**MULLARD SPACE SCIENCE LABORATORY**
**UNIVERSITY COLLEGE LONDON** **Author: K. Al-Janabi**

# EIS Mission data structure

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| Author | K. Al-Janabi | Date: | 20/06/2005 |
| Authorised By | A. James | Date: | 20/06/2005 |
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| EIS-Science | ✓ |
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## CHANGE RECORD

| ISSUE | DATE | PAGES CHANGED | COMMENTS |
|---|---|---|---|
| 01 | 04-01-2001 | All new | Draft release |
| 02 | 30-03-2001 | 9, 12 | Change the definition of sub ID. Also redefine Header Area spare bits.<br>Correct an error in EIS exposure information (size = 224 instead of 244). Also re-adjust window header parameters. |
| 03 | 10-12-2002 | 12, 13 | Added 9 new parameters (17 bytes) to instrument exposure parameters.<br>Various clarifications. |
| 04 | 20-12-2003 | 11 | Updated MHC pointing information, as they became available following FM ICU-MHC integration. Also Added new exposure parameters. These parameters are related to AEC and flare triggers. |
| 05 | 04-08-2004 | 12<br>12<br>13<br>15 | Specified fine mirror range<br>Specified Y height range<br>Specified slit/slot positions<br>Added event trigger parameters |
| 06 | 20-06-2005 | Various<br>12<br><br>12,13<br><br>17 | Clarified issues raised<br>Corrected an error in the MHC exposure time, as in [4]<br>Specified line list ranges for X and Y parameters<br>Added the following parameters (needed for EIS FITS files header):<br>ASRC parameters<br>Number of exposures per raster position<br>FMIR step size |

**LIST OF CONTENTS:**

**Glossary and Convention:**

| | |
|---|---|
| AE | Camera Analogue Electronics |
| AEC | Automatic Exposure Controller |
| b | Binary |
| BC | Block Command, Solar-B Command parameter |
| CAM | Camera |
| CMD-ID | Solar-B command ID (BC1) |
| DC | Discrete Command (Solar-B command header) |
| EIS | Extreme-ultraviolet Imaging Spectrometer |
| EOF | End Of Frame (end of read-out) |
| GSE | Ground Support Equipment |
| HSL | ROE High Speed Link (science link) |
| ICD | Interface Control Document |
| MHC | Mechanism and Heater controller |
| OCB | On Chip Binning (Camera function) |
| PSU | Power Supply Unit |
| ROE | Camera Read-out Electronics |
| SF | CCD Side Flag |
| TI | Time Indicator (Solar-B spacecraft time) |

**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/SP0013.01
4 – MHC S/W ICD (ICU-MHC), V17.1
5 – Private discussion with Chris McFee and Kerrin Rees, on the 22-12-2000
6 – EIS telecommanding structure: MSSL/SLB-EIS/SP016.06
7 – EIS sequence structure overview: MSSL/SLB-EIS/TN014.06
8 – As agreed with the J-side during PM S/C integration
9 – EIS Status: MSSL/SLB-EIS/SP017.06
10 – Pixels X=0 and Y=0 read-out is not supported within the CAM PROM CSG sequences (KJR).

# 1.0 Introduction

This document outlines the structure of EIS Mission Data sent by the ICU. Note that within Solar-B, there are two packet structures; the MDP packet structure as described in this document (ICU to MDP) and CCSDS packet structure. The CCSDS packet structure (MDP to ground) is described in [2], section 8.7.

Prior to specifying the parameters required for EIS mission data, a brief description of EIS science operations are given below.

