Report on the SPIRE Mirrors Detailed Design Review

Bruce Swinyard
2 August 2001

SPIRE-RAL-REP-001654

1. Introduction

The Detailed Design Review for the SPIRE mirrors has been held in order to fulfil the following:

1. To ensure that the opto-mechanical design of SPIRE is sufficiently stable and configured to allow the mirrors to be to be released for manufacture
2. To ensure that the interfaces between the mirrors and the SPIRE structure are correct and under configuration control so that the mirror mounts can proceed to production of manufacturing drawings
3. To review the mirror and alignment tool development plan to ensure that it is compatible with the SPIRE development plan
4. To review the alignment plan for the instrument to ensure that it is feasible in outline and that all equipment necessary to carry out the alignment verification are identified.

To these ends a detailed set of documentation has been produced and a presentation of the design has been made to the SPIRE optical design team on the 10th July 2001 at LAM Marseille.

This report will mostly follow the documentation that has been presented at the review and will make detailed comments in the context of the documentation. These comments arise almost entirely from discussion at the presentation plus e-mail exchange both before and after the presentation.

1.1 Present at the Review

Chair: Bruce Swinyard RAL
Martin Caldwell RAL
Tony Richards RAL
Eric Sawyer RAL
John Coker MSSL
Tully Peacocke ATC
Dominique Pouliquen LAM
Kjetil Dohlen LAM
Pascal Dargent LAM
Yann Alanou LAM
Jean-Paul Baluteau LAM

Documents Submitted:

Name	Author	Reference	Issue date	Submitted file name
Optical system description	K. Dohlen, B. Swinyard	SPIRE-LAM-PRJ-000447	18/12/00	SPIRE_Optics_Design_Document_1_01.doc
Photometer optical design simulator file	K. Dohlen	bolpht155	09/05/01	bolpht155.mac
Spectrometer optical design simulator file	K. Dohlen	bolsp501g	21/03/01	bolsp501g.mac
Photometer optics configuration file	K. Dohlen	LAM.PJT. SPI. ???	June 2001?	SPIREconfigPhot25.pdf
Spectrometer optics configuration file	K. Dohlen	LAM.PJT. SPI. ???	June 2001?	SPIREconfigSpec25.pdf
FIRST SPIRE Optical error budgets	K. Dohlen	LOOM. KD. SPIRE. 2000.002-2	05/12/00	ErrorBudgetsV2_01.doc
SPIRE Mirrors specifications	K. Dohlen, D. Pouliquen	LAM.PJT.SPI.SPT.200007 Ind6	12/06/01	LAM.PJT.SPI.SPT.20000706_Mirrors_Specifications.doc
Mirror drawing tree and drawings	P. Dargent	SPI-MIR-00-LD-01-A – contains list of mirror drawings	09/07/01	Drawing tree LAM-SPI-MIR-00-LD-01-A.pdf Drawings: PM6.pdf PM7.pdf PM8.pdf PM9.pdf PM10.pdf PM11.pdf SM6.pdf SM7.pdf SM8.pdf SM9A.pdf SM9B.pdf SM10A.pdf SM10B.pdf SM11.pdf SM12.pdf *no files provided for common mirrors CM3or CM5 – paper copies only.*
SPIRE Optical alignment verification plan	A. Origne, K. Dohlen	LOOM.KD.SPIRE.2000.001-3	10/04/01	AlignmentPlanIssue3_01.doc
SPIRE alignment sequence	K. Dohlen	LAM.PJT.SPI.???	11/04/01	AlignmentSequence01.xls
Alignment tools specifications	K. Dohlen, A. Origne	LAM.PJT.SPI.SPT.20000x Ind0	26/10/00	AlignToolSpec01.doc
HERSCHEL - SPIRE Mirrors and Alignment tools Development Plan	D. Pouliquen	LAM.PJT.SPI.NOT.200006 Ind3	20/03/01	LAM.PJT.SPI.NOT.20000603_Mirroirs_Dvlpt_20010330.doc LAM_SPIRE_Devplan_20010330.mpp LAM_SPIRE_Devplan_20010330.pdf

No PA plan was submitted – the mirror production will follow the SPIRE Project PA plan.
No Test Plan was submitted.

