Solar B - EIS

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EIS Telecommanding Structure

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CHANGE RECORD

ISSUE	DATE	PAGES CHANGED	COMMENTS
01	December 2000	All new	Draft release
02	11/6/2001	4	Changed memory dump/up-link CMD-IDs as agreed with the system side [8].
		6	Added CMD-ID 0x23 (reset ICU status errors) and modify CMD-ID 0x20.
		28	Deleted CMD-ID 0x8C (not needed) Removed DC and replace with CMD-ID in accordance with [2], throughout this Document.
03	16/12/2002	5	Updated memory managements tables
		7	Updated PSU commands [6]
		9	Updated CAM commands [5]
		12	Updated MHC commands [4]
		19	Modify run raster and added Flat Field exposure command.
		25	Added critical command list
04	18/12/2003	All	All command use **BC** naming convention, in line with Solar commanding terminology.
		All	Added commanding status dependency
		All	Specified SIB commands
		6	Documented ICU soft-reset command (0xF5)
		6	Removed 4 TBDs from OBS table Added BC1's 0x26, 0x27 and 0x2B
		15	Updated MHC commands following FM MHC integration
		38, 39, 41 and 43	Added Appendices 4,5,6 and 7
		24	Added two new sequence commands
05	06/08/2004	Various	EIS sequences number is 128, each 128 bytes long
		7	Changed the size of health monitor table (j-side)
		7	Modified EIS OBS table (128 sequences * 128 bytes)
		9	Defined rules for OBS table handling
		17	Defined the paraffin actuators position
		22	Defined Slit/Slot positions
		28	Defined rules for dark exposures
		32	Defined CAM ROM based CSG-ID
		44	Defined Event trigger control parameters
06	28/06/2005	Various	Clarified raised issues and changes due to NCRs and ECRs
		6,7	Modified ICU data RAM and MHC buffers address ranges. Also corrected the MHC parameter table end address
		8-12	Added CMD BC1's 0x28, 0x29, 0x2A, 0x2C, 0x2D and 0x2E
		14	Modified PSU BO heaters power operations in line with the CCDs closed loop heater controller [13]. Also noted the removal of CCDA and B bake-out heater power commands from Solar-B SIB
		18	Updated MHC commands in line with [4]
		29	Added MHC start-up operations section
		31	Added ICU-MHC communication error recovery
		43	Added internal EEPROM copy double commands
		44	Updated MHC parameter table in line with [4]

List of contents:

Glossary and Convention:

AE	Camera Analogue Electronics
AEC	Automatic Exposure Controller
ASRC	Anti Solar Rotation Compensation
BC	Block Command, Solar-B Command parameter
BO	Bake Out
CAL	Calibration
CAM	Camera
EIS	Extreme ultraviolet Imaging Spectrometer
GRA	Grating
GSE	Ground Support Equipment
HM	Health Monitor
ICD	Interface Control Document
MHC	Mechanism and Heater controller
MMH	MHC Message Header
NA	Not Applicable
OCB	On Chip Binning (CAM function)
P	Parameter (equivalent to BC(s))
PID	Power, Current and Delta
Reg.	Register
PSU	Power Supply Unit
ROE	Camera Read-out Electronics
SAA	South Atlantic Anomaly
SIB	Satellite information database
SLA	Slit/slot subassembly and includes the shutter
SS	Slit/slot mechanism
VOD	CCD Voltage Output Drain
VRD	CCD Voltage Reset Drain
QCM	Quartz Crystal Microbalance (contamination monitor).

Applicable references:

These references appear in [] brackets in this document.

1 – EIS Science requirements: MSSL/SLB-EIS/SP007.07
2 – MDP ICU interface document: NAO/SLB-EIS/SP/MDP3.4
3 – EIS Mode definition: MSSL/SLB-EIS/SP0013.03
4 – MHC S/W ICD: EIS_MHC_swicd_17.1
5 – New CAM status list received on the 29th August 2002
6 – New PSU status and commanding list received on the 31st May 2002
7 – EIS Status: MSSL/SLB EIS/SP17.06
8 – Working meeting at MSSL with ISAS/NAO between 26-28/03/2001
9 – ECR-189
10 – Scale factors for MIR Motion. Preliminary report, NRL
11 – EIS sequence structure overview: MSSL/SLB-EIS/TN014.06
12 – Automatic Exposure Control (AEC) for EIS: MSSL/SLB-EIS/SP027.03
13 – ICU Closed loop bake out heater controller: MSSL/SLB-EIS/TN033.01
14 – EIS Health Monitor (auto safe): MSSL/SLB-EIS/SP052.02

1.0 Introduction

This document describes Solar-B EIS commanding structure to be flown on Solar-B satellite.

Also this document specifies the SIB commands. EIS commands that are not included in the database are either:

1 – Contingency commands that are only used if the need arise. For e.g. MHC test commands.
2 – Commands that are handled internally by the ICU, for e.g. CAM and MHC status acquisitions.
3 – Commands that can only used from the sequence interpreter

All the commands that are not included in the SIB will be stated explicitly as Not a SIB command.

Also this document specifies the commanding and status relationship, i.e. status parameters that are directly changed or affected in response to a ground command or spacecraft commands. Related to this, note that all the commands to the ICU will affect TC_REC_PKTC, LAST_BC1_R, LAST_BC2_R, LAST_BC3_R and LAST_CMD_L_R. With reference to commanding and status parameters cross-referencing, the following should be observed:

1 - Commands that only affect the above parameters are excluded from the status response.
2 - The status response will be stated only if the command is successfully executed. Rejected commands will be reported in TC_FAILED_PKTC, TC_FAILED_CMD_ID and TC_FAILED_EC.
3 – MDP autonomous commands, i.e. status and memory dump requests, are excluded.

While all efforts are made to verify the correctness of commands received on-board, however, it is the user's responsibility to verify the integrity of the commands prior to sending them.

2.0 Solar-B TC packets structure

As specified by the MDP-EIS requirements [2], EIS block commands consists of a command identifier (CMD-ID, BC1) (8 bits) followed by up to 132 bytes command parameters (BCs), as shown below:

CMD-ID (BC1)	Command Parameters (BC(s))
8 bits	Max. 132 bytes

Note that Solar-B command ID identifies the number and type of parameters that follows.

Within this document, **all BCs and command parameters are unsigned**, unless otherwise stated. Also all BCs are in hexadecimal. In line with Solar-B specifications**, Bit 0 is the Most Significant Bit.**

3.0 EIS Commanding Structure

The following Command Identifiers are allocated:

BC1	FUNCTION
01 – 03	Status requests 1, 2 and 3 (Allocated by system side)
04	Memory Dump request (Allocated by system side)
05 – 0F	Memory Dump commands (Agreed with the system side)
E5 – EF	Memory Uplink (Agreed with the system side)
20 – 2F	Mode transitions and miscellaneous commands
30 – 3F	PSU commands
40 – 4F	Camera commands
50 –7F	MHC commands
80 – DF	Sequence Table commands
F5	ICU soft reset command *

* This command is handled by the ICU hardware. It is named ICU soft reset to distinguish it from the ICU power ON reset.

The ICU soft reset command shall be sent twice (request and confirmation).
The time between the reset request and confirmation shall not exceed 40 seconds.
However, it is recommended to send the two commands with a minimum gap, i.e. 65 ms.
The ICU soft reset command will start the ICU bootstrap, as the case of power ON Reset. To start the ICU operational code perform the following operations:

1 – From the bootstrap, select EEPROM by using command 0x2B, as shown in section 3.2.
2 – Wait 5 seconds
3 – Go to Standby mode. In this case there is no need to enable mode transitions as the bootstrap only recognises standby mode.
4 – When the operational code starts (standby mode), enable mode transitions (command 0x20) and resume normal operations.

Operation parameters status parameters that affected:
ICU_SW_ID, for the last uploaded version
EIS_MODE, Standby mode
STATUS_PC, should be incrementing for each status packet

3.1 EIS Memory management (upload/dump) commands

The structures of these commands are controlled by ISAS [2]. EIS memory map is as follows:

MEMORY TABLE ID (UPLOAD/DUMP)	SEGMENT	START ADDRESS (HEX)	END ADDRESS (HEX)
E5/05	ICU Program RAM	000000	0BFFFF
E6/06	Data RAM	000000	07FFFF
E7/07	EIS Obs. Tables	070000	076FFF

MEMORY TABLE ID (UPLOAD/DUMP)	SEGMENT	START ADDRESS (HEX)	END ADDRESS (HEX)
NA/08	ICU PROM	0C0000	0C3FFF
E9/09	ICU EEPROM	0C8000	1C7FFF
EA/0A	MHC RAM See section 3.5.1	000000	00FFFF
NA/0B	MHC ROM	010000	017FFF
NA/0C	MHC PARMS	020000	0200CB
NA/0D	MHC BUF [4]	030000	0E7FFF
EE/0E	CAM RAM	000000	03FFFF
EF/0F	HM TBL [14]	000000	00027F

The **EIS OBS** table structure is as follows:

DATA TYPE	START ADDRESS	END ADDRESS
Sequences (128*128 bytes)	0x070000	0x073FFF
Line lists (48*164 bytes)	0x074000	0x075EBF
AEC exposure time table (112 bytes)	0x75EC0	0x75F2F
AEC Control parameters table (16 bytes)	0x75F30	0x75F3F
XRT Flare trigger Control parameters table (20 bytes)	0x75F40	0x75F53
EIS Flare trigger Control parameters table (24 bytes)	0x75F54	0x75F6B
EIS Event trigger Control parameters table (20 bytes)	0x75F6C	0x75F7F
Reserved	0x75F80	0x76FFF

The **MHC BUF** structure is as follows:

DATA TYPE	START ADDRESS	END ADDRESS
COMMAND TRACE	0x00030000	0x000302FF
FINE MIRROR TRACE	0x00040000	0x000409FF
COARSE MIRROR RESOLVER TRACE	0x00050000	0x00050DFF
SLIT / SLOT RESOLVER TRACE	0x00060000	0x00060DFF
GRA TRACE	0x00070000	0x00070DFF
SHUTTER TRACE	0x00080000	0x000817FF
POWER TRACE	0x00090000	0X000902BF
ERROR TRACE	0x000B0000	0x000B037F
HEATER TRACE	0x000C0000	0x000C07FF
HEATER SCHEDULE	0x000D0000	0x000D0053
ADDITIONAL MOTOR DATA [4]	0x000E0000	0x000E0800

ICU status:

MEM_DMP_STAT: Running or idle when memory dump is requested. However, note that for short memory dump requests, running status may be set for a short time and hence would not be visible in status packets due to MDP status request frequency.

3.2 EIS BCs 0x20 to 0x2F

These commands are used to control EIS modes of operations and general type commands. Note that only 3 Commands are currently defined in this group.

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
20	MODE_EN	Enable mode transitions ICU status: MODE_EN_STAT	None
21	EIS_MODE	Change EIS mode. MODE_EN command must be issued before mode change commands are issued [3]. ICU status: EIS_MODE Byte 40 (power switching flags) Also when in AUTO mode, the following parameters maybe affected: * All sequences SEQ_STAT SEQ_I SEQ_P * Science sequences, i.e. sequences that include 1 or more raster LL_I MD_BUF_STAT EXPOSURE_NO FINE_M_POS SEQ_ABORT_CODE RASTER_RUN_REM SEQ_RUN_REM ET_STAT XRT_FF_STAT EIS_FF_STAT AEC_STAT ASRC_STAT XRT_ERROR FT_ERROR ET_ERROR	BC2: Byte range 1 to 5 1 = Standby 2 = Manual 3 = Auto 4 = Bake-out 5 = Emergency
22	MODE_DIS	Disable EIS mode transitions. This is a **contingency** command whose primary purpose is to inhibit Solar-B OP store commanding in the events of OP table loading and verification errors. Also it can be used in the event of similar EIS OBS table errors. ICU status: MODE_EN_STAT	None
23	RESET_ICU_ ERROR	Reset ICU status error parameters [7], which includes the following: ICU status: TC_FAILED_EC,	None

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
		PSU_STAT_ERROR, CMD_IF_ERROR, TC_FAILED_PKTC, TC_FAILED_CMD_ID, XRT_ERROR, HC_DUTY_ERROR, HC_PSU_TO, MDP_LL_ERROR, AEC_WIN_ERROR, AEC_PARMS_ERROR, AEC_TIME_ERROR, ICU_ERROR_F, MHC_CMD_H, FT_ERROR, Bytes 60 to 63 (HM parameters) CAM_IF_ERROR, SEQ_ABORT_CODE, CMD_ID_FAILED_INT, MHC_IF_ERROR, EEPROM_ERROR. ET_ERROR Plus others parameters as stated in EIS status document.	
24	SET_MD_DOT	Set MD Packet Output Type (DOT) [2]. Setting the new DOT in MD packet takes effect at the start of new exposure data. ICU status: None. However, MD packets Data Output Type should change, accordingly.	BC2: Byte range 0 to 1 0 = MD to ISAS, KSC & DR 1 = MD to KSC & DR
25	HM_CTRL	Enable / Disable ICU health monitor task. Default to enabled. ICU status: HM_MON_STAT	BC2: Byte range 1 to 2 1 = Enable 2 = Disable
26	LOAD_OBS_ DEFAULT	Load specific default observation table. Note that when loading the default AEC exposures timetable, the AEC control parameters table must be loaded separately (as it is AEC reference line profile dependent). Following EIS **power-up**, the following procedure should be used for OBS table operations: 1 – Initialise OBS table to 0XFF (BC2 = 1). 2 – Load OBS table **Note:** The ICU, following **ICU reset double command (BC1 = 0xF5)** retains the last loaded OBS table. However, to verify the correctness of the table, it is recommended to dump	BC2: Bytes range 1 to 6 1 = Initialise observation table to 0xFF. 2 = AEC exposures timetable 3 = XRT flare trigger parameter table 4 = EIS FT table 5 = EIS ET table 6 = Default sequences and line lists.

