threshold	FFFh
04 04 Bank1 channel E threshold	125
05 05 Bank1 channel F threshold	125
06 06 Bank1 channel G threshold	125
07 07 Bank1 channel H threshold	125
08 08 Bank1 channel I threshold	125
09 09 Bank1 channel J threshold	125
10 0A Bank1 channel K threshold	125
11 0B Bank1 channel L threshold	125
12 0C Bank1 event reject level	3F00h
13 0D Bank1 discriminator mode	0002h
14 0E Bank1 deleted	-1
15 0F Bank1 counters control – enabled	3
16 10 Bank1 BB registers – see 2.2.1	-1
17 11 Bank1 OD DAC	0072h
18 12 Bank1 RD DAC	0062h
19 13 Bank1 power control (all on)	0Fh
20 14 Bank2 channel A threshold	125
21 15 Bank2 channel B threshold	125
22 16 Bank2 channel C threshold	125
23 17 Bank2 channel D threshold	125
24 18 Bank2 channel E threshold	125
25 19 Bank2 channel F threshold	125
26 1A Bank2 channel G threshold	125
27 1B Bank2 channel H threshold	125
28 1C Bank2 channel I threshold	125
29 1D Bank2 channel J threshold	125
30 1E Bank2 channel K threshold	125
31 1F Bank2 channel L threshold	125
32 20 Bank2 event reject level	3F00h
33 21 Bank2 discriminator mode	0002h
34 22 Bank2 deleted	-1
35 23 Bank2 counters control – enabled	3
36 24 Bank2 BB registers – see 2.2.1	-1
37 25 Bank2 Output gate	009Dh
38 26 Bank2 Substrate	00D0h
39 27 Bank2 power control (all on)	0Fh

Threshold changed to 125 (from 175) for version 4.2 software onwards

2.2.3 Table 6 Software Parameters

Word	Bit	Default
00 HK packet generation interval Value Seconds 0 = 1 1 = 4 2 = 16 3 = 64 4 = 256 5 = 1024 6 = 1024 7 = 1024		3 = 64s
01 activation period for latch heater in seconds		4,
02 Software options flags:		6900h
	bit 15 1-> enable test CAN pkts 0 -> disable	0
	bit 14 1-> CRC in TM, 0-> no CRC in TM	1
	bit 13 1-> use XSM in sci mode 0-> no XSM	1
	bit 12 1->keep XSM shutter closed until commanded open 0-> Open when run-up complete	0
	bit 11 1-> do XSM cal 0-> no XSM calibration	1
	bit 10 1-> switch off XSM after anneal 0-> restart	0
	bit 09 1-> CIXS door close follows XSM shutter	0
	bit 08 1-> enable servo for SS/OG/RD/OD DACs	1
03 integration time/s for high count spectra		64
04 max event count for time tagged format		180
05 min event count to stay in lunar spectrum fmt		150
06 SCD1 detectors to omit from spectra Det0 in bit 0		Eh
07 SCD2 detectors to omit from spectra Det 12 in bit 0		0
08 Total event count threshold for disabling detectors		1024
09 number of bad detectors to trigger door close		16
10 number of bad detectors below which door opened		0
11 number of (half) steps for autonomous door movement		400h
12 stepsize,flags for autonomous door movements		1003h
13 target stepsize, decrement, for autonomous door movement (V4.0 s/w onwards)–		1000h
14 Delay from offset cal to detector check (V4.0 s/w onwards)		32

Word	Bit	Default
15 Patch ID (V4.0 s/w onwards)		0
16 PIN leakage above which door close ordered		32767
17 d/dt of PIN leakage above which door closed		32767
18 Min. number of minutes to keep door shut		FFFFh
19 temperature limit for annealing – 125C		182
20 SS monitor target ADC reading (1.6V)		5298
21 OG monitor target ADC reading ()		4960
22 RD monitor target ADC reading ()		7140
23 OD monitor target ADC reading ()		4814
24 SS monitor tolerance (6.1mV)		20
25 OG monitor tolerance (2.44mV)		8
26 RD monitor tolerance (9.8mV)		32
27 OD monitor tolerance (24.4mV		80
28 no. off steps below 0 to set mean noise event		2
29 Interval in seconds for 3D+ offset calibrations		256
30 spare		0
31 spare		0
32 XSM default Peltier Target Temp DAC o/p (-8.1C)		102
33 XSM default Discriminator Threshold (.5V)		26
34 XSM max. det temp to keep HV bias on (0 deg C)		35
35 XSM total count threshold. for spectrum transmission		4
36 XSM delta leakage current thres. for annealing		9
37 XSM max leakage curr. at end of calibration		16
38 XSM leakage current settling time in seconds		60
39 XSM number shutter pulses for autonomous activation		2
40 XSM max safe PIN tempr for bias switch-on (-2C)		41
41 XSM calibration integration time in seconds		400
42 XSM number of times to try shutter open/close		2
43 XSM Delta Leakage current in no annealing case		7
44 XSM margin for excess leakage current in calibration		2
45 XSM annealing period in seconds		18000
46 XSM leakge currnt settling time(s) for annealing		
47 XSM spare		0
48 increment for shut-door integrator v4.0		1
49 decrement for shut-door integrator v4.0		3
50 limit for shut-door integrator v4.0		3
51 Start-rest temperature (-9C) v4.3		6368
52 end-rest temperature (-12C) v4.0		6590
53 integration period for low-count spectra v4.0		8
54 period to collect det 23 data in TT mode v4.0		32

Word	Bit	Default
55 variable HK entry v4.1		0A72h
56 ITL ID (set by ground command) v4.3		0

