Preparation for the SPIRE Systems Design and Interface Review

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1. Introduction

In order to complete the detailed design of the SPIRE instrument subsystems it is necessary to freeze all the major interfaces between the instrument and the FIRST system and between the SPIRE sub-systems themselves. In order to do this we must first satisfy ourselves and ESA that the SPIRE instrument system design is compatible with the requirements laid upon it.

The SPIRE project has decided, therefore, to hold a formal "Systems Design Review" with a properly constituted board to verify that the SPIRE instrument level design has no major flaws that will prevent the detailed design of the sub-systems progressing.

For logistics and accommodation arrangements, please contact Judy Long (j.a.long@rl.ac.uk)

2. Systems Design Review

Date: November 30 (All day)
Venue: Cosener's House, Abingdon

2.1 Purposes of the review

The basic purpose is to show that the instrument systems design is mature, thoroughly understood and properly documented – to this end we will….

(i) present the instrument and its operating modes as a set of systems based on the breakdown given in the appendix;
(ii) present the proposed instrument design solutions that are to be adopted to meet the system level requirements;
(iii) present the modelling and analysis of the instrument as a system to show that the design will be compliant with the system level requirements;
(iv) present the instrument development and test philosophy to show that this addresses the verification of the system level requirements;
(v) present the instrument level criticality analysis and show that the instrument design can cope with failures without total loss of operations;
(vi) show how the system requirements flow down to the subsystems;
(vii) present the documentation tree;
(viii) present the interface control scheme.

Development Plan

In addition to the presentation of the instrument systems design we will provide the Instrument Development Plan in document form. This will not be presented at the review but it will be assumed that it is a Review Item and, as such, the board will provide comments and queries in the form of Review Item Discrepancy (RID) reports. The purpose of having the Development plan as a review item at this stage is to:

(i) show that the overall instrument development and verification is compatible with the FIRST schedule;
(ii) assess subsystem qualification status and verification plans in the context of the instrument development plan;
(iii) assess subsystem development plans;
(iv) identify long lead time items necessary for the instrument development.

2.2 Review format and draft agenda

The Systems Design Review will be a formal review with an external panel chaired by Thomas Passvogel (or replacement payload manager) with ESA representation and “neutral” external participation

SPIRE Systems Design Review November 30 Draft Agenda

09.00 Introduction and purpose of review **Griffin or Swinyard**

09.15 Description of the SPIRE Instrument Systems **Swinyard**

- Structure and mechanics
- Opto-mechanical
- Thermo-mechanical
- Radiation detection
- Electrical and EMC protection
- Instrument Control and communication
- Calibration

(I’ve left out the “Data Processing” as being less ready and anyway we’re going to be dead short of time. On-board data handling up to the construction of the telemetry stream is taken under “Instrument Control and communication”)

10.15 Coffee

10.30 Presentations of each system (20 minutes + 10 minutes discussion each)

10.30	**Structure and mechanics**	**Winter**
11.00	**Opto-mechanical**	**Dohlen**
11.30	**Thermo-mechanical**	**Heys**
12.00	**Radiation Detection**	**Bock**
12.30	**EMC protection**	**Cunningham**
13:00-14:00	**Lunch**	
14.00	**Electrical**	**Cara**
14.30	**Instrument Control and Communication**	**King**
15.00	**Calibration**	**Swinyard**

Presentations should follow the following format:

1. Requirements on the system from FIRST (IID-A etc); SRD; IRD; back up from the sub-systems; other systems etc.
2. Description of the design solutions adopted to meet the requirements.
3. Description of the modelling and analysis that shows that the design will meet the requirements.
4. Description of the development and verification plan that will prove that the design will meet the requirements.
5. Description of the appropriate system-level configuration control scheme.
6. Indication of which sub-system specification requirements are critical to the performance at the system level.

15:30 Tea

15.45 System Level Criticality Analysis **Swinyard**

Instrument level criticality; redundancy and failure modes.