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
		and compare the OBS table. ICU status: None. However, a specific table should be loaded by the default values and can be verified by memory dump	
27	PORT_READ	This command reads a specific ICU port. **Note:** This is a contingency command and its use should be authorised by EIS engineers. ICU status: PORT_READ **Not a SIB command.**	BC2 to BC5 is the port address
28	HC_PARM_SET	Set bake-out control temperature. This command can be sent from any mode, **except** bake-out mode [13]. A new control temperature must be set prior to invoking bake-out mode. ICU status: HC_TARGET_T	BC2: Target temperature in PSU ADC unit. Default: +35 °C in ADC units Range: 0 to 255
29	HC_DUTY_CYCLE_P5	Increase duty cycle power by 5%. This command can only be sent from bake-out mode [13]. This parameter is updated at the start of a heater cycle hence there is an uncertainty of up to 20 seconds before it is reported in status type-1 packet. Five minutes must elapse before the ICU will accept a new power update. ICU status: HC_DUTY_CYCLE	None
2A	HC_DUTY_CYCLE_M5	Decrease duty cycle power by 5%. This command can only be sent from bake-out mode [13]. This parameter is updated at the start of a heater cycle hence there is an uncertainty of up to 20 seconds before it is reported in status type-1 packet. Five minutes must elapse before the ICU will accept a new power update. ICU status: HC_DUTY_CYCLE	None
2B	COPY_ICU_SW	This is a **bootstrap** command. This command copies the ICU code from EEPROM to RAM See section 3 for the ICU software re-start. ICU status: None	BC2: EEPROM number. Range 0 to 7.

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
2C	LOAD_MHC_SW	Load MHC code from EEPROMS 3 **OR** 7. Prior to sending this command, the MHC code **must** be resident in fixed portions (32 Kbytes) of EEPROMS 3 or 7, i.e.: EEPROM 3 address = 0x140000 **OR** EEPROM 7 address = 0x1C0000. This command **must** be sent while the MHC is switched ON (using PSU direct commanding from standby mode or in MAN mode). Also the MHC must be running in PROM mode. To verify the load operation, the user should check the following items: **1 –** 256 commands are received by the MHC **2 –** 256 commands are accepted by the MHC **3 –** Dump and compare the MHC code **4 –** The MHC_LOAD_STAT goes from "running" to "stopped" (not aborted). If at least points 1, 2 and 4 are verified, then changing the MHC mode to RAM mode can be undertaken. The procedure specified for the MHC command BC1 = 0x6B should be followed. Note that due to the serial link slow speed (RS422), the MHC code load into the MHC RAM takes approximately 2 minutes. However, it has the advantage of minimizing ground commanding considerably when compared with direct MHC code up-link. Also note that no ground MHC or memory management commands should be sent while MHC code loading is in progress (except abort or safe MHC commands). Both the MHC and memory management software tasks will be busy. ICU status: MHC_LOAD_STAT	BC2: EEPROM number Values = 3 OR 7
2D	E2_COPY_ REQUEST	Request EEPROM copy from EEPROM source (BC2) to EEPROM destination (BC3). This request will be	BC2: Source BC3: Destination

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
		confirmed via status type-1. The copy operation is actually performed when CMD BC 0x2E is sent. Only one EEPROM copy at a time is allowed. **Note that while this command is not a critical command (it cannot damage the instrument), however, care must be taken when it is used. Incorrect copy source or destination may result in the corruption of the EEPROM code.** Note: If an error is made in the E2 copy source or destination, then re-issue this command with the correct parameters. The actual copy will be undertaken when command BC1= 0x2E is issued. ICU status: EEPROM_COPY_S EEPROM_COPY_D The user must verify that both status parameters are in the range 0 to 7 and that the correct source and destination are acknowledged on-board.	Range: 0 to 7
2E	E2_COPY_ PERFORM	Perform EEPROM copy, as specified by CMD BC1 0x2D. It is recommended that this operation is performed from modes other than AUTO mode and while EIS is operating in a quiet mode, i.e. with no other ground commanding. Testing has shown that it takes approximately 1 minute to copy an EEPROM (128 Kbytes). Note that no memory management commands should be sent while EEPROM copying is in progress. The memory management software will be locked. Incoming commands will be rejected due to communication timeout. ICU status: EEPROM_COPY_STAT	None

3.3 EIS PSU Commands

These commands are used to control the operations of EIS PSU [6]. Note that all the PSU parameters are in bytes.

Note that the Main bus supply current (PSU_MBUS_28I) is affected by all power switching, hence is not included in the ICU status below.

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
30	P_CAM_P13V_PWR	CAM +13V Power ICU status: PSU_CAM_P13V_STAT CAM status: PSU_CAM_P13VI	BC2: Byte range 0 to 1 1 = ON 0 = OFF
31	P_CAM_ P8V _PWR	CAM +8V Power ICU status: PSU_CAM_P8V_STAT CAM status: PSU_CAM_P8VI	BC2: Byte range 0 to 1 1 = ON 0 = OFF
32	P_CAM_P7V_PWR	CAM +7V Power ICU status PSU_CAM_P7V_STAT CAM status: PSU_CAM_P7VI	BC2: Byte range 0 to 1 1 = ON 0 = OFF
33	P_CAM_N8V_PWR	CAM –8V Power ICU status: PSU_CAM_N8V_STAT CAM status: PSU_CAM_N8VI	BC2: Byte range 0 to 1 1 = ON 0 = OFF
34	P_CAM_P39V_PWR	CAM +39V Power ICU status: PSU_CAM_P39V_STAT CAM status: PSU_CAM_P39VI	BC2: Byte range 0 to 1 1 = ON 0 = OFF
35	P_CAM_MHTR_PWR	CAM make-up heater Power. The heater is switched ON when the MHC is OFF. ICU status: PSU_CAM_MHTR_STAT	BC2: Byte range 0 to 1 1 = ON 0 = OFF
36	P_MHC_MHTR_PWR	MHC make-up heater Power. The heater is switched ON when the MHC is OFF. ICU status: PSU_MHC_MHTR_STAT	BC2: Byte range 0 to 1 1 = ON 0 = OFF
37	P_MHC_E_PWR	MHC Electronics Power ICU status: PSU_MHC_ELEC_P28V_ STAT	BC2: Byte range 0 to 1 1 = ON 0 = OFF

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
		MHC status: MHC_P5V_D_I	
38	P_MHC_M_PWR	MHC Mechanisms Power ICU status: PSU_MHC_MECH_P28V_ STAT	BC2: Byte range 0 to 1 1 = ON 0 = OFF
39	P_MHC_OHTR_PWR	MHC operational heaters Power ICU status: PSU_MHC_HTR_P28V_ STAT	BC2: Byte range 0 to 1 1 = ON 0 = OFF
3A	P_CCDA_B_HTR_PWR	CCD A bake -out heater Power. **Commanded to 5% heater power, 30 S after bake out mode invoked [13]. ICU software ensures heaters OFF state in other modes [3].** ICU status: PSU_CCD_A_BHTR_ON_ STAT **Not a SIB command**	BC2: Byte range 0 to 1 1 = ON 0 = OFF
3B	P_CCDB_B_HTR_PWR	CCD B bake-out heater Power. **Commanded to 5% heater power, 30 S after bake out mode invoked [13]. ICU software ensures OFF state in other modes [3].** ICU status: PSU_CCD_B_BHTR_ON_ STAT **Not a SIB command**	BC2: Byte range 0 to 1 1 = ON 0 = OFF
3C	P_CCDA_B_HTR_CTL	CCD A bake out heater Enable / Disable. **Auto enabled when bake out mode is invoked [13]. Disabled in other modes.** ICU status: PSU_CCDA_BHTR_EN_ STAT	BC2: Byte range 0 to 1 1 = Enable 0 = Disable
3D	P_CCDB_B_HTR_CTL	CCD B Heater Enable / Disable. **Auto enabled when bake out mode is invoked [13]. Disabled in other modes.** ICU status: PSU_CCDB_BHTR_EN_ STAT	BC2: Byte range 0 to 1 1 = Enable 0 = Disable

3.4 EIS CAM Commands

These commands are used to control EIS camera operations. Note that all CAM parameters are in bytes.

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
40	C_RES	Performs CAM soft reset. Returns the ROE to default mode. All previously programmed parameters are lost (return to default values). ICU status: None	None
41	C_EXIT_DEF	Exit default mode, enter idle state. EIS default mode is used for CAM standalone testing. In this mode, the CAM performs continuous read-outs every N seconds (TBD). ICU status: None. However CAM HK validation flag should become valid following one or two Status type 2 acquisition	None
42	C_START_CSG	Perform one CCD flush or read out, depending on the clocking sequence. There is no foreseen need for sending this command from the ground as the sequence interpreter handles these operations internally. **For the ICU internal use** See Appendix 1 for the CAM PROM CSG IDs **Not a SIB command**	**BC2**: CSG ID
43	C_DUMP_CSG	Dump CSG memory. The ICU accepts Conventional Solar-B memory dump command [2] and generates this command internally. **For the ICU internal use** **Not a SIB command**	**BC2**: Block select Bit 0: pattern/program RAM selector Bit 1: Unused Bits 2 – 7: block 0 – 63 **BC3**: The RAM page address. Bits 0 – 2: Unused Bits 3 – 7: Page Address **BC4**: Address Bits 0 – 1: Unused Bits 2 – 7: Address
44	C_SET_WINDOW	Modify a single byte in CSG memory (window set-up) without the need to modify the full CSG sequence. This is a contingency command to be used from the Sequence interpreter. It is	**BC2**: Block select Bit 0: pattern/program RAM selector Bit 1: Unused Bits 2 – 7: block 0 – 63 **BC3**: The RAM page

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
		envisaged that this command will be used for adjusting the CSG sequences Y-start in orbit. ICU Status: None.	address. Bits 0 – 2: Unused Bits 3 – 7: Page base Address **BC4**: Address Bits 0 – 1: Unused Bits 2 – 7: Address **BC5**: Byte set-up data
45	C_SET_AE	Set analogue electronics parameters. Note that Control reg. 2 sets the R/O nodes for the Analogue electronics. The setting here should match that of the run raster command. Run raster command sets the ICU CAM control board, which needs to route incoming data to the CCD buffer segments, according to the CCD read-outs nodes. Normal science operations are performed with all nodes enabled. One-node read-outs are only performed for calibration purposes or when a node is failed. CAM status: **Echoed back parameters, i.e. set-up (confirmation):** CAM_VOD CAM_VRD CAM_VSS CAM_CONTROL_REG_1 CAM_CONTROL_REG_2 **CAM ADC output (real CAM values):** CCD-A VOD CCD-A VRD CCD-A VSS CCD-B VOD CCD-B VRD CCD-B VSS	**BC2**: Bias reg. 1 Bits 0 – 3: CCDB VOD Bits 4 – 7: CCDA VOD Default: 0x99 **BC3**: Bias reg. 2 Bits 0 – 3: CCDB VRD Bits 4 – 7: CCDA VRD Default: 0x99 **BC4**: Bias reg. 3 Bits 0 – 3: CCDB VSS Bits 4 – 7: CCDA VSS Default: 0x77 **BC5**: Control reg. 1 Bit 0: Reserved Bit 1: Running 1 = Enable internal Pattern generator 0 = Disable internal pattern generator Bit 2: Self test_n 0 = Use internal data pattern generator Bit 3: Stim isolate_n 0 = Isolate stim generators Bit 4: CCDB VOG2 1 = Normal 0 = Low gain Bit 5: CCDA VOG2 1 = Normal 0 = Low gain Bits 6 – 7: Unused Default: 0x2F (CCD read-out) 0x3F (STIM) 0x4F (Internal, i.e. self test) **BC6**: Control reg. 2 Bits 0 – 3: Reserved Bit 4: CCDB L R/O chain enable Bit 5: CCDB R R/O chain enable Bit 6: CCDA L R/O chain enable Bit 7: CCDA R R/O

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
			chain enable Default: 0x0F **BC7**: reserved, 0x00 **BC8**: reserved, 0x00 **BC9**: reserved, 0x00
46	C_SET_CSG	Program CSG RAM. Conventional Solar-B memory uplink command is used. **For the ICU internal use** **Not a SIB command**.	**BC2**: Block select Bit 0: pattern/program RAM selector Bit 1: Unused Bits 2 – 7: block 0 – 63 **BC3**: The RAM page address. Bits 0 – 2: Unused Bits 3 – 7: Page base Address **BC4** – P66: 64 bytes CSG data
47	C_HK_REQ	Request CAM HK parameter **For the ICU internal use** **Not a SIB command**.	**BC2**: Parameter ID Range 0 to 31
48	C_CSG_SIG	Reserved. Not to be used. **Not a SIB command.**	
49	C_AE_REQ	Request CAM Analogue Electronics parameter **For the ICU internal use** **Not a SIB command.**	**BC2**: Parameter ID Range 0 to 7

3.5 EIS MHC Commands

These commands are used to control EIS MHC operations [4]. Note that the MHC commands uses a 16-bit Command Header, which contains Hamming error code detection. Also note that all the MHC parameters are 16-bit parameters. There are two types of MHC commands:

Type 1: BC1 + MHC Command Header
Type 2: BC1 + MHC Command Header + Message Length + Parameters.