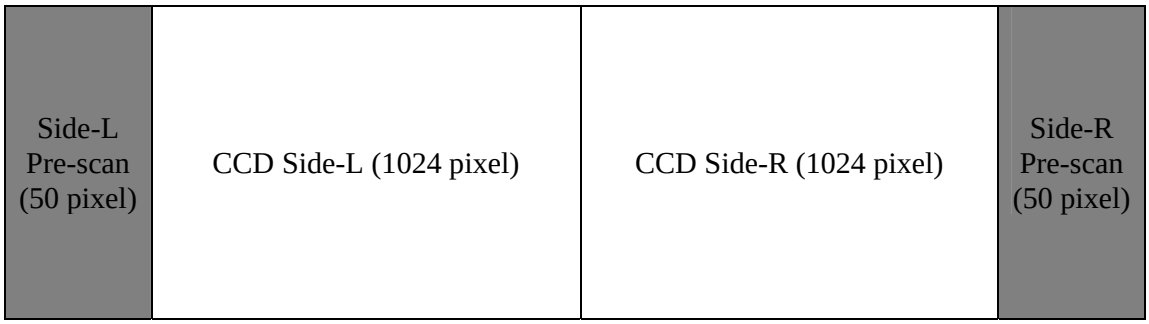
This documents follows Solar-B bit convention where bit 0 is the Most Significant Bit.

# 2.0 EIS science operations

Central to the science operations are EIS sequences. Each sequence can contain any number of commands (Sequence specific commands and sub-systems commands, CAM and MHC). A sequence can include one or more raster. A typical raster performs exposures, interleaved with fine mirror movement. Such a raster may scan EIS full field of view (6'). EIS rasters perform its data processing operations using line list (window) tables. EIS sequence structure and operations are described in [7].

# 3.0 EIS CCDs

Although the specified CCDs length is 2048 pixels, however, the actual length is 2148 pixels when the pre and over-scan pixels, which are extension to the CCD read-out registers, are included, as illustrated below:

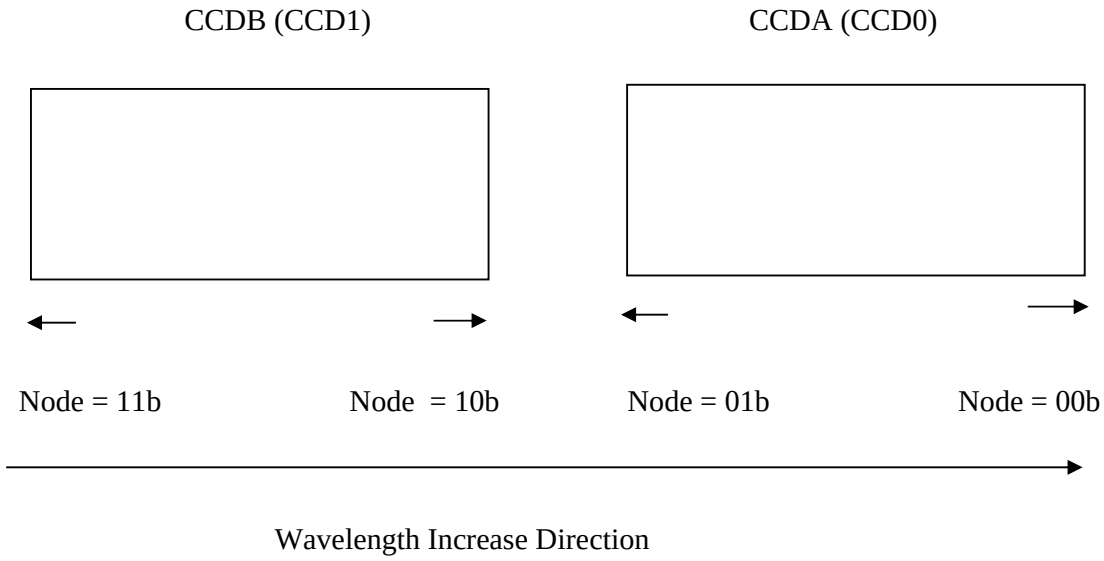



**EIS CCD STRUCTURE**

Note that the pre and over scan pixels are only used for the CCDs calibration, i.e. charge transfer efficiency and 0 pixel level determination, i.e. background noise measurements. Also note that when reading from one node (e.g. Side L), then the first 50 pixels are the pre-scan pixels and the last 50 pixels of the row (side-R in this example) are the over-scan pixels.

Also note that for science data acquisition, the scan pixels are not needed.

