SPIRE-ESA-DOC-000275

Draft issue : 20/02/06

HERSCHEL / PLANCK

Interface Instrument Document - Part B SPIRE

(IID-B SPIRE)

SCI-PT-IIDB/SPIRE-02124

Product Code : 112 000

Written by	*Responsibility-Office -Company*	*Date*	*Signature*
G. Doubrovik	Herschel Instruments Interfaces Manager, AAS-F		
Verified by			
J.J.Juillet	Project Manager, AAS-F		
Approved by			
M. Griffin	Principal Investigator, University of Wales, Cardiff		
Th. Passvogel	Project Manager, ESA/ESTEC/SCI/PT		

Data management : Christiane GIACOMETTI

Entité Emettrice : Alcatel Alenia Space - France - Cannes
(détentrice de l'original)

TABLE OF CONTENTS

Deleted: *4-4*

Deleted: 4-5

Deleted: 5-50
Deleted: 5-50
Deleted: *5-50*
Deleted: 5-50
Deleted: 5-50
Deleted: *5-50*
Deleted: 5-50
Deleted: 5-50
Deleted: 5-51
Deleted: *5-51*
Deleted: 5-51
Deleted: 5-51
Deleted: 5-53
Deleted: 5-54
Deleted: 5-55
Deleted: *5-58*
Deleted: *5-58*
Deleted: *5-58*
Deleted: *5-58*
Deleted: *5-59*
Deleted: *5-59*
Deleted: *5-59*
Deleted: *5-59*
Deleted: *5-59*
Deleted: *5-59*

Deleted: 9-2
Deleted: 9-3
Deleted: 4

LIST OF FIGURES AND TABLES

DISTRIBUTION LIST

Distribution in electronic format (Adobe PDF)

Qty	Organisation	Institute
1	Herschel/Planck Project Team	ESTEC (Noordwijk)
1	Prime Contractor	Alcatel Alenia Space France (Cannes)
1	SVM Contractor	Alcatel Alenia Space Italy (Torino)
1	H-EPLM Contractor	EADS Astrium GmbH (Friedrichshafen)
1	Herschel SPIRE	Univ.Cardiff/RAL
1	ESA Project Scientist	ESTEC (Noordwijk)

Deleted: ESA

A0 . DOCUMENT CHANGE RECORD

Issue-Rev	Date	Version	Pages affected
1-0	01/09/2000	Initial Issue for ITT	New Document
2-0	31/07/2001	Issue for SRR	Complete Revision: Renaming of HERSCHEL by Herschel. Changes maked by change bars (including editorial changes).
2-1	13/02/2001	Unpublished version	According to SCI/PT/MM-11440 And DCN .. Includes HP-SP-RAL-ECR-005, 06, 07, 12, 14. ECR 9 and 10 not agreed.
2.2	01/06/2002	PDR version	According to agreed changes published in Minutes of convergence meeting HP-ASPI-MN-1346
3.0	23/09/2003	Not signed issue	According to changes by SPIRE CR & all comments & changes as here under (*), and minutes of IF& IIDB Meetings: H-P-ASP-MN-3513 and H-P-ASP-MN-3668
3.1	02/12/2003	Not signed issue	According to comments & changes by H-P-ASP-MN-3923, H-P-ASP-MN-3961
3.11	07/01/2004	New Issue for ESA CCB - Not signed issue	According ASP CCB #41
3.2	01/03/2004	New Issue for PLM CDR version – Signed issue	According ESA CCB SCI-PT-MM-024070,
3.3	21/06/2004	New Issue for System CDR version	According: ESA CCB SCI-PT-MM-024070, several SPIRE IIDB 3.3 inputs, H-P-MN-5081, and Sections & pages as here under (**)
4	01/02/2006	New issue	Sections & pages as here under (*)

Formatted

Formatted: Bullets and Numbering

A0.1 (*) Issue 4 changes versus issue 3.3:

- This Section 0, DISTRIBUTION LIST and DOCUMENT CHANGE RECORD
- General in all sections 1 to 10:
  - Changes in pages format and number (but not highlighted)
  - Changes versus issue 3.3 are only highlighted (coloured text and or change bar)
- Section 2.1, AD7: Replaced by ASED-TN-0097 "Alignment Methods, Plan & Results"
- Section 2.2: added RD 29 to RD 35
- Section 3.2, Paola Andreani: TBD changed to 3441
- Section 4.6.8: “Only one (single) command is required by SPIRE to go to safe mode.” is added in last line
- Section 4.7: “TBC” is deleted after “observe mode”
- Section 4.7.1: “as 6 (TBC)” is replaced by “as a number of”
- Section 4.7.1.4: “TBD” is deleted on first line, and TBD is replaced by “will be defined after the PFM test programme” on last line.
- Section 4.7.3.2, in the 2 last sentences: “chopper and “, and last sentence “The feasibility and scientific desirability of this mode is TBD” are deleted
- Section 4.7.6: “TBD” is deleted on first line
- Section 5.1: Reference requirements added (0270 and 0280)
- Section 5.2: figure 5.2-1 is updated with SPIRE_Block_Diagram_6.0
- Section 5.5, Table 5.5-1: Reference requirement added (0300), mass values are updated, column comment is added, note (**) is deleted
- Section 5.6.1.2:
  - Reference requirements added (0360 and 0370)
  - paragraph SPIRE JFET L3 I/F with electrical insulation: in 2d sentence “40mm x 12mm” is replaced by “40mm x 10mm”; in 2d bullet “AD3-1” is replaced by “AD1”; “Ref to “2 JFET” and “6 JFET” ICD’s in Annex 1” is added after 4th bullet

Formatted

- Section 5.6.3: Reference requirements added (0400 and 0410)
- Section 5.7: figure 5.7-1 is updated
- Section 5.7.1.3: Reference requirement added (0420)
- Section 5.7.1.4: Reference requirement added (0430)
- Section 5.7.3: Reference requirement added (0440 and 0450)
- Section 5.7.5.3: Reference requirement added (0460)
- Section 5.8: Reference requirement added (0470)
- Section 5.9.3: Reference requirement added (0490)
- Section 5.9.6.1, Table 5.9-4: column “Long Peak BOL/EOL” is removed
- Section 5.9.6.4: Reference requirement added (0510)
- Section 5.10:

  - in 1st paragraph "(SPIRE-RAL-PRJ-000608)" is added after "RD-19", 2d paragraph "The function … in Annex 5)" is deleted
  - 3rd "External to the CVV … Faraday shield "and 4th paragraph "Internal to the CVV … closed shield " are deleted and replaced by "All harnesses shielding and overshielding implementation shall be in accordance with RD-19 (SPIRE-RAL-PRJ-000608)"
  - 5th paragraph: "is consistent with" is replaced by "should be consistent with"
  - 6th paragraph: "in the SPIRE HDD, are given in Annex 6" is replaced by "in RD-19 (SPIRE HDD), are given in RD- 35"
  - Reference requirements added (0520 and 530)
- Section 5.10.1:
  - 1st paragraph: ", Issue 1.1 and updated pages, for harness bundles 4 and 6, identified by «SPIRE HDD 1.1 Deltas», ref SPIRE-RAL-NOT-001819, given in Annex 5:" is deleted
  - 2d paragraph: "the requirements specified in Annex 3 (Summary of SPIRE cryoharness wiring functions)" is replaced by "RD-19, SPIRE-RAL-PRJ-000608"
  - Reference requirement added (0540)
- Section 5.10.3: Reference requirements added (0550 and 0560)
- Section 5.10.4.3: Reference requirements added (0570, 0580 and 0590)
- Section 5.11.3, Reference HP-SPIRE-REQ-0200: replaced by new tex "When using telescope scan mode, information will be made available to the SPIRE project to enable determination of the start of scan with a precision better than 10ms with respect to the S/C clock"
- Section 5.11.4: last line is added "Safe mode: only one (single) command is required by SPIRE to go to safe mode."
- Section 5.12.2: Reference requirements added (0600 and 0620)
- Section 5.12.3: Reference requirement added (0630)
- Section 5.13.1: Reference requirement added (0640)
- Section 5.13.2: Reference requirement added (0650)
- Section 5.14: New text added
- Section 5.14.3:
  - Reference requirement added (0660)
  - Table 5.14-1: in row PSU "131 kHz TBC" is replaced by "200 kHz"; and note under table is deleted
- Section 5.15.1.2:
  - Above 100 K: dT/dt 20 K/hour is changed by 5 K/hour and Note 1 is added
  - Above and Below 100 K: delta T max from L0 to L1 and from L1 to L2 are added
  - Reference requirements added (0700 and 0710)
- Section 5.15.1.3: Reference requirement added (0720)
- Section 5.15.3.1: Reference requirement added (0740)
- Section 5.16.1.2:
  - paragraph This model comprises the following units: 2 bullets (Spectrometer & Photometer JFET) added after 1st bullet

Formatted

- paragraph Connector savers, safe plugs, covers etc:: in 2d bullet "JFETS" added after "CQM"
- List of equipment necessary to perform EQM/PFM test programme and table 5.16.1-1 is added at end of section

- Section 5.16.1.3:
  - All text and note 1 after 1st paragraph "Initially it will be delivered … *schedule and financial aspects*" is deleted
  - paragraph This model comprises the following units: 2 bullets (Spectrometer & Photometer JFET) added after 1st bullet
  - paragraph Connector savers, safe plugs, covers etc::
    - in 1st bullet: "with the PFM for WU only" is replaced by "fitted to all units"
    - in 2d bullet "PFM in the active connectors only" is replaced by "JFETS bias lines. Note these connectors will not be fitted with savers as well as safe plugs, as these will be subject to very limited mate/demate cycles at S/C level"
- Section 7.1: All text is replaced by "Integration is described in the SPIRE structure assembly, integration and handling plan RD32"
- Section 7.1.3: Reference requirement added (0770)
- Section 7.2: Reference requirement added (0780)
- Section 7.2.3: All text is replaced by "See RD33 (QM thermal test specification (SPIRE-RAL-NOT-002319)"
- Section 7.2.4: "AD 13 (HP-2-ASED-PL-0021_2_0" and "AD 14 (HP-2-ASED-PL-0031_1_0" are changed to "AD 14 (HP-2-ASED-PL-0021_3_1 draft" and "AD 13 (HP-2-ASED-PL-0031_2_0", and table 7.2-1 is updated.
- Section 9.8: new column "Shock" is added in table 9.8-1 (Verification matrix)
- Annex 1 is re-organised in 2 sub-sections, and updated with:
  - Annex 1-1: Note is added "Concerning mass and power (dissipation and load) the tables of sections 5.5 and 5.9 take precedence on values indicated (or not) in all these ICD's"
  - Annex 1-1: Table of drawings configuration is updated according ICD pack issue 14 and new DPU FM ICD (ICD to be officially agreed with CR to be issued)
  - Annex 1-1: All sections 1 (ASED comments) and 2 (SPIRE answer) are deleted
  - Annex 1-2: All drawings updated with SPIRE-IID-B_pack_Oct_Iss13 and new DPU FM ICD
- Annex 2: Note is added "SPIRE reduced TMM Issue 2.5 should be updated by SPIRE"
- Previous Annexes 3 (Summary of SPIRE cryoharness wiring functions), 5 (SPIRE HDD 1.1 Deltas) and 6 (Making SPIRE ESD Safe)are deleted
- Annex "DESCRIPTION OF THE OPERATIONS OF THE 3HE SORPTION COOLER" number is changed to 3 (against 4). All occurrences (see, ref to) of Annex 4 in present document are changed to Annex 3 (in sections 5.7.1.2, 5.7.1.3, 5.9.1)

Formatted

Formatted

Formatted

Formatted

Formatted

Formatted

Formatted: Bullets and Numbering

A0.2 (**) Issue 3.3 changes versus issue 3.2:

- This Section 0
- General in all sections 1 to 10:
  - All figures and tables previously with no name and number are named, and some tables and figures have new numbers
  - Old notes or comment asking for update highlighted in yellow when still not fixed
  - Changes in pages format and number (but not highlighted)
  - Changes versus issue 3.2 are only highlighted (coloured text and or change bar)
- Section 2.2: RD 22 to 27 added (IID-B input-ESawyer 4/6/04)
- Section 2.2: added RD 28 SPIRE Warm electronic integration plan, SPIRERAL-DOC-001132, Issue 0.1, 10/01/02»
- Section 4.6.7: first sentence changed by «The ^{3}He cooler will be recycled every 48 hours»
- Section 5.1, in last sentence: «(TBD, SPIRE to provide a TN)» replaced by «see annex 6 of present IIDB» added
- Section 5.2.1, Figure 5.2.1: Spire Block Diagram – updated to version 5.8
- Section 5.3.1.1: «Spire specific SVM panel picture » is named «Figure 5.3-2»
- Section 5.4.2: Figure 5.4-3 changed and renamed 5.4-2
- Section 5.4.3: Figure 5.4-4 changed and renamed 5.4-3
- Section 5.4.4-1: Figure 5.4-6 is renamed 5.4-4
- Section 5.4.4-2: Figure 5.4-7 is renamed 5.4-5
- Section 5.4.4-3: Figure 5.4-8 changed and renamed 5.4-6, Note under figure is removed
- Section 5.5: table is named « Table 5.5-1: SPIRE Units mass & dimension», dimensions values deleted (only ref to annex 1), note added « Concerning units nominal mass, this table takes precedence to any mass value indicated in drawings of Annex 1»
- Section 5.6.1.2: updated as minutes H-P-ASP-MN-5081:
  - In L3 electrical insulation, remove "and Kapton on the JFET rack I/F. The impact of the Kapton tape at the JFET I/F belongs to the SPIRE thermal budget"
  - figure 5.6-1 replaced by figure in mail from J.Delderfield 9/3/04
  - All text & figure 5.6-2 below «SPIRE level 1 electrical insulation» is removed and replaced by: "SPIRE L1 Electrical insulation is done internal to the FPU. See FPU ICD in Annex 1"
- Section 5.6.3: "TBD devices" replaced by "Tie bases and wrap as defined in IIDA Annex 10"
- Section 5.7: issue 2.3 removed from reference to reduced TMM
- Section 5.7.1: note removed
- Section 5.7.1.3: Table 5.7-2(On ground temperatures & heat flows) is removed, only the 2 last column "non operating temperatures" kept as table moved in §5.7.1.4
- Section 5.7.1.4: note (*) added (baking of 80°C for 72 h plus the ramp-up and ramp down), and table *Table 5.7-2* « SPIRE FPU Non operating temperatures» added
- Section 5.7.3: table named « Table 5.7-3: SPIRE WU temperatures»

- Section 5.7.3, note under table, all 4th bullet " Spire units will be ... for such systems, TBC» is removed
- Section 5.7.5.1: table named « Table 5.7.5-1: SPIRE Instrument Temperature Sensors »
- Section 5.7.5.3: table named « Table 5.7.5-2: SPIRE Satellite Temperature Sensors »
- Section 5.7.5.3, table, 2d row T225: Accuracy «0.001K» is changed by «0.008K»
- Section 5.7.5.3, all notes under table after : «… information only» are removed
- Section 5.9.1: table named «Table 5.9-1: Power dissipation inside cryostat»
- Section 5.9.1, note under table changed by: « for information only, refer to SPIRE RTMM in Annex 2»
- Section 5.9.3: table named «Table 5.9-2: Power dissipation on the SVM », and « When operating in spectrometry … losses in the HSFCU are TBD « is removed under table
- Section 5.9.3, under table : note added « This table takes precedence to any power dissipation value indicated in drawings of Annex 1 »
- Section 5.9.5: table named «Table 5.9-3: Power status versus instrument modes »
- Section 5.9.6.1: table named «Table 5.9-4: Power load on main bus», and note added » SPIRE to update the tables «
- Section 5.9.6.2: full new section (E.Sawyer input §5.9.6.2 & §5.13.3 to 5_11-06-04)
- Section 5.9.6.4.1: figure named « Figure 5.9-1: HSDPU Power Input Circuit Configuration», and added « Note: Power Input Circuit Configuration is given for information only»
- Section 5.9.6.4.2: full new section, text and figure 5.9-2 (SPIRE CR 74v1), and added « Note: Power Input Circuit Configuration is given for information only»
- Section 5.10, after last sentence «All relevant details of the termination connectors … given in Annex 6 (Making SPIRE ESD Safe, SPIRE-RAL-NOT-002028)» is added
- Section 5.10.1: issue and date after «HDD 1.1 Delta, ref SPIRE-RAL-NOT-001819» are deleted.
- Section 5.10.4.2: figure named « Figure 5.10-4 : DPU's 1553B interface to the Herschel S/C»
- Section 5.10.4.2: full section and all requirements deleted, no more Master Clock (SPIRE CR 72v2)
- Section 5.10.4.3: text added and changed as «Comments on IID-B 3.3 draft1, E Sawyer 13/7/04»
- Section 5.11.1.1: table named «Table 5.11-1: Housekeeping and science data rates »
- Sections 5.11.1.1: text changed and added, values in table, text and notes changed as «Comments on IID-B 3.3 draft1, E Sawyer 13/7/04»
- Section 5.11.1.2: «TBC» is removed after «200 kbps»
- Section 5.11.1.3: «100kbps» is replaced by « the maximum packet generation rate» and «TBC» is removed after « once per second » (as «Comments on IID-B 3.3 draft1, E Sawyer 13/7/04»)
- Section 5.11.3: req 0190 changed, text added and figure changed & named «Figure 5.11-1» (SPIRE CR 72v2)
- Section 5.12.2, after: …1.5 arcsec r.m.s.: «TBC» is changed by «goal»
- Section 5.12.3, after: …0.1 second: «TBC» is changed by «TBC, to be relaxed»
- Section 5.13.3: full new section, req 0240 deleted, req 0250 & 0260 changed (E.Sawyer input §5.9.6.2 & §5.13.3 to 5_11-06-04)

- Section 5.13.5: full new section (E.Sawyer input §5.9.6.2 & §5.13.3 to 5_11-06-04)
- Section 5.14.3: table named « Table 5.14-1: SPIRE Frequency Plan»
- Section 5.15.1: full new section (E.Sawyer input §5.15_11-06-04)
- Section 5.15.1.1: full new section (E.Sawyer input §5.15_11-06-04)
- Section 5.15.1.2: Above 50 K changed by 100K and TBC removed, Below 100 K req added, «50 mBar/hour (TBC)» changed by «50 mBar/min», last sentence «As a goal … 100 mbar/h» is deleted (E.Sawyer input §5.15_11-06-04)
- Section 5.15.1.3: partially new section (E.Sawyer input §5.15_11-06-04)
- Section 5.15.1.4: TBW replaced by RD 23 (E.Sawyer input §5.15_11-06-04)
- Section 5.15.2.1: reduced new section. (E.Sawyer input §5.15_11-06-04)
- Section 5.15.2.2: TBW replaced by RD 23 (E.Sawyer input §5.15_11-06-04)
- Section 5.15.3.1: reduced new section (E.Sawyer input §5.15_11-06-04)
- Section 5.15.3.2: « are given in document TBW» is replaced by «will be supplied with the instrument EIDP» (E.Sawyer input §5.15_11-06-04)
- Section 5.16: Notes 1 & 2 deleted
- Section 5.16.1: full new section, with new sub-sections 5.16.1.1 to 5.16.1.4, and new 5.16.1.5 Hardware matrix with tables 5.16-1 to 5.16-7 (E.Sawyer input_04-06-04: but with added text and note), and as «Comments on IID-B 3.3 draft1, E Sawyer 13/7/04»
- Section 5.16.2: partially new section (E.Sawyer input_04-06-04)
- Section 5.16.3: partially new section (E.Sawyer input_04-06-04)
- Section 5.16.4: full new section (E.Sawyer input_04-06-04)
- Section 5.16.6: full reduced new section (E.Sawyer input_04-06-04)
- Section 5.16.7: full reduced new section (E.Sawyer input_04-06-04)
- Section 5.16.8: full reduced new section (E.Sawyer input_04-06-04)
- Section 5.16.9: TBD is removed (E.Sawyer input_04-06-04)
- Section 5.16.10: TBD is removed (E.Sawyer input_04-06-04)
- Section 5.16.11: : TBD are removed, RD 7 added (E.Sawyer input_04-06-04)
- Section6.1: full new section (E.Sawyer input_04-06-04)
- Section6.2: full reduced new section, previous description is deleted (E.Sawyer input_04-06-04)
- Section 7: Note deleted
- Section 7.1.1: full reduced new section (E.Sawyer input_04-06-04))
- Section 7.1.3: full reduced new section (E.Sawyer input_04-06-04)), «see RD 28» added
- Section 7.1.4: full new section (E.Sawyer input_04-06-04)
- Section 7.2.1: new title, full reduced new section, with all tables 7.2-1 deleted (E.Sawyer input_04-06-04)
- Section 7.2.2: partially new section (E.Sawyer input_04-06-04)
- Section 7.2.3: only ref to RD 24 (E.Sawyer input_04-06-04)
- Section 7.2.4: added new section 7.2.4 « EQM and PFM tests list» with new table 7.2-1

- Section 9.1: First sentence « Further details can be found in RD25 (SPIRE Instrument Qualification Requirements)» is added (E.Sawyer input_04-06-04)
- Section 9.2: partially new section (E.Sawyer input_04-06-04)
- Section 9.3: full new section (E.Sawyer input_04-06-04), but with added text
- Section 9.4: full new section (E.Sawyer input_04-06-04)
- Section 9.5: full new section (E.Sawyer input_04-06-04),
- Section 9.6: full new section (E.Sawyer input_04-06-04)
- Section 9.7: full new section (E.Sawyer input_04-06-04)
- Section 9.8: added new section 9.8, with new Table 9.8-1 »SPIRE Verification matrix» (E.Sawyer input_04-06-04)
- Annex 1: New front page (configuration and comments) and new ICD pack 11 (CR 68v1) included
- Annex 2: New SPIRE RTMM v2.5 included, with new diagram on front page
- Annex 3: no changes
- Annex 4: Some typos are corrected (^{3}He and µW)
- Annex 5: new issue 4, dated 08/07/04 of document HDD 1.1 Deltas SPIRE-RAL-NOT-001819
- Annex 6: new annex with document «Making SPIRE ESD Safe, SPIRE-RAL-NOT-002028, draft 02, 18 june 04»

1. INTRODUCTION

The purpose of the Instrument Interface Documents (IIDs) is to define and control the overall interface between each of the Herschel/Planck scientific instruments and the Herschel/Planck spacecraft.

The IIDs consist of two parts, IID-A and IID-B. There is one part A, covering the interfaces to all Herschel and Planck instruments, and one IID-B per instrument:

- The IID-A describes the implementation of the instrument requirements in the design of the spacecraft and will be a result of the spacecraft design activities performed by the Contractor.
- Each IID-B is the result of a specific instrument's design activity. In its 'interface' section (chapter 5) are defined the requirements of the instrument and the resources to be provided by the spacecraft. In its 'performance' section (last section of chapter 4) it defines the scientific performance requirements of the instrument as part of the scientific mission requirements and as agreed between the Principal Investigators and ESA.

After issue 2/0 by ESA, the Contractor will be responsible for maintenance and configuration control of the IIDs in agreement with, and after approval by, the Instruments Principal Investigators and ESA.

In case of conflict between the contents of the IID-A and the IID-Bs, the agreement or definition in the IID-B shall take precedence.

The IIDs will not cover any of the interfaces of the Instrument Control Centres (ICCs for Herschel), the Data Processing Centres (DPCs for Planck) or the Herschel Science Centre (HSC).

2. APPLICABLE/REFERENCE DOCUMENTS

2.1 APPLICABLE DOCUMENTS

All Applicable Documents hereafter are available (with IIDA) on ASP ftp site :

ftp://ftp.hp-instruments.as-b2b.com/industry_to_instruments/IIDs/IID-A/Applicable%20and%20Reference%20documents/

AD 1 Herschel/Planck Instrument Interface Document Part A.
SCI-PT-IIDA-04624

AD 2 Product Assurance Requirements for Herschel/Planck Scientific Instruments
SCI-PT-RQ-04410

AD 3 Herschel/Planck Operations Interface Requirements Document OIRD
SCI-PT-RS-07360.

AD 4 Herschel Science-operations Implementation Requirements Document - SIRD
SCI-PT-03646

AD 5 Herschel/Planck Packet Structure Interface Control Document - PSICD
SCI-PT-ICD-07527

AD 6 Telescope specification / Herschel
SCI-PT-RS-04671

AD 7 Alignment Methods, Plan & Results
HP-2-ASED-TN- 0097 (Annex of AD1)

Deleted: Alignment Plan-Concept / Herschel

Deleted: 0002

AD 8 Software standard
ECSS E 40 B

2.2 REFERENCE DOCUMENTS

All Reference Documents hereafter are available on ESA livelink:

http://www.rssd.esa.int/llink/livelink?func=ll&objId=26764&objAction=browse&sort=name

RD 1 SPIRE Instrument Design Description
SPIRE-RAL-PRJ-000620

RD 2 SPIRE Instrument Requirements Document (IRD)
SPIRE-RAL-PRJ-000034

RD 3 SPIRE Data ICD
SPIRE-RAL-PRJ-001078 (covers both telemetry and command data)

RD 4 SPIRE Management Plan
SPIRE-RAL-PRJ-000029

RD 5 SPIRE Science Requirements Document (SRD)
SPIRE-UCF-PRJ-000064

RD 6 SPIRE Instrument AIV Plan
SPIRE-RAL-DOC -000410

RD 7 SPIRE Product Assurance Plan
SPIRE-RAL-PRJ-000017.