The MHC type 2 commands format is shown below.

16 BIT DATA WORD															
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16 BIT MHC COMMAND HEADER															
MESSAGE LENGTH (BYTES) (EXCLUDES MESSAGE HEADER, MESSAGE LENGTH AND CHECKSUM BYTE). I.e. ONLY THE NUMBER OF PARAMTERS TO FOLLOW															
PARAMETER 1 - MS BYTE								PARAMETER 1 - LS BYTE							
PARAMETER 2 – MS BYTE								PARAMETER 2 - LS BYTE							
PARAMETER N – MS BYTE								PARAMETER N - LS BYTE							
8 BIT XOR CHECKSUM															

Please note that memory management's commands format is different from that of Solar-B. The ICU accepts Solar-B memory management's commands and re-makes them for the MHC use. Also note that the ICU calculates on board the MHC XOR Checksum. The MHC controls its operations using a parameter table. The parameter table is shown in Appendix 3.

Due to the stringent safing requirements on Solar-B, it is recommended that the MHC is commanded into a safe state (MHC safe command) when memory management operations are performed. Memory management command keeps the RS422 interface busy and may interfere with Solar-B emergencies. All efforts were made to ensure fast EIS safing, however, this recommendation is a precautionary measure.

The MHC commands table also lists the housekeeping parameters that are directly changed in response to MHC commands. Note that every MHC command generates either an ACK if successful or a NACK if unsuccessful. Related to this, note that all the MHC successful commands affects MHC_CMD_REC, MHC_CMD_ACK and MHC_CMD_ID, excluding MHC status requests. With reference to commanding and status parameters cross-referencing, the following should be observed:

1 - Commands that only affect the above parameters are excluded from the status response.
2 - The status response will be stated only if the command is successfully executed. Rejected commands will be reported in MHC_CMD_NACK, MHC_SEC_MSW and MHC_SEC_LSW.

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER	ASSOCIATED PARRAMETER TABLE ENTRIES
51	ABORT	Aborts any command in progress. MHC status: None	BC2 and 3 = 0xE881	None
55	ACT_TEST_CMD	Enables test command set. Must be issued immediately before a test command to enable that command. **This command for ground use only.** MHC status: None **Not a SIB command**	BC2 and 3 = 0xC003	COMMAND_TIMEOUT
5D	ACTUATOR_ARM	Arms selected actuator(s). Note that the armed actuator(s) will be Disarmed after a period set by The parameter ACTUATOR_ARM_TIMEOUT ACT1 = Rear (inner) door ACT2 = unused ACT3 = Front (outer) door ACT 4 = unused MHC status: MHC_ACT_STAT	BC2 and 3 = 0x2882 BC4 and 5 = 0x0002 BC6 and 7 = Actuator ID ACTUATOR 1 Prime 0x8E81 Backup 0x04E82 Prime & Backup 0xA603 ACTUATOR 2 Prime 0x2E84 Backup 0xEE88[Prime & Backup 0xA60C ACTUATOR 3 Prime 0x0690 Backup 0XC6A0 Prime & Backup 0xA630 ACTUATOR 4 Prime 0xA6C0 Backup 0x0F00 Prime & Backup 0XCFC0	COMMAND_TIMEOUT ACTUATOR_ARM_TIMEOUT
56	ACTUATOR_DISARM	Disarms all actuators. MHC status: MHC_ACT_STAT	BC2 and 3 = 0x4884	COMMAND_TIMEOUT
5E	ACTUATOR_FIRE	Fires selected actuator(s) Actuator must be armed for fire command to operate. Fire command must be for exactly the armed actuators. All actuators are disarmed and **power is set to OFF when either the ACTUATOR_ARM_TIMEOUT or ACTUATOR_FIRE_TIMEOUT expires.** ACT1 = Rear (inner) door ACT2 = unused ACT3 = Front (outer) door ACT 4 = unused MHC status: MHC_ACT_STAT Note: In order to update doors status parameter in the MHC HK, the clamshell LEDs MUST be enabled (ON) by using the MHC PARAMETER table entry #95 (ID 0xC095).	BC2 and 3 = 0xA005 BC4 and 5 = 0x0002 BC6 and 7 = Actuator ID ACTUATOR 1 Prime 0x1881 Backup 0XD882 Prime & Backup 0x3003 ACTUATOR 2 Prime 0xB884 Backup 0x7888 Prime & Backup 0x300C ACTUATOR 3 Prime 0x9090 Backup 0x50A0 Prime & Backup 0x3030 ACTUATOR 4 Prime 0x30C0 Backup 0x9900 Prime & Backup 0x59C0	COMMAND_TIMEOUT ACTUATOR_ARM_TIMEOUT ACTUATOR_FIRE_TIMEOUT
5F	AUTO_SAFE	Enables / Disables system safe	BC2 and 3 = 0xC09A	COMMAND_TIMEOUT

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER	ASSOCIATED PARRAMETER TABLE ENTRIES
		(MHC internal health Monitor), i.e. out of limit parameter detection. Defaults to Disabled on power-up MHC status: MHC_SYS_STAT	BC4 and 5 = 0x0002 BC6 and 7: Status 0x0001 = Enable 0xFFFF = Disable	RDC_CURRENT_SAFE PZT_OVERTEMP SAFE MIR_C_OVERTEMP_SAFE SHUTTER_OVERTEMP_SAFE GRA_OVERTEMP_SAFE SS_OVERTEMP_SAFE MHC_OVERTEMP_SAFE_D MHC_OVERTEMP_SAFE_AN MHC_OVERTEMP_SAFE_AX PWR_OVERTEMP_SAFE_A PWR_OVERTEMP_SAFE_B RS422_DROPOUT_SAFE +15VM_VOLTAGE_SAFE +5V_VOLTAGE_SAFE +15V_VOLTAGE_SAFE -15V_VOLTAGE_SAFE +5VA_VOLTAGE_SAFE -5VA_VOLTAGE_SAFE +120V_VOLTAGE_SAFE +5V_CURRENT_SAFE +15V_CURRENT_SAFE -15V_CURRENT_SAFE
66	CAL_POWER	CAL LED power switch via relay. Normally ON. Relay should be switched OFF on CAL control failure or leakage current problem (light emission) MHC status: None	BC2 and 3 = 0X00A5 BC4 and 5 = 0x0002 BC6 and 7: ON/OFF Power ON = 0x0001 Power OFF = 0xFFFF	COMMAND_TIMEOUT
65	CAL_SOURCE_CTRL	Turns selected CAL source(s) ON or OFF MHC status: MHC_CAL_SRC_STAT	BC2 and 3 = 0x6006 BC4 and 5 = 0x0002 BC6 and 7: Cal Status LED 1 ON 0x0001 LED 2 ON 0x0002 BOTH ON 0x0003 BOTH OFF 0x0000	COMMAND_TIMEOUT CAL_TIMEOUT
58	CLEAR_ERR	Clears MHC status errors MHC status: MHC_SEC_MSW MHC_SEC_LSW	BC2 and 3 = 0xE824	COMMAND_TIMEOUT

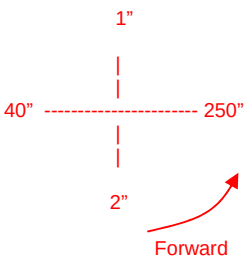
BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER	ASSOCIATED PARRAMETER TABLE ENTRIES
67	DATA_LOG_CTRL	This allows selected trace functions (MHC internal data logging) to be cleared, enabled or disabled. Setting a clear bit to 1 clears data in the selected trace buffer. Setting the set bit to 1 enables the selected trace buffer**. Clear trace buffer is not needed, as all these buffers are circular buffers. However, they are shown here, as it was part of the initial MHC software development.** Note 1: If any of Mir, SS, or GRA traces are disabled, (set bit = 0), the MHC disables all stepper motor data logging, but the shutter trace remains enabled. Disable of shutter trace disables shutter trace only. Note2: If the MHC rejects any of the mechanics move commands (NACKed), then the ICU automatically disables all MHC data logging [9]. This performed by writing 0x0000 to BC6 and BC7, internally for subsequent trace dumps. Trace dump data is required by MHC engineers to ascertain the error cause. Default configuration is all trace buffers enabled. MHC status: None	BC2 and 3 = 0x8888 BC4 and 5 = 0x0002 BC6 and 7: Logging Functions Set Bit 0: Spare trace Bit 1: Clear Power trace Bit 2: Clear Shutter Trace Bit 3: Clear Grating Trace Bit 4: Clear SS resolver trace Bit 5: Clear Coarse Mirror resolver Trace Bit 6: Clear Fine mirror Trace Bit 7: Clear Command Trace Bit 8: Spare Bit 9: Spare Bit 10: Set Shutter Trace Bit 11: Set Grating Trace Bit 12: Set Slit slot Resolver trace Bit 13: Set Coarse mirror Resolver trace Bit 14: Set Fine mirror Trace Bit 15: Spare	COMMAND_TIMEOUT
59	DEFAULT_RESET	Resets all parameter table entries to their default values. **Note:** To prevent unintended side effects, this command disables paraffin actuators and auto-safe. It's also turns OFF all heaters, QCM's, QCM heaters and CAL LED sources. Motor functions remain enabled. MHC status: None. However, the contents of the parameter table should be as that of the default table (appendix 3) and can be verified by memory dump.	BC2 and 3: 0x8887	Command timeout
5A	FIND_SHUTTER_INDEX	Moves shutter to index position. This command shall be sent as part of MHC initialization following power ON or reset. MHC status: MHC_SYS_STAT	BC2 and 3: 0x6009	COMMAND_TIMEOUT SHUTTER_DIRECTION SHUTTER_MAX_RUN_TIME SHUTTER_MAX_STEPS SHUTTER_BRAKE_TIME SHUTTER_BRAKE_LEAD
68	GRA_MANUAL	Move grating focus motor. **NOTE:** For the MHC RAM code, the grating move is locked out by the	BC2 and 3 = 0xA00A BC4 and 5 = 0x0004 BC6 and 7: DIRECTION 0x0001 = FORWARD	COMMAND_TIMEOUT GRA_MAX_RUN_TIME GRA_MAX_STEPS GRA_STEP_RATE GRA_DUTY_CYCLE

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER	ASSOCIATED PARRAMETER TABLE ENTRIES
		following default parameter table entries: GRA_MAX_RUN_TIME GRA_MAX_STEPS MHC status: MHC_GRA_POS_AN This parameter should change by about 7300 counts over +/- 50 steps from centre. Value is ~0xE35 at centre (TBC). MHC_GRA_SW_POS	0xFFFF = REVERSE BC8 and 9: STEPS Range = 5287 steps	GRA_HOLD_TIME
69	HEATER_OFF	Turns selected heater(s) OFF Heaters not selected remain in the last state. 1 = OFF 0 = leave in previous state MHC status: MHC_HTR_STAT	BC2 and 3 = 0xC00C BC4 and 5 = 0x0002 BC6 and 7: selects heater Bit 0: not used Bit 1: not used Bit 2: not used Bit 3: not used Bit 4: H11 Bit 5: H10 Bit 6: H9 Bit 7: H8 Bit 8: H7 Bit 9: H6 Bit 10: H5 Bit 11: H4 Bit 12: H3 Bit 13: H2 Bit 14: H1 Bit 15: H0	None
6A	HEATER_ON	Turns selected heater(s) ON at the specified duty cycle. Heaters not selected remain in the last state 1 = ON 0 = Leave in previous state Note that the Cumulative duty cycle shall be less than 200% MHC status: MHC_HTR_STAT	BC2 and 3 = 0x288D BC4 and 5 = 0x0002 BC6 and 7: selects heater Bit 0: not used Bit 1: not used Bit 2: not used Bit 3: not used Bit 4: H11 Bit 5: H10 Bit 6: H9 Bit 7: H8 Bit 8: H7 Bit 9: H6 Bit 10: H5 Bit 11: H4 Bit 12: H3 Bit 13: H2 Bit 14: H1 Bit 15: H0	COMMAND_TIMEOUT H0 Duty Cycle H1 Duty Cycle H2 Duty Cycle H3 Duty Cycle H4 Duty Cycle H5 Duty Cycle H6 Duty Cycle H7 Duty Cycle H8 Duty Cycle H9 Duty Cycle H10 Duty Cycle H11 Duty Cycle Heater cycle time
54	MOTOR ENABLE	Enables mechanism functions. Default to disabled after Power ON, SAFE or RESET. MHC status: MHC_SYS_STAT	BC2 and 3 = 0xE88E	COMMAND_TIMEOUT
64	MEMORY DUMP	Dumps selected memory area. **For the ICU internal use** **Not a SIB command**	BC2 and 3 = 0x000F BC4 to 7: 32 bit start address, BC8 and 9: Byte count to dump	COMMAND_TIMEOUT
63	MEMORY LOAD	Loads selected memory area, sequential bytes	BC2 and 3 = 0x6090 BC4 to 7: 32 bit start address	COMMAND_TIMEOUT