2. Summary

The optical design of the SPIRE photometer is complete and, barring detailed definition of the interfaces between the mirrors and the apertures and the structure, no further changes will be made ahead of production of the STM instrument.

Immediate activities are to get a dummy mirror made to check whether the company can do the job correctly. This will be done in September/October the actual mirrors will be placed for manufacture in November.

Final approval for the mirror manufacture needs to be given in September and formal closure of the DDR will occur then with approval of the re-submitted documentation.

Several critical items were identified during the review process that need attention before the mirrors can be submitted for production:

1. The rotation of the mirrors around the spigots as defined by the position of the dowel pins was found to be incorrect when the mirror IGES files are imported into the main structural model. This appears to have arisen due to an error in the optical configuration control spreadsheet and needs attention urgently.

2. A final aperture stop needs to be identified in the spectrometer train – discussion has revealed that this is very difficult to implement as a real physical stop at the pupil plane due to space constraints. The final fold mirrors (SM12A and SM12B) can be used as a stop and Martin Caldwell and Kjetil Dohlen will issue a report on this.

3. The need for a baffle between the top optics in the spectrometer arms (SM9A) and the input mirror SM7 needs to be evaluated rapidly. Overspill from SM10A could constitute a straylight path without a baffle present.

4. The arrangement for the baffling of the spectrometer calibration source and the subsequent mounting of SM8B needs to be rapidly investigated and an outline design proposed.

5. A design for the MGSE required to support the optical bench during integration and alignment needs to be rapidly progressed to allow the detailed integration and alignment procedures to written. Whilst it is not expected that the lack of MGSE definition will affect the alignment philosophy, and therefore perhaps the mirror design, it might and therefore rapid definition is required to close out this issue.

Other less urgent items also need to be addressed – these are indicated below in the context of the documentation submitted and the presentation at the review.

3. Notes and Comments on Individual Documents/Topics

3.1 Optical system description

Points arising in the presentation at the review. No specific comments on the document except that it should be brought into line with the “as built” design at some point before delivery of the mirrors.

Telescope Design
The WFE of telescope is now specified as 6 microns. All design files will be updated to include the new Astrium-F telescope design.

Straylight specification
The definition of the straylight specification for the SPIRE instrument is not sufficiently precise. Neither is there any defined test of whether the specification has been achieved. More effort is required to sort out the specification and define how it will be tested – the various notes/documents on the straylight should be consolidated and turned into verifiable specifications.
Action OPT-DDR-01

Physical Implementation of the Cold Stops
This could be provided as a plate to be fixed to the cold box and might be able to have some adjustment. The present assumption is that this will not be necessary and M6 will take out any rotations. The physical implementation of the cold stop needs to be drawn up and the interface sorted out. Note that it is assumed that the inner side will be blackened – MSSL will draw this up and distribute for discussion.

Spectrometer final cold stop is between SM6 and SM7 again a drawing for of the physical implementation of this stop is required – MSSL will provide this a la photometer.
Action OPT-DDR-02

Ghosting due to multiple reflections
In order to model multiple reflections within the instrument from the filters Kjetil wants the actual "channel" response and needs filter R and T to do this. For the time being use the cross talk requirement for point sources as the starting point. Could do this easily in ASAP – more difficulty with synopsis.
Action OPT-DDR-03

Design Temperature
The optics and mirrors are designed cold and the IGES files contain the cold dimensioned design. The mirror drawings are for the warm condition for manufacturing purposes.