RD 8 SPIRE Block Diagram
SPIRE-RAL-DWG-000646

RD 9 SPIRE product tree

RD 10 Instrument WBS (inside RD4)

RD 11 Instrument Science Implementation plan

RD 12 SPIRE Grounding and Screening Philosophy
SPIRE-RAL-PRJ-000624

RD 13 SPIRE CRYOGENIC INTERFACE THERMAL MATHEMATICAL MODEL (ITMM)
SPIRE-RAL-PRJ-000728

RD 14 Instrument reduced FRM Model

RD 15 Spire Straylight References
SPIRE-RAL-NOT-001124

RD 16 Swinyard. B , Power profiles for SPIRE operating modes
RAL-NOT-000068

RD 17 SPIRE Operating Modes
SPIRE RAL-PRJ-000320

RD 18 SPIRE Thermal Configuration Control Document
SPIRE-RAL-PRJ-000560

RD 19 Herschel SPIRE Harness Definition
SPIRE-RAL-PRJ-000608

RD 20 Spire requirements on Cryostat Apertures
SPIRE-RAL-NOT-01242

RD 21 Matching SPIRE - HOB Decentre and tilt amplitudes to the Photometer pupil alignment budget
SPIRE-RAL-NOT-000754

RD 22 The Instrument EGSE for Herschel Integrated System Tests
SPIRE-RAL-NOT-001463

RD 23 SPIRE FPU Handling and Integration Procedure
SPIRE-RAL-PRC-001923

RD 24 EQM test plan
SPIRE-RAL-DOC-001905

RD 25 SPIRE Instrument Qualification Requirements
SPIRE-RAL-PRJ-000592

RD 26 Calibration Requirements Document
SPIRE-RAL-PRJ-001064

RD 27 SPIRE CQM Instrument Level EMC Test Specification
SPIRE-RAL-NOT-001681

RD 28 SPIRE Warm electronic integration plan
SPIRE-RAL-DOC-001132

RD 29 SPIRE System interface FMECA

SPIRE-RAL-PRJ-001260

RD 30 Interface FMECA qualification status report for CDR

SPIRE-RAL0NOT-002087

RD 31 FDIR procedure definition

SPIRE-RAL-PRJ-001978

RD 32 SPIRE structure assembly, integration and handling plan

MSSL-SPIRE-SP011.04

RD 33 EQM thermal test specification

SPIRE-RAL-NOT-002319

RD 34 BDA Sub Systen Specification Document

SPIRE-JPL-PRJ-000456

RD 35 Making SPIRE ESD Safe

SPIRE-RAL-NOT-002028

2.3 LIST OF ACRONYMS

AD	Applicable Document
AO	Announcement of Opportunity
AVM	Avionics Verification Model
BSM	Beam Steering Mechanism
CCE	Central Check-Out Equipment
CDMS	Command and Data Management Subsystem
CQM	Cryogenic Qualification Model
CVV	Cryostat Vacuum Vessel
DPU	Digital Processing Unit
DRCU	Detector Readout and Control Unit
EGSE	Electrical Ground Support Equipment
EMC	Electro-Magnetic Compatibility
ESA	European Space Agency
Herschel	Far InfraRed and Submillimetre Telescope (FIRST)
FM	Flight Model
FOV	Field Of View
FTS	Fourier Transform Spectrometer
GSE	Ground Support Equipment
HIFI	Heterodyne Instrument for the Far Infrared
HSC	Herschel Science Centre
IA	Interactive Analysis
ICC	Instrument Control Centre
ICD	Interface Control Document

IID	Instrument Interface Document
ISO	Infrared Space Observatory
JFET	Junction Field Effect Transistor
KAL	Keep Alive Line
LOU	Local Oscillator Unit (HIFI)
MGSE	Mechanical Ground Support Equipment
MOC	Mission Operations Centre
NEP	Noise Equivalent Power
OBS	On Board Software
OGSE	Optical Ground Support Equipment
OIRD	Operations Interface Requirements Document
OTF	On-Target Flag
PACS	Photoconductor Array Camera and Spectrometer (Herschel)
PFM	Proto Flight Model
QLA	Quick Look Analysis (software)
RAM	Random Access Memory
RD	Reference Document
RF	Radio Frequency
ROM	Read Only Memory
RTA	Real Time Assessment (software)
S/C	Spacecraft
SCOS	Spacecraft Control and Operations System
SIRD	Science –Operations Implementation Requirements Document
SPIRE	Spectral Photometer Imaging Receiver
SPU	Signal Processing Unit
SRD	Software Requirements Document
SVM	Service Module
TBC	To be confirmed
TBD	To be determined
TBW	To be written

3. KEY PERSONNEL AND RESPONSIBILITIES

3.1 KEY PERSONNEL

3.1.1 Principal Investigator

Prof. Matt Griffin
Department of Physics and Astronomy
University of Wales, Cardiff
Cardiff CF24 3YB
United Kingdom

Telephone (Institute) : +44-(0)29-2087-4203
Telefax : +44-(0)29-2087-4056
E-mail : matt.griffin@astro.cf.ac.uk

3.1.2 Co-Principal Investigator

Dr. Laurent Vigroux
CEA - Service d'Astrophysique
CEA Saclay, Bat. 709
Orme des Merisiers
91191 Gif sur Yvette
France

Telephone (Institute) : +33-1-69-08-3912
Telefax : +33-1-69-08-6577
E-mail : lvigroux@cea.fr

3.1.3 Project Manager

Dr. Ken King
Rutherford Appleton Laboratory
Chilton, Didcot
Oxfordshire OX11 0QX
England

Telephone (Institute) : 44-1235-446558

Telefax : +44-1235-446667
E-mail : K.J.King@rl.ac.uk

3.1.4 Instrument Manager

Dr. Eric Sawyer
Rutherford Appleton Laboratory
Chilton, Didcot
Oxfordshire OX11 0QX
England

Telephone (Institute) : +44-1235-44-6385
Telefax : +44-1235-44-6667
E-mail : E.C.Sawyer@rl.ac.uk

3.2 RESPONSIBILITIES

INSTITUTE	RESPONSIBILITIES
ATC, Edinburgh	Beam steering mechanism
CEA, Grenoble	^{3}He cooler
CEA, SAp, Paris	Detector Readout and Control Unit (DRCU); ICC DAPSAS Centre;
DESPA, Paris	FTS expertise and design support
GSFC, Maryland	FTS Expertise and design support;
IAS, Paris	Ground Calibration support
ICSTM, London	ICC UK DAPSAS Centre
IFSI, Rome	Digital Processing Unit (DPU) and related On-board S/W
JPL/Caltech, California	Bolometer arrays and associated cold readout electronics
LAM, Marseille	Optics; FTS mechanism
MSSL, Surrey	Focal Plane Unit Structure
University of Wales, Cardiff	Focal plane array testing; filters, dichroics, beam dividers
RAL, Oxfordshire	Project management and Project Office, System and Thermal Engineering; AIV and ground calibration facilities; ICC Operations Centre
Stockholm Observatory	Instrument simulator; DRCU Simulator
University of Padua	Provision of ICC Operations Staff
University of Saskatchewan	OGSE Fourier Spectrometer + Science Support

INSTITUTE	LOCAL MANAGER	TELEPHONE / FAX EMAIL	ADDRESS
ATC	Phil Parr Burman	Tel.+44-131-668-8260 Fax:+44-131-668-8382 E-mail: ppb@roe.ac.uk	Royal Observatory Blackford Hill, Edinburgh EH9 3HJ, Scotland
CEA, Grenoble	Lionel Duband	Tel.+33-4-38-78-41-34 Fax:+33-4-38-78-51-71 E-mail: Duband@drfmc.ceng.cea.fr	CEA- Grenoble Service des Basses Temperatures 17 av. des Martyrs 38054 Grenoble Cedex, France
CEA, Sap	Jean-Louis Augueres	Tel.: +33-1-6908-3058 Fax: +33-1-69-08-6577 E-mail:augueres@cea.fr	CEA - Service d'Astrophysique CEA Saclay, Bât. 709 Orme des Merisiers 91191 Gif sur Yvette, France
IAS	Francois Pajot	Tel.+33-1-69-85-8567 Fax:+33-1-69-85-8675 E-mail: Francois.Pajot@ias.fr	Institut d'Astrophysique Spatiale Bât. 121, Université Paris Sud 91405 Orsay, Paris, France
ICSTM	Tim Sumner	Tel.+44-207-594-7552 Fax:+44-207-594-3465 E-mail: t.sumner@ic.ac.uk	Blackett Laboratory Imperial College, Prince Consort Rd. London SW7 2BZ, England
IFSI	Riccardo Cerulli-Irelli	Tel.+39-6-4993-4377 Fax:+39-6-4993-4383 E-mail: Cerulli@ifsi.rm.cnr.it	Inst. di Fisica dello Spazio Interplanetario CNR Area di Ricerca Tor Vegata via Fosso del Cavaliere, 00133-Roma, Italy
JPL/Caltech	Marty Herman	Tel. + 1 818 354 8541 Fax: . + 1 818 393 6984 E-mail: Martin.E.Herman@jpl.nasa.gov	Jet Propulsion Laboratory Pasadena, CA 91109, USA
LAM	Dominique Pouliquen	Tel.+33-4-91-05-5949 Fax:+33-4-91-05-6959 E-mail:Dominique.pouliquen@astrsp-mrs.fr	Laboratoire d'Astrophysique de Marseille BP 8, 13376 Marseille Cedex 12, France
MSSL	Berend Winter	Tel. +44-1483-204-215 Fax: +44- E-mail: bw@mssl.ucl.ac.uk	Mullard Space Science Laboratory Holmbury St. Mary, Dorking, Surrey RH5 6NT, England
University of Wales, Cardiff	Peter Hargrave	Tel.+44-29-2087-6067 Fax:+44-29-2087-6682 E-mail: p.hargrave@astro.cf.ac.uk	Department of Physics and Astronomy University of Wales, Cardiff Cardiff CF24 3YB United Kingdom
RAL	Ken King	Tel.+44-1235-44-6558 Fax:+44-1235-44-6667 E-mail: k.j.king@rl.ac.uk	Rutherford Appleton Laboratory Chilton, Didcot Oxfordshire OX11 0QX, England

INSTITUTE	LOCAL MANAGER	TELEPHONE / FAX EMAIL	ADDRESS
Stockholm Obs.	H G Floren	Tel.+46-8-5537-8522 Fax:+46-8-5537-8510 E-mail: floren@astro.su.se	Stockholm Observatory S-133 36 Saltsjöbaden, Sweden
University of Padua	Paola Andreani	Tel.+39-49-829-3441 Fax:+39-49-875-9840 E-mail: andreani@astrpd.pd.astro.it	Dipartimento di Astronomia di Padova vicolo Osservatorio 5 I-35122 Padova, Italy

Deleted: TBD

4. INSTRUMENT DESCRIPTION

4.1 INTRODUCTION

For low background direct detection at wavelengths longer than around 200 µm, the most sensitive detectors are cryogenic bolometers operating at temperatures in the 0.1 - 0.3 K range.

SPIRE (Spectral & Photometric Imaging REceiver) is a bolometer instrument comprising a three-band imaging photometer covering the 200-500 µm range and an imaging Fourier Transform Spectrometer (FTS) with a spectral resolution of at least 0.4 cm^{-1} (corresponding to $\lambda/\Delta\lambda$ = 100 at 250 µm, covering wavelengths between 200 and 670 µm. The detectors are bolometer arrays cooled to 300 mK using a ^{3}He refrigerator. The photometer is optimised for deep photometric surveys, and can observe simultaneously the same field of view of 4 x 8 arcminutes in all three bands.

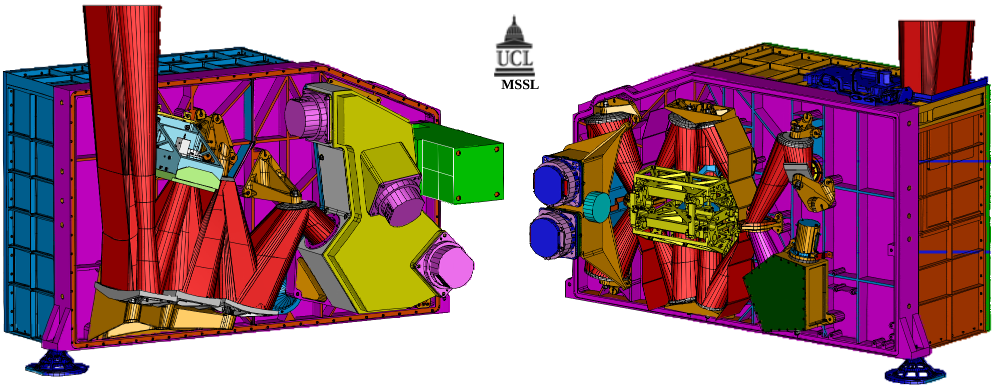


Figure 4-1: Two halves of Spire: photometer shown on left, spectrometer on the right"

4.2 SCIENTIFIC RATIONALE

The wavelength range 200 - 700 µm is largely unexplored. The thermal emission from many astrophysical sources peaks in this part of the spectrum, including comets, planets, star-forming molecular cloud cores, and starburst galaxies. The short submillimetre region is also rich in atomic and molecular transitions which can be used to probe the chemistry and physical conditions in these sources.

Wavelengths between 200 and 350 µm are not observable from the ground and have not be observed by ISO. Between 350 µm and 700 µm, some low transparency submillimetre windows allow some observations to be made with difficulty from the ground, but with far lower sensitivity than can be achieved from space.

One of the most important scientific projects for the Herschel mission is to investigate the statistics and physics of galaxy formation at high redshift. This requires the ability to carry out deep photometric imaging at far-infrared and submillimetre wavelengths to discover objects, and the ability to follow up the survey observations with spectroscopy of selected sources. The Herschel SPIRE instrument is essential for this programme, and is being designed so as to be optimised for these extragalactic imaging and spectral surveys. Another key scientific project for SPIRE is a sensitive unbiased search for proto-stellar objects within our own galaxy. This will also be followed up by spectral observations using SPIRE, other Herschel instruments and ground-based facilities.

4.3 INSTRUMENT OVERVIEW

SPIRE contains a three-band imaging photometer and an imaging Fourier Transform Spectrometer (FTS), both of which use 0.3-K «spider-web» NTD germanium bolometers cooled by a ^{3}He refrigerator. The bolometers are coupled to the telescope by close-packed single-mode conical feedhorns. The photometer and spectrometer are not designed to operate simultaneously. The field of view of the photometer is 4 x 8 arcminute, the largest that can be achieved given the location of the SPIRE field of view in the Herschel focal plane and the size of the telescope unvignetted field of view. Three photometer arrays provide broad-band photometry ($\lambda/\Delta\lambda \approx 3$) in wavelength bands centred on 250, 350 and 500 μm. The 250, 350 and 500 μm arrays have 149, 88, and 43 detectors respectively, making a total of 280. The field of view is observed simultaneously in all three bands through the use of fixed dichroic beam-splitters. Spatial modulation can be provided either by a Beam Steering Mirror (BSM) in the instrument or by drift scanning the telescope across the sky, depending on the type of observation. An internal thermal calibration source is available to provide a repeatable calibration signal for the detectors. The FTS uses novel broadband intensity beam dividers, and combines high efficiency with spatially separated input ports. One input port covers a 2.6-arcminute diameter field of view on the sky and the other is fed by an on-board calibration source which serves to null the thermal background from the telescope and to provide absolute calibration. Two bolometer arrays are located at the output ports, one covering 200-300 μm and the other 300-670 μm. The FTS will be operated in continuous scan mode, with the path difference between the two arms of the interferometer being changed by a constant-speed mirror drive mechanism. The spectral resolution, as determined by the maximum optical path difference, will be adjustable between 0.04 and 2 cm^{-1} (corresponding to $\lambda/\Delta\lambda$ = 1000 - 20 at 250 μm wavelength).

The focal plane unit has three separate temperature stages at nominal temperatures of 4 K, 2 K (provided by the Herschel cryostat) and 300 mK (provided by SPIRE's internal cooler). The main 4-K structural element of the FPU is an optical bench panel which is supported from the cryostat optical bench by stainless steel blade mounts. The photometer and spectrometer are located on either side of this panel. The majority of the optics are at 4 K, but the detector arrays and final optics are contained within 2-K enclosures. The ^{3}He refrigerator cools all of the five detector arrays to 0.3 K. Two JFET preamplifier modules (one for the photometer an one for the FTS) are attached to the optical bench close to the 4-K enclosure, with the JFETs heated internally to their optimum operating temperature of ~ 120 K.

The SPIRE warm electronics consist of two boxes with direct connection to the FPU, the Detector Control Unit (DCU) and the Focal Plane Control Unit (FCU) (together these boxes are termed the Detector Readout and Control Unit (DRCU)) plus a Digital Processing Unit (DPU) with interfaces to the other two boxes and the spacecraft data handling system. The DCU provides bias and signal conditioning for the detector arrays and cold readout electronics and reads out the detector signals. The FCU controls the FPU mechanisms and the ^{3}He cooler and handles housekeeping measurements. The DPU acts as the interface to the spacecraft, including instrument commanding and formats science and housekeeping data for telemetry to the ground.

4.4 HARDWARE DESCRIPTION

The SPIRE instrument consists of:

HSFPU	Focal Plane Unit (FPU) This interfaces to the cryostat optical bench, and the 4-K and 2-K temperature stages provided by the cryostat. Within the unit, further cooling of the detector arrays to a temperature of around 300 mK is provided by a ^3He refrigerator which is part of the instrument.
HSJFP	JFET box for the photometer detectors This box is mounted on the optical bench next to the photometer side of the FPU and contains JFET preamplifiers for the detector signals. The JFETs operate at around 120 K, and are thermally isolated inside the enclosure.
HSJFS	JFET box for the spectrometer detectors This box is mounted on the optical bench next to the spectrometer side of the FPU and contains JFET preamplifiers for the detector signals. The JFETs operate at around 120 K, and are thermally isolated inside the enclosure.
HSDCU	Detector Control Unit (on Herschel SVM) A warm analogue electronics box for detector read-out analogue signal processing, multiplexing, A/D conversion, and array sequencing.
HSFCU	Focal Plane Control Unit (on Herschel SVM) A warm analogue electronics box for mechanism control, temperature sensing, general housekeeping and ^3He refrigerator operation. It conditions secondary power both for itself and for the DCU.
HSDPU	Digital Processing Unit (on Herschel SVM) A warm digital electronics box for signal processing and instrument commanding and interfacing to the spacecraft telemetry.
HSWIH	Warm interconnect harness (on Herschel SVM) Harness making connections between SPIRE electronics boxes.

4.5 SOFTWARE DESCRIPTION

The SPIRE OBS will carry out the following functions:

- Read and log housekeeping data and packetise the data that these produce.
- Control and monitor the instrument mechanisms and internal calibration sources
- Carry out pre-defined observing sequences
- Implement pre-defined procedures on detection of instrument anomalies

The on-board software (OBS) will be written in «C» language and will be designed to allow the instrument to operate in an autonomous fashion for 48 hours as required in the IID-A. The basic implication of this requirement is that there must be the facility to store enough commands for a 48 observing programme and enough mass memory on the satellite to store 48 hours of instrument telemetry. More sophisticated autonomy functions may include the on-board analysis of scientific or housekeeping data and the ability to react on the basis of that analysis. The type of automatic operation undertaken following such an analysis may range from the raising of a warning flag to the switching over to a redundant sub-system or the switching off of a defective sub-system. All autonomy functions will require extensive evaluation and test before they are implemented to avoid the possibility of instrument failure. No instrument autonomy mode will be implemented that will affect the satellite operation.

Commands defined in RD5 and conforming to AD5 will be sent via a HERSCHEL 1553 bus to the active HSDPU. The Spire OBS in the HSDPU will verify and then interpret these commands. Many will result in a sequence of internal digital commands which are then sent with appropriate timings to the HSDCU and/or the HSFCU.

A detailed description of the on-board software will be given in Chapter 5

4.6 OPERATING MODES

This section gives a brief description of the operating modes for the SPIRE instrument.

For latest information, refer to RD 17.

4.6.1 OFF Mode

All instrument sub-systems will be switched off - including the DPU and there will be no instrument telemetry.

4.6.2 Initialise (INIT) Mode

This is an intermediate mode between OFF and ON. This will be the mode the instrument enters after a power on or re-boot. In this mode only a limited sub-set of commands may be executed. This mode allows updates of DPU on-board software and/or tables to be carried out safely before they are used for instrument control.

4.6.3 ON Mode

The DPU will be switched on and can receive and interpret all instrument commands, but no other sub-systems will be switched on (including the DRCU). For engineering purposes it will be possible to command the instrument to switch on individual sub-systems from this mode. Full DPU housekeeping data will be telemetered.

4.6.4 Ready (REDY) Mode

The DPU and DRCU are powered on and the on-board software is ready to receive commands. No other sub-systems are switched on in this mode. DRCU housekeeping data will be telemetered.

4.6.5 Standby (STBY) Mode

The spacecraft may be pointed in an arbitrary direction (observing with another instrument for instance). The instrument will telemeter only housekeeping information, and perhaps some degraded science data -see below, at a rate very much lower than the full telemetry bandwidth. This is presently baselined to be the photometer detectors on and at 300 mK i.e. the cooler will have been recycled previous to entering STANDBY. All other sub-systems will be switched off.

4.6.6 Observe Mode (OBSV) Mode

There are two basic sub-modes for the observe mode Photometer and Spectrometer. The details of the OBSERVATIONS to be carried out in OBSERVE mode are given in section 4.7.

4.6.7 Cooler Recycle (CREC) Mode

The ^{3}He cooler will be recycled every 48 hours. During this time the instrument will be switched off except for vital housekeeping and cooler functions (TBC).

4.6.8 SAFE Mode

The instrument will be switched to SAFE mode in the event of any anomalous situation occurring whilst in autonomous operation. This will be with the DPU on having been rebooted from a restricted set of software stored in ROM.

Only one (single) command is required by SPIRE to go to safe mode.

4.7 OBSERVING MODES

The spacecraft will be pointed in a specific direction or, for mapping, will either slew slowly over a given region of the sky, or execute a raster pattern by movements of the telescope. The instrument will take scientifically meaningful data and use the full telemetry bandwidth. It is assumed that any calibrations required will also be done in the observe mode.

Deleted: (TBC)

For latest information, refer to RD 17.

4.7.1 Photometer Observing Modes

The photometer can carry out essentially three kinds of observation: chopping, jiggling, and scanning, and it is envisaged that these will form the basis of three Astronomical Observation Templates (AOTs) to allow astronomers to specify their observations. The three kinds of observation are implemented as a number of observing modes, named POFs (Photometer Observatory Functions), which are briefly described below. Provision is also made for additional POFs for peak-up and special engineering modes.

Deleted: 6 (TBC)

4.7.1.1 Observation: Point Source Photometry

POF1 Chop without jiggling:

This mode is for point source observations with reliable telescope pointing. The SPIRE Beam Steering Mechanism is used to chop between two positions on the sky at a frequency of typically 2 Hz. The telescope may optionally be nodded with a nod period of typically three minutes.

POF2 Seven-point jiggle map:

This mode is for point source observations for which the telescope pointing or the source co-ordinates are not deemed sufficiently accurate. The SPIRE BSM chops and also executes a seven-point map around the nominal position. Nodding is optional.

4.7.1.2 Observation: Jiggle Map

POF3 n-point jiggle map:

This mode is designed for mapping of extended sources. It is similar to POF2 except that the nominal value of n is 64 rather than 7. It produces a fully sampled map of a 4 x 4 arcminute area.

POF4 Raster map:

This is the same as POF3 except that maps of large regions can be built up by using the telescope rastering capability.

4.7.1.3 Observation: Scan Map

POF5 Scan map without chopping:

This mode is used for mapping areas much larger than the SPIRE field of view. The SPIRE BSM is inactive, and the spacecraft is scanned continuously across the sky to modulate the detector signals.

POF6 Scan map with chopping:

This mode is the same as POF5 except that the SPIRE BSM implements chopping. It allows for the possibility of excess 1/f noise by permitting signal modulation at frequencies higher that POF5.

4.7.1.4 Others

POF7 Photometer peak-up:

Deleted: (TBD)

This mode allows the necessary pointing offsets to be determined in order to allow implementation of POF1 rather than POF2. The observation itself is the same as POF3. On completion, the SPIRE DPU computes the offsets between the telescope pointed position and the source peak emission, and sends this information to the spacecraft, which can then implement the necessary pointing corrections.

