SOLAR-B **EIS** EUV Imaging Spectrometer	***System Requirements***	**sysreq** **draft 1**

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Introduction

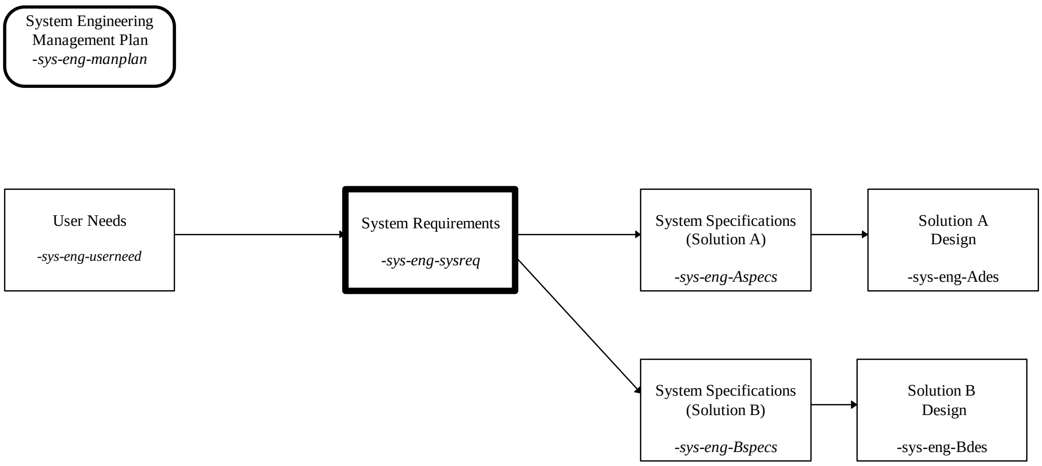
This document is part of the framework for systems engineering for EIS. This is described fully in the Management Plan (ref).

The User Needs document (ref) expresses the goals which the system's operation will achieve.

The System Requirements document (this document) is a functional and performance requirements document. It reflects a subset of the needs by stating the functional requirements of the system and measurable terms (what the system must do).

Requirements which come from the user needs are described in the scientific requirements section of this document. Other sets of requirements or constraints are in separate sections.

The System Specification document describes how the system will meet the requirements. This will refer to the technology to be employed (whereas the Requirements do not).



Scientific Requirements

Table of scientific requirements

These values are related to the User Needs as laid out in *EIS-sys-eng-userneed-1*, but should ideally be independent of the technology of any solution.

	Requirement	Value	Origin	Priority
1	Modes	Primary: Slit spectroscopy Secondary: Monochromatic imaging	EIS-x-2	
2	Wavelength Range	should meet the User Needs (q.v.). Baseline range is 250 Å - 290 Å	EIS-x-2: p. 60-61	
3	Temporal Resolution	commensurate with evolution of features Control of exposure time is required	EIS-x-2	
4	Spatial Resolution	< 2 arc sec	EIS-x-1 : § 4.3.3	
5	Spectral Resolution	< 20 km/s per pixel = 0.0203 Å per pixel	EIS-x-1 : § 4.3.3; EIS-x-3 EIS-x-6 : p 8,10;	
6	Field of View	Imaging: 4' × 2' × 2 fields Spectroscopy : 4' × 4' (scanned)	EIS-x-2 (Strawman) EIS-x-1: § 4.3.4	
7	Sensitivity	effective area: 0.42 cm^2 at 270 Å	EIS-x-1 Table 4.11	
8	FOV misalignment	±1'	EIS-x-6	
9	Alignment measurement	~1" should be compatible with pixel size of EIS and XRT		
10	Pointing (scanning)	TBD fraction of EIS pixel		

Table 1 : Scientific requirements

Notes

1. Modes

There are TBD other modes. These will consist of combination of these two modes and image selections.

There are many possible modes which can use selected regions of the full CCD image. The regions of interest could extract certain spectral lines from the image, from either the slit image (spectra) or the slot image (context) portions of the detector.

The number of necessary regions of interest will be related to the wavelength range.

Some examples of possible modes are given in Table 10, page 59 of the Science Definition Team Report (EIS-x-2).

2. Wavelength range

The EUV wavelength range contains many emission lines suited to velocity diagnostic of the transition zone and corona. The range used by EIS is the subject of discussion in the Science Team. US proposals may suggest other ranges.

EIS-x-2 p 60-61.