2.2.4 Table 7 Analogue HK limits

Parameter	Lower	Upper	Action
00 XSM prm 0: PSU_TEMP	-32767	32767	None
02 XSM prm 1: +12 volt monitor	-32767	32767	None
04 XSM prm 2: -12 volt monitor	-32767	32767	None
06 XSM prm 3: PIN detector temperature	-32767	32767	None
08 XSM prm 4: Detector box temperature	-32767	32767	None
0A XSM prm 5: HV bias voltage	-32767	32767	None
0C XSM prm 6: Leakage current	-32767	32767	None
0E XSM prm 7: not used	-32767	32767	None
10 prm 0: PSU_TEMP – glued to ART2812	-32767	32767	None
12 prm 1: CAN_TEMP – on CAN card	-32767	32767	None
14 prm 2: -Yplate_TEMP – backplane face	2862	32767	Go to STANDBY Mode
16 prm 3: VIDEO_TEMP – digital video tempr	-32767	32767	None
18 prm 4: VIDEO1_TEMP – 3D+ bank 1 tempr	01165	32767	Go to STANDBY Mode
1A prm 5: VIDEO2_TEMP – 3D+ bank 2 tempr	01165	32767	Go to STANDBY Mode
1C prm 6: SCD1_TEMP – SCD column B tempr	2862	32767	Go to STANDBY Mode
1E prm 7: SCD2_TEMP – SCD column E tempr	2862	32767	Go to STANDBY Mode
20 prm 8: 12V – 12 volt rail voltage	-32767	32767	None
22 prm 9: 5V - 5 volt rail voltage	-32767	32767	None
24 prm 10: 3.3V – 3.3 volt rail votage	-32767	32767	None
26 prm 11: PELTIER_V – Peltier supply vlts	-32767	32767	None
28 prm 12: -12V - -12 volt rail voltage	-32767	32767	None
2A prm 13: -5V - -5 volt rail votage	-32767	32767	None
2C prm 14: MTR_P1 – motor phase 1 voltage	-32767	32767	None
2E prm 15: MTR_P2 – motor phase 2 voltage	-32767	32767	None
30 prm 16: SS_VMON – SCD substrate voltage	-32767	32767	None
32 prm 17: OG_VMON – SCD o/p gate voltage	-32767	32767	None
34 prm 18: RSTD_VMON – SCD reset drain vlts	-32767	32767	None
36 prm 19: OPD_VMON – SCD o/p drain voltage	-32767	32767	None
38 prm 20: 32V_MON – 32 V supply voltage	-32767	32767	None
3A prm 21: 0V – spare input connected to 0V	-32767	32767	None
3C not used	-32767	32767	None
3E not used	-32767	32767	None

2.2.5 Table 8 offset conversion factors

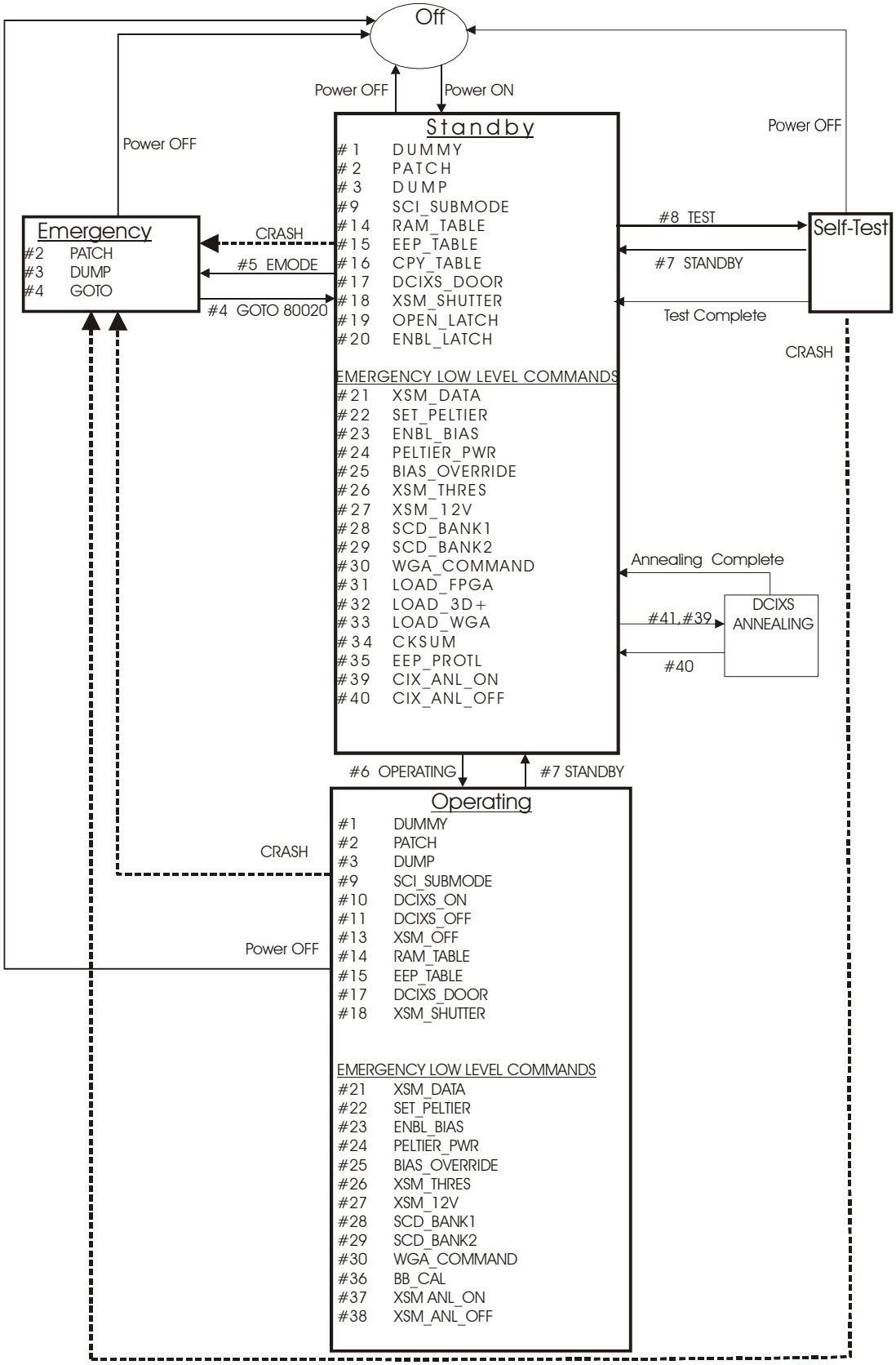
det 00	1770
det 01	1718
det 02	1732
det 03	1774
det 04	1812
det 05	1764
det 06	1753
det 07	1903
det 08	1838
det 09	1785
det 10	1743
det 11	1863
det 12	1791
det 13	1876
det 14	1797
det 15	1771
det 16	1843
det 17	1906
det 18	1834
det 19	1800
det 20	1826
det 21	1912
det 22	1859
det 23	1828

