SPIRE response to ISVR/PDR Review Board Report

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This document is SPIRE's formal response to the *SPIRE Instrument Science Verification Review Completion Review Board Report* (SCI-PT/FINS/07934). The review Board's main comments are reproduced in *italics* and the SPIRE responses are given in regular typeface.

1. ISVR completion

The Board would like to congratulate the SPIRE Team for the progress made and design status reached at the ESA ISVR, respectively the PDR and considers the objectives of both reviews fully achieved.

The board was satisfied with the level of detailed design already achieved for several SPIRE assemblies or units. Items to be mentioned here are

- *Beam Steering Mechanism*
- *Overall mechanical design of the Focal Plane Unit*
- *Optical analysis including alignment and diffraction*
- *0.3 K sorption Cooler.*

We note and appreciate the Board's approval. In the case of the Beam Steering Mechanism, however, we ourselves view the current design and prototyping status as rather immature for this stage, and are taking steps to address this.

2. Inadequacy of SPIRE Systems Engineering/Project Team

The Board is seriously concerned about the current size of the SPIRE System Engineering Team and supports SPIRE's intentions to strengthen this team. The Board urges SPIRE to realise this built up in the near future in order to avoid negative impact(s) on the SPIRE development, system design and analysis.

This criticism was entirely justified, and fully expected. The detector selection and the adjustments to the design and the consortium division of work that ensued led to the UK project team being heavily over-stretched. The scope and level of project activity is now such that an enhanced Project team is needed, with more formal working procedures. In recognition of this situation, and in response to the clear recommendation of the Review Board, we have taken two main steps:

(i) John Delderfield, an experienced Systems Engineer at RAL, has been appointed to the post of SPIRE Systems Engineer. He is now in place, at a 40% level of effort. He and the Instrument Scientist will be assisted at RAL by a new junior appointment which is about to be filled.

(ii) We have defined the core UK Project Team and formalised its operation. The main functions of the Project Team will be as follows:

- to consider, prioritise and monitor all SPIRE System Engineering activities;
- to organise system-level meetings as appropriate;
- to define the format for and organise the consortium-wide preparation for SPIRE reviews and technical meetings with the ESA

The combination of Project Team meetings every two weeks and technical meetings ("summits") that it decides to organise, will cover the role previously played by the SPIRE Systems Team (which will no longer exist in its old form).

The core Project Team membership is as follows:

Instrument Scientist	Bruce Swinyard, RAL (Chairman)
Project Manager	Ken King, RAL
PI	Matt Griffin, QMW
SPIRE Systems Engineer	John Delderfield, RAL
FPU Systems Engineer	Colin Cunningham, ATC
FPU Mechanical Engineer	Berend Winter, MSSL
ICC Development Manager	Trevor Dimbylow, RAL

Other SPIRE team members are invited to attend when appropriate, depending on the agenda and their availability. Although not run in a very formal way, meetings are minuted to provide a concise account of the key points and an action list. Meetings of this group also help define some important issues to be raised in the weekly management telecons organised by the PM.

One of the most important functions of the Project Team will be to facilitate and assist in the work of the consortium as a whole. For practical reasons, mainly the need to meet regularly with minimum travel, the core team does not include various key people from locations distant from RAL. The Project Team will make special efforts to communicate and consult effectively with the rest of the consortium. Its minutes are circulated to all SPIRE institute managers, and meetings are expected to include representatives from the Saclay team every six weeks or so.

The issue of EMC is of particular concern to SPIRE since bolometric detectors can be highly susceptible to various disturbances. In addition to participating in the ESA-organised EMC Working Group, we are setting up an internal SPIRE EMC group which will

(i) clarify the grounding scheme in full detail, document it and put it under configuration control;
(ii) take the ISO EMC spec and cryostat model as a starting point for the environment in which SPIRE has to operate;
(iii) establish an EMC model of the critical parts of the SPIRE system: cryostat, detectors, RF filters, JFETs, cryoharness, first stage of warm electronics
(iv) use this model as a working tool to:
- estimate susceptibility levels and compare them with the ISO spec. (which is the starting point spec. for FIRST)
- determine what are the critical features of the design that affect EMC characteristics
- investigate effects of changing design or parameters as appropriate;

(v) formulate and organise SPIRE inputs to the ESA EMC Working Group.