3. Temporal Resolution

Refer to discussion in EIS-x-2, Figure 17: characteristic time scales. The minimum meaningful cadence of exposures is likely to be of the order of a second. The minimum achievable exposure time (given the instrument's sensitivity and the other requirements) may be greater than this.

The time (e.g. start time) of any exposure should be known to within TBD absolutely, and to within TBD relative to other instruments on Solar-B.

4. Spatial Resolution

Spatial resolution must be as small as possible (1"-2" range), appropriate for the smaller scale structure of the solar atmosphere.

Moreover :

- we want a better spatial resolution than CDS/SOHO (3")
- the spatial resolution must permit one to one correspondence with the X-ray telescope (which has a resolution of 1")
- we want to resolve microflares, jets and expanding loops which can have a width down to 1".

The resolution which can be achieved is related to the Field of View, the detector resolution and the magnification of the system (plate scale).

EIS-x-1: § 4.3.3.

5. Spectral Resolution

The phenomena we will look at have typical velocities between 10 km/s and several 100 km/s (CME).

For an integration time of several seconds we should expect, following suitable analysis (question : how? Under what conditions?) of the spectral line shapes:

- Doppler velocity measurement : 1-2 km/s statistical accuracy
- Line width measurement : 3-5 km/s statistical accuracy (non-thermal broadening).

If the pixel size corresponds to a velocity as small as 20 km/s, it allows the line width and Doppler velocity from profile of lines that emanate from the transition zone and corona to be obtained. The line should be oversampled by the detector, thereby giving an accuracy of the calculated velocity of TBD km/s.

This will depend in practice on the sensitivity and resolution of the optics and detector, as well as the strength of lines.

Sources EIS-x-1 : p 49;
EIS-x-3
EIS-x-6 : p 8,10;

6. Field of View

In the baseline instrument (EIS-x-1 and EIS-x-2), there are two fields of view, one determined by dimensions of the slot, and another by the height of the slit and its scanning range. Refer to figure 1.

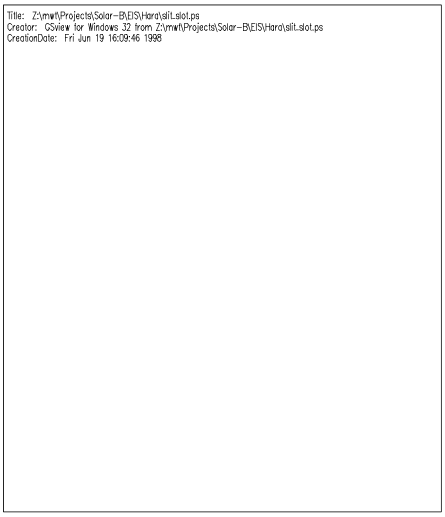


Figure 1. Slit-slot arrangement.

The field of view must be large enough to cover typical structures of the quiet sun and of active regions. Therefore the required field of view is TBD.

Some proposed values are :

Field of view : 4 arc minute.

Scan Range : 4 arcmin x 4 arcmin

The field of view will depend on the focal length of the primary mirror.

7. Sensitivity

A minimum signal to noise ratio (number of signal photons / number of equivalent noise photons) is required for determination of velocities and other plasma diagnostics to the required accuracy.

The available signal is determined by the effective area of the instrument and the intensity of spectral lines in the selected waveband. The effective area is physical area of the primary mirror multiplied by the reflectivities of the optical components and the quantum efficiency of the detector.

The figure in the table is an estimate of the obtainable effective area.

EIS-x-1 : Table 4.11.

8. Misalignment

This refers to the maximum permissible misalignment between the different instruments FOV's. It is a mission requirement that the instrument should obtain correlated information. This alignment is a critical topic which is TBD.

EIS-x-6

9. Alignment Measurement

Knowledge of the relative alignment of the instrument's telescopes will be required.

This measurement should be carried out at TBD intervals.

10. Pointing

The accuracy (linearity, reproducibility etc.) of the scanning mechanism is referred to here.

A system alignment error budget should encompass the requirements for Alignment Measurement and Pointing.

Other requirements

These are requirements of the system that do not emanate from the User Needs, or other constraints. Their origin may be external to the system (as in the case of system interfaces) or internal and may apply to the system as a whole or to individual subsystems. This document is only concerned with constraints that apply to the system as a whole. Subsystem constraints are detailed in the relevant subsystem requirements document.

Spacecraft characteristics table

The instrument must be accommodated on the Solar-B spacecraft, which will have the launch, orbital and environmental characteristics in Table 2.