2.2.6 Table 9 offset Nulling References

det 00	180h
det 01	168h
det 02	168h
det 03	180h
det 04	168h
det 05	168h
det 06	168h
det 07	168h
det 08	168h
det 09	168h
det 10	168h
det 11	168h
det 12	168h
det 13	168h
det 14	168h
det 15	168h
det 16	168h
det 17	168h
det 18	168h
det 19	168h
det 20	168h
det 21	168h
det 22	168h
det 23	168h

2.3 Command Mode Validity

The instrument modes are shown below with each box containing the valid commands and the linking arrows the mode transition commands. The commands are identified by Type no and Name.



2.4 Time-tagged Command Budget

All commands are 14bytes long which includes 6 bytes command and 8 bytes PUS packet header and CRC.
In the event of anomalous operations requiring a memory patch the command length be longer.

Phase	Time-tagged commands
Cruise	100 /4 days
Lunar Observation	16 /4 days

During lunar observation we would in principle just command the instrument into a observation state and leave it run for 6 months.
This is based on a simple situation where the spacecraft is continuously pointing at the moon and there are no regular manoeuvres to view stars for example.

There will be a lunar observation commissioning phase during which we will assess the thermal balance and adjust our operational state to ensure the detectors are cold enough.

With no routine commanding identified at the moment the budget for 16 /4 days during lunar phase gives 4 commands/orbit which should the enable shield closures to be commanded at positions round the orbit.

3. TELEMETRY

The data is formatted as follows:

Header [Sect 3.1]	Telemetry Data Field [sect 3.2]			
	Packet Time [sect 3.2.1]	Data Type [sect 3.2.1]	Data [sect3.3]	Packet Error Control CRC [sect 3.2.3]
0…….5	6……11	12	13….271	278279

3.1 Source Packet Header

Length: 6 bytes

Format:

Packet ID				Packet sequence control		Packet length
Version number 3bits	Type 1 bit	Data Field header Flag 1 bit	Application Process APID 11bits	Segmentation Flags 2 bits	Source Sequence Count 14bits	16bits
000	0	0	0x3EEh or 0x3EFh	11	Variable	Variable

3.1.1 Application IDs

APID	Data Formats
3EEh 1006d	Science data packets and memory dump Data Types 1 2 3 4 5
3EFh 1007d	'Quick-Look Data' – Housekeeping Data Type 0

3.2 Packet Data Field

DCIXS packets are of fixed length with a modified data header for compatibility with existing EGSE.

Data Field Length: 274 bytes.

Sub Fields:
- Data header: 7 bytes
- Data: 265 bytes
- Checksum: 2 bytes

3.2.1 Data Header

Length: 7 bytes

Format:

Packet Time	6 bytes
Data Type	1 byte

Time definition:

Spacecraft Time in Seconds (4bytes)	1/65536 sec units (2bytes)

Data Type definition:

Value	Data Type
0	Housekeeping
1	DCIXS Time tagged events
2	DCIXS Low Count Spectrum
3	DCIXS High Count Spectrum
4	XSM sensor
5	Memory Dump
6	DCIXS Compressed Low Count Spectrum
7	DCIXS SCD Test
8	DCIXS Auxiliary Data
9	DCIXS Auxiliary Data - Detector Means

3.2.2 Data

Length: 265 bytes

DCIXS system has 3 possible data gathering states each with different data packet formats: types 1 2 and 3.

The XSM system has one format.

The two detector systems will be operating simultaneously and packets will be transmitted from both.

3.2.3 Packet Error Control

Length: 2 bytes

A CRC code or checksum will be used for error control.

3.3 Data Formats

3.3.1 Data Type 0: Housekeeping Data [APID=3EFh 1007d]

The housekeeping data is collected and transmitted every 64s.

The experiment housekeeping packet will be of standard length and of the following form.

	Start Byte	Length	Bit	ID	Comment/Calibration
Header	0	6		Header	
	6	6		Packet Time	
	12	1		Data Type	
	13	1		HK Packet Count	
Software Status	14	1		TC error flags	
	15	1		Software Version	
	16	1		TCs Accepted Count	
	17	1		TCs rejected Count	
	18	1		TC Error Code	
	19	1		Software Flags, low byte	
	20	2		Received CRC from last TC packet with bad CRC	
	22	2		Calculated CRC from last TC packet with bad CRC	
	24	1		Door State	
	25		0 - 3	Mode	
	25		4-7	Submode	
	26	2		Max CAN packets in Output queue this HK period	
	28	2		Last calculated time adjustment (high word)	
	30	2		Last calculated time adjustment (low word)	
	32	2		Last calculated time adjustment (fraction)	
	34	2		Worst background elapsed time this HK period	
	36	2		Worst idle loop count this HK period	
	38	2		Count of times CAN TX not ready	