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER	ASSOCIATED PARRAMETER TABLE ENTRIES
		For the ICU internal use **Not a SIB command**	BC8 to BCN: sequential byte wide data	
6B	MEMORY_MODE	Selects program source, RAM or PROM. Defaults to ROM on power ON. RAM mode is only used if the MHC software is patched (loaded). In order to switch to RAM/ROM mode the following steps should be followed: 1 – Send RAM/ROM switch command 2 – Wait 5 seconds (command latency for MHC re-boot) 3 – Send MHC abort command. The need for step 3 is because the MHC does not acknowledge RAM/ROM switch command. The procedure for RAM mode invoke is as follows: Uplink new code to MHC RAM either via memory uplink commands or copy code from ICU EEPROM using CMD BC1 = 0x2C (nominal operation), then follow steps 1 to 3 above. In step 1, switch to RAM mode. MHC status: MHC_SYS_STAT	BC2 and 3 = 0x8811 BC4 and 5 = 0x0002 BC6 and 7: Memory Mode 1 = ROM 0xFFFF = RAM	COMMAND_TIMEOUT
6C	MIR_C_AUTO	Move coarse mirror, automatically Note: +X ◄——► -X The Encoder (resolver) position range travels from +X (0x4195) to –X (0x1408) but wraparound at 0xFFFF, i.e. 0xFFFF, 0, 1 to –X [10]. A CMIR resolver reading is 0.033020 arcsecond. MHC status: MHC_CMIR_POS_STEPS MHC_CMIR_POS (resolver) CAM status: CMIR_POS_ARCS (CMIR position in arcseconds), range 0 to 1780”	BC2 and 3 = 0x2827 BC4 and 5 = 0x0002 BC6 and 7 – Encoder position Range: 0x4195 (+X) 0x1408 (-X)	COMMAND_TIMEOUT MIR_C_MAX_RUN_TIME MIR_C_MAX_STEPS MIR_C_STEP_RATE MIR_C_DUTY_CYCLE MIR_C_MAX_ENCODER MIR_C_MIN_ENCODER MIR_C_HOLD_TIME MIR_C_RESOLVER_RESOLUTION
6D	MIR_C_MANUAL	Move coarse mirror, Manually. The coarse mirror step size is	BC2 and 3 = 0x4812 BC4 and 5 = 0x0004	P1 COMMAND_TIMEOUT P14 MIR_C_MAX_RUN_TIME P15 MIR_C_MAX_STEPS

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER	ASSOCIATED PARRAMETER TABLE ENTRIES
		0.3143 arcsecond [10]. MHC status: MHC_CMIR_POS_STEPS MHC_CMIR_POS (resolver) CAM status: CMIR_POS_ARCS (Position translated to arcseconds), range 0 to 1780”	BC6 and 7: DIRECTION 0x0001 = FORWARD 0xFFFF = REVERSE BC8 and 9: STEPS Range: 0-5660 steps [10].	P16 MIR_C_STEP_RATE P17 MIR_C_DUTY_CYCLE P18 MIR_C_MAX_ENCODER P19 MIR_C_MIN_ENCODER P20 MIR_C_HOLD_TIME
62	MIR_F_AUTO	Sets control loop active, to drive PZT to a strain gauge set point. Position may be set to the nearest 0.12292” (step size) [10]. When rastering, the fine mirror initial position (MIP) in run raster command is set in the range of 0 to 2400 steps (0 to ~300”). The ICU software controls the movement to a SET_POINT, autonomously. MHC status: MHC_SG_OP MHC_PZT_DRIVE MHC_SYS_STAT	BC2 and 3 = 0xA093 BC4 and 5: 0x0002 BC6 and 7: SET_POINT **The SET_POINT range is 600-3000 which corresponds to 0-2400 FMIR steps**	COMMAND_TIMEOUT
6E	MIR_F_MANUAL	PZT drive voltage set to a specific value (auto tracking set to off). This command is for ground testing/backup operations. MHC status: MHC_SG_OP MHC_PZT_DRIVE MHC_SYS_STAT **Not a SIB command**	BC2 and 3 = 0x2814 BC4 and 5 = 0x0004 BC6 and 7: PZT VOLTAGE MSW BC8 and 9: PZT VOLTAGE LSW **Note:** **BC6 to BC9 are 32-bit SIGNED value** **Range in mV:** **-15000 to +120000**	COMMAND_TIMEOUT
6F	PARAMETER_SET	Sets specific parameter table value. See **Appendix 3** MHC status: None. However, the contents of the parameter table can be verified via memory dump.	BC2 and 3 = 0xC095 BC4 and 5 = 0x0004 BC6 and 7: Parameter Identifier BC8 and 9: Parameter value	COMMAND_TIMEOUT
70	QCM_CONTROL	Controls selected QCM(s). QCM operations should be performed from MAN mode, as the same MHC timer is shared between the QCM and the shutter. Note that to turn the QCMs OFF, the integration time should not be 0 (use 1 for example). The QCMs uses a 1.6 kHz clock (0.625 ms clock cycle time) Default configuration is QCM’s OFF. MHC status: MHC_HTR_STAT (QCM’s) MHC_QCM_MSW	BC2 and 3 = 0x0096 BC4 and 5 = 0x0004 BC6 and 7: QCM ID QCM1 ON 0x0001 QCM 2 ON 0x0002 QCM’s OFF 0x0000 BC8 and 9: QCM INTEGRATION TIME Range: 1 – 65535 QCM clock cycles	COMMAND_TIMEOUT

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER	ASSOCIATED PARRAMETER TABLE ENTRIES
		MHC_QCM_LSW MHC_QCM_INT_CLOCK		
71	QCM_HTR	Controls Selected QCM HEATER. Default configuration is QCM's heaters OFF. MHC status: MHC_HTR_STAT (QCM's)	BC2 and 3 = 0xE817 BC4 and 5 = 0x0002 BC6 and 7: QCM HEATER ID QCM1 HTR ON 0x0001 QCM2 HTR ON 0x0002 HTRS OFF 0x0000	COMMAND_TIMEOUT QCM_HEATER_TIMEOUT
52	RESET	Soft reset MHC. Aborts any in process command, closes shutter, remove power from all mechanisms, encoders, resolvers, QCM's, CAL LEDs, and heaters then resets MHC. The MHC does not acknowledge the reset command and an abort MHC command is required in approximately 5 seconds following a soft reset. MHC status: MHC_TIME_MSW MHC_TIME_LSW MHC_SYS_STAT	BC2 and 3 = 0xE818	COMMAND_TIMEOUT
72	RESOLVER_CTL	Forcing resolver state to ON, OFF or AUTO. Note: Coarse mirror AUTO and SLIIT/SLOT AUTO commands are locked out when the Resolver is forced to an OFF state. Should be in AUTO mode if these are used. When in AUTO mode, the resolver is powered ON when needed then OFF following the operation completion (power consumption). When commanded to ON mode, the resolver will be permanently powered. Forcing the resolver to OFF or ON state is for troubleshooting / testing only. Default configuration is RESOLVER AUTO state. MHC status: MHC_RDC_I	BC2 and BC3 = 0x0099 BC4 and BC5 = 0x0002 BC6 and 7: RESOLVER STATE OFF = 0x0001 ON = 0x0002 AUTO = 0x0003	COMMAND_TIMEOUT
50	SAFE	Place the MHC in safe state. Aborts any in process command, closes the shutter, removes power from all mechanisms (Motor disable), encoders / resolvers, QCM's, and CAL LEDs. **Structure Heaters remain active.** MHC status: MHC_SYS_STAT Note: In order to clear the safe bit (exit safe mode), toggle AUTO safe command, "Disable" then	BC2 and 3 = 0x281B	COMMAND_TIMEOUT

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER	ASSOCIATED PARRAMETER TABLE ENTRIES
		"Enable" (CMD BC1 = 0x5F). Also resetting the MHC clears this bit.		
53	SHUTTER_CLOSE	Closes shutter. Shutter close command returns the MHC exposure time and pointing information as defined in [4] (exposure information). Also note that the shutter is auto close and this command would have no effect if the shutter already closed. However, its primary use is to return the MHC exposure information. MHC status: MHC_EXP_T1 MHC_EXP_T2 MHC_SYS_STAT **Not a SIB command**	BC2 and 3 = 0xA09C	COMMAND_TIMEOUT SHUTTER_DIRECTION SHUTTER_MAX_RUN_TIME SHUTTER_MAX_STEPS SHUTTER_BRAKE_TIME SHUTTER_BRAKE_LEAD
61	SHUTTER_OPEN	Opens shutter for duration specified. Shutter auto-close following open time lapse. Note that the minimum shutter open time is 70ms [4]. MHC status: MHC_SYS_STAT **Not a SIB command**	BC2 and 3 = 0x481D BC4 and 5 = 0x0004 BC6 and 7: Shutter open time MSW BC8 and 9: Shutter open time LSW Range: 0 – (2 ^32 –1) ms	COMMAND_TIMEOUT SHUTTER_DIRECTION SHUTTER_MAX_RUN_TIME SHUTTER_MAX_STEPS SHUTTER_BRAKE_TIME SHUTTER_BRAKE_LEAD
73	SLIT_SLOT_AUTO	Moves slit slot (auto) to one of four positions as specified by BC8 and BC9. Note: The slit/slot disc rotates 90° per 324 steps, 20 ms per step. Also note that it is recommended by NRL/Perdix to drive this mechanism in FORWARD direction only (backlash).  MHC status: MHC_SS_POS_STEPS MHC_SS_POS	BC2 and 3 = 0x609F BC4 and 5 = 0x0004 BC6 and 7: Direction 1 = Forward 0xFFFF = REVERSE BC8 and 9: Slit/Slot position (range 0 to 3) 0 Slit width = 1" 1 Slot width = 250" 2 Slit width = 2" 3 Slot width = 40"	COMMAND_TIMEOUT SS_MAX_RUN_TIME SS_MAX_STEPS SS_STEP_RATE SS_DUTY_CYCLE SS_MAX_ENCODER SS_MIN_ENCODER SS_HOLD_TIME SS Position 0 resolver target SS Position 1 resolver target SS Position 2 resolver target SS Position 3 resolver target SS Resolver window
74	SLIT_SLOT_MANUAL	Move slit / slot manual. Note: The slit/slot disc rotate by 90° per 324 steps, 20 ms per step. MHC status: MHC_SS_POS_STEPS MHC_SS_POS	BC2 and 3 = 0xA0A0 BC4 and 5 = 0x0004 BC6 and 7: DIRECTION 0x0001 = FORWARD 0xFFFF = REVERSE BC8 and 9: STEPS 0 – 65535 steps	COMMAND_TIMEOUT SS_MAX_RUN_TIME SS_MAX_STEPS SS_STEP_RATE SS_DUTY_CYCLE SS_MAX_ENCODER SS_MIN_ENCODER SS_HOLD_TIME SS_RESOLVER_RESOLUTION

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER	ASSOCIATED PARRAMETER TABLE ENTRIES
		Not a SIB command		
60	TLM_PARAM_REQUEST	Request one to N TLM parameters (MHC HK parameters) For the ICU internal use in response to status type 3 MDP requests. **Not a SIB command**	BC2 and 3 = 0x8822	COMMAND_TIMEOUT
75	VG_CTL	Vacuum gauge control; enables / disables vacuum strain gauge subsystem via relay Default configuration is LAST commanded relay position MHC status: MHC_VAC_GAUGE	BC2 and 3 = 0x60A3 BC4 and 5 = 0x0002 BC6 and 7: Mode Select 0x0001 = ON 0xFFFF = OFF	COMMAND_TIMEOUT
76	WATCHDOG	Enables Watchdog timer. Note: MHC Watchdog reset time is ~22 Seconds. Default configuration is WATCHDOG disabled. MHC status: MHC_SYS_STAT	BC2 and 3 = 0xC0a9 BC4 and 5 = 0x0002 BC6 and 7: Mode Select 0x0001 = Enable 0xFFFF = Disable	COMMAND_TIMEOUT
77	TEST_CMD_ENC	Hardware test / troubleshooting command to set selected encoder to on / off – Must be preceded by ACT_TEST_CMD to be processed. **Ground testing command** MHC status: MHC_MOTOR_OPT_ENC MHC_ACT_OPT_ENC **Not a SIB command.**	BC2 and 3 = 0x00aa BC4 and 5 = 0x0002 BC6 and 7: Encoder Enable 1 = Enable Bits 0 to 12: Unused Bit 13: Paraffin Actuator Bit 14: Shutter Bit 15: GRA	None
78	TEST_CMD_MOTOR	Hardware test / troubleshooting command to run GRA motor limit-to- limit. Not supported from RAM mode. Must be preceded by ACT_TEST_CMD to be processed. **Not used in flight** MHC status: MHC_GRA_POS_AN MHC_GRA_SW_POS **Not a SIB command**	BC2 and 3 = 0x60AC BC4 and 5 = 0x0004 BC5 and 6: Analogue Centre position lower limit BC7 and 8: Analogue Centre Position upper limit	None

