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EIS-Science	
EIS-Tech	√
EIS-Soft	

CHANGE RECORD

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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 – Requested by M. Whillock and D. Williams

Glossary and Convention:

CAM	EIS Camera
CCD	Charge Coupled Devices
CMIR	EIS Coarse Mirror
DC	Data Compression
DHU	Data Handling Unit
EGSE	Electronics Ground Support Equipment
EIS	Extreme ultraviolet Imaging Spectrometer
FMIR	EIS Fine Mirror
MDP	Mission Data Processor
MHC	Mechanism and Heater Controller
MIP	EIS fine Mirror Initial Position (raster start position)
NA	Not Applicable

List of Content:

1.0 Introduction

This document highlights the key factors affecting EIS cadence and is based on an informal note emailed to the concerned parties. No doubt further refinements will be needed for spacecraft and in-orbit operations.

2.0 EIS Cadence parameters

EIS cadence can be defined as follows:

Cadence = CCD flush time + Exposure time + Read-out time + Shutter open/close time

Cadence = Cadence * (1 + correction factor)

The correction factor accounts for software cumulative code execution time and hardware latencies, e.g. data transmission over interfaces.

Also note that at the start of **each raster (including raster repeats)** the fine mirror is moved to its home position (step 0), and then to the raster MIP position. Each move requires 700 ms (total latency of 1400 ms).

2.1 CCD flush time

The CCDs are flushed using a specific CAM clocking sequence. Such a sequence runs for 60 ms per flush. Note that the number of flushes is a variable that specified in the run raster command.

Total CCD flush time = Number of flushes * flush time

2.2 Exposure time

The exposure time is raster dependent.

2.3 Read-out time

The following parameters are associated with EIS CAM read-out:

Line shift: 150 μs
Pixel read = 2 μs
Pixel discard = 0.75 μs

For example, the time to read a CCD from <u>two nodes</u>, discarding the first 50 pixels (pre-scan pixels) and reading 1024 pixel for 512 lines (slit height) at the centre of the CCD (discarding 255 rows) is as follows:

Time to discard the first 255 rows = 255 * 150 μs = 38 ms

Row read time = 150 μs + 50 * 0.75 μs + 1024 * 2 μs = 2.23 ms

512 rows read = 512 * 2.23 = 1144 ms.