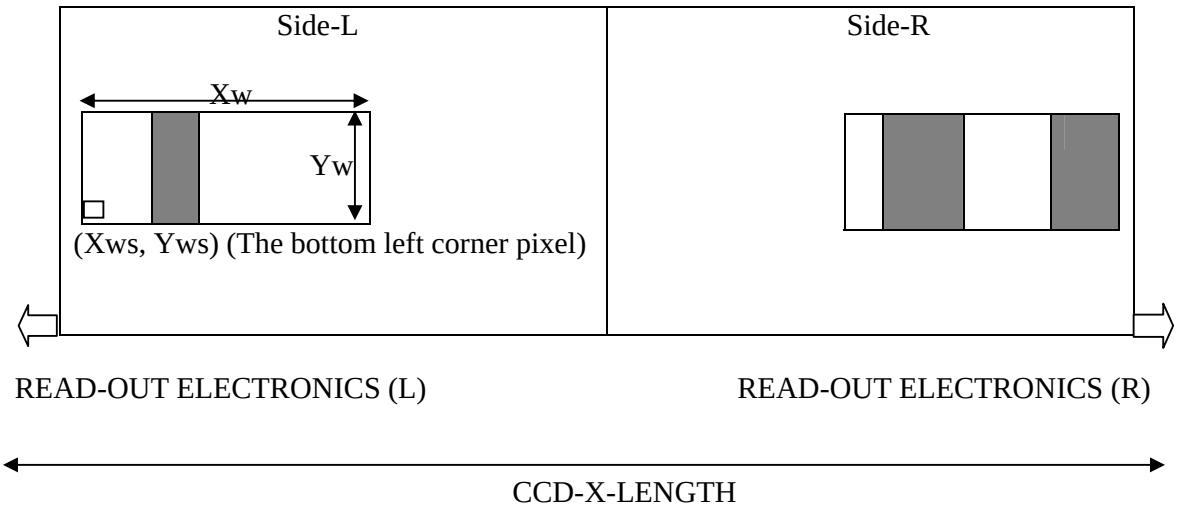
The EIS CCDs naming convention is shown bellow:




Note that a node consists of the CCD number (1 bit) and CCD side (1 bit). Also note that every pixel sent by the CAM consists of side flag (2 bits for the node identifier) and 14-bit energy.

## 4.0 Camera hardware window and software line list terminology

The EIS camera supports one window (hardware window) for both CCDs as shown below:



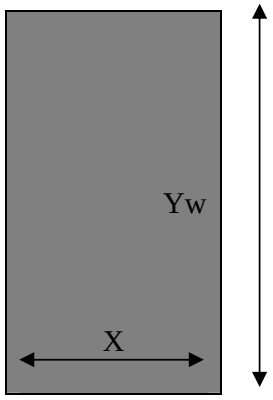

**Camera window coordinates**

For the Camera hardware window, as set by the CAM Clock Sequence Generator (CSG), the following terminology is used in this document:

**Xws**: CAM Window X-start
**Yws**: CAM window Y-start
**Xw**: CAM window X-length

**Yw**: CAM window Y-length
**CCD-X-Length**: The total length of the CCD (including scan pixels if read-out)

Within each hardware window, an N number of software windows (up to 25 window in total [1]) can be selected (the shaded areas in the diagram above). Each window is defined by the following parameters:




(Xs, Yws)

Xs: Software window X-start
Ys: Software window Y-start (same as Yws)
X: Software window X length

Note that all the software windows have the same height and their height should be the same as that of the hardware window (Yw). Similarly all the windows Ys should be the same as Yws.