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER	ASSOCIATED PARRAMETER TABLE ENTRIES
5B	TEST_CMD_ADC	Hardware Test / trouble shooting command. Sets ADC input to ground and log data. Must be preceded by ACT_TEST_CMD to be processed. **Not used in flight** MHC status: None **Not a SIB command**	None	None
79	TEST_CMD_RESOLVER	Hardware test / troubleshooting command to read resolver positions and RDC current (Output is available in HK). Must be preceded by ACT_TEST_CMD to be processed. Not supported in RAM mode **Not used in flight.** MHC status: MHC_RDC_I **Not a SIB command**	BC2 and 3 = 0x482e BC4 and 5 = 0x0004 BC6 and 7: Dummy Value BC8 and 9: Dummy Value	SS_RESOLVER_RESOLUTION MIR_C_RESOLVER_RESOLUTION
7A	TEST_CMD_PZT_V	Hardware test / troubleshooting command to run PZT through full 0 – 4095 – 0 range in open loop (voltage set mode) while logging data to MIR_F trace buffer. Must be preceded by ACT_TEST_CMD to be processed. **Not used in flight** MHC status: MHC_SG_OP MHC_PZT_DRIVE **Not a SIB command**	BC2 and 3 = 0xa0af BC4 and 5 = 0x000A BC6 and 7: Step delay BC8 and 9: DAC low Value BC10 and 11: DAC high Value BC12 and 13: Ramp Step size BC14 and 15: 0x0000 = square wave 0x0001 = ramp	None
7B	TEST_CMD_PZT_SG	Hardware test / troubleshooting command to run PZT thru full 0 – 4095 – 0 SG set point range in closed loop mode while logging data to MIR_F trace buffer. Must be preceded by ACT_TEST_CMD to be processed. **Not used in flight** MHC status: MHC_SG_OP MHC_PZT_DRIVE **Not a SIB command**	BC2 and 3 = 0xc030 BC4 and 5 = 0x000A BC6 and 7 = 0x0001 Forces update of P_SG_ULIM and P_SG_LLIM BC8 and 9: dummy BC10 and 11: step interval (ms) BC12 and 13: Number of steps BC14 and 15: Dummy	None

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER	ASSOCIATED PARRAMETER TABLE ENTRIES
7C	TEST_CMD_TLM	Hardware test / troubleshooting command to send continuous telemetry. Must be preceded by ACT_TEST_CMD to be processed. **Not used in flight** MHC status: None **Not a SIB command**	BC2 and 3: 0x0033 BC4 and 5: 0x0002 BC6 and 7: Test Mode 0x0000 = Test OFF 0x0001 = Replace HK data with HK entry Number 0x0002 = Same as 0x0001 but adds MHC performance code ID in place of performance code for HK 75	None
7D	TEST_CMD_SHUTTER	Hardware test / troubleshooting command to run Shutter and log data to trace buffer. Must be preceded by ACT_TEST_CMD to be processed. Not supported in RAM mode **Not used in flight** MHC status: MHC_SYS_STAT **Not a SIB command**	BC2 and 3 = dummy	SHUTTER_DIRECTION SHUTTER_MAX_RUN_TIME SHUTTER_MAX_STEPS SHUTTER_BRAKE_TIME SHUTTER_BRAKE_LEAD

3.5.1 MHC code start-up

The MHC RAM structure (64 Kbytes) consists of code segment (0 to 0x7FFF) and data area (0x8000 to 0xFFFF). The data area is common for both PROM and RAM modes and used for variable data manipulation and register mapping, as illustrated below:

<table>
<tr><td>PROM code
(0 to 0x7FFF)</td><td>RAM code
(0 to 0x7FFF)</td></tr>
<tr><td colspan="2">RAM variables data area (common to RAM and PROM code)
(0x8000 to 0xFFBF)

Memory mapped H/W registers (common to RAM & PROM code)
(0xFFC0 to 0xFFFF)</td></tr>
</table>

MHC CODE RUN	OPERATIONS
MHC power-up (PROM mode)	This mode can be invoked from • SBY to MAN mode transition (CMD BC1 = 0x21) or • MHC low-level power up via EIS PSU (CMD BC1 = 0x37) or • MHC watchdog reset. Notes: * The MHC copies the PROM code to RAM, autonomously. * The MHC runs code from PROM Uses PROM default parameter table
PROM to RAM mode	This mode is invoked by CMD BC1 = 0x6B, MHC MEMORY_MODE. Notes: * The MHC should be in PROM mode. * Prior to invoking this mode, the MHC code should be copied from the ICU EEPROM to the MHC RAM, using CMD BC1 = 0x2C (nominal operation) or loaded from the ground. * The MHC runs code from RAM Uses RAM default parameter table
RAM to PROM mode	This mode is invoked by CMD BC1 = 0x6B, MHC MEMORY_MODE. Notes: * The MHC should be in RAM mode. * The MHC runs code from PROM (with no code copy to RAM), i.e. RAM code is preserved. Uses PROM default parameter table
Soft reset from PROM mode	CMD BC1 = 0x52 * The MHC should be in PROM mode, obviously * The MHC re-starts code from PROM (with no code copy to RAM), i.e. RAM code is preserved. Uses PROM default parameter table
Soft reset from RAM mode	CMD BC1 = 0x52 * The MHC should be in RAM mode, obviously * The MHC re-starts code from RAM. Uses RAM default parameter table
Watchdog reset	Always starts the MHC in PROM mode, as in the case of MHC power-up described above.

Note: Attempting to run RAM mode from RAM mode or PROM mode from PROM mode is **not allowed**.

3.5.2 MHC not responding (command time-out) fault recovery

The ICU and MHC communicate over the RS422 lines, using a point-to-point, full handshake technique. Each ICU command results in an MHC response (except reset and memory mode commands where the MHC does not acknowledge and the handshake is re-established using an MHC abort command). However, if the ICU does not receive a command response from the MHC within 150 seconds, it assumes that something went wrong (e.g. an MHC software crash) and initiates the following recovery procedure:

1) Send MHC abort command to terminate the current command execution. If a response to the abort command is received (5 seconds time-out), the ICU resumes normal communication with the MHC.

2) If the MHC does not respond to the abort command, the ICU cycles the MHC power lines, via the PSU. The power recycling procedure is as follows:

- Turn the MHC heater power, the MHC mechanism power and the MHC electronic power OFF. Allow a 1-second pause following each power switching to minimise the inrush current, as a precaution.
- Turn the MHC electronic power ON
- Wait 4 seconds. This is to allow the MHC to re-boot.

Following this, the ICU sends the MHC “enable motor command”. If the MHC responds, the ICU commands the MHC into “MHC safe mode”. However, if no response is received for the MHC enable motor command, the ICU invokes EIS emergency mode. The emergency mode invocation indicates that the ICU cannot recover the MHC to an operational state.

See the MHC command-processing error recovery flowchart below.

3.5.3 MHC I am alive fault recovery

If the MHC receives no commands from the ICU in 140 seconds, the MHC assumes that the RS422 transmission line (ICU to MHC command line) went down and sends a specific message (MHC I am alive message; MHC link timeout) over the MHC to ICU data line. When the ICU receives the message, it reports the error in the status type 1 (error flag) and in status type 2 (full MHC report) and attempts the following recovery procedure:

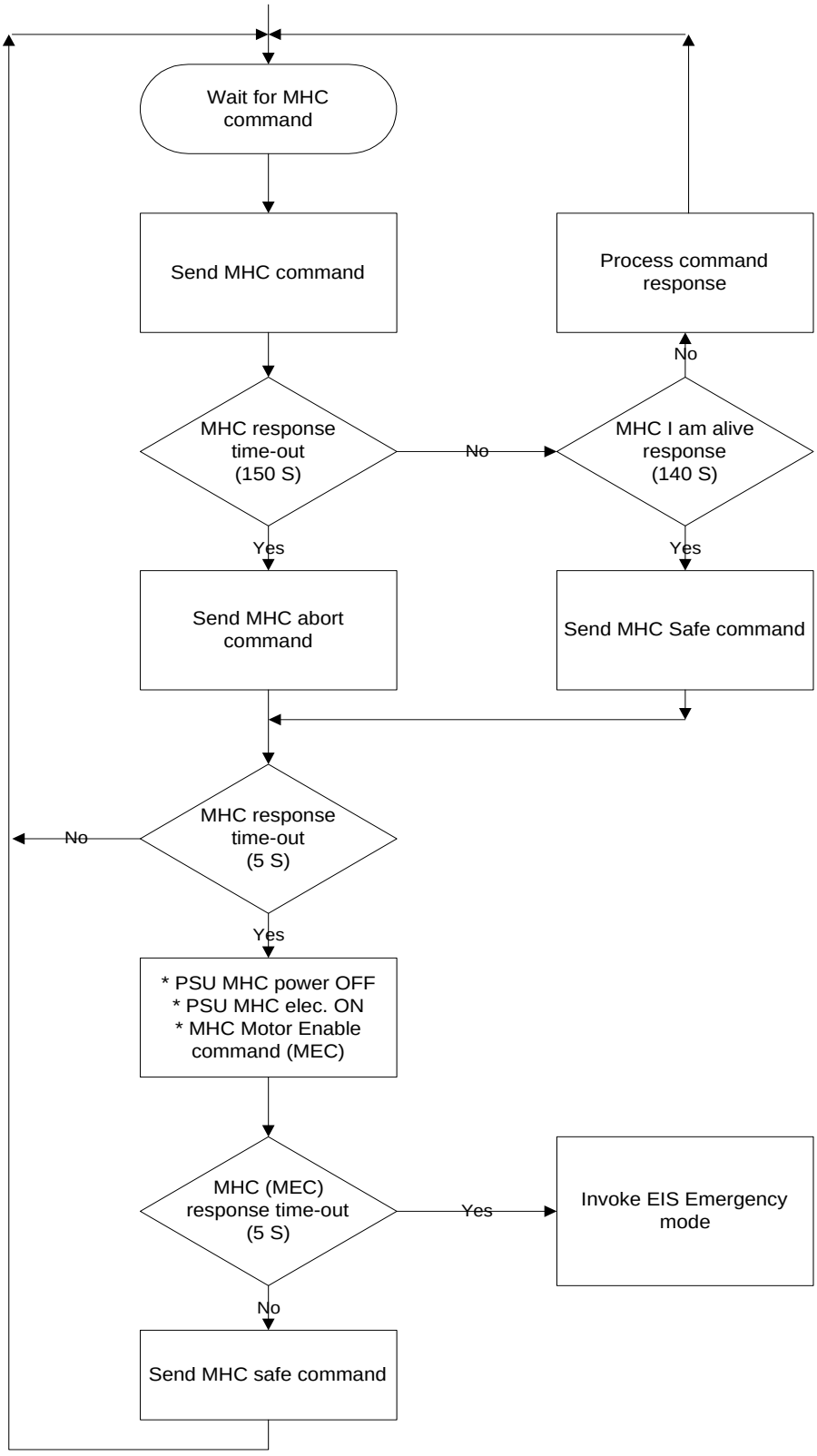
1) Send an MHC safe command (5 seconds time-out). If the MHC responds, then the ICU assumes it was a communication hiccup and resumes normal operations.

2) If the MHC does not respond to the safe command, the ICU cycles the MHC power lines, as follows:

- Turn the MHC heater power, the MHC mechanism power and the MHC electronic power OFF. Allow a 1-second pause following each switching to minimise the inrush current, as a precaution.
- Turn the MHC electronic power ON
- Wait 4 seconds. This is to allow the MHC to re-boot.

Following this, the ICU sends the MHC “motor enable command”. If the MHC responds, the ICU commands the MHC into “MHC safe mode”. However, if no response is received for the MHC “enable motor command” (5 seconds time-out), the ICU invokes EIS emergency mode. The emergency mode invocation indicates that the ICU cannot recover the MHC back to operational state.

See the MHC command-processing error recovery flowchart below.



MHC Command processing error recovery flowchart
*** Status error reporting is not shown**

3.6 EIS Sequence Commands

These commands are used to control EIS sequences. Note that the sequence interpreter commands will be refined when EIS is integrated and finalised during the FM phase.

Within a Sequence there are two identifiers, a Study ID and Raster ID, which are used to identify the science operation type and aid data archiving.

Note that there are 128 sequences, each 128 bytes long.

Note that the sequence commands status parameters cross-referencing shows the status parameters that are most likely to be affected.