16.15 Documentation **Delderfield**

Presentation of the SPIRE documentation tree showing where all the information resides and who is responsible for it all.

16.35 Interface Control Scheme **Delderfield**

May be the same thing as documentation, but need a presentation of scheme for keeping tabs on the sub-system and system interfaces

17.00 Review Board meeting

18.00 Review Board feedback

2.3 Documentation

The following documents have to be revised/provided/completed ahead of time.

These exist in some form:

- IID-B (with all inputs completed)
- Science Requirements Document
- Instrument Requirements Document
- Operating Modes Document
- Electrical System Description
- Optical System Description
- Systems Budget Document
- OBS URD

These don't yet or may be the wrong document (JD to comment):

- Instrument Level Design Description Document (desperately needed!)
- Optics Configuration Control Document(s) – KjD's Excel Sheets + optical model files
- Thermal Configuration Control Document(s) – Sam's Thermal Model
- Structure/Mechanics Configuration Control Document(s) – How to do this? Berend/John to comment
- EMC Protection Configuration Control Document(s) – Ah! The Frequency Plan?

Responsibilities for preparing the above documents:

Document	Responsible
IID-B (with all inputs completed)	John/Bruce /Colin
Science Requirements Document	Matt
Instrument Requirements Document	Bruce
Operating Modes Document	Matt/Bruce
Electrical System Description	Christophe
Optical System Description	Kjetil
Systems Budget Document	John
OBS URD	Anna
Design Description Document	John
Optics Config. Control Document	Kjetil
Thermal Config. Control Document	Sam
Structure/mechanics Configuration Control Document(s)	Berend
EMC Protection Configuration Control Document(s)	John
Criticality and Failure Modes Analysis	Matt/Bruce

2.4 Timetable for review preparation

All documents to be available for review/approval by JD	13 Nov.
First drafts of presentations	17 Nov.
Documentation to be made available to review panel	21 Nov
Finalisation of presentations	24 Nov.

Table 1: Description of the SPIRE systems				
System	**Description/Issues**	**Sub-systems**	**Design analysis Tools**	**Design verification methods**
Structural	To ensure that the SPIRE instrument is mechanically compatible with the FIRST system and capable of withstanding the launch environment Mechanical frequency response Ability to withstand launch environment Mechanical interface with FIRST system Instrument level integration Sub-system mechanical interfaces	Primarily instrument Structure and JFET Enclosure Interfaces to all cold FPU sub-systems	CAD FEM	Prototype material testing STM/CQM instrument model vibration tests CQM system level integration
Opto-mechanical	To ensure that only the legitimate optical radiation reaches the radiation detection system and does so in a manner that fulfils the instrument requirements Optical design Optical interface to FIRST system Straylight Instrument optical performance Integration and alignment Sub-system optical interfaces	Structure Optics Filters Calibration Sources Detector Arrays Baffles SMEC BSM	Synopsis ASAP APART Feedhorn model (Gaussian Mode analysis; HFSS)	Component testing (filters etc) Optical alignment Instrument level tests
Thermo-mechanical	To ensure that the different parts of the instrument run at the correct temperature and that the instrument functions at the correct temperature according to requirements for all defined instrument operating and environmental conditions Thermal performance under all operating conditions Thermal interface to FIRST system Sub-system thermal interfaces Sub-system thermal control	Structure Cooler Thermometry Temperature Control JFET Amplifiers JFET Enclosure Filters Thermal straps SCU	ESATAN model Other computer models	Prototype sub-system tests (cooler; cooler plus strap etc) STM/CQM sub-system cold tests Instrument level STM cold tests Instrument level CQM cold tests System level CQM cold tests
Electro-mechanical	To ensure that the moving parts of the instrument meet the instrument requirements; do not unduly influence the operation of other parts of the instrument and that the instrument can operate according to requirements in the micro-vibration environment expected in the FIRST satellite Micro-vibration environment Mechanism control Harness mechanical frequency response and routing	FPU Harnesses Detector arrays SMEC BSM Shutter JFET Amplifiers Cryostat cold harness Cryostat warm harness MCU Shutter electronics	Dynamical analysis model (DSPACE ?) at sub-system level only FEM???	Prototype sub-system tests Instrument level STM cold tests (?) Instrument level CQM cold tests System level CQM cold tests
Radiation Detection	To ensure that the radiation transmitted by the opto-mechanical system is efficiently detected and converted into digital signals without excess noise or contamination from other electrical signals. Detector performance versus environment (temperature; photon background; micro-	Detector Arrays Thermal Straps Temperature Control Cooler FPU Harnesses RF Filters JFET Amplifiers	Mathcad Models System analysis	Prototype cold units in representative environment with representative electronics STM sub-system cold units for thermal and