The total CCD read-out time = 1182 ms ≅ 1.2 seconds

2.4 Shutter operations

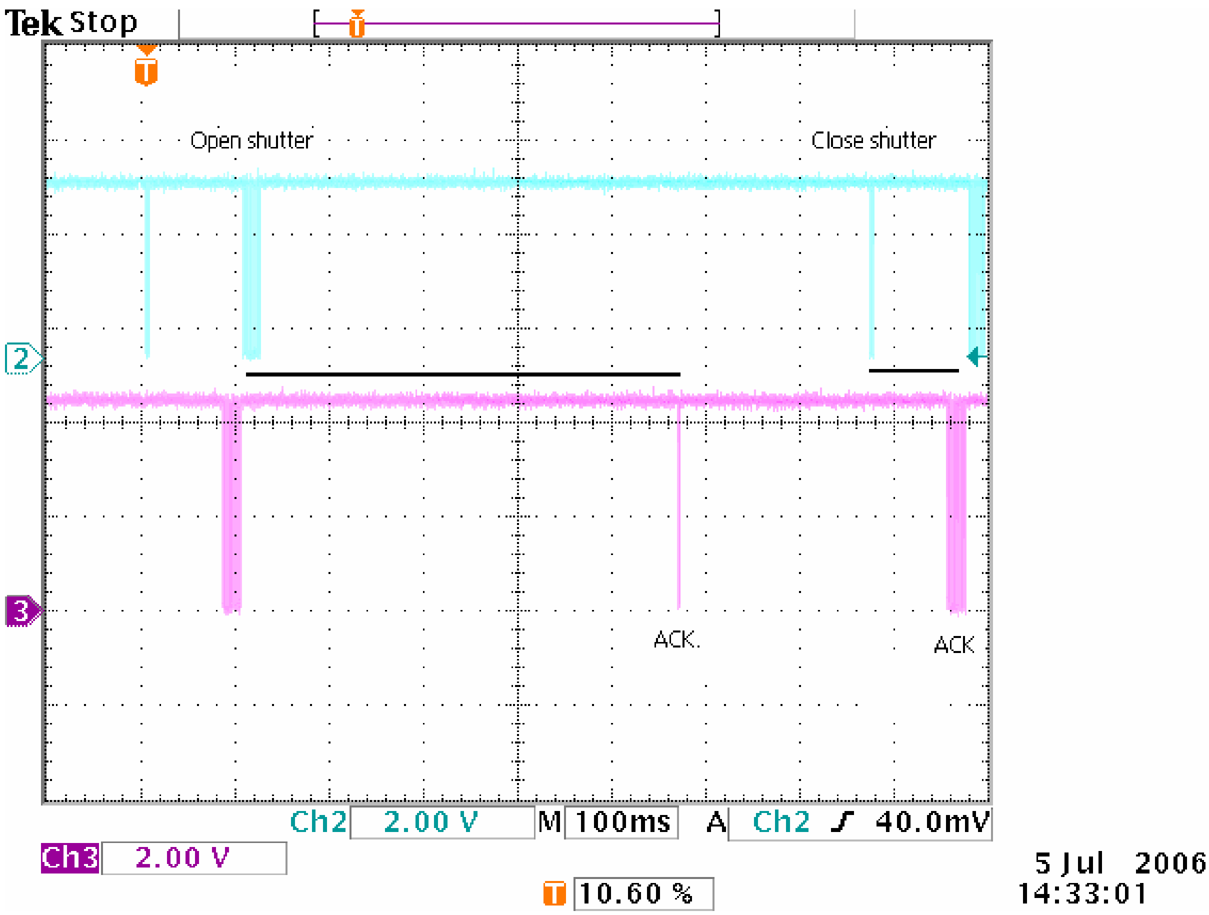
In order to specify the shutter operation latencies, a special engineering sequence was run and the shutter open time (time between the ICU commanding the MHC and the MHC responding by acknowledging the request) was measured. It was found that there is some non-linearity in the MHC shutter open time, as shown in the table below:

Commanded shutter open time (Exposure time in ms)	MHC acknowledgment (ms)
100	380
200	450
300	250
500	250
1000	250

Note that in the above cases, the MHC will perform the required exposure time, accurately.

Note that for the shutter **close time**, the MHC acknowledgment is around 100 ms.

Also note that the figures above are obtained using a digital scope, as illustrated below.



3.0 Estimated raster run-time vs. measured time

In order to quantify the error between the theoretical and the practical run time, a few measurements were made using a study consisting of a single sit and stare raster, full CCD and two nodes read-outs. The line list has a single (8 X 512) pixel line, such that the MDP data acquisition does not have any impact on the measurements. Various cadence equation parameters are as follows:

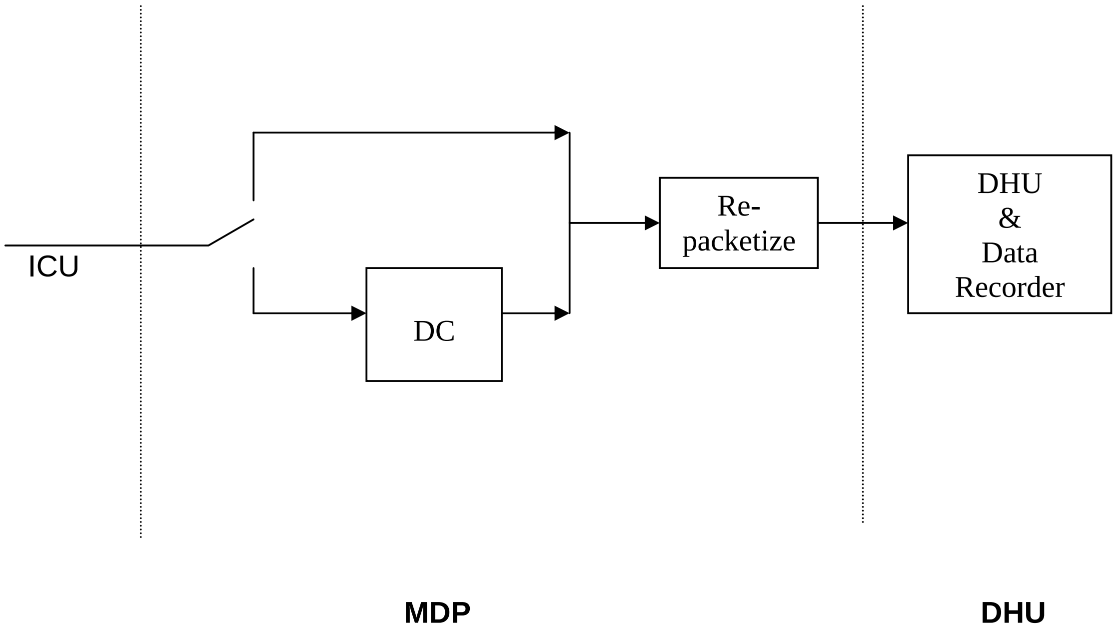
CCD flush time = 5 * 60 ms = 300 ms
CCD read-out = 1200 ms
FMIR time (raster run) = 1400 ms
(Error) % = (measured time – estimated time) / estimated time

Note that the "study run time" is somewhat crude. It was measured using the EGSE clock as the time between the HK reporting of the test sequence running and stopped (completed).

20 exposure raster				
Exposure time (ms)	**Estimated run-time (S)**	**Measured run-time (S)**	**Error**	**Notes**
100	43	46	6.5%	Total shutter duration = 480 ms
200	46.6	50	7.2%	Total shutter duration = 550 ms
300	44.4	48	8.1%	Total shutter duration = 350 ms
400	46.4	50	7.2%	=
500	48.4	52	7.4%	=
600	50.4	54	7.1%	=
700	52.4	56	6.8%	=
800	54.4	59	8.4%	=
900	56.4	61	8.1%	=
1000	58.4	62	6.1%	=
2000	78.4	82	4.5%	=
3000	98.4	102	3.6%	=
4000	118.4	122	3.0%	=
5000	138.4	144	4.0%	=
10000	238.4	242	1.5%	=

4.0 Non EIS factors affecting cadence

The factors described in section 2 impact the Cadence on EIS side. However, the data throughput from the ICU to the S/C may impact the cadence as well. The figure below illustrates the data feed.



The spacecraft data handling system consists of two parts, the Mission Data Processor (MDP) and the Data Handling Unit (DHU).

The ICU to MDP physical transfer speed is 2 M-bit per second. However the maximum data throughput rate is ~1.2 M-bit per second, accounting for pixels processing and packetization.

The data received by the MDP (stage one) can follow one of two routes:

1) Re-packetize EIS data only.
2) Compress data (DC) then re-packetize EIS data. Solar-B data compression is performed by the MDP

The data route is determined by flag settings in the mission data packets. Also all EIS packets are opened and re-packetized by the MDP, irrespective of whether data compression is used.

The EIS maximum data throughput rate between the MDP and DHU is 260 K-bit per second. Related to this, the following limitations apply:

1) The EIS tape recorder allocation is 1/8th of 4.8 G-bit, where the 4.8 G-bit is the total recorder size.
2) Transmitting the data at 260 K-bit per second (**burst rate**) will fill the EIS allocation in a few minutes. When this occurs, the MDP inhibits data transmission from the ICU. This will result in stopping the EIS observations.
3) The EIS **average** throughput rate between the MDP and DHU is ~45 K-bit per second (TBC) and at this rate, EIS can maintain continuous operation.