Final Stop in the Spectrometer
There is a problem with the beam emerging from the detectors it gets clipped on the SM12 fold mirrors anyway. A final stop is required in the spectrometer to avoid extra, un-modulated, power getting onto the detectors. It is physically very difficult to get a stop in the system at the image of the pupil - can we use the fold mirrors as the actual stop. Martin and Kjetil will analyse using the fold mirrors as the stop.
RID TBD-02

Field Rotation in the Spectrometer
As we will now define step and look as a prime rather than a redundant mode, we should try to get the chop axis sensibly arranged onto the detectors. Kjetil needs to tell us what the field rotation is and which way the chop axis goes. This will go into the configuration control file.
Action OPT-DDR-04

3.2 Photometer optical design simulator file

Status

Photometer optical design simulator file Synopsis – BOLPH155 – has new telescope
Spectrometer optical design simulator file Synopsis - BOLSP501g – does not have new telescope. This will be upgraded in the near future.

The ASAP translated files should also be under configuration control. The Synopsis files will be translated directly to ASAP; MEC will run them to verify they run and they will be placed under configuration control in the same manner as the Synopsis; APART and Code V files.

3.3 Spectrometer optical design simulator file

Status

Spectrometer optical design simulator file Synopsis - BOLSP501g – does not have new telescope. This will be upgraded in the near future.

3.4 Photometer optics configuration file

Status

Both this document and the spectrometer configuration file must be properly numbered and issue dates and version numbers updated.

PHOT25 is version provided for IIDR in April 2001. This will change as there is a bug somewhere in here – SM7 has the wrong rotation

Also note that the dichroics are now sized but MSSL still don't have a proper ICD from Cardiff.
Action OPT-DDR-05

3.5 Spectrometer optics configuration file

SPEC25 is version for IIDR in April 2001 – same problem as with PHOT25

3.6 FIRST SPIRE Optical error budgets

Status

Version 2.01 is that of Dec 2000 and does not take into account the change in telescope design. This should not be significant.

Comments

Throughout document Herschel for FIRST and "HOB" for "FOB"

Section 3.3 Page 8 and Figure 4 Page 9
The external alignment requirements for the instrument need much better definition in terms of what is actually required from the telescope and Herschel optical bench. This is the subject of a technical note by Tony Richards (SPIRE-RAL-NOT-000754) and this should be used for the definition of the alignment requirements vis-à-vis Herschel.

Figure 4 Page 9:
Error budget "SOB to FOB" is ambiguous – in discussion it became clear this actually refers not to the external alignment of the instrument but to the uncertainty between the SPIRE reference point location and the SPIRE optical bench itself.

Figure 9 Page 17
There is no budget for the misalignment between the two pupil stops in the spectrometer. This was not included originally as the final stop was to be oversized. Now this is no longer true an alignment budget must be included.

3.7 SPIRE Mirrors specifications

Status
12 June 2001 – version 6 – this version needs updating because of error in configuration files and to update the mass budget for the mirrors from the latest drawings.

Version 8 was released for comment subsequent to the review meeting.

Section 4.1.1
A “scratch and dig” specification should be given for the manufacturing of the mirrors

3.8 Mirror drawing tree and drawings

A drawing tree was provided at the meeting LAM-SPI-MIR-00-LD-01-A

Drawings will be provided for the alignment tools and the mirror blank at a later date.

The mirror masses and spigot tolerances are in the Interface Drawings for the mirrors. The corresponding tolerances for the mirror mounts need to be detailed on the mirror mount interface drawings.
Action OPT-DDR-06

3.9 SPIRE Optical alignment verification plan

Status
Version 3 provided for IIDR in April 2001. This version split out the detailed sequences and tools specification into separate documents. It contains an overall description of the alignment philosophy and tests which are largely unchanged from the May 200 version.

Comments
Section 2.1 page 3
Third paragraph: 'optical reference cube' - should this be cubes plural, as two cross-hair marks are needed to control 'roll' of the instrument about LOS, and for accuracy these need a reasonable spacing, e.g. > 5cm, hence 2 cubes?

Fifth paragraph: The 'special tool' could be named as apex tool, the later figure on p.9 explains what's happening quite well and could be used or referenced here.