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	vibration; EMC) JFET Amplifier performance versus environment (*ditto)* Harness performance Detector sub-system interface compatibility – thermal; electrical; mechanical End-to-end system performance	Cryostat cold harness Cryostat warm Harness DCU		environmental test CQM sub-system end to end test CQM instrument level end to end test CQM system level end to end test
EMI/EMC protoection	To ensure that no radiofrequency EM radiation enters the radiation detection system from any source within the FIRST system. Also that the SPIRE instrument does not emit any radiofrequency EM radiation that might influence the operation of any part of the FIRST system EMC susceptibility and emission – radiated/conducted Electrical grounding Faraday cage integrity and performance RF filter performance Harness performance Power supply cleanliness Digital/analogue separation	Structure FPU Harness RF Filters JFET Box (FSFTB) Cryostat cold harness Cryostat warm harness DRCU (FSDRC)	Belt and braces!? Systems Analysis HSPICE model?	EM and QM electronics units as sub-system with simulator and EMC tested (conductive only?) CQM instrument level testing (conductive only?) CQM system level testing (radiated and conductive?)
Electrical	To ensure that the SPIRE instrument is electrically compatible with the FIRST system and that the different parts of the SPIRE instrument are mutually electrically consistent with each other Electrical interface to FIRST system Power supply distribution and control Sub-system electrical interfaces Wiring tables Analogue to digital interfaces Digital to digital interfaces	DRCU (FSDRC) SPIRE Warm harness (FSWIH) DPU (FSDPU) S/C PDU S/C Warm harness DRCU Simulator FPU Simulator	Systems analysis	EM and QM electronics units tested as sub-system with simulator(s) CQM Instrument level testing AVM and CQM system level testing
Instrument control and communica-tion	To ensure that the SPIRE instrument communicates with the FIRST system; that the different parts of the SPIRE instrument are mutually consistent with the operations concept and that the instrument operates safely and to requirements in all operational modes Data interface to FIRST system Operating mode definition Instrument commanding definition On board software definition Sub-system operational and control interfaces Sub-system data interfaces	DRCU (FSDRC) SPIRE warm harness (FSWIH) DPU (FSDPU) S/C CDMS FPU Simulator DRCU Simulator	Systems analysis Software simulators	EM and QM electronics units tested as sub-system with simulator(s) CQM Instrument level testing AVM and CQM system level testing
Instrument data processing	To ensure that the data produced by the SPIRE instrument are compatible with the requirements of the FIRST system and are processed into the required data products Interfaces to the ICC	DPU (FSDPU) DRCU Simulator FPU Simulator ICC	Systems analysis Software simulators	Data sets produced by simulators EM and QM electronics units tested as sub-system with simulator(s)

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	Data product definition Data processing definition Sub-system data processing interfaces Observing mode data processing interfaces			produces data sets Instrument level CQM tests for observation verification and producing data sets System level AVM and CQM tests for end to end verification
Calibration	To ensure that the data produced by the instrument can be converted into meaningful physical units to allow the correct operation of the instrument in all modes and the processing of the instrument data into the required data products Observing mode calibration definition Ground commissioning and calibration plan Flight commissioning and calibration plan Instrument to ground facility interfaces Ground facility definition Ground based observing programme definition	Photometer Calibrator Spectrometer Calibrator DPU (FSDPU) ICC	Systems analysis Instrument performance models	Prototype sub-system tests CQM instrument level performance verification Ground based observing programme

<u>Order of Play for Interface Review</u>

Based on people's advertised availability here is a suggested order of addressing the interfaces for the meeting on the 28/29th. Comments greatly appreciated.