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
81	TERM_SEQ	Sequence end. Note that a sequence should either terminate or call another sequence. ICU status: SEQ_STAT SEQ_P **Not a SIB command**	BC2: Sequence no. Range: 0 to 127
82	CALL_SEQ	Call a sequence (from a sequence). Note that a sequence should either terminate or call another sequence. ICU status: SEQ_I SEQ_P **Not a SIB command**	BC2: Sequence no. Range: 0 to 127
83	SEL_SEQ	This command is used to select a sequence (from Manual mode [2, 3]) prior to running it, i.e. AUTO mode change. **This command must be issued from the ground or S/C.** ICU status: None	BC2: Sequence no. Range: 0 to 127
84	SEQ_PR	Pause command pauses the running sequence after the completion of the current command execution. Pause may be used prior to Radiation belts or SAA entry. Resume allows the sequence to continue from were it was paused. A sequence can be aborted (EMERGENCY or MAN modes) while in Pause state. However, it is recommended to resume then abort, if	BC2: Operation 1 = Pause 2 = Resume

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
		possible. **This command must be issued from the ground or S/C OP store.** ICU status: SEQ_STAT	
85	FLUSH_CCDS	This command flushes the CCDs N number of times. This may be used prior to running a raster if required. Also may be needed for charge injection operations at a later stage of the mission. ICU status: None **Not a SIB command.**	BC2: number of flushes, range 1 to 255 BC3: Flush sequence ID, range 0 to 255
86	RUN_RASTER	Specify raster parameter. The raster starts when the first command following RUN raster command is executed . ICU status that maybe effected: SEQ_P LL_I MD_BUF_STAT EXPOSURE_NO FINE_M_POS RASTER_RUN_REM SEQ_RUN_REM ET_STAT XRT_FF_STAT EIS_FF_STAT AEC_STAT ASRC_STAT XRT_ERROR FT_ERROR ET_ERROR **Not a SIB command**	See Appendix 1
87	SET_MHC_OP_PARMS	Set MHC operational parameters (required by the ICU software). Note that the Fine mirror slope is a 32 bit unsigned integer multiplied by 10^6. For example, slope value of 0.122992 is uplinked as 122992. The same applies for coarse mirror slope. The MHC operational parameters are reported in EIS tytpe-2 status packet to confirm the correct setting. This command can be issued either from the ground (contingency) or	BC2 and 3: Fine mirror set point offset. Default = 600 BC4 to BC7: Fine mirror slope (X 10^6) Default = 0.12299 BC8 to BC11: Coarse mirror slope (X 10^6) Default = 0.03302(TBC) BC12 and BC13: Coarse mirror resolver +X limit Default: 0x4195(TBC) BC14 and BC15: Coarse mirror resolver - X limit Default: 0x1408(TBC) BC16 and BC17: MHC

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
		from a sequence (nominal operation). EIS X-FOV represents the FMIR scan range in arcseconds, i.e. ~300. This figure is double within the ICU software (internally) when an image movement is considered. EIS X-FOV = 2400 (FMIR steps) * 0.12299" (step size) ≈ 295" Note that when this command is executed, the following status parameters are updated to confirm the ICU setting (Status type 2): CAM status: FMIR_OFFSET FMIR_SLOPE CMIR_SLOPE CMIR_RES_PX CMIR_RES_NX MHC_RESPONSE_TO FMIR_S_TIME CMIR_SPAN_ARCS EIS_XFOV	command response time-out (1 seconds units) Default: 150 BC18 and BC19: FMIR settling time (units of 1 ms). Default: 700 BC20 and BC21: CMIR span in arcseconds Default: 1780" BC22 and BC23: EIS X-FOV, as represented by the FMIR scan range Default: 295"
89	LOOP_BACK	Loop back to a sequence location (within the raster exposure loop). ICU status: SEQ_P **Not a SIB command**	BC2: Loop back position, range 0 to 127
8A	SEQ_WAIT	Sequence delay in units of ms. ICU status: None **Not a SIB command**	BC2 and 3: Delay value. Range 1 to 65535 ms
8B	TEST_CCD_BUF	Test CCD buffer. Writing and reading specific data patterns to the selected CCD buffer is performed in this test. The status of the result of the test is reported in EIS status [7]. **Note that this test cannot be performed from AUTO mode as auto mode overwrites the content of the CCD buffers. It is recommended to perform this test from MAN mode [3]. Also, the CAM must not be in default mode (test mode) as it continuously writes data to the buffers and this will invalidate this test.**	BC2: CCD BUF Select 0 = CCD BUF 0 test 1 = CCD BUF 1 test

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
		ICU status: CCD_BUFF_TEST Status Type 2: CCD_BUF_ADD_F CCD_BUF_COUNT	
8D	START_EXP	Start exposure command. The exposure time is in units of 10 ms [1]. Note that the exposure time required for EIS ranges from 50 ms to 5 minutes. However, start exposure time parameters allows for exposure time of up to 10.9 minutes. **Note**: Start exposure command performs the following operations: 1 – Flush CCDs, if specified 2 – Open shutter (if > 0 ms EXP.) 3 – delay for exposure time 4 – Close shutter 5 – Performs exposure Bookkeeping 6 – Start CCDs read-out 7 – Step fine mirror (if Required) 8 – Wait for read-out Completion 9 – Synchronise science Acquisition 10 – Switch CCDs buffers ICU status: EXPOSURE_NO FINE_M_POS (when rastering) **Not a SIB command**	BC2 and 3: Exposure time, range 1 to 65535
8E	START_FF_EXP	As the case of START_EXP, this parameter must be executed from within a raster. Start Flat Field exposure. Exposure time in units of 10 ms. Note that this type of exposures uses the MHC LED (CAL sources) and the shutter remains in closed position (intact). Note that the case of having both LED's OFF is a special case, which allows for dark exposures (0 to 655.35 seconds). To avoid confusion, it is recommended to use this command for all dark exposures, i.e. avoid using START_EXP for 0 seconds dark exposures. Also note that the CAL source power **should not** be used when the LEDs	BC2 and 3: Exposure time, range 1 to 65535 BC4: LED select 0 = Both LEDs OFF 1 = LED 1 ON 2 = LED 2 ON 3 = Both LEDs ON

BC1	COMMAND NAME	DESCRIPTION	COMMAND PARAMETER
		are used [ECR 171]. The CAL source power command (MHC command) should be issued once only (latching relay) at the start of the mission. Using the CAL source power should only be considered in the unlikely event that the LEDs leakage current is causing the LEDs to emit light that interfere with science operations. **Note**: Start FF Exposure command performs the following operations: 1 – Flush CCDs, if specified 2 – Turn LED(s) ON 3 – delay for exposure time 4 – Turn LEDs OFF 5 – Performs exposure Bookkeeping 6 – Start CCDs read-out 7 – Wait for read-out Completion 8 – Synchronise science Acquisition 9 – Switch CCDs buffer ICU status: EXPOSURE_NO Not a SIB command	

In addition to the sequence commands, CAM and MHC commands **can be sent from a sequence**. However, the following commands are **EXCLUDED**, as they are either ground commands or handled internally by the ICU software:

Excluded CAM commands BCs	
0x42	Start CSG
0x43	CSG memory dump
0x46	CSG memory upload
0x47	CAM Status (HK) request
0x49	CAM AE status (HK) request

Excluded MHC commands BCs	
0x5D	ACTUATOR Arm (Critical command)
0x56	ACTUATOR Disarm (Critical command)
0x5E	ACTUATOR Fire (Critical command)
0x64	MHC memory dump
0x63	MHC memory upload
0x60	MHC status (HK) request

Appendix 1: Run Raster command structure

Bit 0		Bit 15
Raster ID		
Fine Mirror Initial Position		
Loop Counter (Min. = 1)		
Data Compression Parameters		
OCB-X		**OCB-Y**
CAM CSG Flush Sequence ID *		**Number of CCD Flushes**
Spare	**No. Of exposures per raster position**	**ASRC control parameters**
R/O nodes	**Number of raster repeats (Min. = 1)**	
ASRC Skip		**CAM CSG R/O sequence ID ***
Mirror step size		
Line list		**Science operations control**

*** See table below for CAM PROM clocking sequence ID.**

The Raster ID is the raster identifier, which is a unique number to identify a specific science operation.

Fine Mirror Initial Position is the raster starting position within the field of view.

Loop counter is a reference to the number of loops to be performed within a raster (exposures loop). The loop field could be anywhere between the end of run raster parameters and **loop back** command.

Data compression parameter specifies the type of compression required by the raster [2]. A value of 0 indicates that no data compression is required.

OCB X and Y are flags to be set in the MD packets. Note that when OCB is used, an appropriate read-out CSG sequence ID and line list must be used.

CAM CSG flush sequence ID and CAM CSG R/O sequence ID identify the clocking sequences required to perform flushing and CCDs read-out, respectively.

The number of exposure times per raster, i.e. exposures per raster position should have the value of 1 if only one exposure time is needed. However, if more than one exposure per raster position is required then this parameter is set to the required number of exposures. The maximum number of exposure per raster position is 8 (EIS Science meeting, RAL 2003). The exposure time(s) should be included within the raster loop (sequence start exposure command parameter). This parameter is a 4 bits parameter, LS bits. The MS 4 bits are spares.

ASRC defines the Anti Solar Rotation Compensation operations. This parameter consists of two fields:

Bit 0 (MSB): Compensation direction
0 = forward
1 = backward

Bits 1 to 7: The compensation number of fine mirror steps required.

ASRC Skip defines the frequency of the fine mirror compensation. A value of 1 implies that compensation is performed every raster. However, a value of 2 implies that compensation is performed every other raster. This is to allow for short duration rasters compensation.

Mirror step size defines the fine mirror step size per exposure. Note that for sit and stare rasters, this parameter should be set to 0 thus all the exposures are performed at the initial mirror position. Also note that the mirror is moved while the CCD is read-out in order to absorb the fine mirror step time latency. When more than one exposure time per raster position are required, the mirror will be stepped at the end of the "exposures set". For example if three exposures are required, then the mirror is stepped after the completion of the third exposure.

R/O nodes is a 4-bit parameter that defines the CCDs read-out nodes (1 = enabled), which are as follows:

Bit 0: CCDB L R/O chain enable
Bit 1: CCDB R R/O chain enable
Bit 2: CCDA L R/O chain enable
Bit 3: CCDA R R/O chain enable

Note that the read-out nodes setting is for the ICU CAM control board, which needs to route incoming data to the CCD buffer segments, according to the CCD read-out nodes. The setting here should match that of the CAM Control Reg. 2 (see CAM command ID 0x45 [3]).

Number of raster repeats defines the number of raster runs required (4095 repeats). When a raster set of exposures is completed, this parameter is decremented by 1 and if the raster repeats is not equal to 0, then a new jump to run raster command is initiated; otherwise, the next sequence command following the loop back command is executed.

The Science operations control parameter, which controls a specific science operation, is as follows:

Bit No.	**0**	**1**	**2***	**3***	**4***	**5***	**6**	**7**
Control	**Unused**		**XRT FLARE TRIGGER**	**EIS AEC**	**EIS EVENT TRIGGER**	**EIS FLARE TRIGGER**	**Unused**	

*1 = ENABLE
*0 = DISABLE

EIS CAM Clocking sequence IDs, which are PROM based, are as follows:

CAM CSG ID	DESCRIPTION
0	Flush sequence (default mode, i.e. CAM stand alone test mode). **Not to be used from sequence interpreter.** Flush x 5
1	R/O sequence (default mode, i.e. CAM stand alone test mode). **Not to be used from sequence interpreter.**
The following sequences **can be used** from the sequence interpreter	
2	Flush sequence
3	Read out sequence. No bottom line, no first column
4	Copy of CSG ID 3. To be modified autonomously on-board for flare operations (re-pointing).

CAM CSG ID	DESCRIPTION
5	Read out of the CCD in 2x2 OCB, all co-ordinates must be halved. Engineering only. No bottom line, no first column
6	STIMS image, 1024 x 512 per CCD half. Engineering only. Requires correct control of the analogue control registers.
7	Cross talk test. Engineering only, image 1024 x 512 per CCD half.

Appendix2: EIS critical and double commands

The following list identifies EIS critical commands:

Command BC1	Subsystem	Notes
0x5D	MHC	ACTUATOR Arm. Must be sent first. Verify via MHC status.
0x56	MHC	ACTUATOR Disarm.
0x5E	MHC	ACTUATOR Fire. Verify via MHC status.

Note that the ACTUATOR ARM and FIRE are governed by the time-outs as set in the MHC parameter table (see appendix 3). Arming and firing the actuators can be verified via the MHC status [7].

And the following are EIS double commands:

Command BC1	Subsystem	Notes
0xF5	ICU	ICU Reset command
0x2D	ICU	E2 Copy request
0x2E	ICU	E2 Copy perform

Note that for the ICU reset double commands the time between two 0xF5s commands should not exceed 40 seconds. It is **recommended** to send these commands at a minimum Solar-B commands time spacing (65 ms). Resetting the ICU should invoke the ICU bootstrap mode.

For the EEPROM “copy request” and “copy perform” there are no timing restrictions. Note that if two different E2 copy requests are issued without a “copy perform” command, then the second copy request is undertaken when a “copy perform” command is received. However, any subsequent “copy request” and “copy perform” commands must only be sent after the current “copy in progress” changes to “stopped”, as reported in the ICU status type-1.

Appendix 3: MHC parameters table

Note: All parameters are 16 bits in length unless explicitly stated otherwise.