## 5.0 Camera read-out issues

When reading from sides L & R, the ICU CCD Buffer memory is partitioned into 4 blocks. Each block is capable of holding 1024 X 512 pixels, as shown below:

| CCD SIDE | OFFSET WITHIN CCD BUFFER |
|---|---|
| CCD1 Side-L | Offset 3 * 1024 * 512 |
| CCD1 Side-R | Offset 2 * 1024 * 512 |
| CCD0 Side-L | Offset 1024 * 512 |
| CCD0 Side-R | Offset = 0 |

Note that side-L pixels are copied to the buffer in ascending order, however Side-R are inverted (right to left), as illustrated in the example below:

Assume we have a window of 2X2 pixels, as shown below:

| | |
|---|---|
| Pixel 2 | Pixel 3 |
| Pixel 0 | Pixel 1 |

When reading from Side-L, the pixels are sent by the ROE to the CCD buffer in the following order:

Pixel 0, Pixel 1, Pixel 2, Pixel 3

However when reading from Side-R, then the pixels are sent by the ROE to the CCD buffer in the following order:

Pixel 1, Pixel 0, Pixel 3, Pixel 2

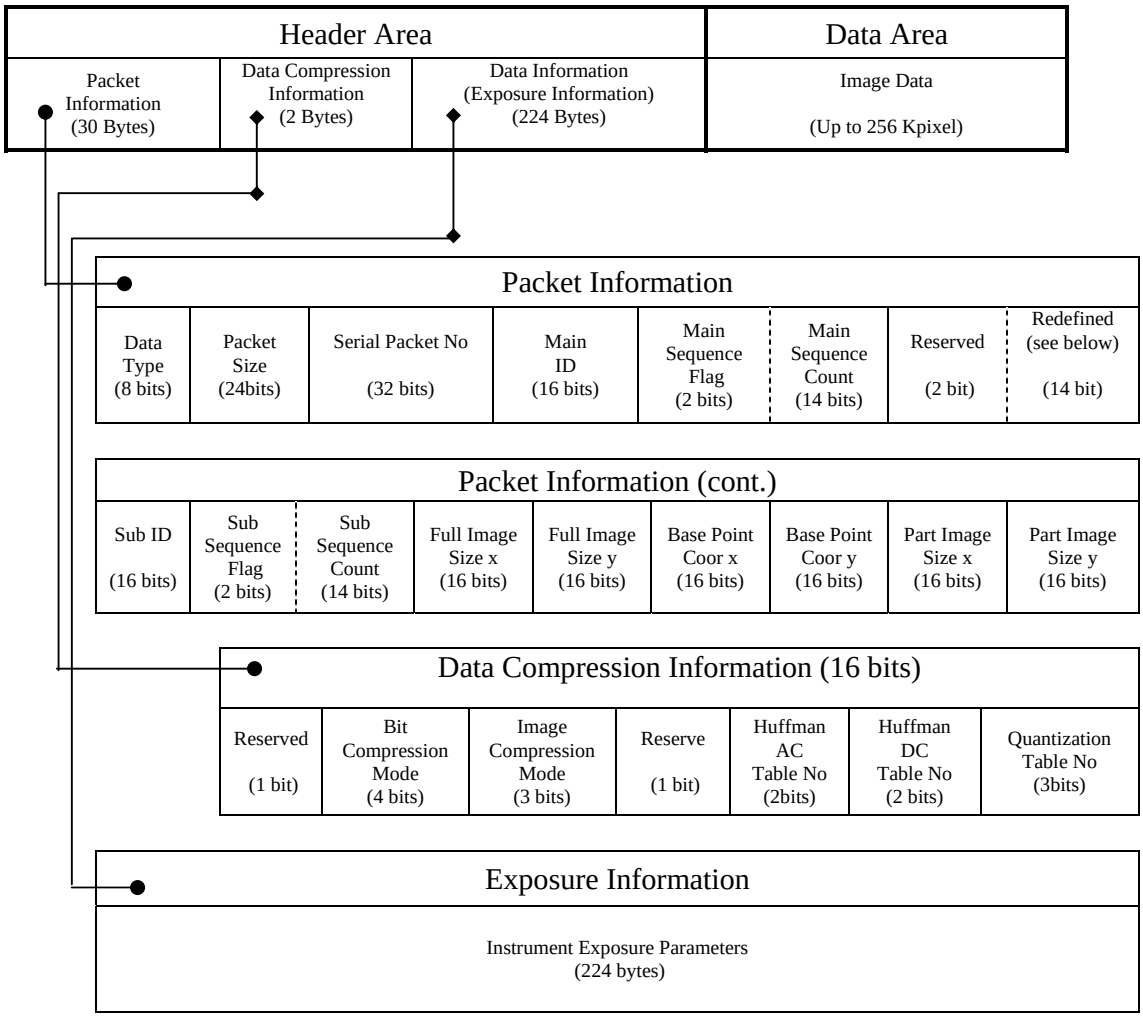
Note: In order to unify the data structure from both CCD sides, the ICU “mirror image” Side-R data such that Side-R data structure is similar to that of Side-L.