	Characteristic	Value	Definition
11	Launch vehicle	M-V	EIS-x-1
12	Launch vibration	evaluated for spacecraft TBD at subsystem (telescope) level	EIS-x-5 p 20
13	Orbit altitude	600 km	“
14	Type, inclination	sun-synchronous polar, 97.8°	“
15	Contact with base station	4x24h, duration is TBD, downlink rate (KSC): 2.2 Mbps minimum (will increase to 5 Mbps if additional DSN sites are used)	p6 AO-98-OSS-05
16	Mission life	Designed for 2 years Fuel for 5 years	“
17	Attitude control	examples: stability X,Y 0.2” /s 0.4”/minute Absolute pointing accuracy, <1’	see full spectrum in EIS-x-5.
18	Doppler shift	Vary : ±0.1 m/s Amplitude less than ± 100 mÅ	EIS-x-2 p62
19	Eclipse	operation desirable during eclipse season (?).	EIS-x-2 p62, eclipse parameters given in EIS-x-5, p25
20	Radiation	TBD	Note R
21	Thermal	TBD	Note T

Table 2 : Spacecraft characteristics

Notes

20. Radiation environment

the radiation environment is relatively well known (e.g. TRACE and SMEI missions) although the detailed predictions have to be determined. The sun-synchronous orbit includes passages through the auroral zones as well as the South Atlantic Abnormally. It also exposes the spacecraft to infrequent but intense solar particle events. The total dosage and the frequency of Single Event Upset (SEU) are TBD.

21. Thermal environment

This can also be deduced from the studies done for the TRACE mission. The constant spacecraft attitude with respect to the sun means that variations of the spacecraft thermal balance are relatively small. The most critical aspect is the barbecue effect due to the earth. This effect has to be evaluated and its impact on the instruments specified.

EMC : no specification is available and no testing is anticipated. It is assumed that best practices will be observed in the design and build and that EMC problems are dealt with after delivery to Japan.

System Interfaces

Table 3 shows the values of spacecraft interface characteristics and allocations of spacecraft physical resources which will apply to the system.

	Characteristic	Value	Origin
22	data rate	64 kbps	proposal
23	Data volume	384 Mbits/orbit	“
24	envelope	~ 3000 x 550 x 550 mm	“
25	mass	< 60 kg	“
26	power	< 20 W	“
27	Vibration	1st resonance frequency > 70 Hz	“

Table 3 : System interfaces characteristics

A full matrix of all interfaces within the system can be found in xxx (for the baseline EIS).

Figure 1 is an extract of that matrix and shows the subsystems which have spacecraft interfaces and the nature of those interfaces.

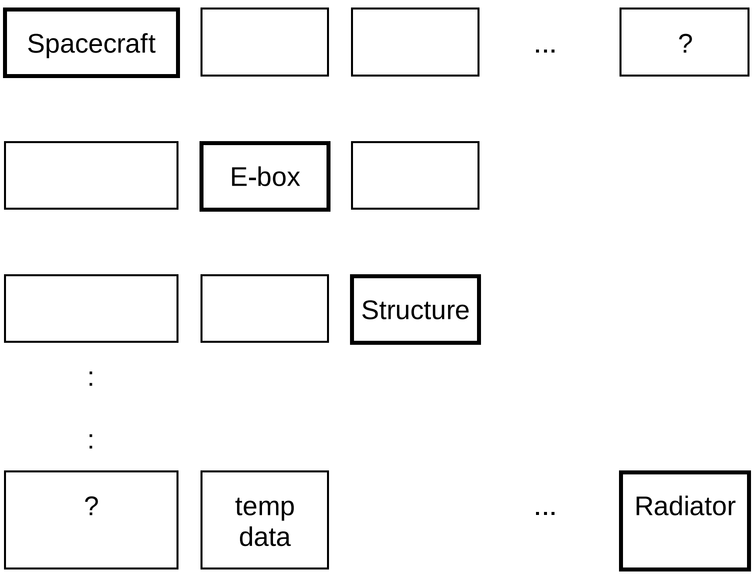


Figure 1 : Spacecraft interfaces

Then, relate the two (enter values in appropriate boxes...).

Other designs will have different interfaces with the spacecraft, and this analysis will be included here when their details become known.

Management

- Development consistent with spacecraft milestone schedule.
- Maintain costs within budgets and staffing levels (PPARC, NASA).