PARM #	PARM ID	PARAMETER	DESCRIPTION	DEFAULT	VALUES
1	0xC065	COMMAND_TIMEOUT	Master command timeout duration – pending command aborted if this parameter is exceeded	125(*1000) ms	1-65535 (x1000) ms. 0 = no timeout
2	0x0066	MIR_C_RESOLVER_RESOLUTION	Sets resolver resolution from a minimum of 10 bits to a maximum of 16 bits Full scale range is 0 –65535 independent of resolution	16 bits, (0x00C0)	0x0000 10 Bit Resolution 0x0040 12 Bit Resolution 0x0080 14 Bit Resolution 0x00C0 16 Bit Resolution
3	0xE8E7	SS_RESOLVER_RESOLUTION	Sets resolver resolution from a minimum of 10 bits to a maximum of 16 bits Full scale range is 0 – 65535 independent of resolution	16 bits (0x00C0)	0x0000 10 Bit Resolution 0x0040 12 Bit Resolution 0x0080 14 Bit Resolution 0x00C0 16 Bit Resolution
4	0xE8E8	GRA_MAX_RUN_TIME	Sets grating motor timeout. Movement inhibited (RAM mode).	0 ms	0 to 65535 * (x100) ms. 0 = Lockout
5	0x0069	GRA_MAX_STEPS	Sets grating motor max step count Movement inhibited (RAM mode).	0 steps	0 – 65535 steps. 0 = Lockout
6	0xC06A	GRA_STEP_RATE	Sets motor step rate (1/interval)	0x000A (One step/10ms)	(1/) 5 – (1/) 65535 steps per ms, i.e. 1 step per 5ms (min) to 1 step per 65535 ms (max)
7	0x28EB	GRA_DUTY_CYCLE	Sets motor drive step duty cycle	0x8000, i.e. 50%	% * 65535
8	0xA06C	GRA_HOLD_TIME	Sets the motor power on time after stop	0 ms RAM mode only	0 – 65535 ms
9	0x48ED	SHUTTER_DIRECTION	Sets Shutter motor direction for auto moves	0x0001	0x0001 = FORWARD 0xFFFF = REVERSE **NOTE: Reverse not supported**
10	0x88EE	SHUTTER_MAX_RUN_TIME	Sets maximum run time for shutter	12000 ms	1 – 65535 ms This parameter should NOT be changed.
11	0x606F	SHUTTER_MAX_STEPS	Sets Shutter motor max step count	0xFFFF	1 – 65535 steps (72 STEPS PER REV) This parameter should NOT be changed.
12	0x00F0	SHUTTER_BRAKE_TIME	Sets Time from shutter stop to brake release	20ms	1 – 65535 ms This parameter should NOT be changed.
13	0xE871	SPARE **This Parameter is NOT USED**		0x0000	
14	0x2872	MIR_C_MAX_RUN_TIME	Sets Primary Mirror coarse motor timeout	1200(*100) ms, i.e. 120 second	0 – 65535 * (x100) ms 0 = Lockout
15	0xC0F3	MIR_C_MAX_STEPS	Sets Primary Mirror coarse motor max step count	600	0 – 65535 steps 0 = Lockout
16	0x4874	MIR_C_STEP_RATE	Sets motor step rate (1/interval)	0x000A, i.e. 1step /10 ms	(1/) 5 – (1/) 65535 steps per ms, i.e. 1 step per 5ms (min) to 1 step per 0xFFFF ms (max)

PARM #	PARM ID	PARAMETER	DESCRIPTION	DEFAULT	VALUES
17	0xA0F5	MIR_C_DUTY CYCLE	Sets motor drive step on duty cycle	0x8000, i.e. 50%	% * 65535
18	0x60F6	MIR_C_MAX_ENCODER	Upper limit to Primary mirror encoder position (+X stop on flight mirror) NOTE: Increasing this value moves stop toward mirror centre position	0x4197	1-65535, 0 = no limit check
19	0x8877	MIR_C_MIN_ENCODER	Lower limit to primary mirror encoder position (-X stop) on flight mirror NOTE: Decreasing this value moves stop toward mirror centre position	0x1409	1 – 65535 0 = no limit check
20	0x8878	MIR_C_HOLD_TIME	Time that power remains on after stop	0 ms RAM mode only	0 – 65535ms
21	0x60F9	SS_MAX_RUN_TIME	Sets SLIT/SLOT motor timeout	1200 (*100) ms, i.e. 120 second	1 – 65535 (x100) ms
22	0xA0FA	SS_MAX_STEPS	Sets SLIT/SLOT motor max step count	60000	1 – 65535 steps
23	0x487B	SS_STEP_RATE	Sets motor step rate (1/interval)	20, i.e. 1step / 20 ms	(1/) 5 – (1/) 65535 steps per ms, i.e. 1 step per 5ms (min) to 1 step per 0xFFFF ms (max)
24	0xC0FC	SS_DUTY_CYCLE	Sets motor drive step on duty cycle	0x8000, i.e. 50%	% * 65535
25	0x287D	MOTOR_READ_DELAY RAM mode only.	Motor off to final RDC read delay, i.e. settling time.	125 ms	0 –65535 ms This parameter should NOT be changed.
26	0xE87E	SS_WINDOW_S RAM mode only.	Defines acceptable resolver offset around defined slit/slot position. This is the “outer window “that determines the “resting” place for the SS compared with parameter #91 “inner window” which determines the target position to stop the motor.	75	SS resolver count
27	0x00FF	SS_HOLD_TIME	Time that power remains on after stop	0 ms RAM mode only	0 –65535ms
28	0x6900	ACTUATOR_ARM_TIMEOUT	Sets max time that an actuator may remain armed	500 (*100) ms, i.e. 50 second	1 – 65535 (x100) ms 0 = arm function disabled
29	0x8181	ACTUATOR_FIRE_TIMEOUT	Sets max time that power is applied to an actuator after a FIRE command	300 (*100) ms, i.e. 30 second	1 – 65535 (x 100) ms 0 = fire function disabled
30	0x4182	QCM_HEATER_TIMEOUT	Sets max time that power can be applied to QCM Heaters	300 (x1000) ms	1 – 65535 * (1000) ms 0 = QCM Heater timeout disabled
31	0xA903	CAL_TIMEOUT	Sets max time that power can be applied to a CAL led. (X10) ms ROM code.	0xFFFF **(X1)** ms (RAM mode)	1 – 65535 0 = CAL LED timeout disabled
32	0x2184	PZT_OVERTEMP_SAFE	Sets PZT safe mode trip point	0X0000	Raw ADC temp value. 0 = limit check disabled
33	0xC905	MIR_C_OVERTEMP_SAFE	Sets MIC_C safe mode trip point	0x3F4A (~60^{o}C)	Raw ADC temp value. 0 = limit check disabled
34	0x0906	SHUTTER_OVERTEMP_SAFE	Sets Shutter safe mode trip point	0x3F4A (~60^{o}C)	Raw ADC temp value. 0 = limit check disabled
35	0xE187	GRA_OVERTEMP_SAFE	Sets GRA safe mode trip point	0x3F4A (~60^{o}C)	Raw ADC temp value. 0 = limit check disabled

PARM #	PARM ID	PARAMETER	DESCRIPTION	DEFAULT	VALUES
36	0xE188	SS_OVERTEMP_SAFE	Sets Slit/Slot safe mode trip point	0x3F4A (~60°C)	Raw ADC temp value. 0 = limit check disabled
37	0x0909	MHC_OVERTEMP_SAFE_D	Sets MHC electronics safe mode trip point	0X0000	ADC temp value 0 = limit check disabled
38	0xC90A	PWR_OVERTEMP_SAFE_B	Sets MHC power converter safe mode trip point	0x3F84 (~70ºC)	ADC temp value. 0 = limit check disabled
39	0x218B	SPARE **This Parameter is NOT USED**		0x0000	
40	0xA90C	RS422_DROPOUT_SAFE	MHC invoke safe mode if no command received by the MHC in 140 seconds. Timing begins after completion of last received command.	140 (*1000) ms	1 – 65535 (x1000) ms
41	0x418D	SPARE **This Parameter is NOT USED**		0X0000	
42	0x818E	SPARE **This Parameter is NOT USED**		0X0000	
43	0x690F	+15VM_VOLTAGE_SAFE	Sets the absolute (+/-) excursion from nominal voltage for to trip a SAFE condition	0X0000	15.009V +/- (1 – 655535) * 2.44mV. 0 = limit check disabled
44	0x0990	+5V_VOLTAGE_SAFE	Sets the absolute (+/-) excursion from nominal voltage for to trip a SAFE condition	0X0000	5.003v +/- (1 – 655535) * 2.44mV. 0 = limit check disabled
45	0xE111	+15V_VOLTAGE_SAFE	Sets the absolute (+/-) excursion from nominal voltage for to trip a SAFE condition	00X0000	15.009V +/- (1 – 655535) * 2.44mV. 0 = limit check disabled
46	0x2112	-15V_VOLTAGE_SAFE	Sets the absolute (+/-) excursion from nominal voltage for to trip a SAFE condition	0X0000	-15.009V +/- (1 – 655535) * 2.44mV. 0 = limit check disabled
47	0xC993	+5VA VOLTAGE_SAFE	Sets the absolute (+/-) excursion from nominal voltage for to trip a SAFE condition	0X0000	5.003V +/- (1 – 655535) * 2.44mV. 0 = limit check disabled
48	0x4114	-5VA_VOLTAGE_SAFE	Sets the absolute (+/-) excursion from nominal voltage for to trip a SAFE condition	0X0000	-5.003V +/- (1 – 655535) * 2.44mV. 0 = limit check disabled
49	0xA995	+120V_VOLTAGE_SAFE	Sets the absolute (+/-) excursion from nominal voltage for to trip a SAFE condition	0X0000	120.078V +/- (1 – 655535) * 2.44mV 0 = limit check disabled
50	0x6996	SPARE		0X0000	
51	0x8117	RDC CURRENT SAFE	Sets MAX RDC current	0x0560 (100ma)	7.266 x10^{-5} *(1 – 65535) A. 0 = limit check disabled
52	0x8118	SPARE (RAM mode only)		0x0000	
53	0x6999	+5V CURRENT_SAFE	Sets the maximum current for to trip a SAFE condition	0x0000	2.907 x 10^{-4*} (1 – 65535) A 0 = limit check disabled
54	0xA99A	+15V_CURRENT_SAFE	Sets the maximum current for to trip a SAFE condition	0x0000	2.907 x 10^{-4*} (1 – 65535) A. 0 = limit check disabled
55	0x411B	-15V_CURRENT_SAFE	Sets the maximum current for to	0x0000	2.907 x 10^{-4*} (1 –

PARM #	PARM ID	PARAMETER	DESCRIPTION	DEFAULT	VALUES
			trip a SAFE condition		65535) A 0 = limit check disabled
56	0xC99C	SPARE (RAM mode only)		0x0000	
57	0x211D	SPARE (RAM mode only)		0x0000	
58	0xE11E	SPARE (RAM mode only)		0x0000	
59	0x099F	PRIMARY Mirror Fine Control PID Mode	PID controller parameter	0xFFFF	0x0000 = S/W 0xFFFF = H/W NOTE: S/W Mode not supported
60	0xC9A0	Primary Mirror Fine Control PID sample period **This Parameter is NOT USED**	PID controller parameter	10	32 bit IEEE 754 Floating point
61	0x2121			0x0000	
62	0xE122	Primary Mirror Fine Control PID Integral Period **This Parameter is NOT USED**	PID controller parameter	10	32 bit IEEE 754 Floating point
63	0x09A3			0x0000	
64	0x8124	Primary Mirror Fine Control PID Derivative Period **This Parameter is NOT USED**	PID controller parameter	10	32 bit IEEE 754 Floating point
65	0x69A5			0x0000	
66	0xA9A6	Primary Mirror Fine Control PID Reset period **This Parameter is NOT USED**	PID controller parameter	10	32 bit IEEE 754 Floating point
67	0x4127			0x0000	
68	0x4128	Primary Mirror Fine Control PID Controller gain **This Parameter is NOT USED**	PID controller parameter	-50	32 bit IEEE 754 Floating point
69	0xA9A9			0x0000	
70	0x69AA	Primary Mirror Fine Control PID Proportional gain **This Parameter is NOT USED**	PID controller parameter	50	32 bit IEEE 754 Floating point
71	0x812B			0x0000	
72	0x09AC	Primary Mirror Fine Control PID Derivative gain **This Parameter is NOT USED**	PID Controller parameter	10	32 bit IEEE 754 Floating point
73	0xE12D			0x0000	
74	0x212E	Heater 0 Duty Cycle	Manual mode heater duty cycle	0xFFFF	% * 65535 0xFFFF = disabled
75	0XC9AF	Heater 1 Duty Cycle	Manual mode heater duty cycle	0xFFFF	% * 65535 0xFFFF = disabled
76	0XA930	Heater 2 Duty Cycle	Manual mode heater duty cycle	0xFFFF	% * 65535 0xFFFF = disabled
77	0x41B1	Heater 3 Duty Cycle	Manual mode heater duty cycle	0xFFFF	% * 65535 0xFFFF = disabled
78	0x81B2	Heater 4 Duty Cycle	Manual mode heater duty cycle	0xFFFF	% * 65535 0xFFFF = disabled
79	0x6933	Heater 5 Duty Cycle	Manual mode heater duty cycle	0xFFFF	% * 65535 0xFFFF = disabled
80	0XE1B4	Heater 6 Duty Cycle	Manual mode heater duty cycle	0xFFFF	% * 65535 0xFFFF = disabled
81	0x0935	Heater 7 Duty Cycle	Manual mode heater duty cycle	0xFFFF	% * 65535 0xFFFF = disabled
82	0xC936	Heater 8 Duty Cycle	Manual mode heater duty cycle	0xFFFF	% * 65535 0xFFFF = disabled
83	0x21B7	Heater 9 Duty Cycle	Manual mode heater duty cycle	0xFFFF	% * 65535 0xFFFF = disabled
84	0x21B8	Heater 10 Duty Cycle	Manual mode heater duty cycle	0xFFFF	% * 65535 0xFFFF = disabled
85	0xC939	Heater 11 Duty Cycle	Manual mode heater duty cycle	0xFFFF	% * 65535 0xFFFF = disabled
86	0x093A	Heater Cycle Time	Heater cycle time	100 (*100) ms	1 – 65535 (x100) ms
87	0xE1BB	SS Position 0	SS Position 0 resolver target	0x0040	0 - 65535
88	0x693C	SS Position 1	SS Position 1 resolver target	0xC040	0 - 65535
89	0x81BD	SS Position 2	SS Position 2 resolver target	0x8037	0 - 65535
90	0x41BE	SS Position 3	SS Position 3 resolver target	0x4082	0 - 65535
91	0xA93F	SS_POSITION_WINDOW	SS Resolver target window (inner window)	0x001A	0 - 65535
92	0XA9C0	SG_ULIM	SG output at FMIR upper limit. This is not used at present and was intended for FMIR closed loop SW controller (implemented in HW due to excessive SW overhead)	0x0FFF	0 – 0x0FFF