POF8 Operate photometer calibrator:

The SPIRE photometer internal calibrator is energised with a pre-determined sequence and the corresponding detector signals are recorded.

POF9 Special engineering/commissioning modes (will be defined after the PFM test programme" on last line).

Deleted: TBD

4.7.2 Spectrometer Observing Modes

There are two kinds of spectrometer observation: point source and fully sampled map. The latter is carried out by repeating the former at a number of separate pointing using the SPIRE BSM (or, alternatively the spacecraft in RASTER Pointing mode). These are implemented as two Spectrometer Observatory Functions (SOFs):

SOF1: Point source spectrum

SOF2: Fully sampled spectral map

In all cases, the telescope pointing and/or Beam Steering Mirror position are kept fixed while the FTS mirror is scanned a predetermined number of times to generate interferograms from which the source spectrum can be derived.

4.7.3 *Other Modes*

4.7.3.1 Photometer Serendipity

During spacecraft slews scientifically useful information can be obtained without the necessity of using the focal plane chopper - essentially these are rapid scan maps. The chopper and spectrometer mechanisms will be switched off in this mode. Accurate pointing information will be required from the AOCS to reconstruct the slew path in the data analysis on the ground.

4.7.3.2 Photometer Parallel

When observations are being made with PACS, scientifically useful data may be obtainable from the photometer, albeit with degraded sensitivity and spatial resolution. In this mode a science data packet will be telemetered alongside the standard housekeeping data. The spectrometer mechanisms will be switched off in this mode.

Deleted: chopper and

Deleted: . The feasibility and scientific desirability of this mode is TBD

4.7.4 *Real-Time Commanding*

During ground contact it may be necessary to command the instrument in real time and analyse the resultant data on the ground in near real time for instrument testing and debugging purposes. In this case the full telemetry bandwidth will be required for the duration of the instrument test in question. It is not anticipated that this will occur frequently.

4.7.5 *Commissioning/calibration Mode*

During the commissioning and performance verification phases of mission operations, many housekeeping and other health check parameters will be unknown or poorly defined. This mode allows the limits on selected health check parameters to be ignored by whatever real time monitoring systems are in place on the spacecraft/instrument.

4.7.6 *FPU operations at Ambient Temperature*

It is anticipated that functional checks will be possible for mechanisms and housekeeping lines. The detectors will not function at ambient temperature. Limited verification of the readout electronics may be possible.

Deleted: TBD.

4.7.7 *FPU Orientation*

During ground tests the FTS mechanism can only operate when the FPU is on its side. In addition, there is a restriction on the orientation of the ^{3}He cooler during recycling.

4.8 INSTRUMENT REQUIREMENTS AND PERFORMANCE SPECIFICATION

4.8.1 *Scientific Requirements*

The scientific performance requirements for SPIRE are summarised in the SPIRE *Scientific Requirements Document* as follows:

Requirement SRD-R 1: The photometer should be capable of diffraction-limited extragalactic blind surveys of at least 60 sq. deg. of the sky, to 1-σ detection limit of 3 mJy in all bands with an observing time of six months or less.

Requirement SRD-R 2: The photometer should be capable of a galactic survey covering 1 deg. sq. to a 1-σ depth of 3 mJy at 250 μm within an observing time of one month or less.

Requirement SRD-R 3: Maximising the mapping speed at which confusion limit is reached over a large area of sky is the primary science driver. This means maximising sensitivity and field-of-view (FOV) but NOT at the expense of spatial resolution.

Requirement SRD-R 4: The photometer observing modes should provide a mechanism for telemetering undifferenced samples to the ground.

Requirement SRD-R 5: The photometer should have an observing mode that permits accurate measurement of the point spread function.

Requirement SRD-R 6: Optical field distortion should be less than 10% across the photometer field of view.

Requirement SRD-R 7: The photometer field of view shall be at least 4 x 4 arcminutes, with a goal of 4 x 8 arcminutes.

Requirement SRD-R 8: For 2Fλ feedhorns, crosstalk shall be less than 1% (goal 0.5%) for adjacent detectors and 0.1% or less (goal 0.05%) for all non-adjacent detectors in the same array; for 0.5Fλ pixels, the requirement is 5% (goal 2%) to adjacent detectors and 0.1% (goal 0.05%) to all others.

Requirement SRD-R 9: The maximum available chop throw shall be at least 4 arcminutes; the minimum shall 10 arcseconds or less.

Requirement SRD-R 10: The rms detector NEP variation across any photometer array should be less than 20%.

Requirement SRD-R 11: The photometer dynamic range for astronomical signals shall be 12 bits or higher.

Requirement SRD-R 12: SPIRE absolute photometric accuracy shall be 15% or better at all wavelengths, with a goal of 10%.

Requirement SRD-R 13: The relative photometric accuracy should be 10% or better with a goal or 5%.

Requirement SRD-R 14: SPIRE photometric measurements shall be linear to 5% over a dynamic range of 4000 for astronomical signals.

Requirement SRD-R 15: For feedhorn detectors, the overlapping sets of three detectors at the three wavelengths should be co-aligned to within 2.0 arcseconds on the sky (goal is 1.0 arcsecond).

Requirement SRD-R 16: The spectrometer design shall be optimised for optimum sensitivity to point sources, but shall have an imaging capability with the largest possible field of view that can be accommodated.

Requirement SRD-R 17: The sensitivity of the FTS at any spectral resolution up to the goal value shall be limited by the photon noise from the Herschel telescope within the chosen passband.

Requirement SRD-R 18: The spectrometer dynamic range for astronomical signals shall be 12 bits or higher.

Requirement SRD-R 19: The FTS absolute accuracy shall be 15% or better at all wavelengths, with a goal of 10%.

Requirement SRD-R 20: The FTS shall be capable of making spectrophotometric measurements with a resolution of 2 cm^{-1}, with a goal of 4 cm^{-1}.

Requirement SRD-R 21: The width of the FTS instrument response function shall be uniform to within 10% across the field of view.

Requirement SRD-R 22: The maximum spectral resolution of the FTS shall be at least 0.4 cm^{-1} with a goal of 0.04 cm^{-1}.

Requirement SRD-R 23: The SPIRE photometer shall have an observing mode capable of implementing a 64-point jiggle map to produce a fully sampled image of a 4 x 4 arcminute region.

Requirement SRD-R 24: The photometer observing modes shall include provision for 5-point or 7-point jiggle maps for accurate point source photometry.

Requirement SRD-R 25: The photometer shall have a "peak-up" observing mode capable of being implemented using the beam steering mirror.

4.8.2 Instrument Performance Estimates

4.8.2.1 Assumptions

The sensitivity of SPIRE has been estimated under the assumptions listed in Table 4.1.

Telescope temperature (K)	80		
Telescope emissivity	0.04		
Telescope used diameter (m) (1)	3.29		
No. of observable hours per 24-hr period	21		
Photometer			
Bands (μm)	250	350	500
Numbers of detectors	139	88	43
Beam FWHM (arcsec.)	17	24	35
Bolometer DQE (2)	0.6	0.7	0.7
Throughput	λ^2		
Bolometer yield	0.8		
Feed-horn/cavity efficiency (3)	0.7		
Field of view (arcmin.) Scan mapping Field mapping	4 x 8 4 x 4		
Overall instrument transmission	0.3		
Filter widths ($\lambda/\Delta\lambda$)	3.3		
Observing efficiency (slewing, setting up, etc.)	0.9		
Chopping efficiency factor	0.45		
Reduction in telescope background by cold stop (4)	0.8		
FTS spectrometer			
Bands (μm)	200-300	300-670	
Numbers of detectors	37	19	
Bolometer DQE	0.6	0.7	
Feed-horn/cavity efficiency	0.70		
Field of view diameter (arcmin.)	2.6		
Max. spectral resolution (cm^{-1})	0.04		

Overall instrument transmission	0.15
Signal modulation efficiency	0.5
Observing efficiency	0.8
Electrical filter efficiency	0.8

Table 4.1: Assumptions for SPIRE Performance Estimation

Notes:

1 The telescope secondary mirror is the pupil stop for the system, so that the outer edges of the primary mirror are not seen by the detectors. This is important to make sure that radiation from highly emissive elements beyond the primary reflector does not contribute stray light.

2 The bolometer DQE (Detective Quantum Efficiency) is defined as :[NEPph/ NEPTotal]^{2}, where NEPph is the photon noise NEP due to the absorbed radiant power and NEPTotal is the overall NEP including the contribution from the bolometer noise.

3 This is the overall absorption efficiency of the combination of feed-horn, cavity and bolometer element.

4 A fraction of the feedhorn throughput falls outside the solid angle defined by the photometer 2-K cold stop and is thus terminated on a cold (non-emitting) surface rather than on the 4% emissive 80-K telescope. This reduces the background power on the detector.

The background power levels on the SPIRE detectors dominated by the telescope emission), and the corresponding photon noise limited NEP values are given in Table 4.2.

		Photometer band (μm)			FTS band (μm)	
		250 μm	350 μm	500 μm	200-300 μm	300-670
Background power/detector	pW	3.9	3.2	2.0	6.0	11
Background-limited NEP	W Hz$^{-1/2}$ x 10^{-17}	8.1	6.1	4.5	10	11
Total NEP (inc. detector)	W Hz$^{-1/2}$ x 10^{-17}	10	7.3	5.4	12	14

Table 4.2: Background Power and Photon Noise Levels

The estimated sensitivity levels for SPIRE are summarised in Table 4.3. The figures quoted are the nominal values, with an overall uncertaintyof around 50% to take into account uncertainties in instrument parameters, particularly feedhorn efficiency, detector DQE, and overall transmission efficiency. The pixel size will be increasingly mis-matched to the diffraction spot size. The trade-off between wavelength coverage and sensitivity of the long-wavelength FTS band must be studied in detail. At the moment, we estimate an effective loss of efficiency of a factor of two at 670mm, and scale linearly for wavelengths between 400 and 670 mm. Performance beyond 400 mm may have to be compromised to maintain the desired sensitivity below 400 mm.

Photometry				
λ µm		250	350	500
ΔS(5-σ; 1-hr) mJy	Point source (7-point) ode)	2.5	2.6	2.9
	4' x 4' jiggle map	8.8	8.7	9.1
	4' x 8' scan map	7.3	7.2	7.5
Time (days) to map 1 deg.^{2} to 3 mJy 1-σ	1º x 1º scan map	1.8	1.7	1.9

Line spectroscopy Δσ = 0.04 cm^{-1}				
λ µm		200	400	670
ΔS (5-σ; 1-hr) W m^{-2} x 10^{-17}	Point source	3.4	3.9	7.8
	2.6' map	9.0	10	21

Low-resolution spectrophotometry Δσ = 1 cm^{-1}				
λ µm		200	400	670
ΔS (5-σ; 1-hr) mJy	Point source	110	130	260
	2.6' map	300	350	700

Table 4.3: SPIRE Estimated Sensitivity

Note: For the FTS, limiting flux density is inversely proportional to spectral resolution (Δσ). Limiting line flux is independent of spectral resolution (for an unresolved line).

These estimated sensitivity levels are comparable to the figures in the SPIRE proposal.

5. INTERFACE WITH SATELLITE

5.1 IDENTIFICATION AND LABELLING

Each individual instrument unit is allocated two unique identification codes:

- a *project code* which is the normal reference used for routine identification in correspondence and technical descriptive material.
- a *spacecraft code* finalised by the spacecraft contractor in accordance with the computerised configuration control system to be implemented, and used in particular for connector and harness identification purposes. All of these have now been given a working designation anyway as work has progressed. The *project code* shall form part of the spacecraft code. (See IID-A section 5.1)

Reference **HP-SPIRE-REQ-0270**

Formatted: Bullets and Numbering

Formatted

The project codes allocated to this instrument are:

Project code	Instrument unit	Location	Temperature
HSDPU	Digital Processing Unit	On SVM	Warm
HSFCU	FPU Control Unit	On SVM	Warm
HSDCU	Detector Control Unit	On SVM	Warm
HSJFS	JFETs (Spectrometer)	See section 5.3	Cryogenic
HSJFP	JFETs (Photometer)	See section 5.3	Cryogenic
HSFPU	Focal Plane Unit	See section 5.3	Cryogenic
HSWIH	Warm interconnect harness	See section 5.10	Warm

Table 5.1-1: SPIRE project codes

#

Formatted: Bullets and Numbering

The HSFCU is a physical unit containing three functions, the HSSCU and the HSMCU meaning the HS Sub-System Control Unit and the HS Mechanisms' Control Unit respectively, plus the HSPSU that provides secondary power to all parts of the Spire DRCU..

[Documentation may refer to a DRCU or Detector Readout and Control Unit. This is no longer a single unit and the term refers collectively to the HSDCU plus the HSFCU.]

There are four groups of harnesses at instrument interface level,

- HSWxx,
- HSIxx
- HSSxx
- HSCxx

where xx represents a number.

Reference HP-SPIRE-REQ-0280

The HSWxx are Warm harnesses between Warm HS units on the SVM.

HSSxx are the SVM cryoharnesses between the SVM connector brackets and the HS Warm Units.

The HSIxx are intermediate cryoharnesses, which are external to the cryostat, and are situated between the vacuum connectors and the connector bracket on the SVM.

The HSCxx are cryogenic cryoharnesses located inside the cryostat, between the vacuum connectors and the HS Cryogenic units.

The HSIxx, HSSxx and HSCxx are all considered to be "Cryoharness" and are not provided by the Spire instrument.

The two F harnesses (FPU sub-system F harness) between JFETs and FPU (HSFPU-HSJFP and HSFPU-HSJFS) are provided by SPIRE with the instrument units.

"ESA's contractor will also provide any safing plugs needed (see annex 6 of present IIDB) for the cryoharness"

#

Formatted: Bullets and Numbering

Formatted

Formatted: Bullets and Numbering

5.2 INTERFACE LOCATIONS

All of the above may be visualised by means of the block diagram, shown in figure 5.2.1 (see RD 8). The Herschel to Herschel-Spire electrical interfaces are in several "planes" shown by dashed blue lines, the categories between each line being labelled along the top. This diagram is for information only, and shall not represent any requirement on the spacecraft.

Note that, to be precise, electrical interfaces are at the connector planes.

5.2.1 MECHANICAL COORDINATE SYSTEM

The unit specific x,y,z origin definitions are shown in the External Configuration Drawings. (see section 5.4)

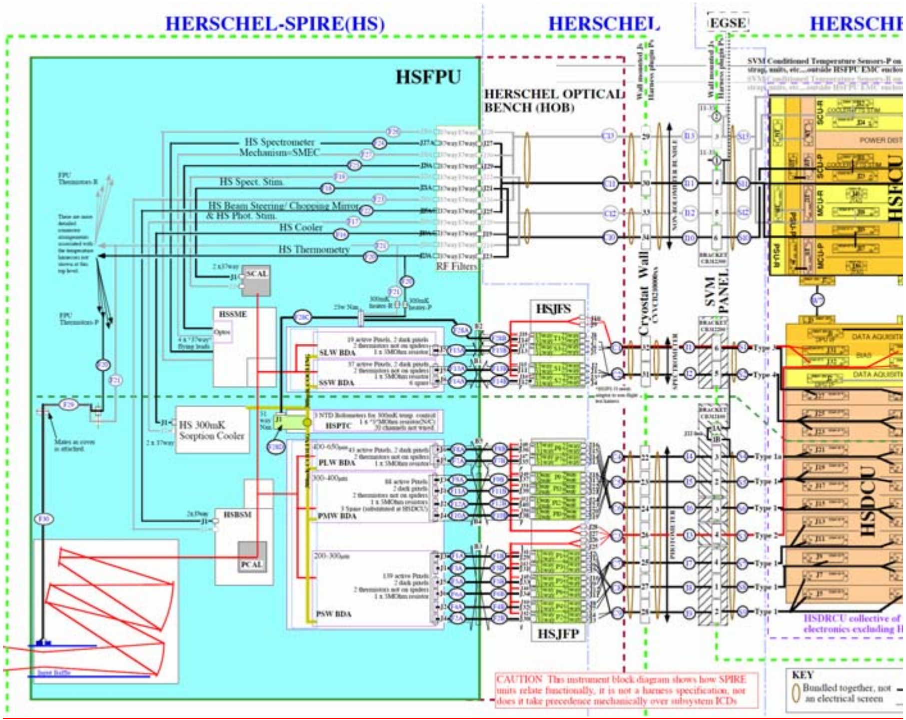


Figure 5.2.1 : Spire Block Diagram

Deleted: 5.8¶

5.3 LOCATION AND ALIGNMENT

Figure 5.3-1 shows the concept of the location of the three Herschel Focal Plane Units (FPUs) for HIFI, PACS and Spire on the Optical Bench (OB) inside the cryostat. The Spire FPU has two nearby JFET racks.

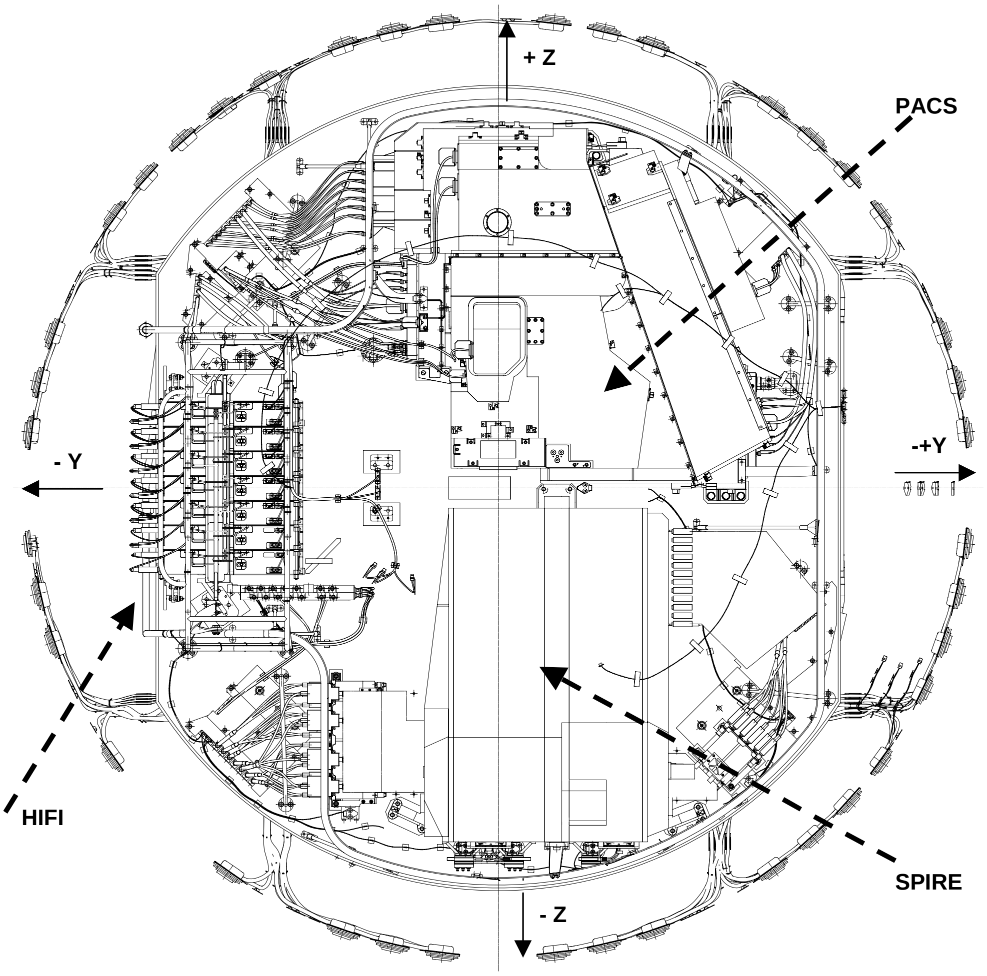


Figure 5.3-1: The Herschel Focal Plane, top view towards –X

5.3.1 Instrument Location

The locations of the Spire units are as listed in section 5.1. Spire has no units supported on the outside of the Herschel cryostat or on the Planck Module. There are no critical alignment requirements on the Spire JFET boxes.

5.3.1.1 Location of units on the SVM

There are no specific requirements for the location of Spire units on the SVM, except that the HSDCU and HSFCU need optimised harness routing towards the Spire quadrant of cryostat 128 way connectors. The length of the instrument provided harness between the HSDCU and the HSFCU is critical. As a goal, the location of these two units on the SVM should enable this length to be kept below 0.8m.

The picture here under shows the Spire specific SVM panel

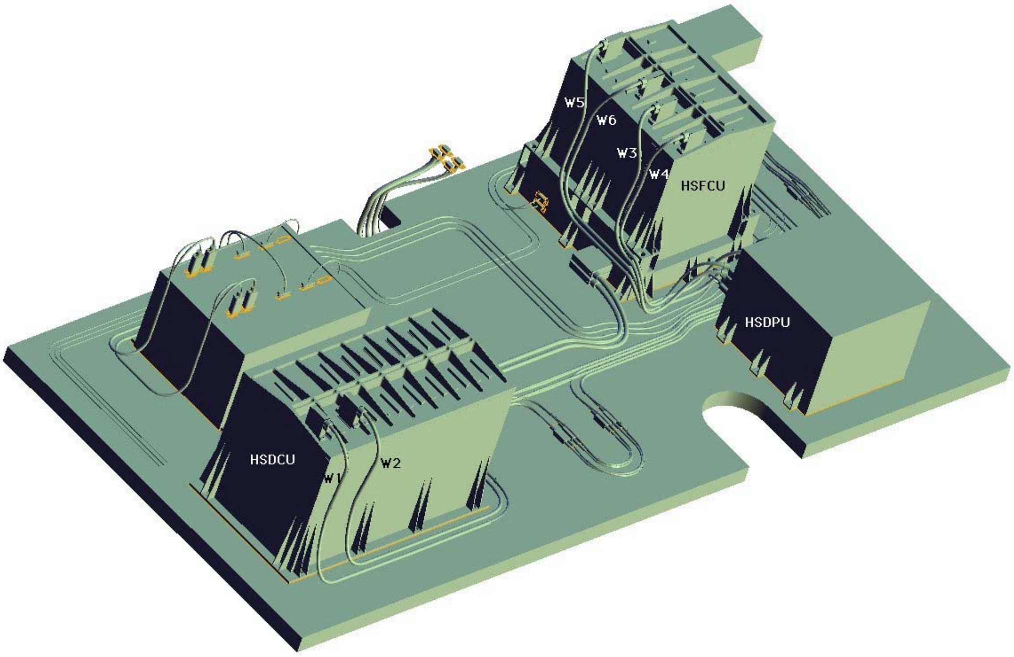


Figure 5.3-2: SPIRE specific SVM panel picture

5.3.2 Instrument Alignment on the HOB

Spire has no critical alignment and/or alignment stability requirements except for those of the HSFPU.

The HSFPU has an externally viewable alignment cube as shown on its ICD. Both the cube's angular alignment and the position of the HSFPU box' feet w.r.t. its internal optics will have been established at instrument level to a defined tolerance before delivery to ESA.

The mechanical process of mounting Spire on the HOB so that it is aligned to the Herschel telescope (when both are at operating temperature) is worked through in AD7. This defines an error budget for how well the alignment has to be achieved, as well as how stable it then has to remain.

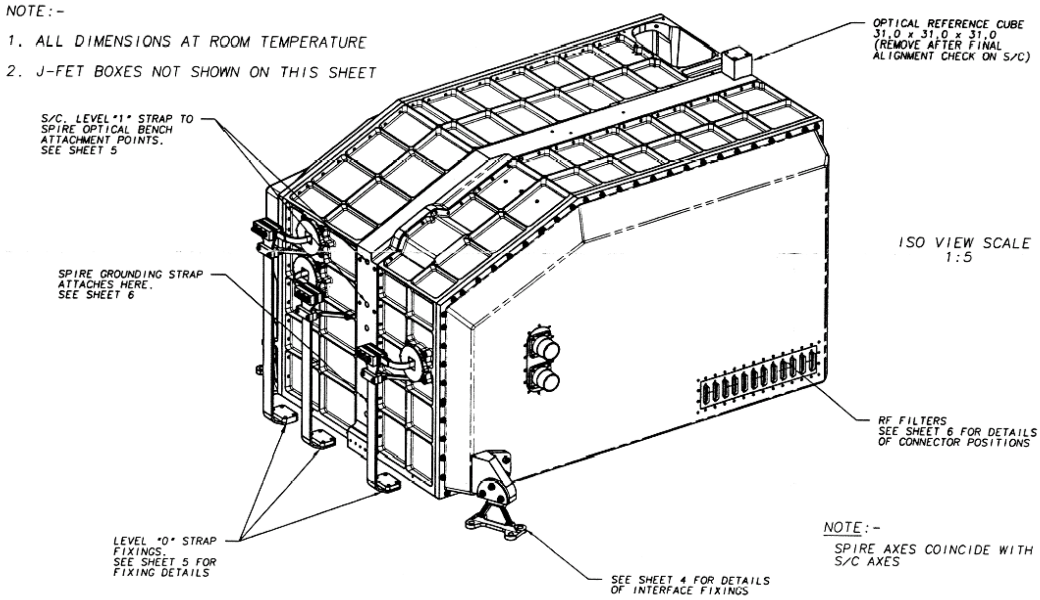
5.4 EXTERNAL CONFIGURATION DRAWINGS

These are included for readability only.