	Start Byte	Length	Bit	ID	Comment/Calibration
	40	2		Count of lost TM PUS packets	
	42	1		Return Stack pointer	
	43	1		Parameter stack pointer	
	44	2		EEPROM write retries	
	46	2		EEPROM write failures	
	48	4		Seconds remaining of minimum door closed interval	
	52	1		Software flags, high byte. v4.0	
	53	1		Door close integrator. v4.0	
	54	1		Seconds since last calibration. v4.1	
	56	1		Last TC Type	
	57	1		Last TC qualifier	
	58	2		Last TC Address/function	
	60	2		Last TC first data word	
	62	1		Last but 1 TC Type	
	63	1		Last but 1 TC qualifier	
	64	2		Last but 1 TC Address/function	
	66	2		Last but 1 TC first data word	
DCIXS Detector Status	68	1		Sensor 16-23 inhibit	'1' = inhibit '0' = enabled
	69	1		Sensor 8-15 inhibit	'1' = inhibit '0' = enabled
	70	1		Sensor 0-7 inhibit	'1' = inhibit '0' = enabled
	71	1		Power monitor	
	72	2		BANK 1 Channel A Event Count	
	74	2		BANK 1 Channel B Event Count	
	76	2		BANK 1 Channel C Event Count	
	78	2		BANK 1 Channel D Event Count	
	80	2		BANK 1 Channel E Event Count	
	82	2		BANK 1 Channel F Event Count	
	84	2		BANK 1 Channel G Event Count	
	86	2		BANK 1 Channel H Event Count	

	Start Byte	Length	Bit	ID	Comment/Calibration
	88	2		BANK 1 Channel I Event Count	
	90	2		BANK 1 Channel J Event Count	
	92	2		BANK 1 Channel K Event Count	
	94	2		BANK 1 Channel L Event Count	
	96	2		BANK 2 Channel A Event Count	
	98	2		BANK 2 Channel B Event Count	
	100	2		BANK 2 Channel C Event Count	
	102	2		BANK 2 Channel D Event Count	
	104	2		BANK 2 Channel E Event Count	
	106	2		BANK 2 Channel F Event Count	
	108	2		BANK 2 Channel G Event Count	
	110	2		BANK 2 Channel H Event Count	
	112	2		BANK 2 Channel I Event Count	
	114	2		BANK 2 Channel J Event Count	
	116	2		BANK 2 Channel K Event Count	
	118	2		BANK 2 Channel L Event Count	
XSM Analogue HK	120	2		XSM +5V monitor	Volts = Count *****10/256
	122	2		XSM +12V monitor	Volts = Count *****14.968/255
	124	2		XSM -12V monitor	Volts = -(Count +1.606)/20.08
	126	2		XSM PIN detector temperature	Temp C = - Count*0.21875
	128	2		XSM Detector Box temperature	Temp C = Count * 3.90625 - 273
	130	2		XSM HV Bias Voltage	Volts = Count *1.5625
	132	2		XSM Leakage Current	pA = Count * 0.78125
DCIXS Analogue HK	134	2		DC Converter Temperature	See section 3.3.1.1
	136	2		CAN/HK PCB Temperature	See section 3.3.1.1
	138	2		-Y plate Temperature	See section 3.3.1.1
	140	2		Video Digital PCB temperature	See section 3.3.1.1
	142	2		VIDEO1 3D+ temperature	See section 3.3.1.1
	144	2		VIDEO2 3D+ temperature	See section 3.3.1.1

	Start Byte	Length	Bit	ID	Comment/Calibration
	146	2		SCD column B temperature	See section 3.3.1.1
	148	2		SCD column E temperature	See section 3.3.1.1
	150	2		12V regulated supply	Volts = Count * 5.525*0.0003052
	152	2		5V regulated supply	Volts = Count * 2.361*0.0003052
	154	2		3.3V regulated supply	Volts = Count * 2*0.0003052
	156	2		XSM Peltier supply voltage	Volts = Count *0.0003052
	158	2		-12V regulated supply	Volts = - (65536-Count) * 5.525*0.0003052
	160	2		-5V regulated supply	Volts = - (65536-Count) * 2.361*0.0003052
	162	2		Motor Phase 1 voltage	
	164	2		Motor Phase 2 voltage	
	166	2		SCD Substrate Voltage Monitor [SS_VMON]	Volts = Count * 5.545*0.0003052
	168	2		SCD Output Gate Voltage Monitor [OG_VMON]	Volts = Count * 2*0.0003052
	170	2		SCD Reset Drain Voltage Monitor [RSTD_VMON]	Volts = Count * 7.818*0.0003052
	172	2		SCD Output Drain Voltage Monitor [OPD_VMON]	Volts = Count * 20.545*0.0003052
	174	2		32V supply voltage [32V_VMON]	Volts = Count * 20.545*0.0003052
	176	2		0V	
	178	1		**Door Mechanism Status**	
			bit 0	not used	
			bit 1	Launch Lock Latch Enabled	'1' = enabled
			bit 2	Launch Lock Bypass Enabled	'1' = enabled
			bit 3	Launch Lock Latch Open = 1 [SW1]	'1' = true
			bit 4	Launch Lock Latch Closed = 1 [SW2]	'1' = true
			bit 5	Door Motor Running	'1' = true
			bit 6	Door Open	'1' = true
			bit 7	Door Closed	'1' = true
	179	1		Spare	

	Start Byte	Length	Bit	ID	Comment/Calibration
	180	2		Door Motor Step Count	
	182	1		**XSM Control Status**	
			bit 0 MSB	Not used	
			bit 1	Not used	
			bit 2	Not used	
			bit 3	Peltier On/Off	1 = On 0 = Off
			bit 4	Shutter	1 = Open 0 = Closed
			bit 5	HV Bias on/off :	1= on 0 = off
			bit 6	HV Override Enable:	'1' = enabled '0' = Disabled
			bit 7 LSB	FIFO write Enable:	'1' = enabled '0' = Disabled
	183	1		**XSM Status**	
			bit 0 MSB	Not used	
			bit 1	Not used	
			bit 2	Not used	
			bit 3	Shutter Open	'1' = true
			bit 4	Shutter Closed	'1' = true
			bit 5	Detector Overtemp HV should be switched down	
			bit 6	HV bias overvoltage HV should be switched down	
			bit 7 LSB	ADC Conversion complete	
	184	1		XSM DAC 0 (last value written to DAC)	
	185	1		XSM DAC 1 (last value written to DAC)	
	186	2		XSM State	
	188	2		XSM second counter	
	190	2		Software Patch ID v4.0	
3D+	192	2		SS DAC Monitor Average	
	194	2		OG DAC Monitor Average	
	196	2		RD DAC Monitor Average	
	198	2		OD DAC Monitor Average	
	200	1		SS DAC demand	