Last paragraph: Reference to ’diamond machining optical quality’ - a more specific issue is the surface roughness - this could now be stated as 10nm RMS ?

Section 4.3 Page 9
Figure and associated text – it is not clear whether the longitudinal axis (MAT focus) is being measured and controlled. It appears from discussion that it is it is not being measured, and a statement to this effect would help. Also a statement that the MAT is then to be re-focused as required on viewing each

apex mark would help in clarifying what is to be done.

It was also noted in presentation that for CM3 and CM5 there will have to be special tools as the spigot is not on the gut ray axis. This should be mentioned in the text and they should be specified separately.

Section 4.4 Page 10
It should be noted that there component-level metrology is needed to ensure that the pellicle BS is adequately identical to the real BS.

Section 4.5 Page 10
It is noted that the same procedure applies to the spectrometer pupil alignment and that there should be a spectrometer CS tool specified.

'large deviations indicate TBD action' . Either delete or specify what TBD actions are! (This also applies to Section 4.6 Page 11)

Section 4.6 Page 11
"Star Test". It was noted in discussion that the 'O-tool' will actually be seen at a high angle of incidence. Therefore we need to ensure that the aperture of the MAT is specified to allow sufficient depth of focus for this test.

"Hartmann test" Specify here the requirement on the size of holes in tools for Hartmann test - 2mm is quoted elsewhere but this needs justification.

Section 4.7 Page 12
Note in passing: The effect of gravity and instrument orientation could be simulated using an FEA mechanical model to see if there is a problem – if we are close then we test it – if not then don't bother.

It should be clarified whether this test will be/is capable of being carried out at cryogenic temperatures. The present assumption is that it can – at least at 77 K.

3.10 SPIRE alignment sequence

Status
A first draft has been provided – this document is subject to some discussion and possible extensive revision. Therefore it is not yet under change or configuration control – informal discussion on the details of the sequences are now ongoing.

Comments
The following comments from Martin Caldwell are recorded here from an e-mail:

General
Diagrams of layout in each stage would be much easier to follow.

The whole sequence begins with 2K box assembly and it is understood in discussion that this is inserted later a clearer explanation that the detector box alignment happens offline would be useful.

Procedure 4.
CM4 alignment seems to be missing. Although this is a replacement for the BSM it should still be

verified or does the fact it is a flat mean that an alignment test is not required?

Proc.5. step 5.
'Move MAT' Note that this is accurate control in linear + angle positions.

Proc. 5. step 12.
'replacing FTS mechanism' when was it removed?
step 13 & 14. In the comment 'image transmitted through SBS2' . Suggest 'image obtained by transmission through SBS2 plus reflection at SM10B'

Proc.7.
In comment 'replace CS with Hartman', should add that this involves alignment of hartmann to CS position?
'determine shape of wavefront' - to a limited degree only.

Proc.8.
Comment mentions environment, but could more explicitly say this is a COLD test. PSD goal is for relative motions only.

Proc.9.
A layout of the PHOT would be really useful to see how this is done.
Detector TBD fiducial marks, I think the only (& best) available may be the horn aperture rims (50um walls) themselves ?
Step 8 swap in dichroics for pellicles. How do we know they've gone in 'snug', i.e. in exact same angle. I know this is being pessimistic but it is critical. A relective reference could be used to verify dichroic orientation = pallicle orientation.
Step 11 adjust MAT wrt SOR, verify CS edges position. We did this in GERB, which being focussed at infinity required the MAT to be scanned in linear position only. I believe in SPIRE the MAT will be at finite focus (onto virtual M2 position) and will have to be scanned in angle position instead, about a point centred on object plane. This may restrict the MAT position & the scanner form ?

Proc.10, step 1.
The SCS tool has to be insertable in and out of the completed system ?

Proc.11, step 3
FIR equipment , some alignment & /or verification might be needed here too ?