There is a further complication:

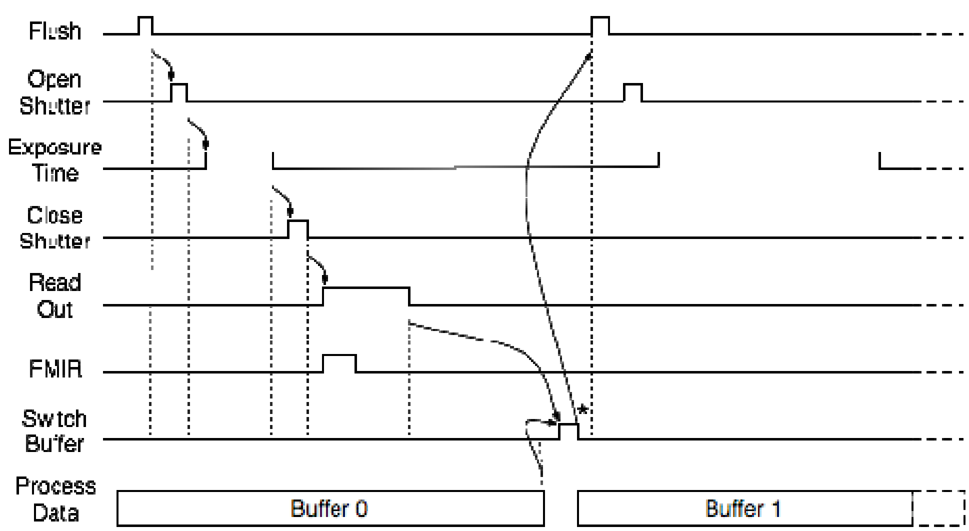
It is possible to estimate the data throughput rate throughout the MDP to DHU chain if no data compression is used. However, if data compression is used, then the estimation is going to be more difficult, as the compression factor is data dependent.

5.0 Items not covered in this document:

1) External factors that are not controlled by the ICU (e.g. MDP operations). The latter, depending on its workload may inhibit the ICU from sending data momentarily via raising its busy flag.
2) Mechanical movements (e.g. slit/slot exchange).
3) Other factors such as sequence delay and sequence pause/resume.

6.0 Appendix 1: Exposure timeline

Readers may omit this section. However, it is added to show the sequence of events related to the exposure timeline [3].



Note: The FMIR is moved while the read-out is active (only for scanning raster)

*** Exposure Synchronization point: Exposure synchronization is performed when the previous exposure buffered data processing and current exposure operations are both completed. A Raster synchronization point is also used prior to starting a new raster whereby the last pixel of the previous raster must be processed before starting a new raster.**

Exposure timing diagram

1 – Prior to exposing the CCDs, the CCDs are flushed using a special CSG sequence that reads and discards pixel data.

2 – Once flushing is completed, the shutter is commanded to an open position. Note that the MHC shutter is automatically re-closed when the exposure time is completed. Thus the exposure time is accurately adhered to.

3 – Once the ICU exposure duration is timed-out, it issues an MHC close shutter command, just in case it is still open. The MHC acknowledges the close shutter command by returning the exposure parameters (MHC exposure time, pointing ... etc).

4 – Once the shutter is closed, the ICU issues a start read-out command to the CAM. When a scanning raster is in use, the ICU moves the FMIR to the next position to take advantage of the read-out dead-time. Note that if the read-out is longer than 800ms (700ms move and settling time plus 100ms MHC latency), then the FMIR move exposure latency is completely absorbed.

5 – Prior to switching the CCDs buffers (two buffers, each capable of holding up to 4096*512 pixels), the ICU synchronises its sequence interpreter operation (exposure controller) and the science data processing task, i.e. **Exposure synchronisation point**. Only when both have finished their current task is the buffer switching performed. Also note when one buffer is selected (CAM use) the other buffer is automatically switched to ICU use (access). For most exposure purposes, the exposure operations are longer than the data processing task (e.g. line list data extraction, packetization and transmission to the MDP). However, in the case of **short exposure times** (e.g. 0 exposure time) and full CCD dump, than the data processing time can be considerably longer (~26 seconds, i.e. 32 M bit at 1.2 M bit/second) [2].