The fully configured detailed interface drawings are provided in Annex 1.

5.4.1 HSFPU

An overview of the HSFPU is provided below in Figure 5.4-1. More detailed drawings of the SPIRE focal plane and JFET units, showing their relationship to the Herschel focal plane, the cryostat radiation shield and the diameter of the HOB, can be found in Annex 1.



Note: figure extracted from Interface Drawing, Issue 17, Sheet1

Figure 5.4-1 : HSFPU overall view

5.4.2 HSJFS

The figure here after provides an isometric view of the Spire Spectrometer JFET rack. More detailed drawings can be found in Annex 1.

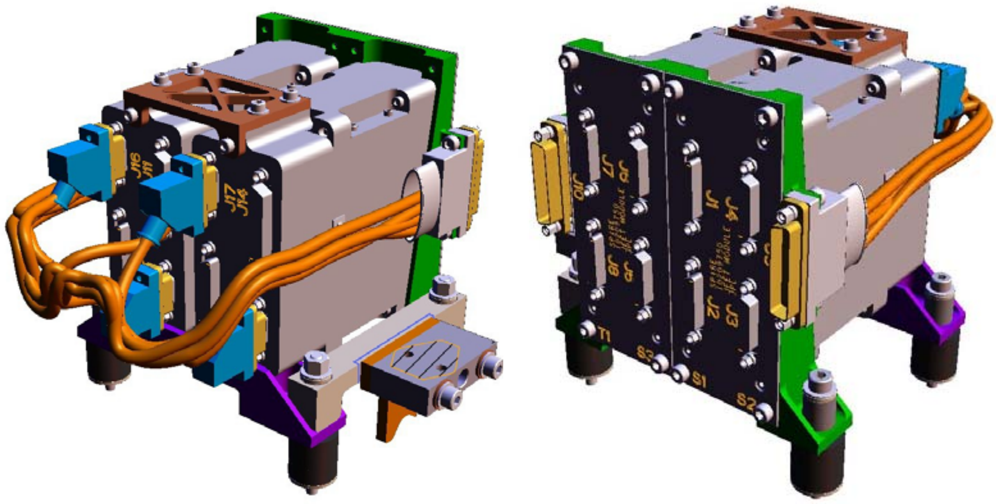


Figure 5.4-2 : SPIRE Spectrometer JFET rack external configuration

5.4.3 HSJFP

The figure here after provides an isometric view of the Spire Photometer JFET rack. More detailed drawings can be found in Annex 1.

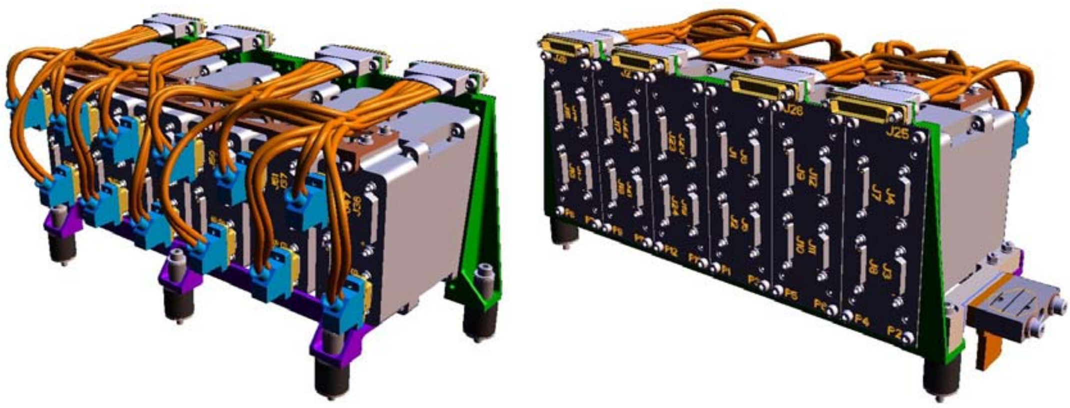


Figure 5.4-3 : SPIRE Photometer JFET rack external configuration

5.4.4 SVM Mounted Units.

Drawings of the layout of the SPIRE Warm Units on the SVM are provided in the corresponding section of the IIDA.

The following sub-sections provide an overview of the warm units, whereas detailed interface drawings can be found in Annex 1.

5.4.4.1 HSDPU

The figure here after shows an isometric view of the Spire Digital Processing Unit More detailed drawings can be found in Annex 1.

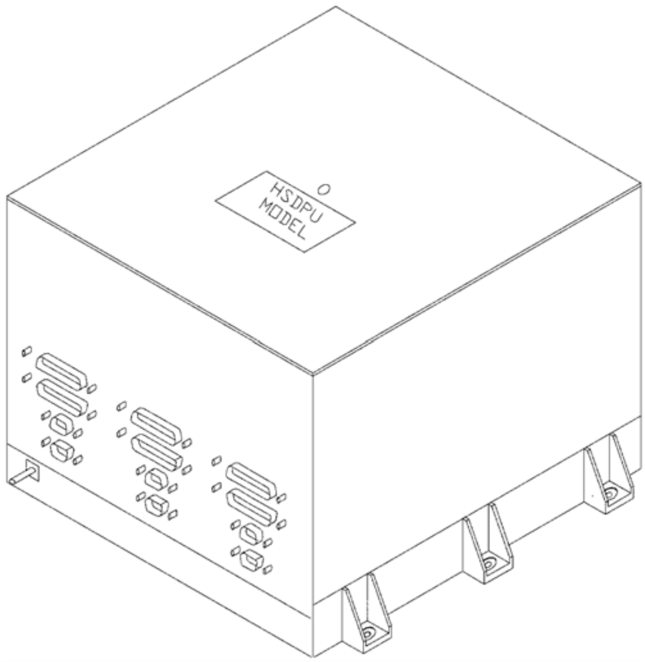


Figure 5.4-4 Isometric view of the DPU

5.4.4.2 HSDCU

The figure here after shows an isometric view of the Spire Detector Control Unit. More detailed drawings can be found in Annex 1.

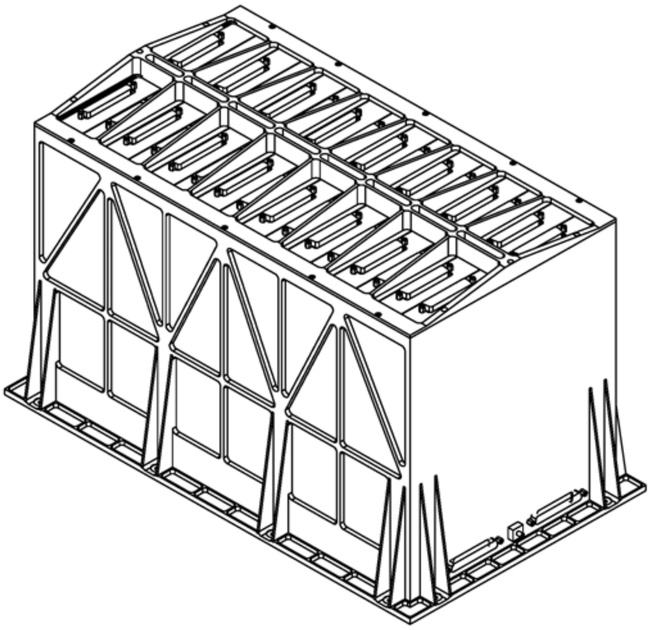


Figure 5.4-5 : HSDCU external configuration

5.4.4.3 HSFCU

The figure here after shows an isometric view of the Spire FPU Control Unit.

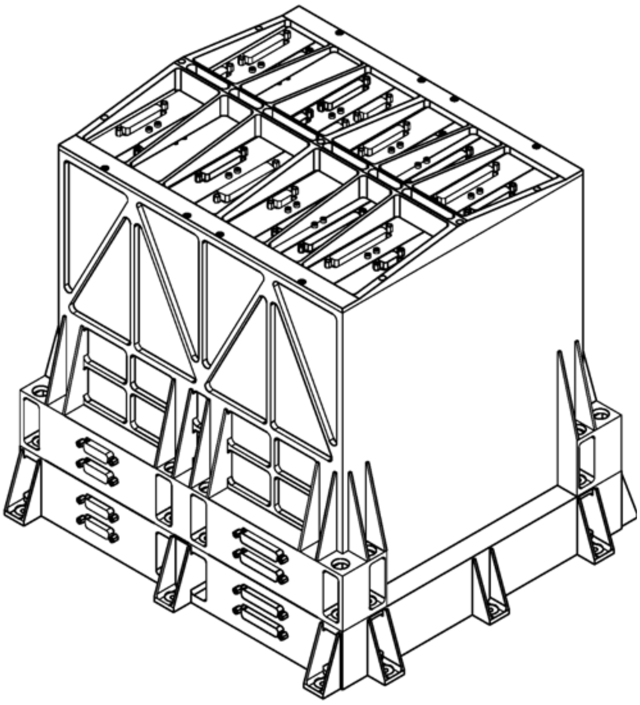


Figure 5.4-6 : HSFCU external configuration

5.5 SIZES AND MASS PROPERTIES

Reference HP-SPIRE-REQ-0300

Project Code	Instrument Unit	Dimenions (mm) including feet	New Estimate/ Nominal Mass of FM (kg)	Allocated Mass (kg)	Comment on new mass
HSFPU	HS Focal Plane Unit (*)	Non-rectangular. See Annex 1	45.0	47.2	Based on weighed FM with QM SMEC, no significant change expected
HSJFP	HS JFET Rack Photometer	See Annex 1	2.73	2.8	Weighed FM
HSJFS	HS JFET Rack Spectrometer	See Annex 1	1.0	1.0	Weighed FM
		Total SPIRE OB Units	**48.73**	**51.0**	
HSFCU	HS FPU Control Unit	See Annex 1	16.48	15.0	Weighed QM No change for FM expected
HSDCU	HS Detector Control Unit	See Annex 1	16.96	15.5	Weighed QM No change for FM expected
HSDPU	HS Digital Processing Unit	See Annex 1	7.23	7.0	Latest estimate
HSW1-8	HS Warm Inter-unit Harness	WIH layout is described in IIDA Annex 8	1.5	1.5	Manufactured not complete
		Total SPIRE SVM Units	**42.17**	**39.0**	
		SPIRE Instrument Total	**90.9**	**90.0**	

(*): HSFPU includes attached flying leads and any FPU thermal strap supports.

The ICD drawings, with all dimensions, for all these items are in Annex 1, in SPIRE-RAL-DWG-001409

Note: Concerning units nominal mass, this table takes precedence to any mass value indicated in drawings of Annex 1

Table 5.5-1: SPIRE Units mass & dimension

#

Formatted
Formatted: Bullets and Numbering
Formatted
Deleted: without margins
Deleted: 44.81 (**)
Deleted: 2.51
Deleted: 0.89
Deleted: 48.21
Deleted: 15.28
Deleted: 15.68
Deleted: 7.18
Deleted: 39.64
Deleted: 87.84
Deleted: ¶
(**):includes 32.07Kg Nominal and 34.77Kg Allocation for Structure mass elements, see Iss 1.4 of RD1 as DDR
Formatted: Bullets and Numbering

5.6 MECHANICAL INTERFACES

Note: Electrical and thermal characteristics conferred by these mechanical interfaces are covered in the appropriate sections, not here.

5.6.1 Inside cryostat

The Focal Plane Unit, the HSFPU, has 3 supporting feet to the Optical Bench. The details of this mechanical interface will be such as to allow the unit alignment and alignment-stability requirements to be fulfilled.

The Spire JFET racks will also mechanically interface directly to the Optical Bench.

5.6.1.1 Microvibrations

Spire's mechanisms (SMEC and BSM) are sensitive to microvibrations between 0.03 Hz and 300 Hz, with the potential effect of displacing the SMEC suspended mirrors from their optical positions. The bolometers, as they are accommodated, probably have a similar susceptibility to HOB-driven microvibrations. This is potentially due to harness flexure /capacitance changes, rather than to movements of the detector elements themselves.

Spire needs knowledge of the level of the microvibration-induced forces on the HSFPU at its HOB interface, in order to ensure they can be mitigated. The expected levels of input acceleration are to be provided by ESA/Alcatel, over the frequency range between 30 Hz and 300 Hz.

5.6.1.2 Thermal Straps

SPIRE requires the following thermal straps:

- 3 Level-0 thermal straps
- 2 Level-1 thermal straps
- 2 Level-3 thermal straps

The mechanical I/F geometry, fixing torque, mechanical load cases, etc. for each of these straps is as baselined in the IID-A. See section 5.4 for positions on Spire and section 5.7 for more details.

The HERSCHEL to Spire interfaces for the L0 straps are at three standardised points just above the HOB plate. For information, inside SPIRE, these thermal straps will be steadied by non-metallic supports on the outside of the FPU, designed to minimise the forces the straps can apply to thermal lead-throughs, but not be Ohmic shorts. Separate supports are needed to minimise cross-coupling between the two sorption cooler straps.

SPIRE JFET L3 I/F with electrical insulation

Reference HP-SPIRE-REQ-0360

The SPIRE JFET L3 thermal strap interface shall be implemented as shown in the figure 5.6-1 below.

#

Reference HP-SPIRE-REQ-0370

The shape of the L3 thermal strap shall have a T-shaped end bracket (40mm x 10mm). The requirement for the two L3 straps are as follows:

– Bolt hole tolerance ∅6.00-6.05mm
– Bolt spacing 25mm +/-0.1 according to AD1
– Gold plated on both I/F sides > 10microns
– Flatness <0.05, roughness <0.4mircrons

Ref to "2 JFET" and "6 JFET" ICD's in Annex 1

#

SPIRE will provide all needed clamping and fixation parts, which will be equipped by SPIRE with an electrical insulation. The H-EPLM Contractor shall supply a T-shaped end-bracket of the flexible link for each JFET rack (i.e. 2-JFET and 6-JFET) as shown below. SPIRE will provide the clamp block with insulated bushes. The arrangement is shown in the figure 5.6-1 below.

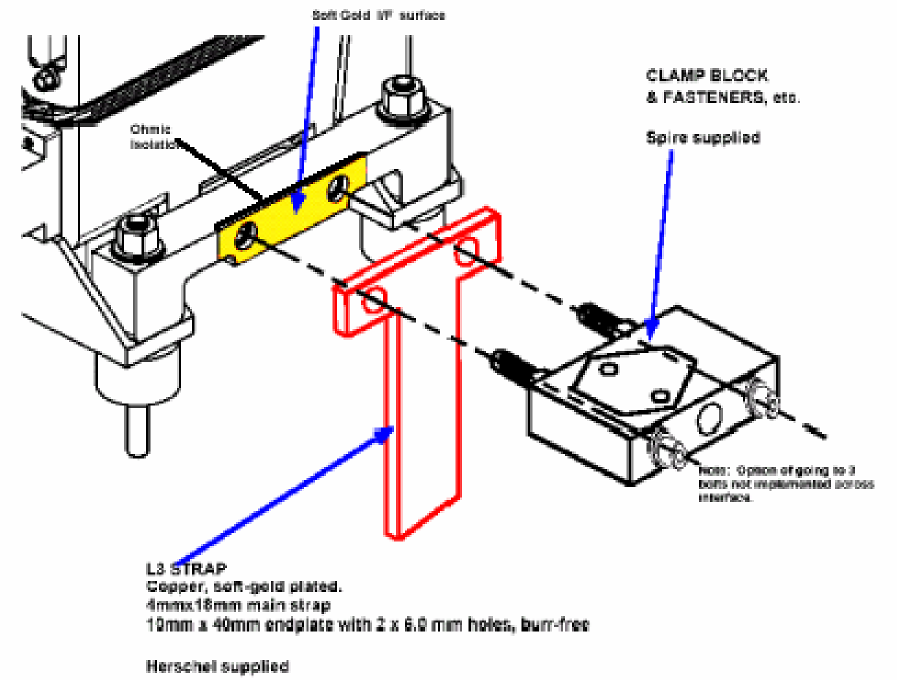


Figure 5.6-1: SPIRE JFET L3 interface including electrical insulation

SPIRE L1 electrical insulation I/F

SPIRE L1 Electrical insulation is done internal to the FPU. See FPU ICD in Annex 1

Formatted
Formatted: Bullets and Numbering
Formatted: Bullets and Numbering
Formatted
Deleted: 2
Deleted: 3-
Formatted: Bullets and Numbering

5.6.2 Outside Cryostat

NA

5.6.3 On SVM

Reference HP-SPIRE-REQ-0400

The three units mounted on the SVM will each have attachment points for fixation to the equipment platform, as shown in their External Configuration Drawings. Interface flatnesses, fasteners and tightening torques are all defined on these drawings (ref Annex 1).

#

Reference HP-SPIRE-REQ-0410

The Spire warm harness will be attached to the SVM via tie bases and wrap as defined in IIDA Annex 10 and provided by Industry.

#

Formatted: Bullets and Numbering

Formatted

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

5.6.4 On Planck Payload Module

NA

5.6.5 Cooler valves and piping

NA

5.7 THERMAL INTERFACES

The cryogenic interfaces are the most important category of interfaces for Spire 's success, and the most complicated. They would provide the most gain to science performance from being improved.

The SPIRE reduced TMM is given in Annex 2 of present IIDB.

SPIRE heat flow diagram is given by the figure here under:

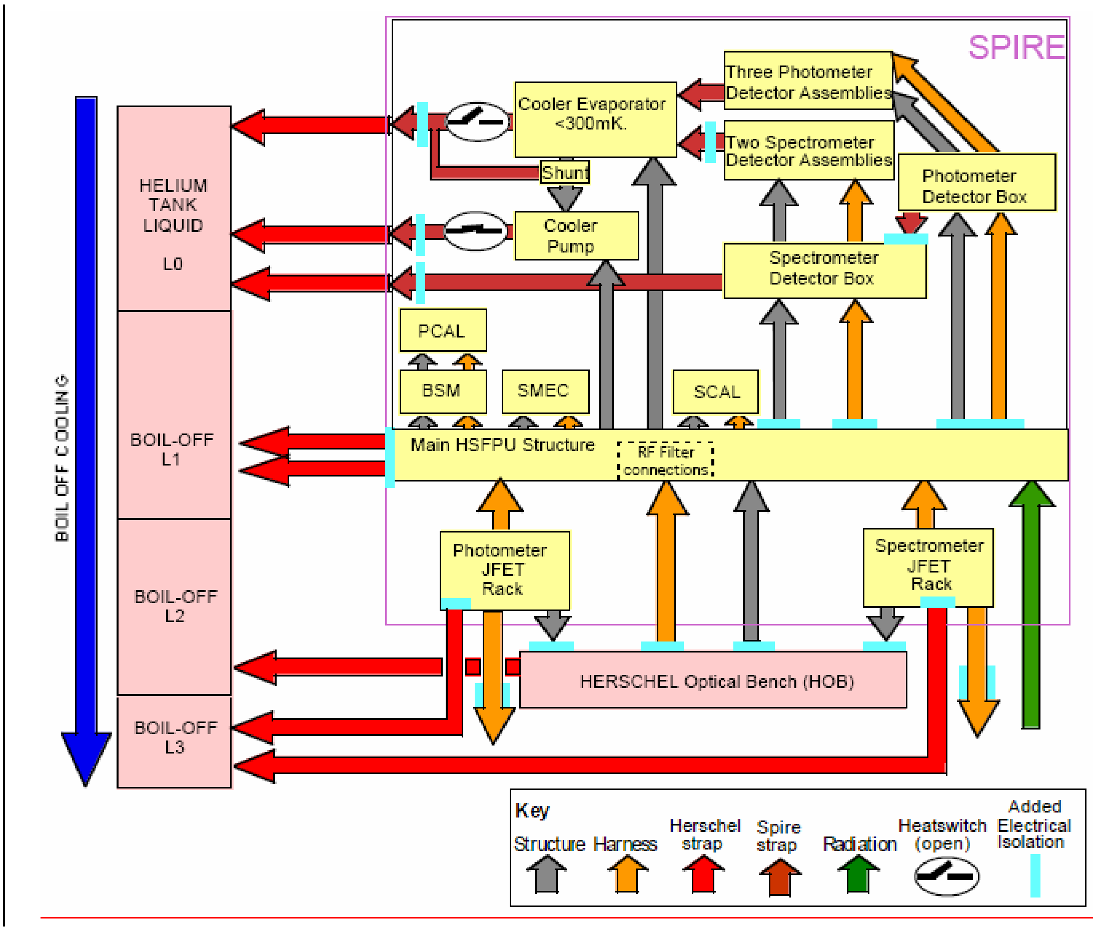


Figure 5.7-1: SPIRE heat flow diagram

5.7.1 Inside the cryostat

5.7.1.1 Description of the thermal interfaces

Spire uses 4 thermal stages to run 300mK detectors inside a ^{4}HeII cryostat. These link into levels provided by the Herschel cryostat. An overview of the Spire system is as follows, drawn with the heat switches associated with its 300mK cooler set as for an observing mode.

Electrical insulation is not shown here for electrical purposes but rather because where high thermal conduction is needed it adds to the design challenge. The radiative loads on Spire, shown in green, potentially come from warm baffles «seen» off-axis up the optical beam aperture. The arrow for external harness loads on the JFETs is not joined to anything specific as this depends on design decisions taken by Astrium.

Spire has two detector optical box structures, one housing the photometer detectors and one the spectrometer's. They mount on thermally isolating mounts inside the HSFPU and, to minimise the heat leak to the 300mK detectors themselves, link to the lowest available temperature, the L0 cryostat liquid sink. The spectrometer box has an external L0 interface and the photometer is then linked from it internally to the HSFPU, so together they only require one external I/F strap to L0.

As shown above in figure 5.7-1, there are two other L0 interfaces associated with the 300mK sorption cooler which is described below.

Not shown in the above overview are the small thermal loads on the Spire side of the I/F on the three L0 straps, due to their necessary mechanical support to the FPU.

The main HSFPU mountings to the HOB are also designed to be thermally isolating, so that the HSFPU can run at L1 whilst the HOB itself is at L2. The HOB tends to warm the HSFPU, which is why the structure and harness heat flow arrows are as shown.

When operational, JFET racks have a comparatively high dissipation. Fortunately, within reason, it is actually advantageous to run them a little warm. They therefore attach further up the boil-off line sequence to L3. Note that Spire plans to only power one rack at a time, either spectrometer or photometer and, depending on which is the more thermally demanding mode to operate in, their order on the L3 pipe is significant. Due to gas flow, the earlier can heat the later (with a heat path back into the FPU) but not visa versa.

To provide the required overall thermal balance boundary, the cryostat's inner instrument shield forms an enclosure at level 2, and the effective temperature seen from the surface of the HSFPU, integrated over an outward hemisphere, needs to be well specified.

5.7.1.2 Description of Operation and Interfaces for the ^{3}He Cooler

The Sorption Cooler interfaces and operation are described in Annex 3

Deleted: 4

5.7.1.3 Thermal requirements

Two major thermal requirements for SPIRE are its sorption minimum cooler cycle time of 48h, and its detector temperature of < 310mK.