	Start Byte	Length	Bit	ID	Comment/Calibration
	201	1		OG DAC demand	
	202	1		RD DAC demand	
	203	1		OD DAC demand	
	204	2		Not used	
	206	2		Milliseconds lost to 3D+ offset adjustment	
	208	2		Most events/sec this period	
	210	4		Memory checksums	
	214	2		Data in address pointed to by table 6 param 55. v4.1	
	216	2		ITL ID table 6 parameter 56. v4.3	
	---	-		Spare	
	278	2		CRC	
Total	280				

3.3.1.1 DCIXS Thermistor Calibration

°C	Counts
-80	8174
-79	8172
-78	8171
-77	8169
-76	8167
-75	8165
-74	8162
-73	8160
-72	8157
-71	8154
-70	8151
-69	8148
-68	8144
-67	8140
-66	8136
-65	8132
-64	8127
-63	8122
-62	8116
-61	8110
-60	8104
-59	8097
-58	8090
-57	8082
-56	8074
-55	8065
-54	8056
-53	8046
-52	8035
-51	8023
-50	8011
-49	7998
-48	7985
-47	7970
-46	7955
-45	7938
-44	7921
-43	7903
-42	7883
-41	7863

°C	Counts
-40	7841
-39	7818
-38	7794
-37	7769
-36	7742
-35	7714
-34	7684
-33	7654
-32	7621
-31	7587
-30	7551
-29	7513
-28	7474
-27	7433
-26	7390
-25	7346
-24	7300
-23	7251
-22	7201
-21	7149
-20	7095
-19	7039
-18	6980
-17	6920
-16	6858
-15	6794
-14	6728
-13	6660
-12	6590
-11	6518
-10	6444
-9	6368
-8	6290
-7	6211
-6	6130
-5	6048
-4	5963
-3	5878
-2	5791
-1	5702

°C	Counts
0	5613
1	5522
2	5429
3	5337
4	5243
5	5149
6	5055
7	4959
8	4863
9	4766
10	4670
11	4574
12	4478
13	4381
14	4286
15	4190
16	4095
17	4001
18	3907
19	3814
20	3722
21	3630
22	3540
23	3451
24	3363
25	3276
26	3191
27	3106
28	3023
29	2942
30	2862
31	2783
32	2706
33	2630
34	2557
35	2484
36	2414
37	2344
38	2277
39	2211

°C	Counts
40	2146
41	2083
42	2022
43	1962
44	1904
45	1847
46	1792
47	1738
48	1686
49	1635
50	1586
51	1538
52	1491
53	1446
54	1402
55	1359
56	1318
57	1278
58	1239
59	1202
60	1165
61	1129
62	1095
63	1061
64	1030
65	998
66	968
67	938
68	910
69	883
70	856
71	830
72	805
73	781
74	758
75	735
76	713
77	692
78	671
79	652

°C	Counts
80	632
81	614
82	596
89	485
90	471
91	458
92	445
93	432
94	420
95	408
96	397
97	385
98	375
99	364
100	354
101	345
102	335
103	326
104	317
105	308
106	300
107	292
108	284
109	277
110	269
111	262
112	255
113	248
114	242
115	236
116	230
117	224
118	218
119	212
120	207
121	201
122	196
123	191
124	187
125	182
126	177
127	173
128	169
129	164

°C	Counts
83	578
84	562
85	545

°C	Counts
86	529
87	514
88	499

130	160

3.3.2 Data type 1: DCIXS Time-Tagged Events [APID=3EEh 1006d]

Each X-ray event detected by any of the 24 detectors is time-tagged and the energy (signal count) measured. These data and the detector channel number are stored for 64 events and transmitted in one packet.

The event times are relative to the Start Time which is the full 6 byte on-board clock time of the first event in the packet.

Relative time is 12 bits split between two bytes and the LSbit = 1/16s

The data gathering time will vary according to event rate.

The longest time before the relative time counter rolls over is 256s

Start Byte.Bit	Length	ID
0	6	Header
6	6	Packet Time
12	1	Data Type
13	1	Not used
14	6 bytes	Event Start Time
20.0	5 bits	Detector Channel Number
20.6	3 bits	RICA Error Flags
21.0	1	Event Time in seconds
22.0	4 bits	Event Time 1/16seconds
22.4	12 bits	Detector Signal Count
24.0	5 bits	Detector Channel Number
24.6	3 bits	RICA Error Flags
25.0	1	Event Time in seconds
26.0	4 bits	Event Time 1/16seconds
26.4	12 bits	Detector Signal Count
~	~	~
272.0	5 bits	Detector Channel Number
273.0	3 bits	RICA Error Flags
272.6	1	Event Time in seconds
274.0	4 bits	Event Time 1/16seconds
274.4	12 bits	Detector Signal Count
276	2 bytes	Not used
278	2 bytes	Checksum
280	Data bytes	

3.3.3 Data type 2: DCIXS Low Count Spectrum [APID=3EEh 1006d]

Energy spectra are formed from each detector covering the full energy range. The spectrum is formed by grouping 8 adjacent A/D conversion levels to give 256 energy bands.

The maximum expected count in each band is 255

For each integration period which is commandable 24 'type 2' packets will be transmitted 1 packet for each spectrum.

