# Solar B - EIS

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## SOLAR B - EIS RISK ASSESSMENT

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## CHANGE RECORD

| ISSUE | DATE | PAGES CHANGED | COMMENTS |
|---|---|---|---|
| 01 | 9 June 2000 | All New | Document re-issued in new numbering system. A major review of risks has been conducted in preparation for the EIS UK PDR |
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## CONTENTS

## 1. SCOPE

This document constitutes the central element of the Solar-B EIS Risk Management Process. Here programmatic (i.e. risks to the delivery for flight of the EIS instrument within the schedule and budget constraints) and operational risks (i.e. risks to the quality and in-flight performance of the delivered instrument) are covered.

Risks are characterised in terms of their nature, likelihood, origin and ownership.

## 2. APPLICABLE DOCUMENTS

| | |
|---|---|
| MSSL/SLB-EIS/SP007 | EIS Science Requirements |
| MSSL/SLB-EIS/SP011 | EIS System Definition |
| EIS Work Break-down Structure | EIS-sys-eng-wbs |
| Management Plan | EIS-man-manplan |

## 3. DISCUSSION

This document contains a risk analysis for the Solar-B EUV Imaging Spectrometer (EIS) at system and sub-system level. Its purpose is to record the sources of risk and their degree for EIS and its subsystems, and the means to reduce them to acceptable levels. Operational and Programmatic risks are considered.

The applicable versions of the systems documents are:

| | | | |
|---|---|---|---|
| EIS Science Requiements | MSSL/SLB-EIS/SP007.01 | | June 00 |
| EIS System Definition | MSSL/SLB-EIS/SP011.01 | | June 00 |
| Work Breakdown Structure | EIS-sys-eng-wbs | 2 | 12 July 99 |

The probability of risks is described in a qualitative way using the following Scheme:

| ***Term*** | ***Notation*** |
|---|---|
| Impossible | 0 |
| Very unlikely | 1 |
| Unlikely | 2 |
| Moderately Unlikely | 4 |
| Moderately Probable | 6 |
| Probable | 8 |
| Very Probable | 9 |
| Certain | 10 |
| Unknown | 99 |

Risks are numbered for reference, according to type.

- PE : Programmatic EIS (system or Mission) risk
- PS : Programmatic Subsystem risk
- OE : Operational (i.e. post-launch) EIS (system or Mission) risk
- OS: Operational Subsystem risk.

Each of the above risk types are described in separate section of this document.

The risk Category is the WBS code of the origin of the risk. 1000 = EIS instrument, 0000 = Solar-B mission.

Ownership indicates the institute that will be responsible for management of the risk.

# 4. PROGRAMMATIC RISK

## 4.1 System level (PE)

Sources of programmatic risk to the project as a whole are considered first.

