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

Title	CCD Procurement specification
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Contents

Change record

Date	Issue	Section	Description of change
16/11/99	1.0		First issue
15/2/2000	1.1	4.3 and onwards 5.1 5.2.2 5.4 5.4.4 5.5.2	Change EEV to Marconi. Adjust number of devices required and change type from 42-10 to 42-20. Device size changed to 2048 x 1024 Operating temperature changed from -80°C to -60°C. Heating/cooling rate changed to ±5°C/minute. CTE performance changed from -80°C to -60°C. 42-10 changed to 42-20.
17/4/2000	1.2	5.1 5.2.5	Adjust the number of setup grade devices required An MPP device is required (previously TBD).
6/7/2000	1.3	5.3.2 5.4.4 5.5.3 5.6	A metal connector and savers will be used. A mate/demate log is to be kept. Allowable temperature rate changed to ±50°C. The basic backthinning technique shall be used. Full well and binning capacities changed to reflect use of MPP device.

26/3/2001	2.0	5.2.5	Dark current relaxed to 250 electrons/pixel/second.
		5.3.3	Details of mounting arrangement added.
		5.3.4	Deleted second sentance.
		5.3.5	Deleted second sentance.
		5.3.6	Details of connector added.
		5.3.7	Marconi to provide alignment marks.
		5.3.9	Additional info on vibration levels added.
		5.4.3	Flatness to be measured at +20°C.
		5.4.4	Rate of temperature change ±5°C per minute.
		5.5.4	PRNU to be measured at 4500Å.
		5.7.2	Range of output port responsivity added.
		5.8.1	Details of packaging arrangement.
		8.1	Reference to test plan added.

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 (MSSL/SLB-EIS/SP/01). 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

CCD	Charge Coupled Device
CTE	Charge Transfer Efficiency
EIS	Extreme Ultra-Violet Imaging Spectrometer
EUV	Extreme Ultra-Violet
FPA	Focal Plane Assembly
IMO	Inverted Mode Operation
Marconi	Marconi Applied Technologies
MPP	Multi-Pined-Phase
MSSL	Mullard Space Science Laboratory
NRL	Naval Research Laboratory
TBD	To Be Decided (i.e, during the CCD fabrication stage)
UV	Ultra-Violet

3 References

EIS - System Requirements Document MSSL/SLB-EIS/SP/01

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 180-204Å 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 (described in MSSL/SLB-EIS/SP/01).

4.3 Marconi 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 42-20 CCD detectors will be required for each focal plane camera. The following mix of detectors will be required:

Option one	Option two
3 flight models	5 Flight models
4 engineering models	4 engineering models
6 'set-up' grade	6 'set-up' grade
4 mock-ups	4 mock-ups

Flight models (FMs) will be of the highest grade (specified in 5.5.5). The CCDs which are eventually installed onto EIS will be selected from this batch.

Engineering models (EMs) will be taken from the same wafer batch as the FMs but can be of a slightly lower grade as they will not be used on flight, but must be totally representative of the FMs in terms of functionality. They will primarily be used during the testing phase for EIS.

The 'set up' devices will be of lowest grade and can be used to check the correct functioning of the camera electronics, and provide a simple imaging capability. The may be supplied in a 'standard' DIN packaging.

The mock ups are non-functioning CCDs. They will be supplied in identical packaging to the flight CCDs and can be used for mechanical setups and testing.

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 1024 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. Marconi 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 only;

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

Thus, the fabrication of the EIS CCDs cannot be tailored towards one particular signal regime.

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.

However, the predicted temperature of the EIS radiator is such that a dither rate of >100ms over am imaging period of >100s may be required to ensure that the CCD dark current of a non-IMO device is similar to that of an IMO device. The total number of dithers required for an image in a low-count regime is thus >1000 and so there is a considerable risk that image quality at the end of mission may be seriously degraded by the production of black/white pairs. Consequently, an IMO (MPP) device shall be used.

The devices must be able to achieve the following specifications:

- IMO devices should have a dark current at 20°C of better than 250 electrons/pixel/second.

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 flexible cables bonded onto the bottom end of each Invar plate - i.e parallel to the serial readout register. Connection to the FPA electronics will be via a metal micro-D type connector. To minimise mates and demates from the connectors savers will be used whenever possible, and a log kept of all mates and demates. Ideally, the CCDs will be supplied with the savers still attached.

5.3.3 Details of the mounting arrangement are shown in the Marconi Interface Drawing, DAS547806AT.

5.3.4 The CCDs will be glued onto an Invar plate (or plates), which will then be mounted onto a suitable mounting plate.

5.3.5 The back of the Invar plate will be connected to a cold finger.

5.3.6 The CCDs will be connected to the preamplifier stage and read out electronics via a flexible cabled connector. The details of this connector are defined in the Marconi Interface Drawing, DAS547806AT.

5.3.7 Marconi shall provide alignment marks on the CCD to aid MSSL in co-aligning the two CCDs.

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 which are TBD. The vibration test will not be conducted as an acceptance test on the flight batch.

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 -60°C.

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

5.4.3 At ~20°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 up to ±5°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 @ -60°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, Marconi 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 42-20s 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 basic backthinning process shall be used.

5.5.4 Photo-Response Non-Uniformity shall be < to 2% @4500Å.

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

The Engineering models will be selected from the same batch as the flight models, but may be of a slightly lower grade:

	Engineering model
Column defects: black or slipped	1
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 if required.

5.6.2 Full well capacity shall be >90Ke- per pixel for a CCD with IMO.

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

- serial readout capacity (i.e vertical binning) - >300ke-
- amplifier readout capacity (i.e horizontal binning) > 540ke-

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 in the range 4µV to 6µV per electron.

5.7.3 Flat band voltage shifts due to ionising radiation should be no worse than 100mV per krad. Marconi 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 The packaging arrangement for the CCDs is shown in drawing JAS 547960AA.

6 Deliverables, documentation and schedule

6.1 In their technical proposal, Marconi 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 Marconi. 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. Marconi 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 Marconi will be performed at MSSL. Final payment will depend on satisfactory completion of these tests. Consequently, Marconi and MSSL will need to agree a suitable test plan, along with timescales for completion of these tests. Marconi 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 Marconi
- 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 defined in the Marconi Test Plan, EIS-MAR-PL-004.