Start Byte	Length	Parameter
0	6	Header
6	6	Packet Time
12	1	Data Type
13.0	3 bits	Not Used
13.3	5 bits	Detector Number
14	4	Integration Start time (seconds)
18	2	Not used
20	2	Integration Time (seconds) (s/w v4.0)
22	256	Spectrum data
278	2	Checksum
280		Data bytes

3.3.4 Data type 3: DCIXS High Count Spectrum [APID=3EEh 1006d]

Energy spectra are formed from each detector covering the full energy range. The spectrum is formed by grouping 8 adjacent A/D conversion levels to give 256 energy bands.

The counts in each band are transmitted as a 4bit Exponent 12 Mantissa

For each integration period which is commandable 48 'type 3' packets will be transmitted 2 packets for each spectrum.

Start Byte	Length	Parameter
0	6	Header
6	6	Packet Time
12	1	Data Type
13.0	1 bit	Flag - Bit=0 : Channels 0 -127 Bit=1 : Channels 128 -255
13.1	2 bits	Not Used
13.3	5 bits	Detector Number
14	4	Integration Start time (seconds)
18	2	Not Used
20	2	Integration Time (seconds)
22	256	Spectrum data
278	2	Checksum
280		Data bytes

3.3.5 Data types 4 : XSM Data [APID=3EEh 1006d]

A 512 channel spectrum is produced for each integration period of 16s. (The period may be changed by memory patch only) Each channel is stored in a Shift count and Mantissa Format described below.

Four of the following packets are transmitted per integration:

Integration time accuracy <1/64s

Shift count and Mantissa Format:

This format allows unsigned integers from 0 to 134184960 to be represented in a 16 bit number with and accuracy of no worse than one part in 2048 (~0.05%). the number is represented as a 12 bit mantissa an a 4 bit shift count:

bit	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
	Shift count (0-15)				Mantissa (0-4095)											

The shift count field gives the number of places that the mantissa must be shifted to the left to give the actual value. For numbers in the range 0-4095 the encoded value is the same as the raw value and no precision is lost.

Examples of encoding:

Number	In hex	shift count	Mantissa	Encoded value	Encoded value (hex)	Reconstructed value (hex)
0	0000	0	0	0	0000	0000
4095	0FFF	0	4095	4095	0FFF	0FFF
4096	1000	1	2048	6144	1800	1000
8193	1FFF	1	4095	8193	1FFF	1FFE
32768	8000	4	2048	18432	4800	8000
65535	FFFF	4	4095	20479	4FFF	FFF0
1048575	FFFFF	8	4095	36863	8FFF	FFF00

For counts of less than 4 million the error introduced by encoding is less than the statistical standard deviation.

Start Byte	Length	ID
0	6	Header
6	6	Packet Time
12	1	Data Type
13.0	2bits	Bits = 00 : Channels 0 -127 Bits = 01 : Channels 128 –255 Bits = 10 : Channels 256 -383 Bits = 11 : Channels 384 -511
13.2	1bit	Not used
13.3	1bit	Shutter Open '1' = true
13.4	1bit	Shutter Closed '1' = true
13.5	1bit	Detector Overtemp HV should be switched down
13.6	1bit	HV bias overvoltage HV should be switched down
13.7	1bit	ADC Conversion complete
14	4	Integration Start time (seconds)
18	2	Integration Time (seconds)
20	2	Not used

22	256	XSM Spectrum
278	2	Checksum

280 Data bytes

3.3.6 Data type 5: Memory Dump Data [APID=3EEh 1006d]

A memory dump packet is generated in response to a memory dump command. The data field is of standard length:

Start Byte	Length	ID
0	6	Header
6	6	Packet Time
12	1	Data Type
13	4	Spare
17	1	Page
18	2	Dump Address
20	2	Length
22	256	Memory Dump Data
278	2	Checksum

280 Data bytes

3.3.7 Data type 6: DCIXS Compressed Low Count Spectrum [APID=3EEh 1006d]

The compressed low count spectral format is generated by firstly producing a spectrum for each enabled detector and then concatenating up to 24 spectra for a single integration period before run length encoding the data at byte level.

3.3.7.1 The following table lists the spectral bin widths:

Width	Bin Numbers
8	0 to 96
12	97 to 144
16	145 to 176
20	177 to 200
24	201 to 224
32	225 to 244
48	245 to 254
56	255

3.3.7.2 Data format prior to encoding

Each detector shall use a 256 byte structure to contain the detector number and the 255 spectral bins, see following table.

Start Byte	Length	Parameter
0	1	Detector number
1	1	Spectral bin 0
.	.	.
.	.	.

.	.	.
256	1	Spectral bin 255

3.3.7.3 Description of run length encoding

If two consecutive bytes in the data are the same value then a third byte is added to give the number of times that that value occurs again. e.g.

data stream = 00,05,05,05,a0,b0,00,00,00,00,00,00,ff
is encoded to
rle = 00,05,05,01,a0,b0,00,00,04,ff

3.3.7.4 Telemetry Packet Format
The run length encoded data is packed into a sufficient number of telemetry packets, the telemetry packet fields are shown in the following table.

Start Byte	Length	Parameter
0	6	Header
6	6	Packet Time
12	1	Data Type
13	1	Integration time (seconds)
14	4	Integration start time (seconds)
18	2	bits 00:06 – Compressed data packet number (lsb is 0) bits 07:15 – no. bytes of compressed data in pkt
20	258	Compressed spectral data
278	2	Checksum

where:

Integration start time = the time current integration period started.
Integration time = Table 6, parameter 53
Compressed data packet number = sequential number commencing at 0 for this set of compressed data.

3.3.8 Data type 7: DCIXS SCD Test [APID=3EEh 1006d]
Data from SELF-TEST Mode - all 576 pixels readout from SCDs after long integration time
5 packets will be transmitted for each detector
The last packet will only contain data for 64 pixels and the remaining 64 words will be zero

Start Byte	Length	Parameter
0	6	Header
6	6	Packet Time
12	1	Data Type
13.0	3 bit	Bits = 000 : Pixels 0 -127 Bits = 001 : Pixels 128 –255 Bits = 010 : Pixels 256 -383 Bits = 011 : Pixels 384 -511 Bits = 101 : Pixels 512 -575
13.3	5 bits	Detector Number
14	8	Not used
22	256	Pixel data

Start Byte	Length	Parameter
278	2	Checksum
280		Data bytes

3.3.9 Data Type 8: Auxiliary Data [APID=3EEh 1006d]

The detector readout electronics configuration parameters are transmitted in this format.