| Category | Element | Risk # | Prob | Owner | Event | Effect | Management | Notes |
|---|---|---|---|---|---|---|---|---|
| 0000 | Solar-B | PE3 | 1 | ISAS | Launch Delay | Extra costs | Revise schedule | Has occurred once. Considered unlikely to occur again. |
| 1000 | EIS | PE4 | 2-4 | MSSL | Incompatibility of sub-system interfaces at pre delivery integration | Failure to integrate hardware or software. Delay and/or additional costs of re-work | Rigorous attention to interface management procedures. Regular system design team meetings. Early integration checks, walkthroughs, configuration management. Allow schedule margin. | |
| | | PE4.1 | 4 | MSSL | Mechanical interfaces | | | |
| | | PE4.2 | 4 | MSSL | Thermal interfaces | | | |
| | | PE4.3 | 2 | MSSL | Optical interfaces | | | |
| | | PE4.4 | 4 | MSSL | Electrical interfaces | | | |
| | | PE4.5 | 4 | MSSL | Cleanliness interfaces | | | |
| | | PE4.6 | 2 | MSSL | PA interfaces | | | |
| 1000 | EIS | PE6 | 2 | MSSL | System failure during environmental testing | Delay in delivery whilst reworks and retests occur | Design margins and derating of components. AIV schedule to include contingency for such events. Items which are both critical and particularly susceptible to have spares available - within budgetary constraints. | Each subsystem item should have been qualified to appropriate levels by analogy, analysis or test prior to system test. Lessons learned during EM and STM environmental tests should allow us to identify the susceptible items. |
| | | PE6.1 | 2 | BU | MTM/TTM | | | |
| | | PE6.2 | 2 | MSSL | EM | | | |
| | | PE6.3 | 2 | MSSL | FM | | | |
| 1000 | EIS | PE7 | 2-4 | MSSL | incompatibility with spacecraft discovered during integration | Delays to entire mission. Increased costs of support of rework in Japan. Possibility that instrument performance be compromised. | Close co-operation with the spacecraft design teams. Identification and control of comprehensive interface specification. | This would arise from inadequacy of interface management between the EIS and spacecraft teams. There is a vital need for prompt and reliable exchange of accurate interface information with the spacecraft teams. |
| | | PE7.1 | 3 | BU | MTM/TTM | | | |
| | | PE7.2 | 2 | MSSL | EM | | | |
| | | PE7.3 | 2 | MSSL | FM | | | |
| 1000 | EIS | PE8 | 4-6 | MSSL | Late delivery of instrument | Schedule impact on spacecraft programme | Establish and agree realistic delivery schedule<br>Establish and agree realistic requirements for each model<br>Rigorously control internal schedules | |
| | | PE8.1 | 6 | BU | MTM/TTM | | | |
| | | PE8.2 | 4 | MSSL | EM | | | |
| | | PE8.3 | 4 | MSSL | FM | | | |

## 4.2 Sub-system level (PS)

Programmatic risks are now considered for major WBS items in the Hardware (WBS Code 1000) and AIV (3000) branches.

