Solar-B **EIS** * EUV Imaging Spectrometer	CCD Procurement Specification

Title	CCD Procurment specification
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1 Scope

This document gives the CCD requirements which must be met to achieve the system requirements for the Extreme UV imaging spectrometer (EIS) camera assembly (EIS-CCD-eng-sysreq). As such, it defines the CCD procurement specification for Solar-B EIS, and will be used as the basis for the associated test plan.

2 Acronyms

3 References

4 Introduction

4.1 EIS is a key component of the Solar-B spacecraft, due for launch in 2004. EIS is a collaborative effort between the Naval Research Laboratory (NRL) in the US and groups from Birmingham, Rutherford Appleton and University College London/Mullard Space Science Laboratory (MSSL) in the UK. EIS is designed to primarily image in the Extreme UV at wavelengths of 170-210Å and 250-290Å and will provide EUV spectral images (at approximately 2") resolution of the Sun.

4.2 MSSL is responsible for producing the focal plane camera assembly, which will contain two CCD detectors (one for each wavelength range) at the focal plane. The purpose of this document is to state the performance requirements which these CCDs must meet to achieve the EIS science requirements.

4.3 A formal quotation is not required at this stage. Instead, EEV should produce a proposal for supplying a package of CCDs, the approximate numbers and grades of which are described below. The proposal should indicate the range of options available for the proposed price, but it is recognized that there will need to be trades in the final CCD selection (such as grade versus numbers of flight models) to remain within that price.

5 Requirements

5.1 General requirements

Two 42-10 CCD detectors will be required for each focal plane camera. The following mix of detectors will be required:

Option one	Option two
4 flight models	5 Flight models
3 engineering models	4 engineering models
4 mock-ups	4 mock-ups

5.2 Architecture

5.2.1 The CCDs shall be full frame devices

5.2.2 The CCD format shall be 2048 pixels in the horizontal (dispersion) direction and 512 pixels in the vertical (spatial) direction.

5.2.3 The pixel size shall be 13.5µm by 13.5µm. MSSL are concerned about the effect charge spreading may have on the eventual image quality from the device. It is MSSL's understanding that the choice of detector structure (for example, the device resistivity) can be tailored somewhat with no overall impact on cost. EEV should discuss how choice of device structure could impact on charge spreading, and the likely impact on device resolution that each choice could have.
There are three possible signal regimes in which EIS may be operated for the majority of measurements:

- small signals;
- a wide dynamic range of signals;
- strong signals.

5.2.4 The device shall be a three phase device.

5.2.5 The CCDs will need to be operated at room temperature for integration and alignment test with the spectrometer optics. The image quality must be sufficient to allow changes in image features to be easily distinguishable. For example, it will be necessary to be able to detect changes in signal intensity which are essentially Poisson limited. Consequently, it is necessary to have a lower dark current than that quoted for non-IMO devices (10k electrons/pixel/s). There are two ways in which a substantial reduction in dark current could be achieved:

- using IMO (MPP) devices;
- dither clocking of non-IMO devices.

EEV should include in their proposal, the costs (and implications for the overall procurement package) of either of the above options. In either of the above two cases, the devices must be able to achieve the following specifications:

- IMO devices should have a dark current at 20°C of better than 100 electrons/pixel/second;
- dither-clocked non-IMO devices should have a dark current (including during readout) at 20°C of better than 300 electrons/pixel/second when a dither period of 30µs is used.

5.2.6 Two output amplifiers shall be provided, one at each end of the horizontal readout register. It shall be possible to clock the serial register such that charge may be transferred in either direction along the serial register, allowing one or both of the amplifiers to be used to measure charge accumulated in the image area. It shall also be possible to split the register so that charge can be clocked out from both registers simultaneously.

5.2.7 A dump gate shall be provided parallel to the serial registers to allow rapid dumping of unwanted charge

5.3 Mounting

5.3.1 Each CCD chip shall be bonded onto an Invar plate

5.3.2 Electrical connections to each chip shall be provided by a "flexi" cable bonded onto the bottom end of each Invar plate - i.e parallel to the serial readout register. Connection to the FPA electronics shall be by a connector TBD

5.3.3 Exact details of the mounting arrangement are TBD. A working diagram of the current mounting concept is shown in appendix ****. Although small details of the design may change, the basic design requirements are described in the following paragraphs.

5.3.4 The CCDs will be glued onto an Invar plate (or plates), which will then be mounted onto a suitable mounting plate. The spacing between the two CCDs is TBD but must be mounted with a tolerance of no more than ±½ pixel width.

5.3.5 The back of the Invar plate (or possibly the mounting plate itself), will be connected to a Cold finger. The exact design of this finger is still TBD.

5.3.6 The CCDs will be connected to the preamplifier stage and read out electronics via a flexible connector. The details of this connector are TBD but, as far as possible, the flexi shall be flush with, or lower than the CCD surface.