When reading from a single side (L or R), the ICU CCD Buffer memory is partitioned into 2 blocks. Each block is capable of holding 2 X 1024 X 512 pixels, as shown below:

| CCD | OFFSET WITHIN CCD BUFFER |
|---|---|
| CCD1 | Offset 2 * 1024 * 512 |
| CCD0 | Offset = 0 |

# 6.0 Mission data structure

The mission data structure (exposure data packets) as specified by the J-side for Solar-B [2] is shown below. As described in [2], a mission data packet consists of a packet header (header area) and pixel data. The maximum packet size consists of packet header (256 bytes) plus 256 Kpixel (16-bit pixel). The size of the packet header (header area) shall be **a multiple of 16 bytes and of fixed length [2]. Also note that the maximum mission data packet rate (ICU to MDP) is one packet every 0.5 second [2].**




**Mission data header format**

## 6.1 Packet information

**Data type:** 110 0001 (0 or 1) b **(**Mission Data Packets going to KSC&DR, and ISAS)

**Packet size:** Packet length in bytes, including mission data header area.

**Serial Packet No.:** Mission data packet counter. This is a 32-bit unsigned counter (range 0 to (2^32 –1). This counter is initialised to 0 on re-boot and incremented by 1 for every mission data packet sent to the MDP. Any discontinuity (jump) in this counter indicates a mission data packet loss.

**Main ID:** Raster counter. This is a 16-bit counter. This counter starts at 0 at reboot and incremented by 1 for every raster run. Aborting a sequence will also reset this counter to 0 [8].

**Main Sequence Flag:** Raster sequence flag.

00: Continuation exposure of a raster
01: First exposure of a raster **(Start new FITS file)**
10: Last exposure of a raster
11: Stand-alone exposure (single exposure raster). **(Start new FITS file)**

**Main Sequence Count:** exposure counter within a raster. This is a 14 bit counter (range 0 to (2^14 – 1). This counter initialised to zero for the first exposure of a raster and incremented by 1 for each subsequent exposure.

**Reserved:** 2 Bits.
**MD packets per exposure:** This is an 8-bit parameter indicating the total number of MD packets per exposure.
**Image per frame:** This is a 6-bit parameter. Always set to1 for EIS.

**Sub ID:** Exposure counter. This is a 16-bit counter (range 0 to 2^16 – 1). This counter is initialised to 0 on re-boot and incremented by 1 for every exposure performed.

**Sub Sequence Flag:** Exposure packet(s) sequence flag (exposure based).

00: Continuation packet within an exposure
01: Initial packet of exposure
10: Last packet of exposure
11: Stand-alone exposure packet (single packet exposure)

**Sub Sequence Count:** Exposure packet counter. This counter is initialised to 0 for the first packet of an exposure and incremented by 1 for each subsequent exposure packet.