| Category | Element | Risk # | Prob | Owner | Event | Effect | Management | Notes |
|---|---|---|---|---|---|---|---|---|
| 1100 | Structure | PS1 | 4 | BU | Composite material shows excessive out-gassing | Contamination of optical components | Select and evaluate materials. Plan out-gassing paths | |
| 1300 | Optics | PS2 | 99 | NRL | Multilayer coating fails to provide adequate reflectivity or other property | Instrument throughput threatened. | Seek to fully understand the coating technology and the sources of variation of performance. Consider possibility of re-coating or provision of uncoated spares. Allow contingency for this. Consider alternative coating technologies. | This is mainly an issue with the so-called EIS-400 wavelength range coating, range 6 in EIS Science Notes (EIS-sci-notes), operating near 400 Å, which is baselined to use the relatively unknown Si/Sc multilayer pair. This risk also pertains to the ageing properties of coatings. |
| 1300 | Optics | PS3 | 2 | NRL | Optic inadequately figured or polished | Poor focusing properties leading to loss of spatial and spectral resolution. Possible need for re-work. | Form an error budget for each optical surface, allowing the system PSF to be estimated. Measure samples to validate the error budget. Unit level test. | |
| 1300 | Optics | PS4 | 99 | NRL | Grating manufacturing faults | Loss of throughput. | Error budget, with quantified error sources, is required. Test of grating performance prior to multilayer coating. | All comments also apply as per PS2 |
| 1300 | Optics | PS5 | 2 | NRL | Proposed mechanism fails to meet spacecraft disturbance torque requirement | Other Solar-B instrumentation jeopardised. | Seek alternative mechanisms (mass penalties are likely), or propose spacecraft-level observation (i.e. mechanism) control protocol. Seek to avoid this risk in the early stages of the programme. Another alternative would be to omit the mechanism in question. | This is an important requirement for the successful operation of Solar-B SOT. The nature of the mechanisms is dependant on the telescope type selection. |
| 1600 | Shutter | PS6 | 2 | NRL | Motor unavailable | Shutter redesign, possible life test program (costs & schedule affected) | Explore likelihood of this, if necessary study replacement options. | The shutter design currently baselined, which has substantial spaceflight heritage, uses a specific (brushless) motor. |
| 1400 | Filters | PS7 | 6 | NRL | Accidental breakage of filter | Possible debris in the instrument - as well as the big hole | non-flight protective covers, spares, design for exchange procedures (including cleaning) | With thin foils (1500 Å Al is being considered) this is a moderately probable event. |
| 1500 | Slit | PS8 | 2 | NRL | Slit exchange mechanism fails disturbance torque criteria | Mechanism cannot be used. | Choose a single slit (or slit/slot) that gives best all-round performance, or seek alternative mechanisms. | See also the comments on PS2 – PS6 |
| 1710 | CCD | PS9 | 6 | MSSL | Loss of device due to (e.g.) static discharge | Replacement needed | Provide for (in contract) adequate test-grade devices during development programme and spares of flight devices. Design for late replacement of CCD. Consider static discharge protection procedures. | Simulators may be used for many test purposes. |
| 1730 | ROE | PS10 | 2 | MSSL | High power consumption of readout electronics | Exceed instrument power budget | carefully engineer for low power. Demonstrate at breadboard level | Possible tradeoff between readout rate and power consumption |
| 1922 | Radiator | PS11 | 6 | MSSL | Radiator cannot provide necessary CCD cooling | Radiation damage (see Operational Risks - 1740 CCD) causes unacceptable performance degradation | Seek to minimise CCD radiation damage by alternative clocking regimes and/or shielding. Consider radiator designs that avoid viewing the Earth. | The orbit and spacecraft configuration mean that Earthshine becomes a problem for efficient thermal design with a simple radiator. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3410 | Electronic Ground Support Equipment (EGSE) | PS12 | 1 | MSSL | EGSE software not ready for AIV programme caused by lack of continuity of Norwegian effort | AIV cannot be accomplished | Design for interoperability with sub-system EGSE. Specify early delivery of an EGSE version which is capable of supporting a subset of functions for test use. | |
| 3420 | Mechanical Ground Support Equipment (MGSE) | PS13 | 1 | BU | Gas purge equipment - contaminates instrument | Dismantle, clean and reassemble structure and optics | Obtain certificates of purity or equip with in-line gas analysers | A purged structure is considered to be considerably easier to produce than a vacuum vessel (especially given the Solar-B mass constraints). |
| 3800 | Calibration | PS14 | 6 | RAL + MSSL | Insufficient time to complete calibration | Poor knowledge of in-flight performance - value of science data reduced | Allow schedule contingency at this stage of the programme. Rehearse calibration procedures prior to arrival of FM instrument. | |
| 1100 | Structure | PS15 | 8 | BU | Non-delivery of suitable structure | Catastrophic | BU to commission expert help in design and manufacture of composites. | BU may need to solicit additional funding. |
| 1710 | CCD | PS16 | 4 | MSSL | CCD quality poor | Degraded science performance | Take out option to purchase further devices | Contract for CCD foresees this possibility |
| | Sub-system<br><br>Structure<br>Camera<br>ICU<br>QCM<br>Optics/Mech'<br>MHC<br>Software<br>GSE | PS17<br><br>PS17.1<br>PS17.2<br>PS17.3<br>PS17.4<br>PS17.5<br>PS17.6<br>PS17.7<br>PS17.8 | 2-6<br><br>6<br>4<br>4<br>2<br>3<br>4<br>4<br>3 | See below<br>BU<br>MSSL<br>MSSL<br>RAL<br>NRL<br>MSSL<br>MSSL<br>Var | Late delivery of subsystem for integration | Schedule delay | Establish realistic schedule and then rigorously enforce. | |
| | MHC | PS18 | 4 | MSSL | NRL software not transferable to flight standard | Schedule delay through need for extra work | Close Liaison between NRL and MSSL | Issue raised at NASA PDR |