PARM #	PARM ID	PARAMETER	DESCRIPTION	DEFAULT	VALUES
93	0X4141	SG LLIM	SG output at FMIR lower limit. As above (#92).	0x0000	0 – 0x0FFF
94	0X8142	SG_SCALE	FMIR Travel range. As above (#92).	0x0176	0 – 65535
95	0X69C3	PAR_ENC_ENA	Paraffin Actuator Encoder Read enable/disable. Enabling allows continuous clamshell door status reporting in status type 3. Must be disabled when not needed as the encoder LED emits light and that may interfere with science operations.	0x0001 (RAM only)	0x0001 = enabled Others = disabled (0xFFFF is used for disable)
96	0XE144	SHUTTER_BRAKE_LEAD	Shutter brake advance steps	2	0 – 65535 steps This parameter should NOT be changed.
97	0X09C5	MIRC_WINDOW	MIR_C target position resolver window	0x000F	0 - 65535
98	0XC9C6	MIRC_CENTER	MIR_C Centre position	0xAAD0	0 – 65535 (raw RDC output)
99	0X2147	MHC_OVERTEMP_SAFE_AN	MHC Analogue board over temp safe	0x0000	Raw ADC temp value 0 = limit check disabled
100	0X2148	MHC_OVERTEMP_SAFE_AX	MHC Aux board over temp safe	0x0000	Raw ADC temp value. 0 = limit check disabled
101	0XC9C9	PWR OVERTEMP_SAFE_A	MHC Power converter A over temp safe	0x3F84 (70ºC) (RAM mode)	Raw ADC temp value. 0 = limit check disabled
102		CHECKSUM	Parameter table checksum. Checksum will change if parameter settings are changed. Requires at least 1 parameter table poke for the checksum to become valid, otherwise MHC auto-safe is entered (parameter table checksum error), if enabled (PROM code only).	0xB383 RAM mode only	XOR 16 Bit Checksum

Appendix 4: AEC control parameters

The implementation details and the AEC algorithm description are given in [12].

Bit 0 **Bit 31**

Upper threshold		Lower threshold
High-energy pixel count limit		
Low-energy pixel count limit		
Exposure ID	Binning	AEC maximum run time (seconds)

Where:

Bit 0 – Bit 15: Upper threshold (high energy pixel threshold), range 0 to (2^14 – 1).
Bit 16 – Bit 31: Lower threshold (low energy pixel threshold), range 0 to (2^14 – 1)

Bit 0 to 31: High-energy pixel count limit, range 1 to (2^32 – 2). This parameter specifies the high-energy pixel number beyond which the exposure time is reduced (over-exposed condition)

Bit 0 to 31: Low energy pixel count limit, range 1 to (2^32 – 2). This parameter specifies the low-energy pixel number beyond which the exposure time is increased (under-exposed condition).

Note that for the above 2 parameters, 0's and all F's are illegal values (software trapping for un-initialised values).

Bit 0 to 4: Exposure ID, range 0 to 27 that represents the AEC start-up exposure time
Bits 5 to 14: Binning factor (average pixels in the Y-direction), range 1 to 512. It is unlikely that binning is required, however, in the event of "too many" dead pixels or columns near the end of the mission, binning may need to be introduced.
Bit 15 to 31: AEC run time, range 0 to (2^17 –1) in seconds, i.e. **36.4 hours**, maximum. If 0 seconds run-time is specified then the AEC will run until either stopped (the specified number of exposures is completed) or aborted via Manual mode transition. Specifying a non zero run-time will result in the sequence being terminated internally (aborted) when the run time has lapsed or via Manual mode transition, which ever comes first.

In **addition to setting the AEC control parameters and AEC exposures time table**, an AEC reference line **must** be specified in the line list [11]. Failing to do so will result in the raster running at a **fixed exposure time** (22 seconds which is the middle position of the AEC default exposures timetable).

Appendix 5: XRT Flare trigger control parameters

The implementation details description to be documented.

Bit 0 **Bit 31**

Sequence no.	Raster ID				Control flags
Y start address					
Y height address					
X0		Y0			Filler sequence no.
θ	XRT OCB	XRT P-Size	FS enable	EIS FOV flag	Spare bit

Where:

Sequence no.: Is an 8 bit parameter which specifies EIS XRT flare trigger response sequence number. This sequence will run when XRT flare is triggered.
Raster ID: Is a 16-bit parameter, which specifies the response raster identifier. Raster parameters are used for EIS autonomous repointing, if required. Raster ID should not be 0 or 0xFFFF (software error trapping for un-initialised values).

Control flags: These flags are as follows (1 bit flags),

Verify FOV: When set, the ICU software verifies whether the flare is within EIS FOV.
Adjust Y: When set, a repointing in the Y-direction is performed, via reducing the number of rows read out.
Adjust X: When set, a repointing in the X-direction is performed, via the fine mirror.
Note that Adjust X and or Y must be accompanied by Verify FOV setting. It is not possible to repoint if the flare is outside EIS FOV
X0 sign: EIS-XRT alignment error sign in the X direction (dispersion). Setting the flag to 1 indicates –X0 alignment error.
Y0 sign: EIS XRT alignment error sign in the Y direction (spatial). Setting the flag to 1 indicates –Y0 alignment error.
θ Sign: EIS XRT angular alignment error sign. Setting the flag to 1 indicate –θ alignment error.
X Conversion: EIS-XRT X-direction optical orientation. Setting the flag to 1 indicates –X conversion (inversion). This flag should be set to 1 as EIS-XRT images are inverted in the X direction, relative to each other.
Y Conversion: EIS-XRT Y-direction optical orientation. Setting the flag to 1 indicates –Y conversion (inversion). This flag should be set to 0, as EIS-XRT images have the same orientation in the Y direction.

Y Start Address: The Camera read-out sequence Y start address memory location (32 bit parameter). The address is generated by CSG complier and should be treated as a constant, as long as the CAM read-out sequence is not changed. For example, using the FM CAM RROM CODE, CSD-ID 4, this parameter has the value (0x04000C00).

Y height Address: The Camera read-out sequence Y height address memory location (32 bit parameter). The address is generated by CSG complier and should be treated as a constant, as long as the CAM read-out sequence is not changed. For example, using the FM CAM RROM CODE, CSD-ID 4, this parameter has the value (0x04001400).

X0: Is a 12-bit parameter that specifies EIS-XRT alignment error in the X-direction, in arcseconds. The alignment sign is set to +/- using X0 sign control flag (see control flags).

Y0: Is a 12-bit parameter that specifies EIS-XRT alignment error in the Y-direction, in arcseconds. The alignment sign is set to +/- using Y0 sign control flag (see control flags).

Filler sequence number: If the flair flag resets by XRT (flare end), a “follow on” sequence can be run to fill the time gap until a next sequence is run via Solar-B deferred command store, i.e. OP/OG command store. This is an 8-bit parameter. This parameter is used if **FS enable flag is set.**

θ: Is a 16-bit parameter that specifies EIS-XRT angular alignment error, in arcseconds. The alignment sign is set to +/- using the θ sign control flag (see control flags).

XRT OCB: XRT flare detection algorithm OCB. This parameter should be set to 8. However, in the unlikely event of XRT changing their OCB factor, EIS can respond by changing this parameter. This is a 4-bit parameter (range 1 to 15).

XRT P-Size: Is an 8-bit parameter that specifies XRT pixel size, in arcseconds. A scale factor of 100 is applied to this parameter. For example, if XRT pixel size is 1.1”, then this parameter is set to 110.

FS enable: This is a 1-bit flag, which enables running a follow on sequence, when set to 1. See Filler sequence number.

EIS FOV flag: This is a 2-bit parameter to acquire EIS FOV centre (wavelength direction). EIS FOV is obtained from the coarse mirror position, as reported by the MHC HK. Prior to EIS integration, this parameter could have one of the following values:

1 = Coarse mirror position” + (EIS_FOV / 2)”
2 = Coarse mirror position” - (EIS_FOV / 2)”
3 = Coarse mirror position”

This parameter **must** be set to 01b.

Spare bit: Reserved for internal use. **Must** be set to 0.

Appendix 6: EIS Flare trigger control parameters

The implementation details description to be documented.

Bit 0			**Bit 31**
Sequence no.	Raster ID		Control flags
X Threshold			
Y Threshold			
Y start address			
Y height address			
X MIN LIMIT	Y MIN LIMIT	**EIS P-Size**	Reserved

Where:

Sequence no.: Is an 8 bit parameter which indicates EIS flare trigger response sequence number. This sequence will run when EIS flare is triggered.

Raster identifier: Is a 16-bit parameter, which specifies the response raster identifier. Raster parameters are used for EIS autonomous repointing, if required. Raster ID should not be 0 or 0xFFFF (software error trapping for un-initialised value).

Control flags: These flags are as follows (1 bit flags)
Adjust Y: When set, a repointing in the Y-direction is performed, via reducing the number of rows read out.
Adjust X: When set, a repointing in the X-direction is performed, via the fine mirror.
Locate Y: Locate flare peak (e.g. flare Kernel) or flare centre. This flag can have the following values:
0: Locate flare Y centre
1: Locate flare Y peak
The Y position is obtained from binning a line rows (dispersion direction)
Locate X: Locate flare peak (e.g. flare Kernel) or flare centre. This flag can have the following values:
0: Locate flare X centre
1: Locate flare X peak
The X position is obtained from binning spectral line columns (spatial direction)
Left repointing: Fine mirror adjustment to centralize the flare within the flare line. Flare location to the left of Xλ (flare line centre). This flag can have the following values:
0: Subtract from fine mirror position
1: Add to fine mirror position
Must be set to 0, as determined following EIS integration.
Right repointing: Fine mirror adjustment to centralize the flare within the flare line. Flare location to the right of Xλ (flare line centre). This flag can have the following values:
0: Subtract from fine mirror position
1: Add to fine mirror position
Must be set to 1, as determined following EIS integration.
Spare flags: 2 bits

X Threshold: A 32-bit threshold used for the flare line X-direction binning (row sums).

Y Threshold: A 32-bit threshold used for the flare line Y-direction binning (column sums).

Y Start Address: The Camera read-out sequence Y start address memory location (32 bit parameter). The address is generated by CSG complier and should be treated as a constant, as long as the CAM read-out sequence is not changed. For example, using the FM CAM RROM CODE, CSD-ID 4, this parameter has the value (0x04000C00).

Y height Address: The Camera read-out sequence Y height address memory location (32 bit parameter). The address is generated by CSG complier and should be treated as a constant, as long as the CAM read-out sequence is not changed. For example, using the FM CAM RROM CODE, CSD-ID 4, this parameter has the value (0x04001400).

X MIN LIMIT: Number of consecutive sample measurements above which a flair trigger is considered. For example, setting this parameter to 12 means that at least 12 consecutive row sums above the X-threshold for “valid flair”. This is an 8-bit parameter.

Y MIN LIMIT: Number of consecutive sample measurements above which a flair trigger is considered. For example, setting this parameter to 12 means that at least 12 consecutive column sums above the Y-threshold for “valid flair”. This is an 8-bit parameter.

EIS P-Size: EIS pixel size in arcseconds. A factor of 100 is applied to this parameter. For example, if EIS pixel size is 1.15”, then this parameter is set to 115.

Reserved: An 8-bit parameter reserved for internal use. **MUST** be set to 0.

Appendix 7: EIS Event trigger control parameters

The implementation details description to be documented.

Bit 0		**Bit 31**
Sequence no.	Raster ID	Control flags
X Threshold		
Y Threshold		
Y start address		
Y height address		

Where:

Sequence no.: Is an 8 bit parameter which indicates EIS event trigger response sequence number. This sequence will run when EIS event is triggered.
Raster identifier: Is a 16-bit parameter, which specifies the response raster identifier. Raster parameters are used for EIS autonomous repointing, if specified. Raster ID should not be 0 or 0xFFFF (software error trapping for un-initialised values).

Control flags: These flags are as follows
Adjust Y: This is a 1-bit flag, when set; a repointing in the Y-direction is performed, via reducing the number of rows read out.
Adjust X: This is a 1-bit flag, when set; a repointing in the X-direction is performed, via the fine mirror.
X MIN LIMIT: This is a 3-bits parameter; which specifies the number of consecutive sample measurements above which an event trigger is considered. For example, setting this parameter to 4 means that at least 4 consecutive row sums above the X-threshold for “valid event”.
Y MIN LIMIT: This is a 3-bits parameter; which specifies the number of consecutive sample measurements above which an event trigger is considered. For example, setting this parameter to 4 means that at least 4 consecutive column sums above the Y-threshold for “valid event”.

X Threshold: A 32-bit threshold used for the event line X-direction binning (row sums).

Y Threshold: A 32-bit threshold used for the event line Y-direction binning (column sums).

Y Start Address: The Camera read-out sequence Y start address memory location (32 bit parameter). The address is generated by CSG complier and should be treated as a constant, as long as the CAM read-out sequence is not changed. For example, using the FM CAM RROM CODE, CSD-ID 4, this parameter has the value (0x04000C00).

Y height Address: The Camera read-out sequence Y height address memory location (32 bit parameter). The address is generated by CSG complier and should be treated as a constant, as long as the CAM read-out sequence is not changed. For example, using the FM CAM RROM CODE, CSD-ID 4, this parameter has the value (0x04001400).