**Full Image Size ($X_f$, $Y_f$), Partial Image Size ($X_p$, $Y_p$):** as shown below, unit = pixel

**Base Point Coordinates (Bx, By):** Coordinates of left lower corner of partial image data.

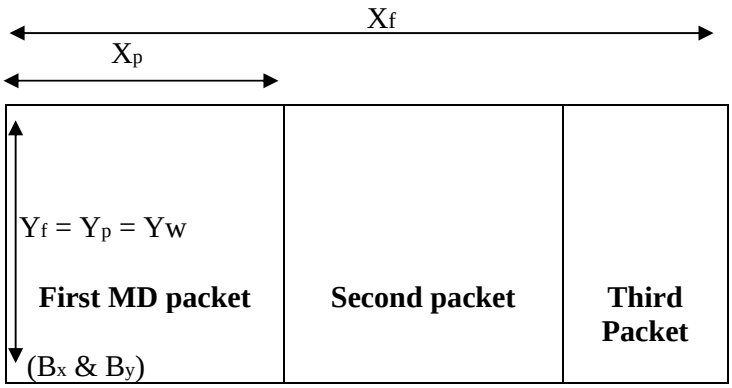



**Image partitioning**

## 6.2 Data compression information

**Reserve (1 bit):** Reserved area

**Bit Compression Mode (4 bits):**

0 [HEX]: No bit compression
1–7 [HEX]: 16 bits-to-12 bits compression
8–F [HEX]: 12 bits-to-8 bits compression

**Image Compression Mode (3 bits):**

000 (b): No image compression
001 (b): Reserved
010 (b): 8 bits DPCM
011 (b): 12 bits DPCM
110 (b): 8 bits JPEG
111 (b): 12 bits JPEG

**Image Compression Parameters (8 bits):**

Reserved (1 bit)
Huffman AC Table (2 bits): 00(b), 01(b), 10(b), 11(b)
Huffman DC Table (2bits): 00(b), 01(b), 10(b), 11(b)
Quantization Table (3bits): 000(b), 001(b), 010(b), 011(b), 100(b), 101(b), 110(b), 111(b)

Note that when data compression is specified in EIS Run Raster Command [6, 7], the side flags described in section 3 (2 MS bits of each pixels) are reset to zero internally by the ICU SW. This applies to setting any bit in the data compression parameter, i.e. none zero data compression value.

## 6.3 Exposure information

The exposure parameters should be 32-bit word aligned (internal ICU usage).

| PARAMETER | SIZE (BITS) | NOTES |
|---|---|---|
| Exposure time information | | |
| TI - 1 (shutter open time) | 32 | Exposure time: Spacecraft time (**start** exposure time). TI units. |
| TI - 2 (shutter close time) | 32 | Spacecraft time (**end** exposure time). TI units. |
| Exposure duration as measured by the MHC | 32 | MHC exposure time, i.e. the time between open and closed shutter as seen by the MHC (units of 1 μ second ticks) |
| Exposure duration | 16 | The exposure time as used in the raster (units of 10 ms) [1] |
| Observation table information | | |
| Sequence number | 8 | Sequence table number |
| Line list number | 8 | Window table number |
| Sequence ID | 16 | This a unique number for each sequence (allow identification and archiving) |
| Raster ID | 16 | As for sequence ID, but for rasters |
| Line List information (extracted from the selected line list table) | | |
| Number of windows | 5 | Max. 25 windows [1] |
| Unused | 3 | (TBC). Read-out nodes are reported in CCD read-out nodes selected and HSL status. |
| CCD-X-LENGTH | 12 | Max. CCD length **including** the scan pixels (12 bit max.).<br>Always 2148 for 1X1 OCB |
| Xws | 12 | CAM X window start (max. 12 bits)<br>Range: 0 to 2147,<br>1 to 2147 accounting for [10] |
| Xw | 12 | CAM X window length (width)<br>Range: 1 to 2148,<br>1 to 2147 accounting for [10] |
| Yws | 10 | Window Y-start (max. 1023). Bottom left hand corner of window.<br>Range: 0 to 1023 [10]<br>1 to 1023 accounting for [10] |