It will be transmitted when an offset adjustment is performed every 256s.

The experiment auxiliary packet will be of standard length and of the following form.

Start Byte	Length	ID	Default Values
0	6	Header	
6	6	Packet Time	
12	1	Data Type	
13	1	Spare	
14	2	Bank1 chan A-C configuration	0x0
16	2	Bank1 chan A offset	0x200
18	2	Bank1 chan B offset	0x200
20	2	Bank1 chan C offset	0x200
22	2	Bank1 chan A gain	0
24	2	Bank1 chan B gain	0
26	2	Bank1 chan C gain	0
28	2	Bank1 chan D-F configuration	0x0
30	2	Bank1 chan D offset	0x200
32	2	Bank1 chan E offset	0x200
34	2	Bank1 chan F offset	0x200
36	2	Bank1 chan D gain	0
38	2	Bank1 chan E gain	0
40	2	Bank1 chan F gain	0
42	2	Bank1 chan G-I configuration	0x0
44	2	Bank1 chan G offset	0x200
46	2	Bank1 chan H offset	0x200
48	2	Bank1 chan I offset	0x200
50	2	Bank1 chan G gain	0
52	2	Bank1 chan H gain	0
54	2	Bank1 chan I gain	0
56	2	Bank1 chan J-L configuration	0x0
58	2	Bank1 chan J offset	0x200
60	2	Bank1 chan K offset	0x200
62	2	Bank1 chan L offset	0x200
64	2	Bank1 chan J gain	0
66	2	Bank1 chan K gain	0
68	2	Bank1 chan L gain	0
70	2	Bank2 chan A-C configuration	0x0
72	2	Bank2 chan A offset	0x200
74	2	Bank2 chan B offset	0x200
76	2	Bank2 chan C offset	0x200
78	2	Bank2 chan A gain	0

Start Byte	Length	ID	Default Values
80	2	Bank2 chan B gain	0
82	2	Bank2 chan C gain	0
84	2	Bank2 chan D-F configuration	0x0
86	2	Bank2 chan D offset	0x200
88	2	Bank2 chan E offset	0x200
90	2	Bank2 chan F offset	0x200
92	2	Bank2 chan D gain	0
94	2	Bank2 chan E gain	0
96	2	Bank2 chan F gain	0
98	2	Bank2 chan G-I configuration	0x0
100	2	Bank2 chan G offset	0x200
102	2	Bank2 chan H offset	0x200
104	2	Bank2 chan I offset	0x200
106	2	Bank2 chan G gain	0
108	2	Bank2 chan H gain	0
110	2	Bank2 chan I gain	0
112	2	Bank2 chan J-L configuration	0x0
114	2	Bank2 chan J offset	0x200
116	2	Bank2 chan K offset	0x200
118	2	Bank2 chan L offset	0x200
120	2	Bank2 chan J gain	0
122	2	Bank2 chan K gain	0
124	2	Bank2 chan L gain	0
126	2	Bank1 channel A threshold	0
128	2	Bank1 channel B threshold	0
130	2	Bank1 channel C threshold	0
132	2	Bank1 channel D threshold	0
134	2	Bank1 channel E threshold	0
136	2	Bank1 channel F threshold	0
138	2	Bank1 channel G threshold	0
140	2	Bank1 channel H threshold	0
142	2	Bank1 channel I threshold	0
144	2	Bank1 channel J threshold	0
146	2	Bank1 channel K threshold	0
148	2	Bank1 channel L threshold	0
150	2	Bank1 event reject level	0
152	2	Bank1 threshold mask	0x3
154	2	Bank1 summation mask	0x3
156	2	Bank1 counters control - enabled	1
158	2	Bank1 BB registers - see previous table	0x1F
160	2	Bank1 OD DAC	0x80
162	2	Bank1 RD DAC	0x80
164	2	Bank1 power control (all on)	0x0F
166	2	Bank2 channel A threshold	0
168	2	Bank2 channel B threshold	0

Start Byte	Length	ID	Default Values
170	2	Bank2 channel C threshold	0
172	2	Bank2 channel D threshold	0
174	2	Bank2 channel E threshold	0
176	2	Bank2 channel F threshold	0
178	2	Bank2 channel G threshold	0
180	2	Bank2 channel H threshold	0
182	2	Bank2 channel I threshold	0
184	2	Bank2 channel J threshold	0
186	2	Bank2 channel K threshold	0
188	2	Bank2 channel L threshold	0
190	2	Bank2 event reject level	0
192	2	Bank2 threshold mask	0x3
194	2	Bank2 summation mask	0x3
196	2	Bank2 counters control - enabled	1
198	2	Bank2 BB registers - see previous table	0x1F
200	2	Bank2 OD DAC	0x80
202	2	Bank2 RD DAC	0x80
204	2	Bank2 power control (all on)	0x0F
206	16	XSM Parameters	
222	48	Standard Deviations for the 24 signal channel Offset calibrations	
270	2	Time to last Offset calibration (1/1024s units)	
272	6	Spare	
278	2	Checksum	
280			

3.3.10 Data Type 9: Auxiliary Data - Detector Means [APID=3EEh 1006d]

The detector noise parameters are transmitted in this format.
It will be transmitted when an offset adjustment is performed every 256s.
A sample of the raw data for a detector is provided in the last 108 words. The data for each detector is provided as a sub-commuted data set with the detector number given in Byte 13
The packet will be of standard length and of the following form.