3.11 Alignment tools specifications

Status
This is the first draft from October 2000. No effort has been available to work on the alignment procedures or the detailing of the alignment tools. This situation has been resolved by the appointment of Yann Alanou to work with Kjetil Dohlen.

Comments
Section 4.2 Page 6
It should be made clear that CM3 and CM5 have to have “special” tools due to their off-axis nature (see comment on alignment plan above)

Section 4.5. Page 9
O-tool, no mention that the 'object plane' surface is spherical - how would a flat plate be fitted to this (depth of focus of MAT etc. – see comments on alignment plan above.).

Section 4.7 Page 11
It should be noted that the CS tools are used in the warm test only. It would be useful to state the reasons for this here or in the alignment plan. The assumption is that they are not needed to verify pupil location cold, as all possible effects are covered by the image alignment cold test.

Section 4.9 Page 13
For the Hartman test tools consideration should be given to whether a polar hole-grid should be used as this may be easier to interpret?

3.12 HERSCHEL - SPIRE Mirrors and Alignment tools Development Plan

Comments raised at review
Only two sets of mirrors will be built.
It maybe that the CQM and PFM will be built together – this may impose a one month delay owing having to do extra testing
Alignment tools will come June 2002 at same time as mirrors.

4. Matters Arising not covered in the documentation

We will need to make provision at RAL for support of optical alignment during instrument integration – LAM will only "support" alignment but will not take responsibility.

No special handling requirements are needed for the mirrors other than to keep them in a clean room and standard class 100 handling procedures (gloves etc). Mirrors will be inspected with UV light and vacuumed if necessary.

Dedicated alignment meeting required for September/October at RAL.
Action OPT-DDR-07

Annex I: Actions list

Action Item	Description	Actionee/ Actioner	Due Date
OPT-DDR-01	Precise definition of the SPIRE instrument straylight specification and how it will be tested.	RAL/BMS	14/09/01
OPT-DDR-02	The physical implementation of the cold stops in the photometer and spectrometer to be drawn up and the interface defined	MSSL /BMS	For structure DDR
OPT-DDR-03	Kjetil wants the actual overall "channel" response and needs filter R and T to do this.	CDF /BMS	17/08/01
OPT-DDR-04	Define the spectrometer field rotation at the detector image plane and which way the chop axis goes.	ObsM /BMS	30/07/01
OPT-DDR-05	Provide interface drawing for the dichroics and filters.	CDF/ JC	For filters DDR
OPT-DDR-06	Provide mirror mount interface drawings with tolerances for spigot and interface surfaces corresponding to those on mirror drawings	MSSL /ES	For structure DDR
OPT-DDR-07	Set up dedicated meeting on instrument alignment in September/October time frame	BMS /KD	17/09/01

Annex II: Meeting Agenda

9.00 Welcome (DP)
 9.10 Goals of the review (BMS)
 9.30 Presentations
       - Optical system requirements (KD)
       - Optical design (KD)
       - Error budgets (KD)
       - Strategy for transfer to mechanical model (KD)
       - Mirror specifications (KD)
       - Mirror drawings and fabrication (PD)
       - Optical alignment strategy, OGSE (KD)
       - Development plan (DP)
11.00 Coffee
11.15 Review board, mirrors
12.30 Lunch
14.00 Review board, alignment
15.30 Conclusions
16.00 Departure

Rutherford Appleton Laboratory	Review Item Discrepancy	PRODUCT ASSURANCE Space Science and Technology Department

RID Number: HR-SP-LAM-RID- 001

Spacecraft/Project	Herschel	**Document No**	SPIREConfigPHOT25 SPIREConfigSPEC25
Instrument	SPIRE	**Organisation**	LAM
Document Title	Photometer/Spectrometer Optical Configuration Files		

Action

The rotation of the mirrors around the spigots as defined by the position of the dowel pins was found to be incorrect when the mirror IGES files are imported into the main structural model. This appears to have arisen due to an error in the optical configuration control spreadsheets and needs attention urgently.

