Informal Report on the SPIRE IIDR

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Introduction

This is an ***informal*** note to the SPIRE consortium on the outcome of the IID, and is distributed also to ESA and Alcatel for their information. It is based on the verbal feedback and discussions immediately after the review. The Review Board will produce a formal report and SPIRE will act on it and respond formally in due time.

This review has been extremely useful to SPIRE. We appreciate the very positive and helpful manner in which the Review Board approached the exercise. Project Team members and others were invited to listen in on the Board caucus at the end of the review, and to comment and discuss key points there and then. This early feedback and the open and direct manner in which it has been provided will allow us to act all the more quickly on the key recommendations.

The purpose of this note is to start that process immediately. *It does not in any way pre-empt the report of the Review Board, which is of course completely independent.* What we have tried to do below is to list and discuss the main points that came up in the feedback from the Board and the subsequent discussions. This summary will certainly not be a complete or accurate account of what the Board will say in their report. But that will not be produced for some weeks, and we need to maintain momentum and start to address the important issues and recommendations without delay.

While there is much to be done to fulfil the requirements of the IBDR by the end of the year, the Board Chairman indicated that it is not felt necessary to convene a delta-IIDR between now and the IBDR. Progress should be made and monitored through the regular contacts and meetings between SPIRE and ESA/Alcatel.

Summary of Review Board feedback and discussions

1. Objectives of the IIDR

The Board noted that for all Herschel/Planck instruments, the IIDR objectives as outlined in the IID-A had turned out to be rather too ambitious given the state of development of the whole programme. However, for the IBDR at the end of the year, finalisation of the detailed design will be expected.

SPIRE response: We agree.

2. Documentation

The Board was critical of the fact that SPIRE (and the other instruments reviewed recently) had not provided the documentation well in advance of the review (20 working days is the requirement stated in the IID-A). This made the job of the Board much more difficult and was not conducive to making the review as effective and productive as it should be. In future, ESA should insist on the documentation being produced in time.

SPIRE response: We agree and apologise for the late availability of the documents. This was due to a combination of problems with late availability and distribution that should have been better handled. Every effort will be made to produce mature documentation on time for future reviews.

3. System-level work and progress since the last review

The Board felt that while a good deal of system design work may have been done since the last review in November, it was not easy to identify this.

SPIRE response: We accept that the Board's job was not easy in this respect, with the documentation for the review available only very late with insufficient time for it to be properly studied. Much of the progress should be apparent from the documentation when it is read (in fact much of the progress ***is*** in the form of the documentation). Since November, we have concentrated efforts on attending to the main recommendation of that review - to sort out the model philosophy and development plan. For the current review we have emphasised (as requested by ESA) the Design Description Document, the Development Plan and the IID-B update.

4. Product Assurance

Board members were very critical of the fact that PA issues were not well covered in the dedicated presentation or in the individual presentations. We expect a strong recommendation to sort this out at both project and subsystem level.

SPIRE response: We agree - this is something to which we must pay much more attention.

5. The need for an FMECA on the instrument

The Board was critical of the fact that the recommendation of the November review that we carry out a full FMECA has not been followed. There will be a strong recommendation that we take our criticality analysis to the next stage of detail.

SPIRE response: After the November review we had declined to do a full FMECA this as (a) it's not appropriate without a fully detailed design, which is not quite there yet; (ii) we have limited resources and our highest priority was to sort out the development plan, as specifically required in the one formal recommendation of the November Review Board. We stated this out at the February Technical Meeting at ESTEC.

But we agree that reliability is an important issue, and will look at further elaborating the analysis already done. A full FMECA on the complete system is certainly beyond our resource capabilities at present, especially given the many meetings and studies that will now be needed with the newly-appointed Prime Contractor - these must have priority.

6. Management

The Board felt that the project management was not firm enough, especially in ensuring that subsystem groups' activities were monitored and appropriately directed. They had noted several problems in the course of the review: that information flow and response from institutes was sometimes slow, resulting in delays to the finalisation of designs; that important issues could slip through the net; that the PM was not getting a complete set of monthly reports from participating institutes; that attendance at weekly management telecons was often poor. There will be a strong recommendation to exercise tighter control of the subsystem programmes.