| PARAMETER | SIZE (BITS) | NOTES |
|---|---|---|
| Yw | 10 | CAM Y height (same for software window height)<br>Range: 1 to 512 pixel |
| **Software** window specific parameters<br>**Space is reserved for 25 windows**<br>**Allocation used as per Number of windows parameter** | | |
| Window header | 8 | Header structure:<br>**Bits 0 – 2**: Spare<br>**Bits 3**: AEC flag window<br>1(b): Use this window for AEC<br>0(b): Do not use this window<br>**Bits 4**: EIS event trigger window<br>1(b): Use this window<br>0(b): Do not use this window<br>**Bits 5**: EIS internal flare flag window<br>1b: Use this window<br>0b: Do not use this window<br>**Bits 6 – 7**: CCD read-out node<br>00b: CCD0 side-R<br>01b: CCD0 side-L<br>10b: CCD1 side-R<br>11b: CCD1 side-L<br><br>**Bits 3, 4 and 5 must be used in conjunction with the raster science operations control parameter [7].** |
| Window Xs | 12 | Window X start<br>Range: 0 to 2147,<br>1 to 2147 accounting for [10] |
| Window X | 12 | Window X-length<br>Range: 1 to 2148,<br>1 to 2147 accounting for [10] |
| MHC Pointing information, acquired from the MHC following the shutter close (Invalid for 0 exposure time, flat field exposures, STIM/test pattern type CAM exposures or communication problem between the ICU and the MHC) | | |
| Coarse mirror position | 16 | MHC Coarse mirror position, resolver count [9].<br><br>0xFFFF = Invalid |
| Fine mirror position | 16 | The MHC ADC fine mirror set point [9].<br>Bit 0: mode<br>0 = Manual Mode<br>1 = Auto mode (sequence use)<br>Bits 1 – 3: unused<br>Bits 4 to 15: Fine mirror set point position.<br>Range 600 to 3000 which corresponds to |

| PARAMETER | SIZE (BITS) | NOTES |
|---|---|---|
| | | 0-2400 mirror steps.<br><br>0xFFFF = Invalid |
| Slit number | 16 | MHC Slit/slot resolver position (**range**) [9].<br>Position 0 (1") ≈ 0x0040<br>Position 1 (250") ≈ 0xC040<br>Position 2 (2") ≈ 0x8037<br>Position 3 (40") ≈ 0x4082<br><br>0xFFFF = Invalid |
| OCB parameters (acquired from run raster command [6]) | | |
| X OCB | 8 | Spectral direction OCB |
| Y OCB | 8 | Spatial direction OCB |
| Number of raster exposures required | 32 | No of raster exposures, as specified by run raster command |
| Raster exposures counter | 32 | This counter is initialised to 0 at the start of a raster and incremented by 1 for every exposure performed. If the final count is not equal to the number of exposures required, then the raster is **aborted**. |
| Number of raster repeats required | 12 | As specified in run raster command, range from 1 to 4095 |
| Number of raster repeats performed | 12 | 12 bit counter, range from 1 to 4095. This counter is incremented for each raster repeat. |
| Number of sequence repeats required | 8 | As specified in a sequence header, range from 1 to 255 |
| Number of sequence repeats performed | 8 | 8 bit counter, range from 1 to 255. This counter is incremented for each sequence repeat. |
| CCD read-out nodes selected | 8 | Read-out nodes as specified by run (set) raster parameters [6]<br><br>**1 = Selected, 0 Disabled**<br><br>**Bits 0 to 3**: un-used = 0000b<br>**Bit 4**: CCD-A Right<br>**Bit 5**: CCD-A Left<br>**Bit 6**: CCD-B Right<br>**Bit 7**: CCD-B Left |

| PARAMETER | SIZE (BITS) | NOTES |
|---|---|---|
| HSL status | 16 | This parameter specifies the acquired ROE HSL status following the completion of a read-out.<br><br>**1 = Active/enabled**<br><br>**Bit 0**: unused<br>**Bit 1**: CCD-B left hand side port status<br>**Bit 2**: CCD-B right hand side port status<br>**Bit 3**: CCD-A left hand side port status<br>**Bit 4**: CCD-A right hand side port status<br>**Bit 5**: CCD bank selected<br>0 = Buffer 0<br>1 = Buffer 1<br>**Bit 6**: Link Error Detected while transferring data over link (corrupted frame). **Don't process frame.**<br>1 = Error<br>**Bit 7:** EOF detected<br>1 = Detected (OK)<br>**Bit 8-15**: Last value written by HLS (should be **0xCC** for correct operation, otherwise CAM read-out error) |
| Science operations control parameters | 8 | Study control parameters as specified by the running study (Raster mandatory parameter [7]), which indicates science operation status.<br><br>**1 = Enabled, 0 Disabled**<br><br>**Bits 0 - 1**: un-used<br>**Bit 2**: XRT flare trigger status<br>**Bit 3**: EIS AEC status<br>**Bit 4**: EIS event trigger status<br>**Bit 5**: EIS flare trigger status<br>**Bit 6** - 7: un-used |
| XRT flare flag received | 8 | 0 = No flare<br>1 = Flare |
| XRT Flare X-Coordinate | 8 | As received from the MDP |
| XRT Flare Y-Coordinate | 8 | As received from the MDP |
| AEC high energy pixel count | 32 | Number of pixels exceeding the AEC high-energy threshold. Initialised to 0xFFFFFFFF if AEC is disabled or CAM frame transmission error (HSL error) |
| AEC low energy pixel count | 32 | Number of pixels exceeding the AEC low energy threshold. Initialised to 0xFFFFFFFF if AEC is disabled or CAM frame transmission error (HSL error) |