# 5. OPERATIONAL RISK

## 5.1 System Level (OE)

| Category | Element | Risk # | Prob | Owner | Event | Effect | Management | Notes |
|---|---|---|---|---|---|---|---|---|
| 1000 | EIS | OE2 | 6 | RAL | Contamination - optics or detector | Progressive loss of sensitivity and ultimate loss of instrument, uncertainty in intensity calibration | Contamination control plan, Front door closure, Purging, QCM, CCD Heater, venting paths | |
| 1000 | EIS | OE3 | 99 | MSSL | Electronic Component failure | Possible loss of instrument or reduced scientific return | Appropriate component quality, fault tolerant design, redundant interfaces | Failure mode analysis to unit, board or component level will be carried out as the designs mature. |
| 1000 | EIS | OE4 | 2 | MSSL | “bad command” | ranges from severe (damage to hardware?) to nearly benign (although an observation could be missed). | Identify hazardous states of the instrument. Do not allow these to be reached without operator confirmation. Allow detection of such conditions (e.g. by recording all tele-commands). | A bit error in a command sequence should be detected by checksum mechanisms incorporated into the data link protocols. This risk concerns the possibility that the operator sends a valid command that nevertheless is not the intended or appropriate one. |
| 1000 | EIS | OE5 | 8 | MSSL | on-board software error | control program halt, output data error, & effects in "bad command" | Allow detection and reboot, periodically compare memory checksum with nominal value | probable cause: SEU |

## 5.2 Sub-system level (OS)

Risks associated with individual WBS elements are considered.

| Category | Element | Risk # | Prob | Owner | Event | Effect | Management | Notes |
|---|---|---|---|---|---|---|---|---|
| 1200 | Door | OS1 | 2 | BU | Clamshell Door(s) mechanism failure | Fail closed - Loss of instrument. Fail open - possible contamination during thruster firings. | Life-test programme Redundant heaters in actuators | |
| 1300 | Optics | OS2 | 99 | NRL | Ageing of multilayer coatings | Instrument throughput reduced. | Perform life tests on coatings whose ageing properties are unknown. | |
| 1300 | Optics | OS3 | 2 | NRL | Scanning mechanism failure | Loss of scanning and alignment compensation | Life test programme. No possibility to move outside of functional position. Monitoring and management of movements during mission. | |
| 1300 | Optics | OS4 | 2 | NRL | Grating focus mechanism failure | (fail in focussed position) Flat-fielding of detector no longer possible. (fail in de-focussed position) loss of science | Life test programme. Redundant actuators. | |
| 1600 | Shutter | OS5 | 1 | NRL | Shutter failure | (fail closed) Loss of instrument (fail open) image smearing | Select proven technology. Life test | |
| 1400 | Filters | OS6 | 1 | NRL | meteoroid strike on front filter | possible debris in the instrument. White light ingress to detector - worsens SNR. Heat input to instrument - thermal stresses and consequent misalignment | Recess filter in exterior baffle. Use segmented filter design to limit area od breakage. | |
| 1500 | Slit | OS7 | 99 | NRL | Slit exchange mechanism fails | Fail in a nominal slit position - loss of rapid imaging facility Fails in viewfinder position - loss of spectroscopy in intermediate position - some spectroscopy retained | Select proven technology. Life test. | (assuming mechanism with one or more spectroscopy slit and a wide viewfinder slit) |
| 1710 | CCD | OS8 | 8 | MSSL | Radiation Damage to CCD | 1. Dark current distribution 2. CTE change 3. clock bias drift 4. no longer operates (output FET latch-up) | Appropriate shielding to ensure life commensurate with mission Monitor dark current distribution periodically. Provide means to adjust operating temperature and clocking rate. Provide ability to adjust the clock bias levels. | |
| | ICU/MHU | OS9 | 4 | MSSL | Radiation Damage to electrical component | Data degradation Latch-up – loss of function | Component selection to be rad hard to required level. Local shielding as required. | |