People known to the police:

Present on the 28th in the morning:
Matt Griffin; Alex Ellery; Peter Hargrave;
Bruce Swinyard; John Delderfield; Ken King;
Dominique Pouliquen; Didier Ferrand; Jean-Paul Baluteau;
Berend Winter (not confirmed); John Coker (not confirmed)
Joe Taylor; Don Peterson

Arriving on the 28th from distant shores (here by 10:00?):
Colin Cunningham(?); Laurent Vigroux; Jean-Louis Augueres; Christophe Cara;

Arriving on the 28th (here by 12:00?)
Anna Di Giorgio

Arriving on the 29th from distant shores (here by 12:00?):
Kjetil Dohlen

Not confirmed
Lionel Duband

Day One:
Given the likely attendance I suggest we do things in this order:

Start 9:30.
i) Interfaces between structure (mechanical and thermal) and
 SMEC;
 Shutter;
 Spectrometer calibrator;
 BSM (if Colin is here…..)

10:30 Coffee
10:45
i) ctd – Some of these in the absence of the "other half" but…..
 Detectors (including to bus bar)
 Cooler (including to bus bar)
 Bus bar
 Thermometers

11:45
(Hopefully we will have a quorum by then and….)
ii) Wiring Harness Definition – number; type; connector allocation; bundling (15 mins each?)
 Detectors – John D
 BSM+PCAL – Colin

SMEC – Didier/Dominique
SCAL – Pete
Cooler – Christophe(?)

13:00 Lunch

13:45
ii) ctd…
Shutter – Joe
Thermometers – John D

14:15
iii) Having defined the wiring harness we can complete
Structure to mechanism wiring harness
Structure to detector wiring harness
Structure to RF Filters
15:00 Tea
15:15
iii) Ctd
Structure to JFET enclosure
JFET modules to enclosure
RF Filters to enclosure

16:00
iv) DPU to FIRST electrical and mechanical - Anna

16:30
v) DRCU to FIRST electrical and mechanical - Christophe

17:00
Discussion wrap up and actions

17:30 End

Day 2:

Start 9:00
vi) DPU to DRCU – Christophe (90 minutes – enough?)

10:30 Coffee
10:45
vii) Warm electronics wiring harnesses number; type; connector allocation – Christophe

11:00 DRCU interfaces to cold sub-systems - Christophe
Detectors
SMEC
BSM
Calibrators
Cooler

Thermometers

13:45 (Hopefully Kjetil's here – Martin and Tony should also attend)
viii) Optical interfaces to:
- FIRST telescope and cryostat
- Structure and Baffles
- SMEC
- Filters; dichroics and beam splitters
- BSM
- Detectors

Kjetil as optomeister should lead these.

15:00 Tea
15:15
ix) Structure mechanical interfaces to
- Mirrors
- Filters; dichroics and beam splitters
- Baffles

15:45
ix) Budgets:
- Mass budget – Colin
- Thermal Budget – John
- Warm Electrical – Christophe/Anna

16:15
x) IID-B Tidy Up – section by section through IID-B
- Any other SPIRE-FIRST interfaces? - at least structure interface drawing

17:30 Finish

If necessary we may need to have a Videocon with JPL one evening to tidy up any outstanding issues with the detector interfaces – I suggest we go for the Wednesday as all relevant interface issues will have been discussed by then.

To do this a sub-set of participants will have to decamp to RAL – I will anyway book the Videocon facility for 18:00 GMT on the 28th.