5.3.7 A means of ensuring alignment will be required. For example, dowel pins may be necessary to ensure adequate alignment. Details are TBD but EEV should indicate their proposed method(s).

5.3.8 The CCD shall have a "taped on" window for protection during storage and transfer.

5.3.9 The CCD and its mounting shall be designed to withstand vibration under the conditions outlined in appendix two.

5.4 Operating Temperature

5.4.1 The CCD shall operate within the temperature range -100°C to +30 °C, and will perform to the agreed specifications at -80°C.

5.4.2 Non operating temperature range shall be -100° C to +60°C.

5.4.3 At ~-80°C the flatness across the CCD surface (bonded to the Invar plate) shall be ±10µm from one side of the CCD to the other (in both spatial and dispersion directions measured wrt to the CCD face).

5.4.4 The CCD should be capable of being heated/cooled from the operating temperature extremes, at a rate no greater than 1°C/minute.

5.5 Imaging characteristics

5.5.1 The CCDs shall be full frame devices.

5.5.2 Charge transfer efficiency (CTE) shall be > .999995 @ -80°C at the start of the mission. MSSL are concerned that CTE will decrease during the mission (due to radiation effects) sufficiently to lead to a noticeable degradation of image quality. In their proposal, EEV should:

- discuss the problems of CTE and its likely effects over the mission lifetime;
- discuss any methods that could be adopted to try and mitigate the loss of CTE (for example, a buried channel to spatially confine the charge and thus minimise the potential number of electron traps available;
- indicate a plan for identifying (as far as is possible) the performance of the 42-10s wrt CTE. For example, it may be possible to measure the CTE for a number of irradiated devices early in the development program, and the information used to inform the final choice of device structure.

5.5.3 The CCDs are to be back-illuminated devices to improve the quantum efficiency at the required wavelengths. The backthinning process to be used is still TBD after discussions between MSSL and EEV. EEV should briefly discuss in their technical proposal the back thinning options available within the agreed price range.

5.5.4 PRNU shall be <~ to 2% @4000Å.

5.5.5 The cosmetic quality required for the flight models is as follows:

	Flight model
Column defects: black or slipped	0
Column defects: white	0
Black spots	40
Traps > 200e-	2
White spots	20

5.6 Full Well capacity, anti-blooming characteristics

5.6.1 The CCDs shall contain provision for anti-blooming to be implemented

5.6.2 Full well capacity shall be >120Ke- per pixel for a CCD without IMO.

5.6.3 The design of the CCD shall allow on-chip binnning to be implemented. The capacity of each register shall be as follows:

- serial readout capacity (i.e vertical binning) - >240ke-
- amplifier readout capacity (i.e horizontal binning) > 680ke-

5.7 Electrical

5.7.1 Readout noise shall be ~2e-rms @20kpixels/s readout rate, and ~ 5 e-rms @500kpixels/s readout rate.

5.7.2 The output port responsivity shall be 4.5µV per electron

5.7.3 Flat band voltage shifts due to ionising radiation should be no worse than 100mV per krad. EEV should discuss both the projected decrease in CTE expected over the mission lifetime and procedures which could be adopted to mitigate the effect of this decrease.

5.8 Packaging

5.8.1 EEV should indicate their preferred packing arrangement

6 Deliverables, documentation and schedule

6.1 In their technical proposal, EEV should suggest a suitable delivery schedule for the CCDs, with an appropriate payment schedule tied in to these deliveries. MSSL would prefer a structured delivery of CCDs, i.e individual CCDs are delivered as when they have been satisfactorily tested at EEV. A structured delivery (for example, as in the current SXI contract) would allow MSSL to characterise each device at a more structured pace.

6.2 Final payment shall be tied to successful completion of a range of acceptance tests. EEV should describe those requirements for which they can provide satisfactory in-house testing (which MSSL may wish to witness) and which could be provided as evidence of meeting each requirement. Tests which cannot be undertaken at EEV will be performed at MSSL. Final payment will depend on satisfactory completion of th
ese tests. Consequently, EEV and MSSL will need to agree a suitable test plan, along with timescales for completion of these tests. EEV should indicate when they think the test plan should be agreed by.

6.3 Suitable documentation must be provided. This documentation must include:

- For each CCD, full documentation of all device characterisation tests performed at EEV

- Production details for each CCD, such as production tests measurements, should be available for inspection by MSSL if they so wish.

7 Management

7.1 Informal progress meetings (occasionally via telephone if both sides agree) will be held about once a month. During the production phase, these meetings will enable MSSL to monitor the progress of the CCD delivery schedule, and will also enable any changes to the design of EIS to be discussed.

7.2 Technical meetings will be held when required.

8 Qualification programme and acceptance tests

8.1 These are TBD