Reference HP-SPIRE-REQ-0420

The table below shows the required operating temperatures and design heat flows at the thermal interfaces of the instrument unit with the cryostat or parts thereof :

In-Orbit thermal requirements				
SPIRE FPU thermal I/F		Max I/F Temp @ Max Heat Load		Cooler State
		Requirement	Goal	
L0	Detector Box	2 K @ 4 mW	1.71 K @ 1 mW	Operating
	Cooler Pump	2 K @ 2 mW	2 K @ 2 mW	Operating
		10 K @ 500 mW peak	10 K @ 500 mW peak	Recycling
	Cooler Evaporator	1.85 K @ 15 mW	1.75 K @ 15 mW	Recycling
L1		5.5 K @ 15 mW	3.7 K @ 13 mW	Operating
L2	Optical bench / FPU legs	12 K @ no load	8 K @ no load	Operating
L3	HSJFP (JFET Photometer)	15 K @ 50 mW	15 K @ 50 mW	-
	HSJFS (JFET Spectrometer)	15 K @ 25 mW	15 K @ 25 mW	-
-	Instrument shield (eq. Radiative temperature)	16 K @ -	16 K @ -	-

Notes: Assuming a He² tank temperature of 1.7 K

Sorption Cooler Recycling phase is composed of 2 phases in sequence, see Annex 3 for information

Table 5.7-1: In-Orbit thermal requirements

#

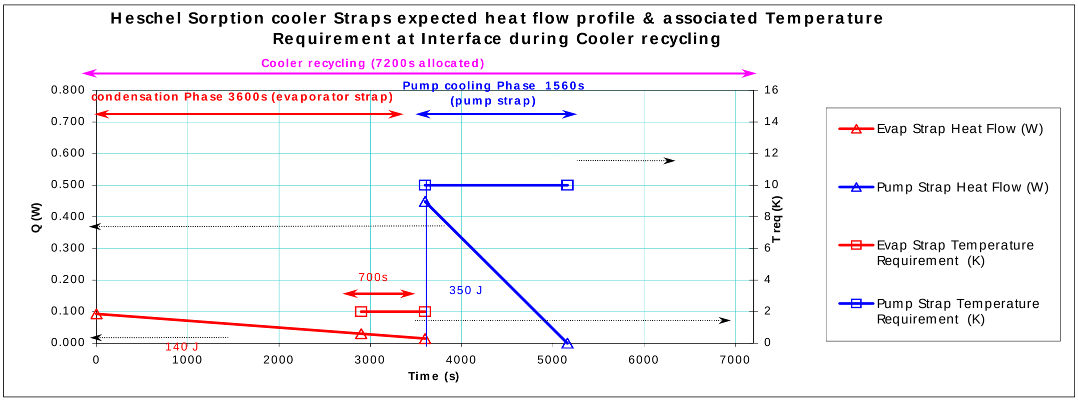


Figure 5.7.2: Expected heat profiles on evaporator and Pump strap, during recycling

Formatted: Bullets and Numbering

Formatted

Deleted: 4

Formatted: Bullets and Numbering

5.7.1.4 Worst case temperatures

Reference HP-SPIRE-REQ-0430

The cryogenic units must withstand the full thermal environment given in the IIDA, including repeated max. 72hr. 80°C bake-outs (*) and indefinite 60°C soak.

(*): The units must withstand a baking of 80°C for 72 h plus the ramp-up and ramp down operations. Taking into account the ramp-up and ramp down operations between room temperature and 80°C, the complete bake-out duration will be about 2 weeks (IID-A, § 5.15.2.5)

SPIRE FPU Thermal I/F		Non operating temperatures	
		Max continuous Temp	**Bake out Temp (72h max)**
L0	SPIRE SM Detector enclosure (814)	60 °C	80 °C
	SPIRE Cooler Pump strap (node 815)	60 °C	80 °C
	SPIRE Cooler Evaporator strap (node 816)	60 °C	80 °C
L1	SPIRE L1- FPU structure (two straps) (node 800)	60 °C	80 °C
L2	SPIRE L2 (Optical bench / FPU legs)		80 °C
L3	SPIRE L3 HSJFP, HSJFS		80 °C

Table 5.7-2: SPIRE FPU Non operating temperatures

#

5.7.2 *Outside the Cryostat*

NA

Formatted: Bullets and Numbering
Formatted
Formatted: Bullets and Numbering

5.7.3 On the SVM

Reference HP-SPIRE-REQ-0440

The table below shows the required operating temperatures at the interface of the instrument unit with a mounting platform or parts thereof:

Project code	Operating		Start-up	Switch-off	Non-operating	
	Min. °C	Max. °C	°C	°C	Min. °C	Max. °C
HSDPU	- 15	+ 45	- 30	+ 50	- 35	+ 60
HSFCU	- 15	+ 45	- 30	+ 50	- 35	+ 60
HSDCU	- 15	+ 45	- 30	+ 50	- 35	+ 60

Table 5.7-3: SPIRE WU temperatures

Notes: Acceptance temperature range is from 5 °C below min. to 5 °C above max. operating temp.

Qualification temperature range is from 10 °C below min. to 10 °C above max. operating temp.

#

Reference HP-SPIRE-REQ-0450

During nominal operation in-flight, the SVM units will not move at more than 3K/hour.

#

5.7.4 On the Planck Payload Module

NA

Formatted: Bullets and Numbering

Formatted

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

5.7.5 Temperature channels

5.7.5.1 Instrument Temperature Sensors

For information the table below shows the measurement of instrument cryogenic temperatures. These data are available in DPU science packets (unless otherwise indicated) via whichever is powered of the prime and redundant sides of the Spire electronics. They may also be included in some housekeeping packets.

Each Prime/Redundant side uses different, electrically isolated sensors and will therefore have subtlety differing electrical to temperature calibrations. Note that the accuracy columns that follow refer to the performance of the complete system including cryoharness and electronics, not the sensors alone. "Resolutions" and "Accuracy" will need to be further defined as they are actually temperature dependant.

Cernox sensors type CX-1030 are used for all HSFPU SPIRE conditioned housekeeping temperatures. The below table is consistent with RD19.

Location IN HSFPU	Acronym	Sensor Type	Temp. Range	Resol.	Acc.
PSW BDA_1	T_PSW_1	NTD Ge Thermistor*	0.2 K>5 K	0.5mK	2mK
PSW BDA_2	T_PSW_2	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
PMW BDA_1	T_PMW_1	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
PMW BDA_2	T_PMW_2	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
PLW BDA_1	T_PLW_1	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
PLW BDA_2	T_PLW_2	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
SSW BDA_1	T_SSW_1	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
SSW BDA_2	T_SSW_2	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
SLW BDA_1	T_SLW_1	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
SLW BDA_2	T_SLW_2	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
300mK Plumbing Cntrl_1	PTC_Ch1	NTD Ge Thermistor	0.2 K>5 K	0.05mK	0.2mK
300mK Plumbing Cntrl_2	PTC_Ch2	NTD Ge Thermistor	0.2 K>5 K	0.05mK	0.2mK
300mK Plumbing Cntrl_3	PTC_Ch3	NTD Ge Thermistor	0.2 K>5 K	0.05mK	0.2mK
HSFPU EMC filters	EMCFIL	CX-1030	3K>100K	25mK	50mK
Spectrometer 2K box	T_SL0	CX-1030	1K>10K	2mK	2mK
Photometer 2K box	T_PL0	CX-1030	1K>10K	2mK	2mK
M3,5,7 Optical SubBench	T_SUB	CX-1030	3K>100K	25mK	50mK
HSFPU Input Baffle	T_BAF	CX-1030	3K>80K	5mK	5mK
BSM/SOB I/F	T_BSMS	CX-1030	3K>80K	5mK	5mK
HS Spect. Stimulus Flange	T_SCST	CX-1030	1K>50K	10mK	10mK

Location IN HSFPU	Acronym	Sensor Type	Temp. Range	Resol.	Acc.
Sorption Pump	T_CPHP	CX-1030	1K>50 K	10mK	10mK
Evaporator	T_CEV	CX-1030	0.2 K>5 K	1mK	1mK
Sorption Pump Heat Switch	T_CPHS	CX-1030	1K>50K	10mK	10mK
Evaporator Heat Switch	T_CEHS	CX-1030	1K>50K	10mK	10mK
Thermal Shunt	T_CSHT	CX-1030	0.2 K>5 K	1mK	1mK
HS Spect. Stim 4%	T_SCL4	CX-1030	3K>80K	5mK	5mK
HS Spect. Stim 2%	T_SCL2	CX-1030	3K>80K	5mK	5mK
BSM	T_BSMM	CX-1030	3K>20K	10mK	10mK
SMEC	T_FTSM	CX-1030	3K>20K	10mK	10mK
SMEC/SOB I/F	T_FTSS	CX-1030	3K>100K	25mK	50mK

*NTD Ge Thermistor is equivalent to a detector element, but it is not mounted on an isolating web.

Table 5.7.5-1: SPIRE Instrument Temperature Sensors

5.7.5.2 Shutter Temperature Sensors

The SPIRE shutter has been removed. Temperature sensors are therefore not required

5.7.5.3 Satellite Temperature sensors

Reference HP-SPIRE-REQ-0460

Formatted: Bullets and Numbering

Formatted

In addition to the Spire conditioned temperature channels, Spire requires that Herschel itself shall monitor the temperatures of certain locations on the cryostat and SVM. These are given in the table below.

			CCU Measurement		EGSE Measurement	
Position	Type (1)	Name (1)	Range	Accuracy	Range	Accuracy
On Instrument Shield, close to SPIRE	C100	T213	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
L0; Cooling Strap 5; to "SPIRE SM Detector enclosure"	C100	T225	1.6K - 2.0K	± < 0.001K	1.6K - 2.0K	± < 0.008K
L0; Cooling Strap 6; to "SPIRE Cooler Pump HS"	C100	T226	2.0K - 10.0K	± 0.01K	2.0K – 10.0K	± 0.01K
L0; Cooling Strap 7; to "SPIRE Cooler Evaporator HS"	C100	T227	1.5K - 2.2K	± < 0.01K	1.5K - 2.2K	± < 0.01K
L1; on Ventline upstream strap 4 to "SPIRE Optical Bench"	C100	T235	2.0K - 10.0K	± 0.01K	2.0K – 10.0K	± 0.01K
L1; on Ventline downstream strap 4 to "SPIRE Optical Bench"	C100	T236	2.0K - 10.0K	± 0.01K	2.0K – 10.0K	± 0.01K
L3; on Ventline to JFET-Phot	C100	T246	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
L3; on Ventline to JFET-Spec	C100	T247	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
L1; on Strap 4 on SPIRE FPU side	C100	T248	2.0K - 10.0K	± 0.01K	2.0K – 10.0K	± 0.01K
On Spire JFET-Spec (Pos on Structure or L3 strap)	PT1000	T249			13K – 370K	± 1K
On Spire JFET-Spec (Pos on Structure or L3 strap)	C100	T250	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
On Spire JFET-Phot (Pos on Structure or L3 strap)	PT1000	T251			13K – 370K	± 1K
On Spire JFET-Phot (Pos on Structure or L3 strap)	C100	T252	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
OB Plate near SPIRE foot (center)	PT1000	T253			13K – 370K	± 1K
OB Plate near SPIRE foot (center)	C100	T254	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
OB Plate near SPIRE foot (-z+y)	PT1000	T255			13K – 370K	± 1K
OB Plate near SPIRE foot (-z+y)	C100	T256	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
OB Plate near SPIRE foot (-y-z)	C100	T258	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K

(1): Type and name for information only

Table 5.7.5-2: SPIRE Satellite Temperature Sensors

#

Formatted: Bullets and Numbering

5.8 OPTICAL INTERFACES

Reference **HP-SPIRE-REQ-0470**

The cryostat and baffle structures shall be compatible with the SPIRE beam.

#

Formatted: Bullets and Numbering

5.8.1 Straylight

The instrument straylight model and its conclusions related to alignment etc. are described in RD-15.

The dimensions of the Spire optical beam stayout envelopes are defined in the HSFPU ICD annexed to the IID-B. These are simplified inclusive shapes, detailed ones can be found in RD-20

For information, Figure 5.8-1 illustrates the SPIRE optical beam envelope viewed as it passes out of the HSFPU, showing the contributions from the photometer and the spectrometer. The differing beams result from the extremes of the BSM's jiggle and chop displacements. The beam envelope formed is the geometric optical beam passing through the Spire cold stop. The 6mm clearance around the beam is the allowance required for beam diffraction.

The figure 5.8-1 here under takes into account the removing of SPIRE shutter

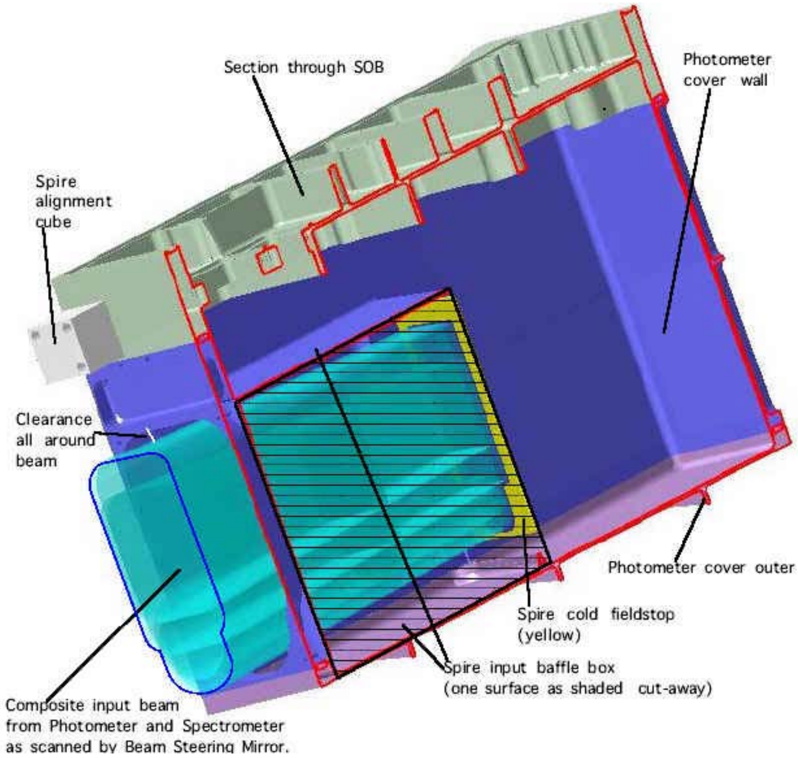


Figure 5.8-1 Spire optical beam envelope as it leaves the HSFPU

The spectrometer's almost circular used beams are the farther from HERSCHEL field centre, and lie to the side of the semi-rectangular beams of the photometer. FOV switching is not used within SPIRE to boresight the photometer and the spectrometer; both are illuminated simultaneously by the HERSCHEL telescope.

5.9 POWER

The thermal design and thermal model is still under evaluation at system level, with industry and ESA project. The values given in 5.9.1 reflect the current known status.

5.9.1 Power inside the cryostat

The SPIRE components which dissipate power inside the cryostat are described in the Table below. It should be noted that the individual component dissipations vary according to the operational mode of the instrument, as described in section 5.9.5.

Component	Dissipation. at component level (mW)
Photometer Cal	0.033
Spectrometer Cal	1.5
300 mK Cooler *	1.8
BSM / Photometry	3
BSM / Spectroscopy	0.2
SMEC / Photometry	0
SMEC / Spectroscopy	3.2
JFETS / Photometry	42
JFETS / Spectrometry	14

* Recycling is a special case, see section 5.7 and Annex 3

Deleted: 4

Table 5.9-1: Power dissipation inside cryostat

Note: dissipation values of this table are for information only, refer to SPIRE RTMM in Annex 2 of present IIDB

5.9.2 Power outside the Cryostat

NA

5.9.3 Power on the SVM

Reference HP-SPIRE-REQ-0490

Formatted: Bullets and Numbering

The following table shows the heat dissipation (in Watts) of the warm electronic units mounted on the SVM. Note that the power passed through to the Cryoharness and the HSFPU is negligible, such that the dissipation values given here are the same as those corresponding to the unit power loads on the bus (Section 5.9.6.1) :

Code	Instrument Unit	Dissipation	Comment
HSDPU	HS Digital Processing Unit	15.3 W	
HSFCU	HS FPU Control Unit	42.9 W	Includes power cond. losses
HSDCU	HS Detector Control Unit	37.0 W	Lower in spectrometer Mode
HSWIR	HS Warm Inter-unit Harness	0.1 W	
	Total	**95.3 W**	

Table 5.9-2: Power dissipation on the SVM

Note: This table takes precedence to any power dissipation value indicated in drawings of Annex 1

The above dissipations are essentially independent of observing mode, with the exception that the baseline is to power EITHER the spectrometer OR the photometer bolometer systems at any one time. The above figures are based on the higher dissipation values expected with *photometer* operation

The baseline is to empower either prime or redundant modules of Spire. The instrument will therefore appear to the S/C as simply cold redundant.

#

Formatted: Bullets and Numbering

5.9.4 Power on Planck Payload Module

NA

5.9.5 Power versus Instrument Operating Modes

The table below shows the status of the instrument subsystems in the various instrument modes.

Unit	Subsystem	Recycle	Off	On	Standby/ Parallel/ Serendipity	Observing	
						Photom.	Spectro.
HSFPU	Detector Bias	OFF	OFF	OFF	ON	ON	ON
	Photometer Cal Source	OFF	OFF	OFF	OFF	X	OFF
	Spect. Cal Source	OFF	OFF	OFF	OFF	OFF	ON
	Cooler	ON	OFF	OFF	ON	ON	ON
	BSM	OFF	OFF	OFF	ON	ON	ON
	FTS Mechanism	OFF	OFF	OFF	OFF	OFF	ON
HSFTB	JFET amplifiers	OFF	OFF	OFF	ON	ON	ON
HSFCU + HSDCU	Read-out electronics & mechanism drive electronics	ON	OFF	OFF	ON	ON	ON
HSDPU	Digital Processing Unit	ON	OFF	ON	ON	ON	ON

LEGEND: ON : Operational

OFF : Inactive

X : Either ON or OFF depending on instrument configuration.

Table 5.9-3: Power status versus instrument modes

5.9.6 Supply Voltages

5.9.6.1 Load on main-bus

The total power load Spire places on the 28V main-bus is defined In the Spire Budgets' Document. The following is an extracted summary:

Reference **HP-SPIRE-REQ-0020**

The SVM shall provide the allocated power budget as defined hereafter.

The "average" and "peak" power values correspond to "worst-case" conditions, i.e. taking into account the specified supply bus voltage range : 26V and 29V.

Spire Operating Mode	[1]Max. Ave. BOL	[1]Max. Ave. EOL	
Observing	95.3 W	95.3 W	
Parallel	95.3 W	95.3 W	
Serendipity	95.3 W	95.3 W	
Standby	95.3 W	95.3 W	
Cooler Recycle	95.3 W	95.3 W	
On	15.3 W	15.3 W	
Off	0 W	0 W	

Deleted: [1]Long Peak BOL/EOL
Deleted: TBD
Deleted: TBD
Deleted: TBD
Deleted: TBD
Deleted: TBD
Deleted: TBD
Deleted: 0

Project Code	Instrument Unit	Mean load per LCL
HSDPU	HS Digital Processing Unit	15.3 W [2]
HSFCU	HS FPU Control Unit	80.0 W [3]

1 The "average" and "peak" power values correspond to "worst-case" conditions, i.e. taking into account the specified supply bus voltage range : 26V ~ 29V. The average "with-margin", and peak "with-margin" total power loads are also to be provided.

2 The maximum associated "Long Peak" load on this LCL is understood to be the mean value (above) X 1.20, i.e. 18.5 W.

3 The **maximum** associated "Long Peak" load on this LCL is understood to be the mean value (above) X 1.20, i.e. 96 W.

Table 5.9-4: Power load on main bus

*

5.9.6.2 Power Nominal Turn-on.

This sequence takes the SPIRE instrument from its OFF configuration to the REDY configuration. In this final configuration the instrument is ready to be switched into either operational mode (Photometry or Spectrometry) or to perform a cooler recycle.

OFF to INIT:

Having checked that SPIRE is all unpowered, the spacecraft shall power on HSDPU (Prime).

The DPU will check its health and, if its status is OK, shall issue a TM(5,2) event packet indicating its readiness to accept commands. (In the event that an anomaly is found the DPU shall issue TM(5,4) event packets indicating the problem.)

INIT to DPU_ON:

A TC(8,4) command 'Force Boot' is sent to the DPU to load the On Board Software from EEPROM and start its execution. The result of this is the generation of TM(3,25) Nominal and Critical Housekeeping reports, which indicate that the OBS is configured to MODE=0x0000.

At this time 3 TM(5,1) event packets will also be generated indicating that the SPIRE DRCU subsystems are not responding to commands from the DPU - this is normal as the DRCU is not yet powered on.

DPU_ON to DRCU_ON:

Telecommands are sent to the DPU to stop collection of housekeeping data from the DRCU subsystems during power on. The stream of Nominal and Critical housekeeping TM packets will be interrupted at this time.

The spacecraft is commanded to power on the HSFCU (Prime).

Telecommands are sent to the DPU to restart collection of housekeeping data from the DRCU. The stream of Nominal and Critical housekeeping TM packets will be restarted at this time. Additional TM(5,1) event packets will be generated indicating that the DRCU subsystems are now responding to commands from the DPU, and the Nominal and Critical Housekeeping telemetry will indicate nominal operation.

The configuration MODE parameter is set by telecommand to 0x0100.

DRCU_ON to REDY:

Telecommands are sent to the instrument to:

- Switch on the DC and AC (Sub-K) temperature channels
- Power on the Cooler Sorption Pump Heat Switch
- Boot up the MCU DSP
- Set the MODE parameter to 0x0200

The affect of these commands is reflected in the housekeeping data.

5.9.6.3 Interface circuits

Reference **HP-SPIRE-REQ-0030**

The HSDPU and the HSFCU receive both primary and redundant 28V feeds. The configuration is shown in figure 5.2.1, and the connectors are HSDPU J1-2 and HSFCU J5-6.

*

Their S/C power interfaces circuits shall be designed not to generate unwanted interactions with LCL switching limiters. Instrument power circuits are shown in sections 5.9.6.4.1 & .2.

Reference **HP-SPIRE-REQ-0040**

The HPCDU shall telemeter the Spacecraft's LCL current to a resolution of better than 25mA or 1/256 of (trip x 1.5), whichever is the larger. The stated resolution, to be provided by the current telemetry, does imply any particular level of current measurement *accuracy.*

*

5.9.6.4 LCL fault conditions

Reference **HP-SPIRE-REQ-0050**

The S/C shall not allow simultaneous powering of both FCUs, even in the event of a single point LCL failure.

*

Reference **HP-SPIRE-REQ-0060**

Both DPUs may be powered but only under LCL fault conditions. To permit this, other design features must be present. The unwanted although powered DPU shall be kept in-active by not commanding the inactive unit, and neither HCDMU shall turn on the corresponding HSFCU. To permit commanding the DPUs to work like this, each HSDPU uses a different 1553 bus address.

*

Reference **HP-SPIRE-REQ-0510**

The Herschel platform shall monitor that LCL's are behaving correctly. With certain timing restrictions, it shall regularly check that an "off" LCL is passing less than a minimum current, and that an "on" LCL is passing a current between a minimum and a maximum that depends on circuit. It shall re-check this before and after implementing a command to change an LCL's state. The formal status of the functionality of LCLs [working, stuck on, stuck open-circuit, dubious, etc.] shall be stored somewhere in the Herschel commanding system (probably on the ground?) to stop any attempt to switch a failed LCL without specific over-ride .

#

Formatted: Bullets and Numbering

An open-circuit LCL is not a particularly difficult case to consider as it would just preclude the use of one side of Spire.

5.9.6.4.1 HSDPU Power Input Circuit Configuration

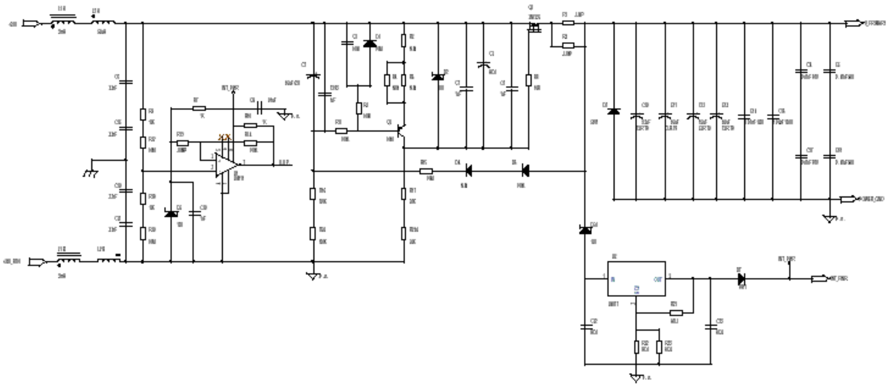
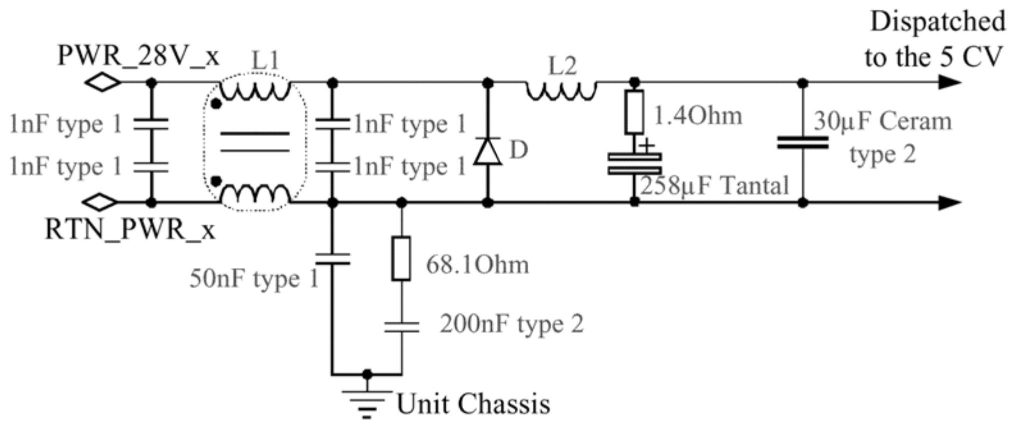


Figure 5.9-1: HSDPU Power Input Circuit Configuration

Note: This HSDPU Power Input Circuit Configuration is given for information only

5.9.6.4.2 HSFCU Power Input Circuit Configuration



On the schematic, «_x» signifies «_P» for nominal Board (J05) or «_R» for redundant. (J06).