| PARAMETER | SIZE (BITS) | NOTES |
|---|---|---|
| EIS translation of XRT flare X-Coordinate | 16 | This parameter is initialised to 0xFFFF if XRT flare mode is disabled.<br>Bit 0: Sign<br>0 = Positive<br>1 = Negative<br>Bits 1 to 15: EIS X position in arcseconds, relative to EIS X-FOV imaging (0 to 590”). If outside this range, then it implies that the flare is outside EIS X-FOV. |
| EIS translation of XRT flare Y-Coordinate | 16 | This parameter is initialised to 0xFFFF if XRT flare mode is disabled.<br>Bit 0: Sign<br>0 = Positive<br>1 = Negative<br>Bits 1 to 15: EIS Y position in arcseconds, relative to EIS Y-FOV (0 to 511”). If outside this range, then it implies that the flare is outside EIS Y-FOV. |
| MHC fine mirror strain gauge output | 16 | This parameter is acquired from the MHC as it is needed for the fine mirror position calibration |
| EIS flare trigger X-coordinate | 16 | This parameter indicates the flare X position relative to the flare hunt window, i.e. window X.<br><br>This parameter is initialised to 0xFFFF if EIS flare trigger is disabled or no flare is detected. Any other value means a flare response is triggered by EIS. |
| EIS flare trigger Y-coordinate | 16 | This parameter indicates the flare Y position relative to the flare hunt window Yw.<br><br>This parameter is initialised to 0xFFFF if EIS flare trigger is disabled or no flare is detected. Any other value means a flare response is triggered by EIS. |
| EIS event trigger X-location | 16 | This parameter indicates the event X position within a raster (Raster fine mirror position is steps) (0 to 2400 steps)<br><br>This parameter is initialised to 0xFFFF if EIS event trigger is disabled or no event is detected. Any other value means an event response is triggered by EIS. |

| PARAMETER | SIZE (BITS) | NOTES |
|---|---|---|
| EIS event trigger Y-coordinate | 16 | This parameter indicates the event Y position relative to the event hunt window Yw.<br><br>This parameter is initialised to 0xFFFF if EIS event trigger is disabled or no event is detected. Any other value means an event response is triggered by EIS. |
| ASRC status | 8 | Anti Solar Rotation Compensation status. This parameter consists of two fields:<br><br>Bit 0 (MS): Compensation direction<br>0 = forward (add to FMIR position MIP)<br>1 = backward (subtract from FMIR MIP)<br><br>Bits 1 to 7: The number of FMIR steps required for compensation [7].<br><br>0 means ASRC is disabled |
| ASRC skip | 8 | ASRC Raster Skip defines the frequency of the fine mirror compensation [7]. Raster repeat must be used in conjunction with ASRC Raster Skip. |
| Number of exposures per raster position | 8 | Range: 1 to 8 |
| FMIR step size | 16 | FMIR step size as specified in the raster. This parameter allows straightforward distinction between “sit and stare” raster and a “scanning raster”. In the former, this parameter is set to 0. |
| Total (in bytes) | 183 bytes | 224 bytes allocated |