SPIRE response: We agree that this has been a problem (although not one that is unique to SPIRE). It is a consequence of our small project team (essential given our limited funding) and the complexities involved in such a multi-institute and multi-national project. Matters were not helped by the illness of the Systems Engineer early in the year. We believe that good progress has actually been made recently in that

the main recommendation of the November review has been addressed through detailed interaction between the Project Team and the subsystem providers on the development plans. However, although we are making progress, further improvements are needed. Steps have already been taken, as announced at the review, to address the problem with the re-organisation and strengthening of the management team and the appointment of a dedicated Instrument Development Manager.

In summary, we must do better in this respect and the project team will have to work *very* hard on this. It will be essential for subsystem groups now to regard high-bandwidth communication with the project team and adherence to actions, deadlines, and milestones as of the highest priority.

7. The status of the DRCU

The Board was concerned at the status of the DRCU. They felt that the design was still changing when it should be stable; grounding scheme still needing definition, etc. They noted the recently identified problem with the DRCU delivery, and were concerned that it must not be allowed to undermine the schedule.

SPIRE response: On the design, things are not as worrisome as the Board felt; the technical design and documentation are fairly well defined with some details to be sorted out. The main design changes (already announced in November) are all rational and beneficial. Budgets are all under control. Our warm electronics are small and light on the whole.

Addressing the schedule issue is high priority and we have already started to act on this. The grounding and redundancy scheme is critical to freezing the PSU design which, for administrative reasons, has a long procurement time. Steps are already being taken to close this off ASAP.

8. The schedule and development plan

1. The Board noted that the schedule was tight in all areas.

SPIRE response: Yes it is - just like every other Herschel/Planck activity. This requires a fresh look at the challenge to fly in 2007 on the part of ESA, Alcatel, the instrument teams and the national agencies.

In the case of SPIRE, the Structure schedule is on critical path and so will be carefully monitored.

It is known that the three Herschel instruments all have problems in delivering their CQMS, and PFMs on time. Some solution to this situation will be needed if the launch date is not to slip. This can only be achieved by looking anew at the overall AIT plan for the complete system and seeing if all the necessary tests and verifications can be achieved, perhaps with a different approach to the one currently laid out in the IID-A.

2. The Board was interested that we have allowed structure mass to increase slightly to ease schedule pressure.

SPIRE response: The SPIRE FPU mass has been vigorously constrained and minimised since the start of the project, resulting in us being the lightest of the three Herschel instruments. A consequence of this is that the Structure thermal/mechanical design and integration are complex and challenging, and this was having a significant impact on the schedule form its detailed design and production. Having been asked to speed up the schedule, the project deemed it appropriate to back off from a very "heroic" Structure design in order to simplify the detailed design and manufacture. This was thought to be a reasonable approach for the sake of 2 kg or so.

4. The Board was concerned at the planning for only two cool-downs and the lack of testing time in the CQM schedule for calibration and AOT testing.

SPIRE response: Time for calibration is actually explicit in the schedule. The remark made during the review that this could be taken as margin implies only that this is the last phase of testing and therefore the one most likely to suffer in the event of pressure to deliver. Nevertheless, it is clear that the CQM test programme is severely pressed for time. SPIRE will therefore list and prioritise the tests to be carried out on the CQM in the AIV facility, and discuss this with ESA and Alcatel. We maintain that it is quite appropriate to rely to some extent on the Flight Spare programme to continue AOT testing and optimisation of the instrument performance and operating modes.

9. Thermal Modelling and JFET power dissipation

During the review, it was noted that

(i) the cryostat boil-off will be very slow to respond to FPU power dissipation changes;
(ii) SPIRE has stringent requirements on the temperature of the 4-K stage (although only during scan mapping);
(iii) the JFET power dissipation allocation is 50 mW vs. the initial estimate of 33 mW (as already announced in November). This dissipation on the Hershel Optical Bench level is now driving the thermal behaviour of the whole SPIRE FPU.

Possible consequences are:

(i) with maximum JFET dissipation, the temperature of the optical bench may be far too high - this will feed through to all lower temperature stages including the detectors, resulting in excessive thermal loads on 4 K in particular and in detector temperature far above spec.;

(ii) when SPIRE changes JFET or internal FPU dissipation (e.g., switching from FTS to photometer), there may be large and lengthy thermal transients that could seriously affect operations;

(iii) there may be a significant effect on the lifetime;

(iv) the need to redesign the SPIRE FPU supports using material of lower thermal conductance material (rather than the stainless steel supports in the current design).