L1 : common mode inductance , the value is : 210 µH.

L2 : differential mode inductance , the value is : 170 µH no load, 150 µH for nominal current (2.8 A), 140 µH for maximum current (4.2 A)

D is composed of four 1N5811 rectifiers, connected in series / parallel.

Figure 5.9-2: HSFCU Power Input Circuit Configuration

Note: This HSFCU Power Input Circuit Configuration is given for information only

5.9.7 Keep Alive Line (KAL)

Because Spire should not be switched-on/off frequently, a KAL will not be implemented.

5.10 CONNECTORS, HARNESS, GROUNDING, BONDING

Spire provides the SVM interconnect harnesses wired as per RD-19 (SPIRE-RAL-PRJ-000608), and suitable for routing/installation on the SVM as illustrated in the IID-A as regards length, connector back-shells, etc. This is illustrated in figure 5.3-2 *(as in section 5.3.1.1).*

Reference **HP-SPIRE-REQ-0520**

Herschel provides the «cryoharness» between the warm Spire units and the cryogenic ones on the HOB inside the CVV. Figure 5.2.1illustrates how these are all in three sections, S, I and C.

#

Reference **HP-SPIRE-REQ-0530**

All harnesses shielding and overshielding implementation shall be in accordance with RD-19 (SPIRE-RAL-PRJ-000608).

This implementation should be consistent with the grounding drawing figure 5.10-2

All relevant details of the termination connectors, not included in RD19 (SPIRE HDD), are given in RD35 (Making SPIRE ESD Safe, SPIRE-RAL-NOT-002028)

5.10.1 Harness and Connectors

Reference **HP-SPIRE-REQ-0540**

The cryoharness interface pinout shall be compliant with RD-19, SPIRE-RAL-PRJ-000608.

The Spire harnesses shall be compliant with RD-19, SPIRE-RAL-PRJ-000608t.

#

Figure 5.10-1 below gives an overview of the Spire harness layout.

Note that the Cryo-harness, i.e. series C, I, and S are ESA provided and not Spire flight H/W, whilst the T series apply only for instrument test and are not Spire flight items.

The two F harnesses (FPU sub-system F harness) between JFETs and FPU (HSFPU-HSJFP and HSFPU-HSJFS) are provided by SPIRE with the instrument units.

Formatted

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

Deleted: The function pin allocations in the cryoharness has adopted RD-19's definitions up to issue 1.1 with corrections (i.e. updated pages, given in Annex 5).

Formatted: Bullets and Numbering

Deleted: External to the CVV the harnesses are double isolated shielded, with the outer shield linking the CVV connector bodies to the warm unit connector backshells and the inner one also linked to the warm unit connector backshells but passing through the CVV connectors on a ring of pins to join to the HSFPU+JFET Faraday shield.¶

Deleted: Internal to the CVV there are no harness overshields. For the bolometer harnesses, C1-C9, the Faraday shields are carried on internal cable when the second outer cable shield is connected to the connector back-shells. For the non-bolometer harnesses, C10-C13, these links are discrete wires rather than a closed shield.

Deleted: is

Deleted: the

Deleted: Annex 6

Formatted: Bullets and Numbering

Formatted

Deleted: , Issue 1.1 and updated pages, for harness bundles 4 and 6, identified by:¶
«SPIRE HDD 1.1 Deltas», ref SPIRE-RAL-NOT-001819, given in Annex 5

Deleted: he requirements specified in Annex 3 (Summary of SPIRE cryoharness wiring functions)

Formatted: Bullets and Numbering

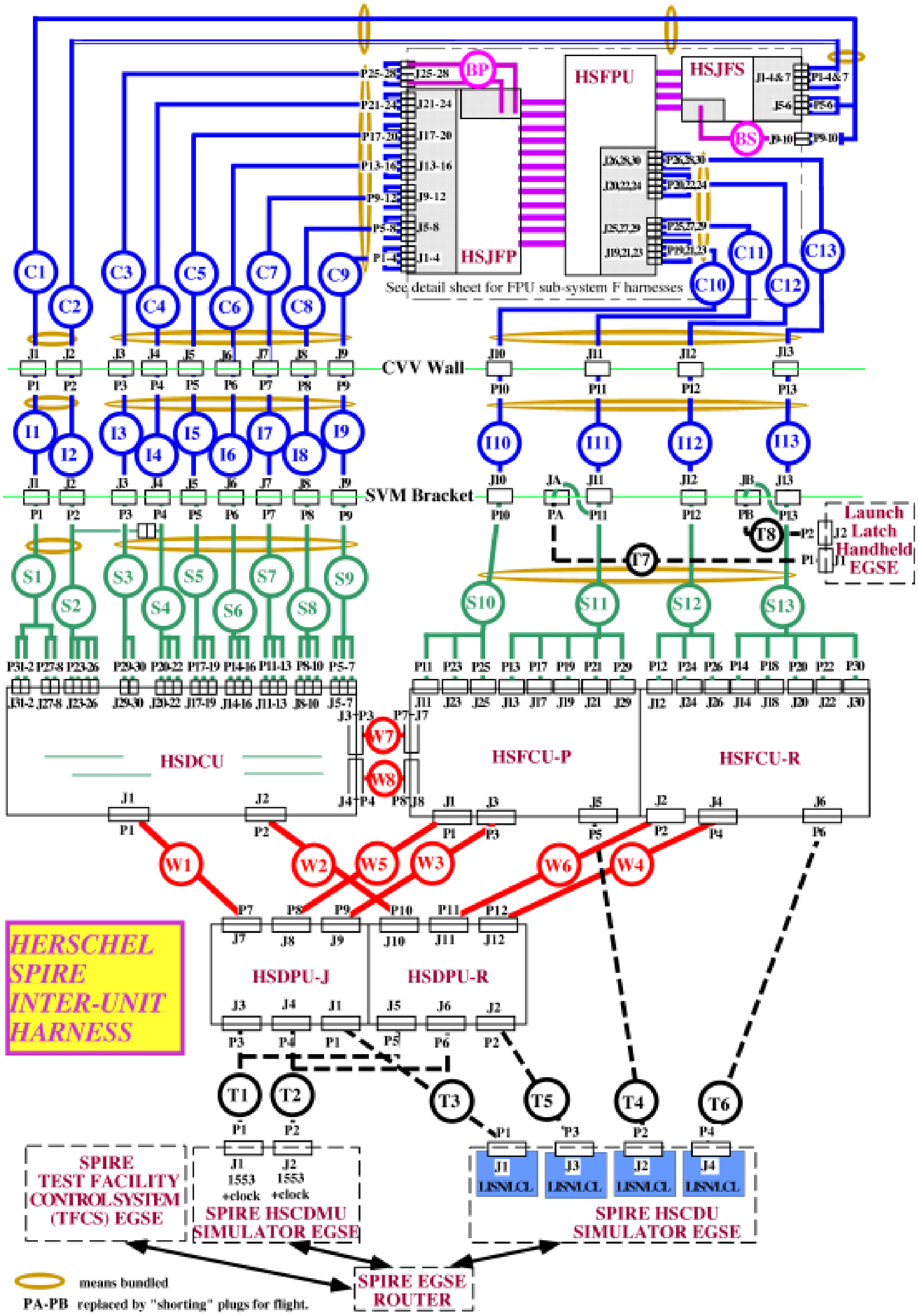


Figure 5.10-1 : SPIRE harness layout

5.10.2 Grounding

To fulfil Spire's grounding requirements, the HSFPU and both of the JFET racks need to be electrically isolated from the Optical Bench, at their mechanical mounting points. The same applies to the bolometer system harness screens.

SPIRE grounding diagram provided in the figures 5.10-2 and 5.10-3 below is for information.

The mechanical implementation of thermal straps insulation is described in section 5.6.1.2

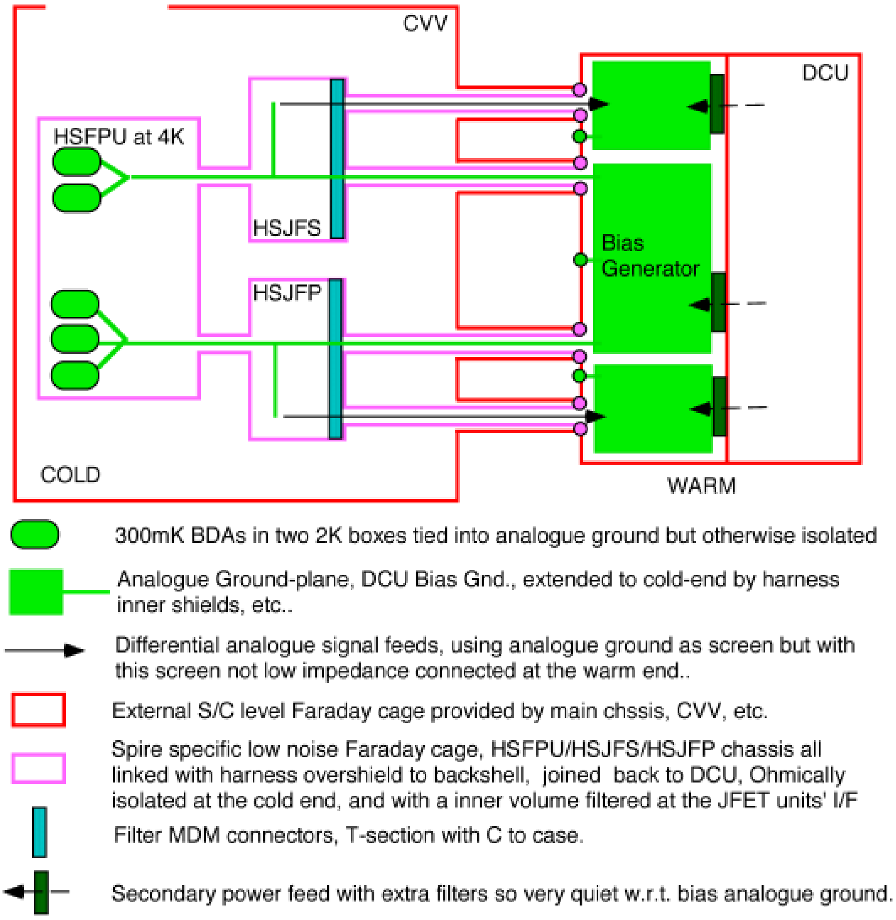


Figure 5.10-2 : SPIRE Simplified Grounding scheme

The Spire FCU itself and the DPU use a "standard" ESA-type secondary power system, whereas the DCU/FPU and FCU supply sections shown above are an optimised system w.r.t. minimising the overall bolometer analogue ground noise. The FCU powers the DCU, keeping the latter free of conditioning noise. The FCU driven items in the FPU, see figure 5.2.1, are considered less critical and will all be Ohmically grounded in the FCU.

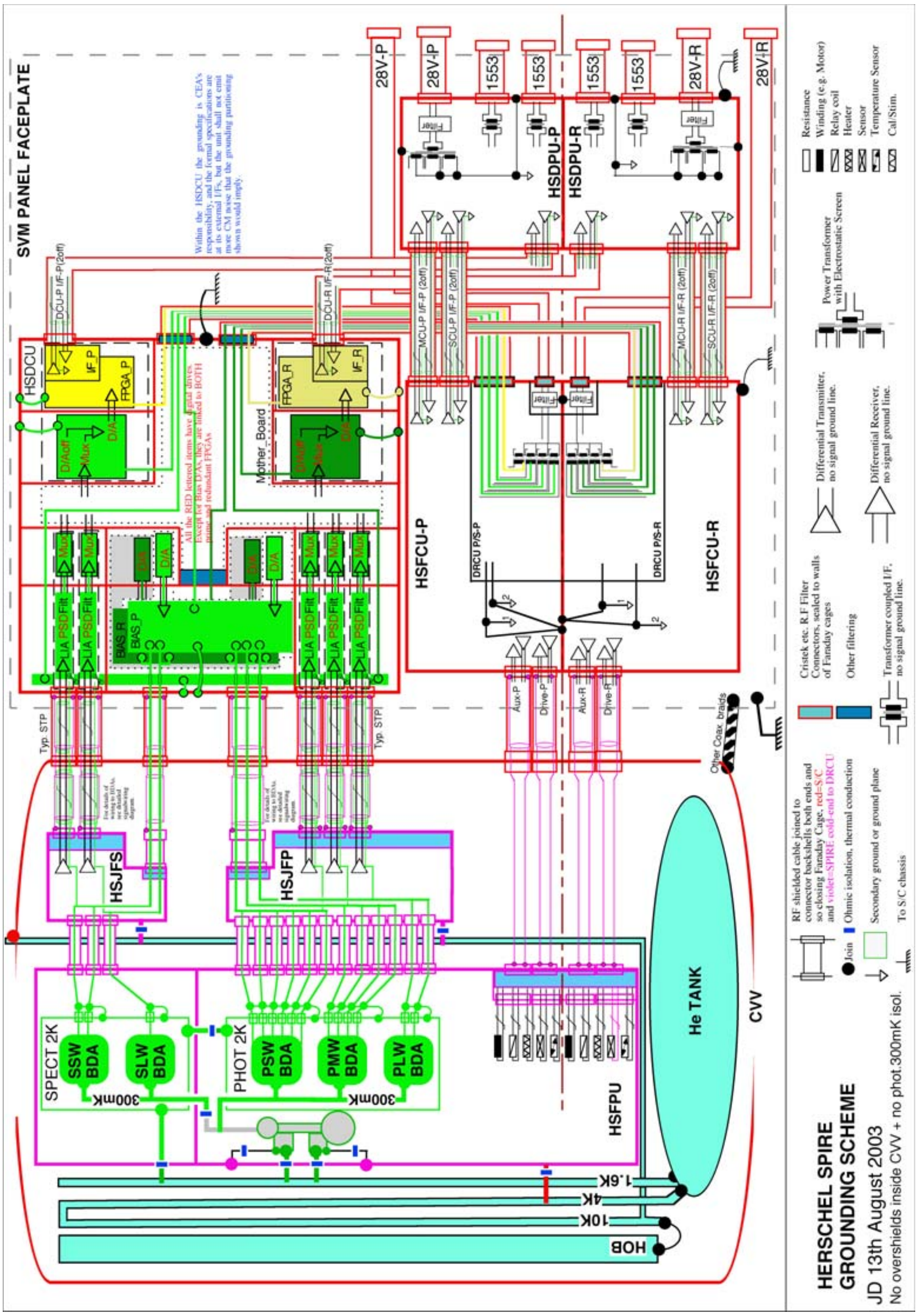


Figure 5.10-3 : SPIRE Grounding scheme

5.10.3 Bonding

Reference HP-SPIRE-REQ-0550

Formatted

Formatted: Bullets and Numbering

It is understood that Herschel bonding applies to harness shields used to maintain closed Faraday cages. Bonded interfaces shall not be used as routine current return paths.

#

Formatted: Bullets and Numbering

We note that presently all Warm Electronics units rely in conductivity via their mechanical mounting feet to S/C.

The DRCU decreases interface inductance by using conductive interface gasket, see Annex 1

Reference HP-SPIRE-REQ-0560

Formatted: Bullets and Numbering

A bonding strap is connected to each SPIRE SVM mounted unit.

#

Formatted: Bullets and Numbering

5.10.4 Electrical Signal Interfaces

5.10.4.1 1553 Data Buses

Reference HP-SPIRE-REQ-0070

The 4 interfaces to the two (prime and redundant) buses between the Spire instrument DPUs and the CDMU shall conform to MIL-STD-1553B, with the CDMU controlling the bus.

*

Reference HP-SPIRE-REQ-0080

The 4 Spire interfaces shall have unique bus addresses, consistent with Herschel properly controlling the use of Prime and Redundant equipment.

*

Reference HP-SPIRE-REQ-0090

A long stub configuration shall be used for each of the 4 interfaces, one transformer for each stub in the bus wiring and one in the instrument I/F.

*

Reference HP-SPIRE-REQ-0100

Connector use is as follows:

DPU Connector	Prime Bus	Redundant Bus
Prime DPU	J3	J4
Redundant DPU	J5	J6

*

The DPU's 1553B interface to the Herschel S/C is configured as follows inside each SPIRE HSDPU :

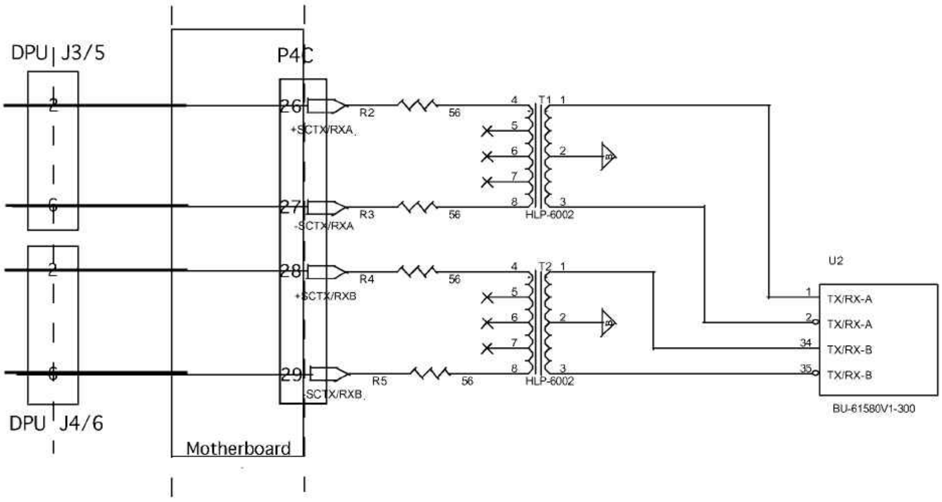


Figure 5.10-4 : DPU's 1553B interface to the Herschel S/C

5.10.4.2 Master Clock

NA (no more Master Clock)

5.10.4.3 Launch Latch confirmation

Reference **HP-SPIRE-REQ-0570**

Formatted

Formatted: Bullets and Numbering

Spire has one cryogenic mechanism, the SMEC, which is fitted with a launch lock device to retain the mechanism during launch and ground handling. This launch lock should be maintained in the locked position except during specific on ground test sequences and once in orbit. The latching of this mechanism will need to be confirmed after launch stack integration. All functions are Prim, and Redundant.

#

Formatted: Bullets and Numbering

Reference **HP-SPIRE-REQ-0580**

Formatted

After transportation to Kourou, and the last operation of SPIRE prior to launch, hand-held Spire provided EGSE will require cable access to the two connectors JA and JB shown in the Harness configuration drawing.

This EGSE will be small and light and require no external power supply. A detailed procedure will be supplied by SPIRE.

If the latch is found to be un-latched, the instrument shall be powered up and the latch re-latched by command.

#

Formatted: Bullets and Numbering

Reference **HP-SPIRE-REQ-0590**

Formatted

Connector blanking plugs PA-PB that interconnect connector contacts as defined by Spire will be HERSCHEL provided and fitted whenever the EGSE is not connected, which includes in-flight.

#

Formatted: Bullets and Numbering

5.11 DATA HANDLING

5.11.1 Telemetry

5.11.1.1 Telemetry rate

The table below gives the estimated telemetry rates in the different SPIRE modes, excluding event packets. For observing modes, the Data Rate value gives the maximum continuous data rate during an observation (the average data rate will be less due to the limited data rate used during configuration periods) and the Packet Rate gives the number of telemetry packets generated by the instrument per second (fractions indicate a packet is generated at a frequency of less than one per second, i.e.2/3 indicates two packets are generated every 3 seconds). The data rates include both instrument data and the TM packet overheads.

Description	Data Rate (Kbps)	Packet Rate (packets/s)
Housekeeping data rate (non prime)	1.9	1/2 + 1/4
Housekeeping data rate (prime)	6.5	1 +1/2
Science data rate: Photometer only	110.7	20 + 1/16 + 4/3
Science data rate: Spectrometer only	119.5	12 + 3 +1/16 + 1/3
Science data rate: Parallel mode	50.0	10 + 1/11
Science data rate: Serendipity mode	99.3	20 + 1/11

Table 5.11-1: Housekeeping and science data rates

Notes:

- Any increase in telemetry rate would have science benefits.
- The total data rate allocation of 130Kbps is a limit on the average including orbit recycling/commanding

Reference **HP-SPIRE-REQ-0150**

Deleted: a

SPIRE requires an average of 126 kbps of TM data rate during operations, and 2.0 kbps when in non-prime mode.

*

5.11.1.2 Data-bus rate

Reference **HP-SPIRE-REQ-0160**

Deleted: a

For the purpose of possible (up to 5 minutes) higher instrument data-rates, the bus interconnecting the instrument and the HCDMU shall have the capability of handling a telemetry rate of > 200 kbps .

*

This will allow for the rapid emptying of Spire on-board data storage units at the end of each observation, thus keeping overheads due to data transfer to a minimum.

5.11.1.3 Data Packets

Spire is capable of buffering 10 seconds of data at the maximum packet generation rate.

Reference **HP-SPIRE-REQ-0170**

Deleted: _a

In order to prevent data overflow in this Spire data storage, the HCDMU shall request packets from Spire at least as frequently as once per second .

\# *

5.11.2 S/C housekeeping

Reference **HP-SPIRE-REQ-0180**

The S/C should be capable of collecting and range checking the following instrument parameters every minute. It shall provide a data packet to the ground that includes these housekeeping values, together with any range violations and any actions taken thereon.

- Voltages to instrument
- Currents to instrument
- Power status – i.e. which Spire units are on i.e. HSDPU and HSDRC.
- Requested temperatures in Section 5.7.5.2.

\# *

5.11.3 Timing and synchronisation signals

Reference **HP-SPIRE-REQ-0190**

The S/C shall provide Spire with a timing synchronisation typically every second to allow cross reference or synchronisation of the Spire clock to the spacecraft clock.

*

Reference **HP-SPIRE-REQ-0200**

When using telescope scan mode, information will be made available to the SPIRE project to enable determination of the start of scan with a precision better than 10ms with respect to the S/C clock.

*

This is required so that the Spire data can be located in time and correctly ground processed to link to Herschel attitude; it is not required for the operation of the Spire instrument.

The Spire instrument typically works by its DPU unpacking S/C commands to a lower level, and sending those lower level commands to the DCU and FCU with timings that they can guarantee to keep up with. There is a minimum of handshaking on internal interfaces and, for instance, the DPU has to be ready to receive science data packets from the DPU and FCU whenever they reasonably send them. In these internal data packet headers are counter values permitting accurate datation of all values back to sequence start pulses sent from the DPU. The scheme can be viewed on figure here after.

Considering Spire Data Timings figure:

1. The DPU has an internal free-running 1MHz. crystal clock that runs continuously from when its power quality becomes correct at power turn on. This drives a counter that continuously synchronously increments and rolls over every ~71.6 minutes. The CDMU sends an asynchronous spacecraft time value message every second across the1553 S/C bus followed by a «seconds» marker message at that spacecraft time. At this time, the DPU stores the spacecraft time and the current value of its internal counter. For approximately the next second, i.e. until it has determined the next spacecraft time and counter value pair, the DPU determine times to label Spire data as the stored spacecraft time incremented by the delta between the value of its counter corresponding to this time and the value of its counter when the data were sampled.

The DPU controls the Spire DRCU by passing commands across the Spire internal Slow Speed Interface, sending all commands simultaneously to all three DRCU command interfaces. At appropriate intervals, it sends a DRCU counter reset command. At the time of the end of the transmission of each such command, the DPU assigns a time to this event as described and puts the result in Spire's housekeeping telemetry.

2. The DRCU's two units, the HSDCU and the HDFCU, both have command input buffers that handle the Slow Speed Interface a single command at a time. Each interface receives a 312.5KHz. clock from the DPU as part of the Slow Speed electrical protocol and this is used to increment DRCU internal counters, the values of which are then routinely used in the DRCU to label the science data sent to the DPU. Each counter will be reset to zero within 6µsec(TBC) of the end of the receipt of a counter reset command, and then immediately starts incrementing again on the next edge of the 312.5KHz. clock. It is the responsibility of the SPIRE command timeline to reset the DRCU counters sufficiently frequently that they do not overflow (i.e. at least every 229 minutes). [Note: It has to be ensured that the DPU sends commands to the DRCU sufficiently timespaced that each can be fully obeyed before the next is sent].

Deleted: a

Deleted: So when using the telescope scan mode, a «start of scan» indication will be sent be to the DPU to give a timing precision of better than 5 milliseconds, although the actual UT of the pulse only needs to be within one second of its planned time.