Start Byte	Length	ID	Default Values
0	6	Header	
6	6	Packet Time	
12	1	Data Type	
13	1	Raw Data Detector Number	
14	2	Detector #0 Mean	
16	2	Detector #1 Mean	
18	2	Detector #2 Mean	
20	2	Detector #3 Mean	

Start Byte	Length	ID	Default Values
22	2	Detector #4 Mean	
24	2	Detector #5 Mean	
26	2	Detector #6 Mean	
28	2	Detector #7 Mean	
30	2	Detector #8 Mean	
32	2	Detector #9 Mean	
34	2	Detector #10 Mean	
36	2	Detector #11 Mean	
38	2	Detector #12 Mean	
40	2	Detector #13 Mean	
42	2	Detector #14 Mean	
44	2	Detector #15 Mean	
46	2	Detector #16 Mean	
48	2	Detector #17 Mean	
50	2	Detector #18 Mean	
52	2	Detector #19 Mean	
54	2	Detector #20 Mean	
56	2	Detector #21 Mean	
58	2	Detector #22 Mean	
60	2	Detector #23 Mean	
62	218	108 samples from Detector identified in Byte #13	
278	2	Checksum	
280			

4. MISSION PHASE DATA RATES

The instrument has three basic conditions OFF STANDBY and 'Operating' which includes a SELF-TEST mode in addition to the OPERATIONAL mode. The only significant difference between the 'operating' modes and STANDBY is that the detectors are not being clocked and the solar monitor peltier coolers are off - hence the power is reduced.

The OPERATIONAL mode has 5 states which correspond to variations in data collection. The contents of the telemetry packets will vary according to mode and state selected.

The modes/states which are likely to be used in the Spacecraft modes are summarised in Table 4-1.

A detailed breakdown is given in sections 4.2 and 4.3 for the active operational detector modes.

Table 4-1 Experiment/Spacecraft Mode Correlation – Data rates

Instrument Mode	Spacecraft Mode / Instrument Data Format	Pre-Launch	LEOP	Safe	De-tumble	EP	Observation Inertial Staring	Observation Lunar Nadir Pointing
OFF		X	X	X	X	X	X	X
EMERGENCY	Memory dumps by command only	X					X	X
STANDBY	Housekeeping	X					X	X
	Auxiliary Data	X					X	X
SELF-TEST	SCD Pixel dumps	X					X	X
OPERATIONAL	DCIXS formats						X	X
	XSM						X	X
	Housekeeping	X					X	X
	Auxiliary Data	X					X	X

Table 4-2 Data Format Packet Numbers

Data Type No	Data Format	Packets /Format
0	Housekeeping	1
1	DCIXS Time tagged events	1 = 64 events
2	DCIXS Low Count Spectrum	24 = 1 spectrum
3	DCIXS High Count Spectrum	48 = 1 spectrum
4	XSM sensor	4 = 1 spectrum
5	Memory Dump	1
6	DCIXS Compressed Low Count Spectra	24 = 1 spectrum (poor compression) 10 = 1 spectrum (typical compression)
7	DCIXS SCD Test	5 = 1 detector 120 = all 24 detectors
8	DCIXS Auxiliary Data – 3D+ Gain and Offset	1
9	DCIXS Auxiliary Data - Detector Means	1

4.1 Inactive modes

STANDBY and SELF-TEST modes do not have full data collection from the DCIXS or XSM detectors. Only housekeeping data is transmitted as one 280 byte packet every 64s.
History dump can be taken in Standby.

4.2 Inertial Staring/ Cruise Phase

There may be some cruise phase orbits where all of the observing states will be used for some part of the orbit. Consequently the calculation of the data collected in a 4 day period must take this into account. This will be possible when a more detailed analysis of the observational constraints and commanding logistics have been made.

The observation programme will be constructed to be compatible with spacecraft resources – mass memory allocation and CAN BUS usage.

Observation	Data Format	Event Rate /s	Packets /s	Observation Duration (hours)	Total Data Packets /4 days	Mbits
Earth's X-ray aurora: Argon line and N-S Conjugacy.	DCIXS Time tagged events	50	0.78125	1	2812.5	6.30
Earth's Magnetotail.	DCIXS Low Count Spectrum		3	1	10800	24.19
Astronomical objects	DCIXS High Count Spectrum		3	20	216000	483.84
XSM Solar Monitoring	XSM sensor		0.25	48	43200	96.77
X-ray emission from Comets	DCIXS Time tagged events	64	1	0	0	0.00
DCIXS Calibration Spectral	DCIXS High Count Spectrum		3	2	21600	48.38
DCIXS Calibration FoV	DCIXS High Count Spectrum		3	0	0	0.00
Housekeeping	Housekeeping		0.015625	96	5400	12.10

Table 4-3 Cruise Phase Observations

The DCIXS Field of View (FoV) calibration is a measurement which will be made only once when it possible to open the radiation shield and view an appropriate celestial X-ray source. The total amount of data will depend on the spacecraft manoeuvre rates.

4.3 Lunar Observations

The event rate is dependent on the state of the sun and the sun/moon/spacecraft geometry.
A typical case is given in the table below.

Observation	Data Format	Event Rate /s	Packets /s	Observation Duration (hours)	Total Data Packets /4 days	Mbits
Lunar geochemistry -DCIXS	DCIXS Time tagged events	2	0.03125	44.25	4978.125	11.15
Lunar geochemistry -DCIXS	DCIXS Low Count Spectrum		3	3.75	40500	90.72
Lunar plasma interaction – DCIXS only	DCIXS Time tagged events	0.08	0.00125	48	216	0.48
XSM Solar Monitoring	XSM sensor		0.25	48	43200	96.77
Housekeeping	Housekeeping		0.015625	96	5400	12.10
				Total Packets/4 days	94294.125	211.22

The worst case event rates generate more packets than can be accommodated by the mass memory allocation.
The observation times will therefore be optimised within the allocation

5. CAN WORD DATA RATE

CAN BUS Maximum DCIXS/XSM Data transfer rate	7.5kbps

6. EXPERIMENT SPACECRAFT RESOURCE REQUIREMENTS

Mass memory allocation	213Mbits