SPIRE response: This is a *payload system* problem and has to be approached as such. We have been asking for some time for a dynamic thermal model of the cryostat to attach to our comprehensive model of the instrument. The SPIRE thermal model was presented in November (and we were complimented on it by the Board) and has been refined since then. It has used as an input the thermal model provided by ESA, in which the boil-off is a parameter that *does* respond to the FPU dissipation (it is essentially a steady state model, and we have used it in the absence of any information on the dynamic response). It is now clear that there are potentially serious problems. Regardless of the history, we must now work on assessing and solving these.

Proposed steps:

(i) SPIRE looks at all possibilities for reducing the JFET dissipation, and on the implications of so doing (Project Team and JPL);

(ii) SPIRE produces more detailed power dissipation budget estimates and temporal power profiles for likely operational modes and transitions between modes;

(iii) ESA, the Prime and SPIRE work together as matter of urgency to
- review properly SPIRE's thermal modelling done to date;
- establish and use a representative cryostat/FPU thermal model to investigate the static and dynamic effects of SPIRE FPU dissipation
- propose design solution.

At present we have a mature Structure design. Considerable effort has gone into verifying it by FEA and thermal modelling and experimental tests. A redesign will cost considerable effort and time which we do not have and will lead to budgetary and schedule problems. It should therefore be avoided if at all possible. We do not propose to make any change unless the outcome of the system-level thermal modelling shows it to be essential.

10. Microvibrations

The panel noted that SPIRE is potentially sensitive to microvibrations, and that this needs to be reliably analysed and quantified.

SPIRE response: We agree. We have to do more to quantify our susceptibility (both for the detector readout and the FTS mechanism) and ESA/Prime have to do more to quantify the spacecraft environment.

11. EMC

The Board was concerned that EMC analysis and planning are not under good control, and were not convinced by the general nature of the presentation on this subject.

SPIRE response: EMC has been raised as a key system issue by SPIRE since the start. EMC susceptibility and environment are notoriously difficult to quantify. SPIRE has led the way in establishing our own programme of EMC modelling. We have been sufficiently concerned about it to adopt a very conservative design philosophy: the FPU enclosure is configured as a Faraday cage - and this is extended to encompass the JFET modules; all wires entering that enclosure (not just detector wires) are RF filtered; the readout electronics are differential; the internal harness design and the specification of the external cryoharness are designed to minimise susceptibility.

Effort on EMC analysis has been sidelined in the course of preparation for the IIDR to give priority to writing the *Design Description Document* in response to specific recommendations from ESA that this was a key element to be reviewed.

SPIRE will make every effort to enhance work on EMC modelling and estimation of our own susceptibility. But proper modelling can only be done at system level and requires information on the detailed implementation and routing of the cryoharness, the properties of the cryostat and the satellite radiation environment. It should be taken forward by a team involving the instrument teams and the Prime. We recommend that the EMC Working Group take responsibility for leading this activity.

12. DPU and OBS status

The Board could not see what progress had been made on the hardware or OBS since November. The SPIRE-specific software was felt to be the bulk of the OBS work and there was no evidence of progress in this area.

SPIRE response: The DPU hardware is common to all instruments, and SPIRE needs it later than the others. Some of these issues are therefore not SPIRE-specific. The hardware is already being procured, but SPIRE must work on the definition of the instrument-specific OBS and produce a mature *Software Specification Document* by the time of the IBDR.

13. Instrument subsystem budgets

The Board stressed the importance of keeping control of instrument budgets (especially mass and power), and appeared concerned at the lack of margin and the manner in which margin appears to have been used up - the JFET power dissipation being a case in point.

SPIRE response: We agree the maintaining strict control of these budgets, and have already put the system to do this in place. Some increases with respect to the version of the IID-B sent out with the ITT

for the spacecraft contract have not been "sudden" but have been discussed and justified to ESA at previous technical meetings and reviews. Nevertheless, SPIRE accepts the recommendation to be very strict on maintaining the margins from now on.

14. Scientific optimisation

The Board was concerned that effort devoted to this might draw resources and attention away from other high priority work, and questioned whether it was appropriate at this stage of the project

SPIRE response: The basic instrument design has been fixed and stable for some time. In fact, for the reasons mentioned, design changes of any kind have been ruled out with the exception of the possibilities to make small changes to the photometer and spectrometer bands. These are still being considered on condition that they have no effect on the interfaces and schedule. The FTS bands will be frozen very soon. A decision on changing the long wavelength photometer band is deferred until after CQM build as it requires a detailed scientific and technical trade-off. SPIRE will adopt a conservative approach to this issue: the instrument design is satisfactory at present, and any change will only be scientifically beneficial if it does not adversely affect instrument readiness.