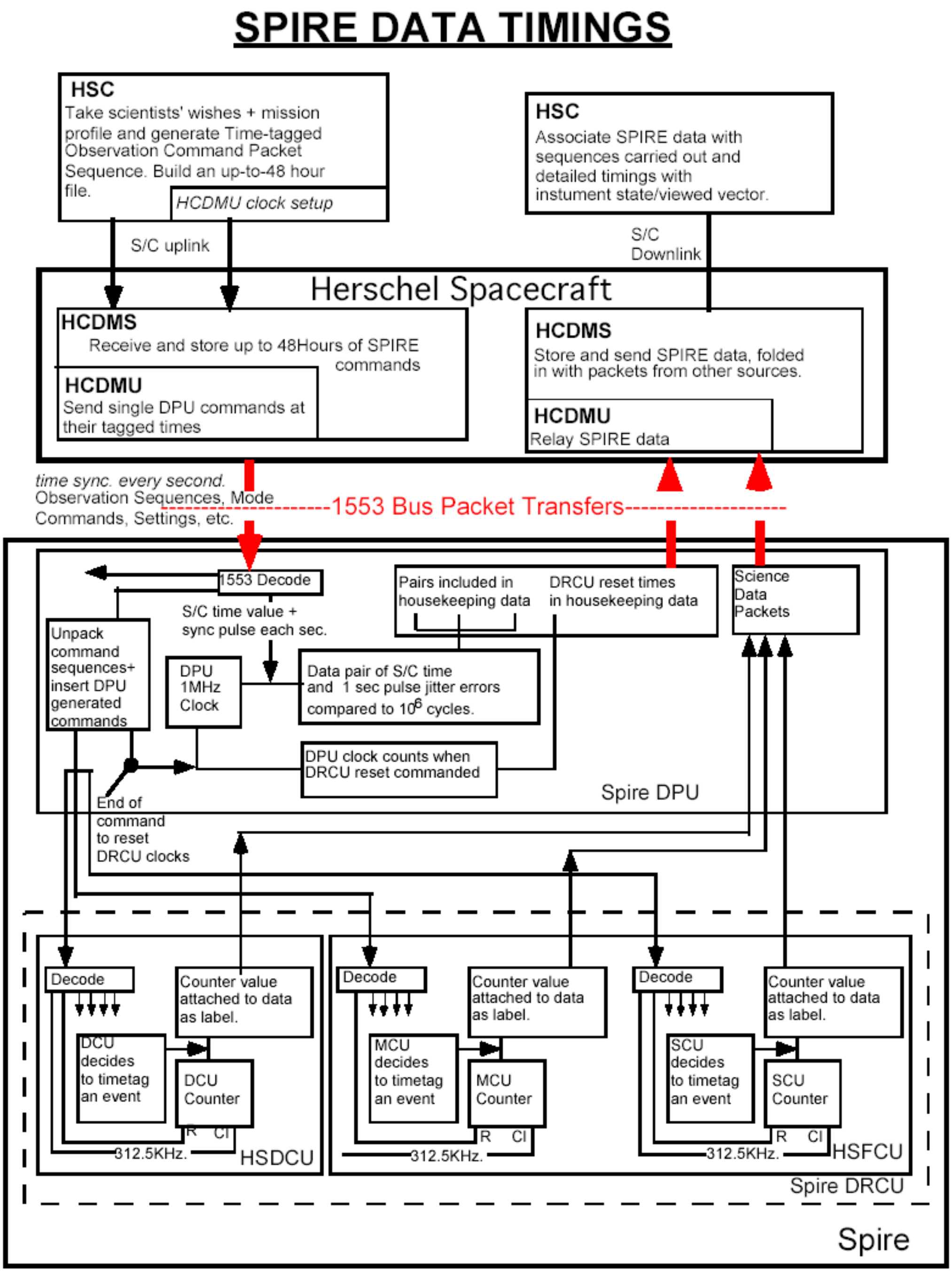


Figure 5.11-1: SPIRE Data Timings

5.11.4 Telecommand

It is assumed that the observation schedule for each 24 hour period will be uplinked during the data transfer and commanding phase (DTCP). It is further assumed that the correct receipt of all Spire commands is verified by the S/C during the DTCP.

Reference **HP-SPIRE-REQ-0210**

The maximum rate of sending command packets from the CDMS to the Spire instrument is less than 10 per second.

*

Reference **HP-SPIRE-REQ-0220**

The maximum telecommand packet length is 256 octets.

*

Reference **HP-SPIRE-REQ-0230**

All Spire telecommands are defined in document RD3.

*

Safe mode: only one (single) command is required by SPIRE to go to safe mode.

5.12 ATTITUDE AND ORBIT CONTROL/POINTING

5.12.1 Attitude and orbit control

For information, Spire has the following **instrument** pointing modes:

- Peak up mode. The ACMS pointing ability quoted in the IID-A (3.7 arcsec APE – see also section 5.12.2) will not be good enough to prevent unacceptable signal loss when observing point sources with the photometer or spectrometer. The Spire beam steering mirror will be used to perform a cruciform raster over the observation target and the offset between the required pointing and the actual pointing of the telescope will be provided via an ACMS Data Packet (TM(5,1) from the Spire instrument to the S/C. The S/C will then adjust the pointing accordingly.
- Nodding mode. If the telescope temperature stability time constant proves to be short compared with a typical pointed observation with Spire; then the telescope must be capable of being pointed to another fixed position on the sky between 10 arcsec and 4 arcmin from the original pointing in an arbitrary direction with respect to the spacecraft axes. The transition time between the 2 position for 4 arcmin apart shall be less than 32s.
- Line scan mode. To map large areas of the sky, the telescope must be capable of being scanned up to 20 degrees at a constant rate in an arbitrary orientation with respect to the spacecraft axes. The rate of scan must be variable between 0.1 arcsec/sec and 60 arcsec per second. It is expected that the RPE will be maintained in the orthogonal direction during the scan. The S/C must be capable of reaching any scan speed up to the maximum within 20 seconds of the observation commencing.
- Raster mode. To finely sample the Spire FOV the instrument beam steering mirror will be used to step the FOV across the sky in an arbitrary direction. The step size will be between 1.7 arcsec and 30 arcsec. The beam steering mirror can also be used to chop a portion of the Spire FOV at a rate up to 2 Hz.
- The S/C is specified as being able to perform its own raster mode, i.e. stepping the FOV of the overall Herschel telescope view to follow predetermined patterns. This is acknowledged to be much less efficient than using the internal Beam Steering Mirror (BSM), but is needed as a backup in the event of Spire BSM failure. The spacecraft shall be capable of performing a rectangular raster with steps of between 2 and 30 arcsec in any arbitrary orientation with respect to the S/C axes.
- To map extended regions using the spectrometer, the Spire instrument will use the Herschel telescope Normal Raster Mode. The instrument may perform fine sampling of each raster pointing using its internal BSM.

5.12.2 Pointing

Reference **HP-SPIRE-REQ-0600**

The Spire instrument requires an absolute pointing error of better than 1.5 arcsec r.m.s. (goal), and a relative pointing error of better than 0.3 arcsec r.m.s. per minute.

#

This is achieved by the peak up mode in case the pointing goal values are not fully achieved by the S/C.

Formatted: Bullets and Numbering

Formatted

Formatted: Bullets and Numbering

Reference HP-SPIRE-REQ-0620

Spire requires to be able to deduce where Herschel is pointing to 0.1 of its smallest pixel IFOV.

#

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

5.12.3 On-Target Flag (OTF)

Reference HP-SPIRE-REQ-0630

For pointed observations, SPIRE requires, an On-Target Flag. It will be provided in the spacecraft telemetry, and will specify the acquisition time to a precision of better than 0.1 second (TBC, to be relaxed). This is required for the correct processing of the Spire data on the ground; it is not required for Spire operations.

#

Formatted

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

5.13 ON-BOARD HARDWARE/SOFTWARE AND AUTONOMY FUNCTIONS

5.13.1 On-board hardware

Formatted

Reference HP-SPIRE-REQ-0640

Formatted: Bullets and Numbering

There is a single on-board computer in each of the prime and redundant SPIRE HSDPUs. Each HSDPU shall have a different 1553 address. The HSDPUs have the only non-hard-coded on-board software used in SPIRE.

#

Formatted: Bullets and Numbering

5.13.2 On-board software

It is assumed that the Spire warm electronics will remain powered during all operational phases. The DPU will download baseline software from ROM during power up but some additional software may be required (TBD) to be unlinked before observations commence, either patches or whole modules/objects.

Reference HP-SPIRE-REQ-0650

No single instrument command nor any sequence of instrument commands will constitute a hazard for the instrument so the HSDPU is required to trap out any such situations. For the same reason, the HSDPU shall ensure its own correct function, at least as far as checking memory function in the background, check-summed read only areas, and an inhibitable SEU safing capability.

#

Formatted: Bullets and Numbering

5.13.3 Autonomy functions

All S/C Autonomy functions are defined in the SPIRE FDIR (SPIRE-RAL-PRJ-001978). They are used either following detection of a problem with the instrument by the S/C - see the SOFDIR (H-P-1-ASPI-SP-0209) - or following receipt of an event packet from the SPIRE instrument.

Reference HP-SPIRE-REQ-0250

Deleted: a

The S/C must be capable of taking predefined action when a particular event packet is received from the SPIRE instrument. Examples of the action to be taken are:

– Switching off the power to the SPIRE instrument (HPFCU and/or HSDPU)
– Stopping/restarting the current instrument sub-schedule
– Inhibiting commands to the instrument
– Sending fixed command sequences to the instrument

*

Reference HP-SPIRE-REQ-0260

Deleted: a

The S/C must be capable of receiving and identifying SPIRE Event Reports (PUS Service Type 5, Subtypes 1, 2 and 4) that will alert the S/C of anomalies detected by the SPIRE DPU autonomy monitoring software.

*

5.13.4 Instrument Autonomy Housekeeping Packet Definition

N.A.

5.13.5 Instrument Event Packet Definition

All event packets are described in the SPIRE Data ICD (SPIRE-RAL-PRJ-001078).

This section details only those instrument event packets which have been identified as requiring action by the S/C.

All events are sent as TM(5,2) 'Exception Reports' (See PS_ICD) with

- APID = 0x0500
- SID = 0x0520
- Parameters A contains the Observation ID and Building Block ID
- Parameters B is not used

The event packets therefore have the following format:

0 0 0 0 1 0x500
1 1 Sequence Count
Length=25
0 0 0 0 0 0 0 0 | 0 0 0 0 0 1 0 1
0 0 0 0 0 0 1 0 | 0 0 0 0 0 0 0 0
Time
Event ID
0x0520
Observation ID
Building Block ID
Event Sequence Counter
Checksum

Event IDs :

The following event IDs have been identified:

- 0xC000 DRCU Anomaly

  The DPU has detected an unrecoverable anomaly in the DRCU.
- 0xC010 DPU Anomaly

  The DPU has detected an unrecoverable anomaly in the DPU.
- 0xC100 Observation Anomaly

  The DPU has detected a problem during an observation.
- 0xC110 Observation Corrected

  The DPU has corrected an observation anomaly

5.14 EMC

The SPIRE instrument is particularly susceptible to EMI due to the fact that the signal to noise ratio of the detector signal is very low for faint astronomical sources. To achieve the required sensitivity dictated by the instrument science requirements, the detector signals need to be integrated for long periods of time. Excess EMI noise on the detector signals will degrade the SNR and lengthen the time required to conduct the observations.

The detector signal can be degraded due to two separate but related effects: (1) direct coupling of DM and or CM EMI voltages into the detector, front-end electronics (JFET Modules) , harness and back-end electronics (DCU), and (2) direct coupling of DM EMI current into the detector inducing I^2R heating of the bolometer. This I^2R heating results in a false detector signal output indistinguishable from the real astronomical signal. These two signal degradation modes are common to all bolometric detection systems.

The overall noise budget for the instrument is contained in the BDA SSSD. This noise budget contains a budget entry for EMI together with the other detector and readout noise sources broken down for each detector array. Due to the fact that: (1) many of the noise sources in the budget are strongly temperature dependent and (2) the detectors must be at operating temperature for I^2R heating effects to be detectable, any EMC testing on the detectors must be carried out with the instrument at the nominal flight operating temperature.

EMI can couple into the detector system via either CS or RS paths. The following elements have been incorporated into the design of the instrument to ensure immunity of the instrument against EMI:

- The entire detector system is enclosed within a Faraday cage comprised of, (1) the chassis of the DCU, (2) the overshield of the instrument cryoharness, (3) the FPU and JFET modules.
- The analogue ground reference for the detectors has a single star point at the chassis of the DCU which minimises EMI currents within the detector elements causing I^2R heating
- The cryoharnesses entering the FPU and JFET modules enter through filtered MDM connectors which attenuate high frequency EMI voltages and improve the overall integrity of the FPU/JFET faraday cage
- The detector signals are readout differentially (with an associated system CMRR specification) to lower the susceptibility to common mode pickup
- Differential JFET amplifiers lower the output impedance of the detectors thereby reducing the susceptibility of the cryoharness to EMI

Formatted: Bullets and Numbering

5.14.1 Conducted Emission/Susceptibility

None to be found under required test conditions

5.14.2 Radiated Emission/Susceptibility

None to be found under required test conditions

5.14.3 Frequency Plan

Reference HP-SPIRE-REQ-0660

Formatted

Formatted: Bullets and Numbering

The Spire frequencies are arranged to minimise noise problems in the bolometer sub-system's highly sensitive analogue sections, and are provided in the following table.

SPIRE Unit	Frequency Source – subsystem	Frequency Range		Wave-form	Signal level(s)		Comments
		Lower	Upper				
DCU	Cmd IF Clock	312 kHz		Rect.	0	5 V	Differential RS422 – Continuous
	Data IF Clock	1MHz	2.5 MHz	Rect	0	5 V	Differential RS422
	Master Clock	10 MHz		Rect		5 V	Crystal Oscillator – Internal to unit
	Bolometer Bias	50 Hz	300 Hz	Sine	0	100 mV	Differential – Highly sensitive signal
	T/C Bias	50 Hz	300 Hz	Sine	0	500 mV	Differential – Highly sensitive signal
MCU	Cmd IF Clock	312 kHz		Rect.	0	5 V	Differential RS422- Continuous
	Data IF Clock	1MHz	2.5 MHz	Rect	0	5 V	Differential RS422
	Master Clock	40 MHz		Rect		5 V	Crystal Oscillator – Internal to unit
	DSP Clock	20 MHz		Rect		5 V	Master clock / 2 - Internal to unit
	LVDTexcitation	2.5 kHz		Sine		3 V	Differential +/- 20 %
	DAC change	3.0 kHz	10 kHz	Rand.		10 V	Internal to unit
	Position encoder	0	2.5 kHz	Sine		3 mV	Differential 250 Hz at nominal speed
SCU	Cmd IF Clock	312 kHz		Rect.	0	5 V	Differential RS422- Continuous
	Data IF Clock	1MHz	2.5 MHz	Rect	0	5 V	Differential RS422
	Master Clock	10 MHz		Rect		5 V	Crystal Oscillator – Internal to unit
	300 mK TS Bias	20 Hz		Rect		6 mV	Tr/Tf = 1ms Highly sensitive signal
	Photo Stimulus	0	5 Hz	Rect			
PSU	DC/DC switching frequency	200 kHz					Free runing - ± 10% - internal to unit

Deleted: 131

Deleted: TBC

Deleted: Note: PSU DC/DC switching frequency to be confirmed/clarified by SPIRE

Table 5.14-1: SPIRE Frequency Plan

#

Formatted: Bullets and Numbering

5.15 Transport and Handling Provisions

5.15.1 Focal Plane Unit

The FPU is a delicate optical instrument and should be handled with extreme care at all time.

Contamination of the optical surfaces within the instrument is prevented by the aperture cover. This cover should remain in place unless it is necessary to remove it.

The bipod legs on two corners of the instrument are very thin section and easily damaged. Care must be taken at all times not to put side loads into these items. These are at risk at all times when the FPU is not attached to a rigid plate. When it is attached to a rigid plate i.e. the HOB or its transport plate then it is tolerant of loads from vibration, lateral expansion, thermal tests, etc.

The SPIRE instrument contains very sensitive detectors that are susceptible to damage by Electro static discharge.

On delivery all connectors will be protected by covers or shorting plugs as appropriate.

When handling, all personnel shall wear anti static protection (wrist straps or other suitable method). When the FPU is not connected electrically to the warm electronics, the chassis is isolated from ground.

5.15.1.1 Transport Container

The Spire FPU (HSFPU) will be transported in a purpose built container that provides environmental protection; the inner bagging or container shall be opened only in the Herschel cleanroom.

The transport container is fitted with shock recorders. The HSFPU transport container is described in RD23.

5.15.1.2 Cooling and Pumping restrictions

Reference **HP-SPIRE-REQ-0700**

During cryostat warm-up or cool-down phases:

Temperatures:

- Above 100 K:
  - o the rate of temperature change dT/dt shall not exceed 5 K/hour (Note 1).
  - o delta T max from L0 to L1 shall not exceed 30K
  - o delta T max from L1 to L2 shall not exceed 20K

  Note 1: tests have shown that higher rates will permanently damage the SMEC
- Below 100K:
  - o the rate of temperature change dT/dt shall not exceed 50 K/hour.
  - o delta T max from L0 to L1 shall not exceed 70K
  - o delta T max from L1 to L2 shall not exceed 50K

#

Formatted
Formatted: Bullets and Numbering
Formatted
Formatted: Bullets and Numbering
Deleted: 20
Formatted
Formatted: Bullets and Numbering

Reference HP-SPIRE-REQ-0710

The rate of depressurisation/pressurisation dP/dt shall not exceed 50 mBar/min

#

Formatted: Bullets and Numbering

5.15.1.3 Mechanism positions

Reference HP-SPIRE-REQ-0720

Formatted: Bullets and Numbering

Formatted

For reasons of possible damage caused by vibration during transport, the spectrometer mechanism (SMEC) will be transported in its launch-latched state

#

Formatted: Bullets and Numbering

There are no limitations on any other mechanism

5.15.1.4 Unpacking Procedure

The procedure for removing and installing the HSFPU from its transport container is given in document RD 23

5.15.2 JFET/Filter Boxes

5.15.2.1 Transport Container

The Spire JFET/Filter Boxes (HSFTP/S) will be transported in the same container as the FPU.

5.15.2.2 Unpacking Procedure

The procedure for removing and installing the HSFTP/S from its transport container is given in document RD 23

5.15.3 Electronics Units

5.15.3.1 Transport Container

Reference HP-SPIRE-REQ-0740

The Spire warm electronics units (HSDPU; HSFCU; HSDCU, HSWIH) will be transported in a purpose built container that provides environmental protection. Containers to be opened only in class 100 000 clean conditions.

#

Formatted: Bullets and Numbering

The transport containers are fitted with shock recorders .

5.15.3.2 Unpacking Procedure

The procedures for removing and installing the Spire from warm electronics units their transport containers will be supplied with the instrument EIDP

5.16 DELIVERABLE ITEMS

5.16.1 Instrument Models.

5.16.1.1 AVM – The Avionics Model

This is an electrical model of the SPIRE instrument and will allow the electrical and software interfaces between the SPIRE instrument and the spacecraft to be validated. This will include the capability of testing the SPIRE autonomy functions and any exchange of information required between the spacecraft and SPIRE for any SPIRE operational mode.

This model comprises the following units:

- DPU (AVM1)
- DRCU simulator
- Test harness

The DPU will have the full functionality of the flight version but it will be built with commercial grade parts and will not have redundant systems fitted. It will be identical in external form and fit to the flight unit.

The DRCU simulator will be a computer with interface cards to the DPU that is capable of receiving commands from the DPU and returning realistic data to mimic the operation of the DCU, FCU, cold FPU and JFET boxes.

A test harness will be supplied by SPIRE to connect the DPU and DRCU simulator

NOTE. The DPU AVM1 is the same unit as used in the CQM.

5.16.1.2 CQM - Cryogenic Qualification Model

This is a model of the instrument that will be used to characterise and verify the instrument scientific performance with functionally representative cold sub-systems and warm electronics units. Not all the cold FPU units will be functional, see below. The purpose of the CQM is to verify that the design of the PFM will be capable of meeting the instrument level performance requirements and that the instrument is compatible with integration into the Herschel satellite.

This model comprises the following units:

- FPU (CQM)
- Spectrometer JFET assembly
- Photometer JFET assembly
- DPU (AVM1)
- DCU (QM1)
- FCU (QM1)
- Power supply (bench power supply)
- WIH
- Fixings etc.

Formatted: Bullets and Numbering

Formatted

JFET fixation hardware:

- Isolation washers, special screws and studs

Thermal strap fixation hardware:

- L3:
  - Pressure plates 2-off
- L1:
  - Screws and isolating bushes:
    - M8 2off,
    - M3 4off

    (these screws will be prepared for wire locking)
  - Wire for locking above screws.
  - M4 non isolating bushes for the vent line end of the strap 16 off

Connector savers, safe plugs, covers etc

- Savers will not be supplied with the CQM JFETS
- Safe plugs will be supplied fitted to the CQM in the active connectors only.
- Aperture cover (red tag item)
- Alignment cube.

Note1: according IIDA section 5.10.1.2 « Flight-quality connectors shall be protected against frequent mating/demating operations by connector savers. These savers shall be supplied with the instrument»

The FPU will be as per the PFM with the following exceptions:

Only the PLW detector will be fitted, all other detectors will be mass thermal dummies.

The SMEC (spectrometer mechanism) will be a non functioning structural/thermal dummy.

The BSM (beam steering mechanism) will be a non functioning structural/thermal dummy.

Only the PLW JFET will be fitted, the other JFETs will be mass thermal dummies.

The thermal isolating supports on both the FPU and the detector boxes will be stainless steel whereas it is planned to fit CFRP supports for improved thermal isolation to the PFM.

The DPU will have the full functionality of the flight version but it will be built with commercial grade parts and will not have redundant systems fitted. It will be identical in external form and fit to the flight unit.

The DCU and FCU (which together form the DRCU) will not be form and fit compatible with the PFM. They will be built using commercial or MIL spec components and will have the functionality of the PFM, but no redundancy will be incorporated.

The power supply is required to power the FCU as no DC/DC converter will be available for this model.

This power supply is a mains powered (220-240v 50 Hz) and its approximate dimensions are 550x550x350 mm (LWH), its mass is 45Kg.

Note 2: Concerning AVM/QM, if connectors layout is not identical to FM , the instrument shall deliver with AVM/QM unit all necessary devices (like extensions, ...) in order to connect the FM-like Cryo and SVM harnesses (or QM baseline specific cryo-harness when exist) to the concerned AVM/QM unit.

List of equipment necessary to perform EQM/PFM test programme.

Formatted

Not listed above:

Equipment	Supplied by	Remarks
Specialised tools	SPIRE	Any non standard tools, e.g. non metric spanners etc will be supplied by SPIRE, all interface fasteners are metric
28v power supply	ASED	for DPU
Break out box	SPIRE	For testing JFETs and BDAs
Mulit meter	SPIRE	For testing JFETs and BDAs And continuity/isolation tests
Shorting plugs	ASED	For cryo harness when warm units not connected
Connection to crane	ASED	From small shackle on SPIRE MGSE to crane hook
HYDRA set	ASED	For fine lifting adjustment

Table 5.16.1-1: List of equipment necessary to perform EQM/PFM test programme

Formatted

5.16.1.3 PFM- Proto-Flight Model

This will be the model that is intended for flight, built to full flight standards.

Deleted: Initially it will be delivered with the QM2 FCU and DCU. These units will be fully functional, be form and fit compatible, but will not contain full flight standard (HI-REL) components. The FCU will be delivered with the PFM power supply fitted.¶
The PFM FCU and DCU will be delivered later and the power supply will be transferred from the QM2 to the PFM.¶
Note 1: The late delivery of SPIRE FCU and DCU PFM is not the baseline for industry, as the complete set of SPIRE instrument units (cold and warm) should be delivered together. This is still to be fixed and agreed for all schedule and financial aspects

This model comprises the following units:

- FPU
- Spectrometer JFET assembly
- Photometer JFET assembly
- DPU
- DCU
- FCU
- WIH
- Fixings etc.

Formatted: Bullets and Numbering

JFET fixation hardware:

- Isolation washers, special screws and studs

Thermal strap fixation hardware:

- L3:
  - Pressure plates 2-off
- L1:
  - Screws and isolating bushes:
    - M8 2off,
    - M3 4off

    (these screws will be prepared for wire locking)
  - Wire for locking above screws.
  - M4 non isolating bushes for the vent line end of the strap 16 off

Connector savers, safe plugs, covers etc

- Savers will be supplied fitted to all units
- Safe plugs will be supplied fitted to the JFETS bias lines. Note these connectors will not be fitted with savers as well as safe plugs, as these will be subject to very limited mate/demate cycles at S/C level.
- Aperture cover (red tag item)
- Alignment cube.