3. SPIRE schedule

SPIRE presented a first iteration of a bottom up development schedule. This schedule appears not yet fully validated and consistent. In several cases the schedule for subsystems, units and components seem to follow need dates defined by the SPIRE project, and consequently result in a delivery of the instrument units just in time with nearly no margin. The Board is concerned about the credibility of this schedule and its fidelity and asks SPIRE to consolidate it with all subsystem responsibles and to identify means to re-introduce margins in the planning. The board would like to ask SPIRE to specifically review the schedule of the design and manufacturing of the FPU structure. This appears to be a schedule driver and SPIRE should find ways to reduce the total duration, e.g. by freeze of subsystem interfaces and/or optimisation of the design for easier manufacturing.

Much of the schedule information was only available just before the review, partly due to the very complex redefinition of consortium responsibilities and design changes after detector selection. The PM is now working with the institute Project Managers to consolidate the schedule and to create margin (with a goal of ~ 1 month per year). This is not an easy task. Our main strategy for finding margin is to modify the CQM programme: the Structural-Thermal Model will be upgraded to allow earlier identification of problems, and to allow it to undergo cold vibration for qualification instead of the CQM itself. This scheme is an improvement in that it will mitigate risk by earlier testing, and at the same time allows later delivery of

flight-grade components for some critical subsystems. A consolidated schedule will be presented at the Systems Design review in November.

Delivery of the FPU Structure for the STM is currently the critical item, and the present schedule still has a significant delay with respect to the need date for STM integration. We are working with MSSL to address this, and will make every effort to solve the problem by the time of the November review.

4. SPIRE funding status

The Board takes note of the statement from SPIRE that the funding for all elements of SPIRE is secure, however, very tight. In view of the funding limits the board considers the requested actions on the system engineering team and schedule extremely important.

The need to enhance the UK Project Team, the explicit inclusion of the envisaged costs of cold vibration and the already existing shortfall on ICC funding, have resulted in a significant excess in the projected UK costs over PPARC's cash-limited allocation. Note that this excess is consistent with the statement made by PPARC at the time of the FIRST/Planck payload funding meeting in October 1998, that the fixed PPARC funding envelope for SPIRE was not adequate to cover fully both the hardware provision and the ICC provision. It is clearly essential that the ICC be developed to a satisfactory state at the time of launch. Therefore, in carrying out the recent re-costing we have assumed that the UK *will* need to fund the ICC at a minimally viable level without any assistance from ESA - hence the problem manifests itself on the hardware side.

There are two feasible solutions to the problem:

Option 1: Delete the Beam Steering Mirror from the instrument. This would save enough to make the UK programme viable with some margin. It would have serious consequences for SPIRE's sensitivity for point sources and small maps. The estimated reduction in observing speed for point sources is a factor of around 7, while the speed for field mapping would be degraded by around a factor of 2 - 3. It would also pose a risk to the sensitivity in the event of excess 1/f noise degrading the non-chopped scan-map mode.

Option 2: Change the SPIRE Model Philosophy by deciding not to deliver a Flight Spare Instrument, but instead to have a limited "return-to-base repair service". Spare units would be available only for instrument/mission critical subsystems (for instance, no spare unit would be provided for the BSM). This would also save enough to make the UK programme viable, although possibly still with some shortfall remaining on the ICC funding.

These options have been considered by the SPIRE Co-Investigators and by PPARC, and the unanimous view is that the BSM should not be deleted and that the alternative model philosophy represents a more rational balance between cost and risk.

Although SPIRE agrees with ESA that provision of a full Flight Spare instrument is highly desirable, we will therefore wish to re-open the discussion with ESA concerning Flight Spare provision.

5. Instrument Design Description Document

An overall Instrument Design Description Document is missing for SPIRE and the board asks SPIRE to establish this document reflecting the baseline design.

This will be compiled and will be available for the November Systems Design Review.

6. Science Requirements Document

The Board notes that the SPIRE science requirements document is no longer fully in line with the actual baseline design of SPIRE and asks SPIRE to consider update to achieve consistency.

The SRD will be tidied up and updated for the November Systems Design Review.