15. Observing modes

The Board pointed out that Serendipity and SPIRE-PACS Parallel modes would have cost implications for the ground segment, and an early decision on their implementation would be welcome.

SPIRE response: We accept that this is the case, and will assess the use of these modes at the earliest possible times. In the case of Serendipity mode, it should be possible to make a decision relatively soon. In the case of Parallel mode, our view is that at present there is a clear possibility that this mode may prove to be scientifically beneficial. A complete assessment requires good knowledge of the actual instrument performance levels and of the high priority scientific programmes that astronomers will want to do at the end of the decade: it may be necessary to decide after launch. We propose that parallel mode continue to be incorporated in ground segment development.

16. Identification and solution of problems

The Board was pleased to note that SPIRE was open about key issues and problems, allowing the review to focus on these. They were concerned that in several cases problems were highlighted but convincing plans to address and solve them were not yet apparent.

SPIRE response: We accept the Boards concern here. The first step in solving a problem is to identify it. While some issues are SPIRE-specific, some of the most critical ones are problems that require information and participation by ESA and the Prime to solve - they are system issues (for example, thermal and EMC questions) - the review has afforded an excellent opportunity to discuss these

It is important to bear in mind that SPIRE has limited resources at the Project Team level, and must prioritise its efforts. We wish to have a continuing and open assessment of the relative importance of various issues, with full visibility to ESA and the Prime, to make sure that highest priority issues are properly attended to.

17. Active thermal control

The Board noted that it was not planned to implement this for the CQM and were concerned that this might affect CQM performance and make it difficult to implement afterwards. They wished to have a better understanding of our plans.

SPIRE response: Active thermal control of the ^{3}He stage is something that has usually not proved necessary in previous ground-based bolometer instruments and in the IRTS satellite instrument, built by Caltech/JPL. In the case of SPIRE, we have been conservative in making provision for it. The implementation is complex and there is a strong desire to leave it out if at all possible. The provision

made for it in the design, and the plan to decide based on CQM tests should therefore be seen as the identification of a possible risk and provisional planning for addressing that risk should it prove necessary.

18. IID-B

The Board noted that the proposed version of Chapter 5 (which contains much of the information on spacecraft interfaces) that SPIRE has submitted as part of the IIDR documentation has been substantially updated but still contains many TBDs. They would like to see as many of these filled in as soon as possible.

SPIRE response: We agree. It is important to work immediately with the Prime on this. As agreed at the review, SPIRE will prepare a list of critical information which we need to close off as much of the IID-B as possible and provide this to Alcatel/ESA. It is also important that, in parallel, Alcatel/ESA provide a detailed response to what has already been provided.

We note that the version of the IID-B that went out with the ITT for the spacecraft contract is now considerably out of date, and cannot be used as a baseline for interface definition in many cases.

Some additional issues noted by SPIRE during the review

Cryoharness definition: SPIRE needs to place an order for the AIV facility cryoharness very soon (~ 1 month). It will not be possible to specify the Herschel harness in detail on that timescale. Alcatel have noted this and that some compromise must be found which will allow SPIRE to define what is to be ordered and be ensured that it will be as representative as possible.

SPIRE DDRs and IBDR preparation: It is intended that the various subsystem DDRS that will take place over the summer should satisfy the documentation requirements of the IBDR. This means that the DDR documentation requirements will need to be will be defined and made available to DDR organisers.

300-mK thermal strap programme: This is much less mature than it should be at this stage of the project. The thermal straps are a potential single-point failure and are also schedule-critical for the STM. This programme must now be a high priority for the Structure development (even at the expense of other aspects, if necessary).

Instrument external interfaces: We need to freeze the instrument external interfaces to allow detailed AIV facility design to proceed.

Stray light impact of SMEC optical encoder: This needs to be studied by modelling of the filter out-of-band rejection at 780 nm, and investigating possibilities for baffling if necessary.

Thermal control by cooler pumping speed modulation: The requirements on the warm electronics and software for ^{3}He pump control need to be clearly defined.

Cryogenic vibration facility: To accommodate the STM schedule, SPIRE will probably need this earlier than the other instruments. At present there is not much margin (1-2 months) in the envisaged readiness date.