Source of Action	Mirrors Detailed Design Review 9/7/2001

Closure Comments

Initiator	BMS	**Actionee**	Kjetil Dohlen
Date Raised	9/7/2001	**Due Date**	10/9/2001

RID Signatures and Closure Date required

Project Manager	Date	PA Manager	Date

RID Number: HR-SP-LAM-RID- 002

Spacecraft/Project	Herschel	**Document No**	SPIREConfigPHOT25 SPIREConfigSPEC25
Instrument	SPIRE	**Organisation**	LAM
Document Title	Photometer/Spectrometer Optical Configuration Files		

Action

A final aperture stop needs to be identified in the spectrometer train – discussion has revealed that this is very difficult to implement as a real physical stop at the pupil plane due to space constraints. The final fold mirrors (SM12A and SM12B) can be used as a stop and Martin Caldwell and Kjetil Dohlen will issue a report on this.

Source of Action	Mirrors Detailed Design Review 9/7/2001

Closure Comments

Initiator	BMS	**Actionee**	Kjetil Dohlen Martin Caldwell
Date Raised	9/7/2001	**Due Date**	10/9/2001

RID Signatures and Closure Date required

Project Manager	Date	PA Manager	Date

RID Number: HR-SP-LAM-RID- 003

Spacecraft/Project	Herschel	**Document No**	SPIRE-LAM-PRJ-000447
Instrument	SPIRE	**Organisation**	LAM
Document Title	Optical Design Description		

Action

The need for a baffle between the top optics in the spectrometer arms (SM9A) and the input mirror SM7 needs to be evaluated rapidly. Overspill from SM10A could constitute a straylight path without a baffle present.

A technical note on this is required and then the design description will be updated.

Source of Action	Mirrors Detailed Design Review 9/7/2001

Closure Comments

Initiator	BMS	**Actionee**	Martin Caldwell
Date Raised	9/7/2001	**Due Date**	10/9/2001

RID Signatures and Closure Date required

Project Manager	Date	PA Manager	Date

Rutherford Appleton Laboratory	Review Item Discrepancy	PRODUCT ASSURANCE Space Science and Technology Department

RID Number: HR-SP-LAM-RID- 004

Spacecraft/Project	Herschel	**Document No**	SPIRE-LAM-PRJ-000447
Instrument	SPIRE	**Organisation**	LAM
Document Title	Optical Design Description		

Action

The arrangement for the baffling of the spectrometer calibration source and the subsequent mounting of SM8B needs to be rapidly investigated and an outline design proposed. Technical note on this is required and then the design description will be updated.

Source of Action	Mirrors Detailed Design Review 9/7/2001

Closure Comments

Initiator	BMS	**Actionee**	John Coker MSSL
Date Raised	9/7/2001	**Due Date**	10/9/2001

RID Signatures and Closure Date required

Project Manager	Date	PA Manager	Date

Rutherford Appleton Laboratory	Review Item Discrepancy	PRODUCT ASSURANCE Space Science and Technology Department

RID Number: HR-SP-LAM-RID- 005

Spacecraft/Project	Herschel	**Document No**	LOOM.KD.SPIRE.2000.001-3
Instrument	SPIRE	**Organisation**	LAM
Document Title	Alignment Plan		

Action

A design for the MGSE required to support the optical bench during integration and alignment needs to be rapidly progressed to allow the detailed integration and alignment procedures to written. Whilst it is not expected that the lack of MGSE definition will affect the alignment philosophy, and therefore perhaps the mirror design, it might and therefore rapid definition is required to close out this issue.

A technical note or outline specification for the MGSE is required. Once the MGSE has been defined the alignment plan will be updated to reflect this.

Source of Action	Mirrors Detailed Design Review 9/7/2001

Closure Comments

Initiator	BMS	**Actionee**	John Coker MSSL
Date Raised	9/7/2001	**Due Date**	10/9/2001

RID Signatures and Closure Date required

Project Manager	Date	PA Manager	Date