7. Development Plan and Documentation Tree

The Board notes the large number of specifications and development plans produced for the review, and would like SPIRE to put the existing documents in context to the instrument system documents and to update the SPIRE Instrument documentation tree accordingly. It is noted that the SPIRE Instrument Development Plan was not reviewed by the Board, since not available in due time.

SPIRE plans to issue above 100 Interface Control Documents. The Board feels that this high number will cause confusion and lead to the overview being lost. It asks SPIRE to consider rationalisation of the interface documentation.

These are the highest priorities for the SPIRE Systems Engineer, and will be addressed for the Systems Design Review in November.

8. FTS mechanism

The Board considers the FTS mechanism a complex design and challenging development. The Board would like SPIRE to intensify the efforts put in this development. The question of micro-vibration level at the FPU and corresponding control loop should be clarified in near future.

Considerable resources are being devoted to the FTS development and prototyping at LAM, and good progress has been made since June. A technical summit on the FTS (including also BSM control electronics) was held in Marseille in early October, at which many issues were clarified. The latest test results on the GSFC prototype mechanism, in combination with the LAM breadboard electronics and controller, are very encouraging, and indicate that the required performance should be achievable.

9. FMECA

The Board asks SPIRE to address within the near future the failure modes of the complete instrument (FMECA) and to identify the corresponding degraded operations modes.

Doing a full FMECA at this time is not feasible given the status of the design and the resources available for such a major effort. SPIRE proposes to adopt a staged approach. A top-level analysis will be carried out and documented by the Instrument Scientist and Systems Engineer for the November Review. This will concentrate on critical subsystems and degraded operational modes. It will subsequently be refined and extended through detailed failure mode analysis at subsystem level. We note that a comprehensive FMECA is already available for the ^{3}He cooler.

10. Instrument Software Simulator

The Board asks SPIRE to clarify the definition, functionality and intended use of the Instrument S/W Simulator.

SPIRE would first like clarification from ESA on the functionality and intended use of the simulator before responding to this request.

11. Inconsistency of terminology

The Board notes that there exist several discrepancies in the terminology used in and contents of various documents presented. It asks SPIRE to remove these inconsistencies.

Such inconsistencies will be eliminated in the course of preparation of the documents for the Systems Design Review.

12. SPIRE-PACS parallel mode

The Board notes that no decision has been reached yet on the need to include a SPIRE parallel mode. It urges SPIRE (and PACS) to complete the investigations required to reach a yes/no decision by the end of the year.

SPIRE and PACS will confer on this and report to the FST in November.

13. FIRST Instrument Commonality

In the area of commonality of SPIRE with the two other FIRST instruments, HIFI and PACS, it appears that each instrument started a development on black paint. The Board would like SPIRE to explore the possibility of a common development.

SPIRE notes that this is a sensible idea - but, of course, we are not able to take responsibility for the design of the other instruments. There are also other areas in which the three FIRST instrument teams can usefully collaborate (such as stray light analysis, harness implementation, EMC modelling, mechanisms, launch lock devices, etc.). It is now two years since the Focal Plane Commonality meeting held at QMW. SPIRE proposes that another such meeting be organised and suggests that it could be held at ESTEC in early 2001.

14. Information requested by SPIRE

The Board would like to specifically mention the following areas where input from the spacecraft design definition or the ESA project is needed in support to the SPIRE development:

- FIRST Telescope

  SPIRE awaits information on the final definition of the telescope, particularly aspects which influence the stray light input to the SPIRE FPU.

- Electromagnetic Compatibility (EMC)

  SPIRE is participating in the EMC Working Group and has established an internal EMC group as described above.

- Cryo-harness

  This is a critical issue for SPIRE as the procurement of the cryo-harness for the AIV facility must be arranged soon.

- Cryostat mechanical and thermal interfaces to the Focal Plane Unit and the JFET box

  The mechanical interface with the FIRST optical bench is now well understood. It would be advisable now to confirm formally that the footprints and beam envelopes of the three instruments are compatible.

  SPIRE is using the static thermal model of the cryostat in conjunction with the instrument thermal model. Some features of the model need to be clarified. It would be extremely helpful if SPIRE had access to a dynamic thermal model of how cryostat interface temperatures change with the instrument thermal loads.

- Structure noise micro-vibration for the FTS.

  SPIRE awaits information on the level of micro-vibrations that obtained in the case of ISO.