Deleted: with the PFM for WU only

Deleted: PFM in the active connectors only

Note 2: according IIDA section 5.10.1.2 « Flight-quality connectors shall be protected against frequent mating/demating operations by connector savers. These savers shall be supplied with the instrument»

5.16.1.4 FS – Flight Spare

The flight spare cold FPU will be made from the refurbished CQM. The flight spare warm electronics will consist of spare electronics cards/modules/harness.

5.16.1.5 Hardware deliverable matrix

The SPIRE Hardware deliverable matrix is given by the following tables:

Unit: HSFPU Subsystem / component	AVM	CQM	PFM
Structure/baffles/wiring standoffs etc	none	Flight Representative structural components	Flight
L0 straps	none	Detector boxes –protoflight design Cooler –protoflight design	Flight
Mirrors	none	All mirrors fitted - protoflight design	Flight
Filters	none	CFIL-1 – flight representative PFIL-2 – flight representative PFIL-3 – flight representative PDIC-1 – flight representative PDIC-2 – flight representative SFIL-2-- flight representative SBS-1- not fitted SBS-2- mass dummy SFIL-3-S- flight representative SFIL-3-L - flight representative	Flight
Beam steering mirror	none	STM	Flight
^{3}He Cooler	none	Flight representative (CQM)	Flight
300 mK thermal straps and supports	none	Flight representative with 0.29 mm Kevlar on “in line” mounts	Flight
300 mK Thermal control system	none	Not fitted	Flight
Photometer LW array	none	Flight representative (CQM)	Flight
Photometer MW array	none	Unsuspended STM	Flight
Photometer SW array	none	Unsuspended STM	Flight
SMEC	none	STM	Flight
Spectrometer SW array	none	Unsuspended STM	Flight
Spectrometer LW array	none	Unsuspended STM	Flight
Photometer Calibrator	none	CQM	Flight
Spectrometer Calibrator	none	CQM	Flight
FPU RF Filters	none	Flight representative box and connectors	Flight
Thermometry	none	Flight representative	Flight

Unit: HSFPU Subsystem / component	AVM	CQM	PFM
FPU internal harnesses	none	Flight representative	Flight

Table 5.16-1: HSFPU Hardware Matrix

Unit: HSJFP Subsystem / component	AVM	CQM	PFM
JFET Structure	none	Flight representative	Flight
JFET Modules	none	One 48 channel module flight representative Rest STMs	Flight
JFET Backharness	none	Flight representative	Flight
JFET/FPU Harness	none	Flight representative	Flight

Table 5.16-2: HSJFP Hardware Matrix

Unit: HSJFS Subsystem / component	AVM	CQM	PFM
JFET Structure	none	Flight representative	Flight
JFET Modules	none	Both STM	Flight
JFET Backharness	none	Flight representative	Flight
JFET/FPU Harness	none	Flight representative	Flight

Table 5.16-3: HSJFS Hardware Matrix

Unit: HSDCU Subsystem / component	AVM	CQM (QM1)	PFM QM2	PFM
DCU Structure	Simulator only	Non Flight representative	Flight representative	Flight
Electrical Interfaces	Simulator only	Flight representative	Flight representative	Flight
Functionality	Simulator only	48 LIA-P channels functional DPU interface functional no redundancy	Flight representative	Flight
Electrical Component Level	NA	Commercial/industrial	MIL spec	Flight

Table 5.16-4: HSDCU Hardware Matrix

Unit: HSFCU Subsystem / component	AVM	CQM	PFM QM2	PFM
FCU Structure		Non Flight representative	Flight representative	Flight
MCU		QM1 Fitted		Flight
Electrical Interfaces	Simulator only	Flight representative	Flight representative	Flight
Functionality	Simulator only	Flight representative (no redundancy)	Flight representative	Flight
Electrical Component Level	NA	Commercial/industrial	MIL spec	Flight
SCU		QM1 Fitted	Flight representative	Flight
Electrical Interfaces	Simulator only	Flight representative	Flight representative	Flight
Functionality	Simulator only	Flight representative (no redundancy)	Flight representative	Flight
Electrical Component Level	NA	Commercial/industrial	MIL spec	Flight
PSU		Not fitted – replaced by EGSE “Power Bench”	Flight	Flight
Electrical Interfaces	Simulator only	N/A	Flight	Flight
Functionality	Simulator only	N/A	Flight	Flight
Electrical Component Level	NA	N/A	Flight	Flight

Table 5.16-5: HSFCU Hardware Matrix

Unit: HSDPU Subsystem / component	AVM (AVM1)	CQM	PFM
DPU Structure	Flight representative	Flight representative	Flight
Electrical Interfaces	Flight representative	Flight representative	Flight
Functionality	Flight representative-No redundancy	Flight representative-No redundancy	Flight
Electrical Component Level	Commercial/industrial	Commercial/industrial	Flight

Table 5.16-6: HSDPU Hardware Matrix

Unit: HSWIH Subsystem / component	AVM	CQM	PFM
WIH Mechanical form	Test leads to connect DPU to	Flight representative	Flight
Electrical Interfaces		Flight representative	Flight

Unit: HSWIH Subsystem / component	AVM	CQM	PFM
Functionality	simulators	Flight representative (no redundancy required)	Flight
Electrical Component Level	Commercial/industrial	Flight representative	Flight

Table 5.16-7: HSWIH (Warm interconnect harness) Hardware Matrix

5.16.2 Electrical Ground Support Equipment (EGSE)

Electrical Ground Support Equipment (EGSE) will be needed to provide Spire instrument level monitoring during instrument integration with the S/C and system level testing.

A full description of EGSE can be found in RD22 (The Instrument EGSE for Herschel Integrated System Tests)

Deliverables:

- FPU electrical simulator, including simulation of the HSFTP/S (JFET/Filter Boxes), to enable integration of the HSDCU,HSDPU, HSFCFU and HSWIH
- Quick Look Facility to enable testing of the instrument at system level. This will interface to the S/C test environment
- Common instrument EGSE

5.16.3 Mechanical Ground Support Equipment (MGSE)

MGSE is required to ensure safe handling of all instrument components during assembly integration and test procedures. Further details can be found in RD 23 (SPIRE FPU Handling and Integration Procedure)

MGSE ICD is given in annex 1.

Deliverables:

- Transport containers
  - FPU and JFETs
  - DPU
  - DCU
  - FCU
- FPU handling/lifting frames
  - FPU on transportation baseplate
  - FPU on its own

5.16.4 Optical Ground Support Equipment (OGSE)

The SPIRE FPU will be supplied with an alignment cube to allow an alignment check on the HOB to be carried out

This SPIRE alignment cube can be removed and replaced such that the alignment is still valid

Deliverables:

- Alignment cube : included in FPU ICD in Annex 1

5.16.5 System Test Software

Will be based on the Quick Look Facility - computers and software that allow the monitoring in near real time of the instrument housekeeping parameters and instrument data. This is the basic facility to be used for the ICC operations monitoring for the monitoring of the instrument in-orbit. The same facility with enhanced capabilities will be used for the ground tests and in-orbit check out of the instrument.

5.16.6 Hardware for the Observatory Ground Segment

Quick Look Facility for the Mission Operations Centre for instrument in-flight commissioning. This will consist of an identical system to that used for instrument system level testing

5.16.7 Software for the Observatory Ground Segment

The software for the Quick Look Facility will be delivered to the MOC for instrument in-flight commissioning.

5.16.8 Instrument Software Simulator

An instrument software simulator will be produced

5.16.9 Test Reference Data

The Spire instrument test reference data will be delivered in the form generated during instrument and system level testing.

5.16.10 Instrument Characterisation Data

The Spire instrument characterisation data will be delivered in the form generated during instrument and system level testing..

5.16.11 Technical Documentation

The following documents will be delivered:

- Instrument User Manual following the requirements laid down in the OIRD (AD3)
- Instrument database – this will be delivered in the form generated during instrument and system level testing.
- Each instrument model will be delivered with an End Item Data Package in accordance with RD 7 (SPIRE PA Plan)

6. GROUND SUPPORT EQUIPMENT

6.1 MECHANICAL GROUND SUPPORT EQUIPMENT

MGSE is required to ensure safe handling of all instrument components during assembly integration and test procedures. Further details can be found in RD 23 (SPIRE FPU Handling and Integration Procedure).

A list of MGSE supplied equipment can be found in section 5.16.3 of present IIDB

6.2 ELECTRICAL GROUND SUPPORT EQUIPMENT

After delivery of the Herschel instruments to industry they will be integrated on to the payload/spacecraft and tested as part of the verification activities of the integrated system. Instrument testing requires the participation of the instrument teams in order to verify the correct operation of their instrument and to do this they will use a set of equipment delivered and integrated into the system-level test system. This equipment has been labelled the 'Instrument Station' in earlier documentation, even though it will consist of several workstations and associated peripherals. To clarify this situation, the equipment is now called the Instrument EGSE (IEGSE).

The SPIRE EGSE is fully described in RD 22 (The Instrument EGSE for Herschel Integrated System Tests)

A list of EGSE supplied equipment can be found in section 5.16.2 of present IIDB

6.3 COMMONALITY

Taking into account that it is a fundamental design goal of the Herschel/Planck mission that commonality should be pursued to the maximum extent possible, the Herschel instrument teams have been actively engaged in investigating such possibilities.

6.3.1 EGSE

A common EGSE system has been developed as a collaborative effort between instrument groups.

In addition, it has been agreed that this system would be applicable at various times during all the phases of the mission listed below:

- Subsystem Level Testing
- Instrument Level Testing
- Module and System Level Testing
- In-orbit instrument commissioning
- Performance Verification
- Routine operations

In the interests of minimising the cost and maximising the reliability of such a system through the different phases the EGSE will:

- be based on SCOS 2000 – this system will be used in the ground segment by the MOC for controlling the satellite. The cost of the system (essentially free), its proven use in similar situations for other space projects and the support provided by ESOC, contribute to a cheaper and more reliable system.

– use the same interfaces between the EGSE and other systems, in order to improve reliability through reuse throughout the mission.
– Provide a constant implementation of the
  - Man Machine Interfaces
  - Data Archiving and Distribution facilities
  - On-board Software Management
  - On-board Maintenance (e.g. Software Development Environment, Software Validation Facility)
  - Common User Language (for Test procedures and in-orbit operations)

6.3.2 Instrument Control and Data Handling

All three Herschel instruments are using the same supplier (IFSI) for their on-board control and data handling hardware and software systems, which interface to the spacecraft. This has ensured commonality in the areas of;

– on-board microprocessors
– instrument internal interfaces
– On-board Programming language
– Software Development Environments
– Software Validation Facilities

In addition, the on-board software provides commonality in its non instrument-specific functions. A common instrument commanding scheme has also been agreed and will be implemented by the instrument teams.

6.3.3 Other areas

Other areas of possible commonality will be addressed by working groups set up as and when necessary. These may cover:

– Follow-up on Herschel Common Science System data archive activities
– A common approach to IA/QLA systems

7. INTEGRATION, TESTING AND OPERATIONS

Information in this chapter covers all instrument-related activities after the acceptance of SPIRE by ESA and its handover to the Contractor.

7.1 Integration

Integration is described in the SPIRE structure assembly, integration and handling plan RD32

Deleted: Procedures detailing the individual integration steps will be prepared and reviewed in due time

7.1.1 HPLM Integration

Integration of the SPIRE FPU onto the HPLM is described in RD23

7.1.2 PPLM Integration

NA

7.1.3 SVM Integration

Reference HP-SPIRE-REQ-0770

Formatted: Bullets and Numbering

Formatted

The SVM warm units shall be first integrated as panels, and the SPIRE units linked by warm Spire warm harness. See RD 28

#

Formatted: Bullets and Numbering

7.1.4 Herschel/Planck Integration

Precautions listed in RD23 to be taken into account during all activities

7.2 Testing

After completion of the integration, be it at the level of the FPLM, PPLM, SVM or Herschel/Planck, a series of verification tests will be carried-out.

Reference HP-SPIRE-REQ-0780

Formatted: Bullets and Numbering

Formatted

Each test will be defined in detail in a test procedure to be written by the Contractor, based on instrument group inputs. It will be reviewed and approved by the Herschel/Planck project group.

#

Formatted: Bullets and Numbering

7.2.1 EQM Testing (SPIRE CQM)

Details of testing at EQM level can be found in RD24 (EQM test plan), and its associated applicable/reference documents

7.2.2 PFM Testing

The PFM system level test procedures for SPIRE will be based on those carried out on the EQM. A separate document will be issued by SPIRE. It is expected that they will be for instrument and system verification and validation purposes only as the CQM testing will have addressed all fundamental operational issues. The sequencing and test environment requirements for the PFM testing will be the same, or very similar, as for the CQM testing.

7.2.3 *Thermal on ground Test*

See RD33 (QM thermal test specification (SPIRE-RAL-NOT-002319).

Deleted: 24
Deleted: (EQM test plan)
Deleted:

7.2.4 *EQM and PFM tests list*

The list of TRS (test requirement sheets) of table here after is extracted from applicable documents of IIDA: AD 13 (HP-2-ASED-PL-0021_2_0 - Instrument testing at HPLM EQM level), and AD 14 (HP-2-ASED-PL-0031_1_0 - Instrument testing at HPLM FM level)

Instrument testing on PLM EQM Level HP-2-ASED-PL-0021		Instrument testing on PLM PFM & S/C Level HP-2-ASED-PL-0031	
TRS ref	TRS title	TRS ref	TRS title
11.1.1	Instrument EGSE Check Out SPIRE	10.1.3	Instrument EGSE Check Out SPIRE
11.2.5	SPIRE Short Functional Test Warm	10.2.5	SPIRE Short Functional Test Warm
11.2.6	SPIRE Short Functional Test Cold	10.2.6	SPIRE Short Functional Test Cold
11.3.9	SPIRE Cooler Recycle	10.3.9	SPIRE Cooler Recycle
11.3.11	SPIRE Ambient Background Verification	10.3.10	SPIRE Ambient Background Verification
11.3.10	SPIRE Photometer Chop Mode	10.3.11	SPIRE Photometer Mode
		10.3.12	SPIRE Spectrometer Mode
11.3.12	SPIRE PACS/SPIRE Parallel Mode	10.3.13	SPIRE PACS/SPIRE Parallel Mode
11.4.3	SPIRE Integrated Module Test	10.4.3	SPIRE Integrated Module Test/IST
11.5.3	SPIRE EMC Test	10.5.3	SPIRE EMC Test
		10.6.3	SPIRE TB/TV Test
		10.7.3	SPIRE SVT Test

Table 7.2-1: SPIRE Instrument testing

7.3 Operations

Covered in other applicable documentation as follows:

AD3 Herschel/Planck Operations Interface Requirements Document (OIRD)

AD 4 Herschel Science-operations Implementation Requirements Document (Herschel-SIRD)

7.4 Commonality

The SPIRE system level integration and test programme is compatible with that laid out in the IID-A chapter 7.

8. PRODUCT ASSURANCE

The instrument will comply with the ‘Product Assurance Requirements for Herschel/Planck Scientific Instruments’ (AD2).

Details are to be found in SPIRE Product Assurance Plan (RD7).

9. DEVELOPMENT AND VERIFICATION

9.1 General

Further details can be found in RD25 (SPIRE Instrument Qualification Requirements)

These are guidelines that will be followed in constructing the instrument AIV programme:

- The instrument will be fully tested in compliance with the satellite level AIV plans as set out in the IID part A and reference documents therein.
- The AIV flow will be designed to allow the experience gained on each model to be fed into both the design and construction of the next model and into the AIV procedures to be followed for the next model.
- A cold test facility to house the instrument will be constructed that will represent as nearly as possible the conditions and interfaces within the Herschel cryostat.
- The instrument Quick Look Facility and commanding environment will be the same or accurately simulate the in-flight environment to facilitate the re-use of test command scripts and data analysis tools during in-flight operations.
- The EGSE and instrument Quick Look Facility will interface to HCSS.
- Personnel from the ICC will be used to conduct the instrument functional checkout to allow an early experience of the instrument operations and to facilitate the transfer of expertise from the ground test team to the in-flight operations team.
- A more detailed description of the system level AIV sequence is given in reference document RD4. This document will form the basis of the *Herschel* SPIRE *Instrument Test Plan,* which will provide the baseline instrument test plans and detailed procedures and will be submitted to ESA for approval.
- Detailed procedures for the sub-system level AIV will be produced by all sub-system responsible groups.
- Sub-systems will undergo individual qualification or acceptance programmes before integration into the instrument.
- Sub-systems will be operationally and functionally checked at the appropriate level before integration into the instrument.

9.2 Model Philosophy

The model philosophy to be adopted bythe SPIRE instrument will as described in RD6 (SPIRE AIV Plan). The instrument models to be produced are:

- AVM - Avionics Model. (*)
- SM - Structural Model
- AM – Alignment Model
- CQM - Cryogenic Qualification Model. (*)
- PFM 1 - Proto Flight Model , build 1
- PFM 2 - Proto Flight Model, build 2 (*)
- FS - Flight Spare. (*)

See section 5.16.1 for more details

Only models marked (*) are delivered to ESA or their contractor.

9.3 Mechanical Verification

Subsystems will be mechanically verified by a combination of analysis and test.

Qualification model subsystems will be subjected to vibration tests at ambient and cold temperatures at qualification levels and durations. At sub-system level only, cold testing in all three axis may not be possible, in that case the most sensitive axis or the axis with the highest input will be used.

Subsystem test levels will be derived from analysis of the FPU which will be refined after vibration tests on the SM and CQM models.

The FPU will be verified by a combination of analysis and test.

Vibration testing will be carried out on the structural model (SM) at ambient temperature at RAL, and on the CQM at cryogenic temperature in the dedicated facility at CSL.

The PFM FPU will also be subjected to a cold vibration test.

Test levels will be agreed between the SPIRE project and ESA before the test.

Warm electronics boxes will be vibrated at ambient temperature only, as specified in AD 1 (IIDA).

9.4 Thermal Verification

FPU

An extensive programme of thermal analysis will be performed at FPU level and combined with the Herschel cryostat model.

The thermal design will be validated by testing in a purpose built test cryostat at RAL. This facility will be able to simulate an environment close to that of the spacecraft in orbit.

Warm units

These will be subjected to a traditional thermal vacuum test programme using qualification temperatures on the qualification models and acceptance temperatures on the flight models, as specified in AD 1 (IIDA)

9.5 Verification of Scientific Performance

Extensive testing and calibration will be carried out in the test facility.

Each model will be subjected to a set of tests as described in that model test specification.

This will result in all criteria as specified in the RD2 being verified.

Full calibration as described in RD26 (Calibration Requirements Document), will be carried out on the flight model.

9.6 Electrical Testing

Electrical functional and performance testing will be carried out on units at subsystem and instrument levels.

All interfaces will be verified at subsystem and instrument level.

9.7 EMC Testing

Details of EMC testing can be found in RD27, CQM Instrument Level EMC Test Specification.

9.8 Verification matrix

The SPIRE Verification matrix Is given by the table 9.8-1 here after:

Model	Unit	Vibration	Shock	Thermal	Performance	Functional	El in		
AVM	DPU (AVM1)	no	no	no	yes	yes			
SM	FPU	Warm only	no	no	no	no			
AM	FPU	no	no	no	Warm and cold alignment verification	no			
CQM	FPU	Ambient and cold Qual	no	yes	Yes limited to PLW detector channel	yes			
	JFET	Ambient and cold Qual	no	yes	Yes limited to PLW detector channel	yes			
	DPU (AVM1)	no	no	no	Yes	Yes			
	FCU (QM1)	no	no	no	Yes	Yes			
	DCU (QM1)	no	no	no	yes	yes			
QM	DPU (QM)	Qual	no	TV qual	yes	yes			
non	FCU (QM2)	Qual	yes	TV qual	yes	yes			
deliverable	DCU (QM2)	Qual	yes	TV qual	yes	yes			
PFM	FPU	Acceptance cold	no	Yes	yes	yes			
	JFET	Acceptance cold	no	Yes	yes	yes			

Model	Unit	Vibration	Shock	Thermal	Performance	Functional	El in		
	DPU	acceptance	no	TV acceptance	yes	yes			
	FCU	acceptance	no	TV acceptance	yes	yes			
	DCU	acceptance	no	TV acceptance	yes	yes			

Table 9.8-1: SPIRE Verification matrix

10. MANAGEMENT, PROGRAMME, SCHEDULE

All relevant information can be found in the SPIRE Management Plan, RD4.

A1 . ANNEX 1: SPIRE UNITS ICD

A1.1 Drawings configuration and Industry comments

Note: Concerning mass and power (dissipation and load) the tables of sections 5.5 and 5.9 take precedence on values indicated (or not) in all these ICD's

From SPIRE-RAL-DWD-001409 - Issue 14 – February 2006

Unit	CR (*)	Drawing ref/number	Issue	Date	Notes & Comments
DPU FM	TBD	20-SPIRE-00.02	/	24/01/06	New FM (previous ICD was QM) Coating is Black anodise ICD to be officially agreed with CR to be issued
DCU	NA	SPIR-MX-5100 000	G	08/2004	Changes versus iss E: only added informations (base plate height 4mm, position Xp-Zp of on top connectors, position Xp 470mm of fixation hole)
FCU	NA	SPIR-MX-5200 000	K	08/2004	Changes versus iss J: only added informations (base plate height 4mm, position Xp of on top connectors, position Xp 350mm of fixation hole)
DPU QM/AVM	NA	HER S005/03	4	23-02-03	No change versus IIDB 3.3 and 3.2 (Idem since ICD pack issue 8). This ICD is no more used as FM ICD.
DCU QM1	NA	SPIR-MX-5101 000	A	02/12/02	No change versus IIDB 3.3, Same drw as in pack iss 11
FCU QM1	NA	SPIR-MX-5201 000	C	08/09/03	No change versus IIDB 3.3, Same drw as in pack iss 11
FPU (SPIRE IF)	NA	A1 5264 300 sheets 1 to 7	20	08/09/05	Changes versus ICD iss 19: see change list, agreed by ASED
2 JFET	NA	0-KE-0104-360	L	05/08/05	Changes versus iss K: see change list, agreed by ASED
6 JFET	NA	0-KE-0104-350	J	05/08/05	Changes versus iss H: see change list, agreed by ASED

Formatted: Bullets and Numbering
Deleted: ICD issue 11
Formatted
Deleted:
Formatted
Deleted: ¶
Formatted
Formatted

Unit	CR (*)	Drawing ref/number	Issue	Date	Notes & Comments
MGSE	NA	A1 5264 404 sheet 4, sheet 6 and sheet 7	3 9 9	26/03/04 23/09/05 23/09/05	3 new sheets agreed by ASED

(*) SPIRE CR's versus SPIRE IIDB 3.3

Table A1-1: SPIRE Drawings configuration

A1.2 Set of drawings SPIRE-RAL-DWD-001409 - Issue 13 – October 2005

All ICD's, drawings and associated change records are attached here after

Formatted

Deleted: (*) FPU and MGSE ICD's and drawings listed in this table and included in this annex 1 shall be updated by SPIRE according here under ASED comments and SPIRE answer and agreement here after:¶
1. ASED comments: ¶
Extract from fax ASED HP-ASED-FX-0316-04 dated 10/05/04: Fast Loop Assessment HP-SP-RAL-ECR-068 IID-B SPIRE Mechanical Interface Drawings, SPIRE-RAL-DWG-001409, Update to Issue 11¶
SPIRE FPU: ¶
Sheet 1: Mass properties (mass, CoG and MOI) updated. Updates acceptable, but note that update of the FPU MTD design is considered to be not necessary. The SPIRE FPU MTD will be provided with mass properties, as in Issue 18.¶
Sheet 5: L0 thermal strap interfaces updated as agreed with one exception. L0 flexstrap clearance holes shall be 5.0mm and not 4.5mm. See also ASED comments in HP-ASED-EM-0740-03, dated 28/11/03¶
Sheet 5: L1 thermal strap interfaces: Agreed interface may be changed to implement electrical insulation at FPU side. Updated IF drawings are urgently awaited by ASED.¶
Sheet 6: Harness stay-out areas updated. Updates acceptable to ASED.¶
FPU/JFET MGSE: ¶
<#>It shall be noted that the proposed MGSE is a deviation from the current baseline, which assumed that the SPIRE FPU and the JFETs are integrated independently. EADS Astrium reserves the right to raise ECP, if the detailed analysis revealed an increased required effort.¶
<#>The assumptions and comments made in HP-ASED-EM-0231-04 are still valid concerning the provided MGSE drawings. As the MGSE I/F drawings ... [1]

Formatted: Bullets and Numbering

Formatted: Bullets and Numbering

A2 . ANNEX 2: SPIRE REDUCED TMM

SPIRE Reduced TMM Issue 2.5

Formatted

Formatted

Note : SPIRE reduced TMM Issue 2.5 should be updated by SPIRE, but new TMM issue was not available when issuing the present IIDB issue 4.

The SPIRE reduced TMM Issue 2.5 diagram is given by the figure here under:

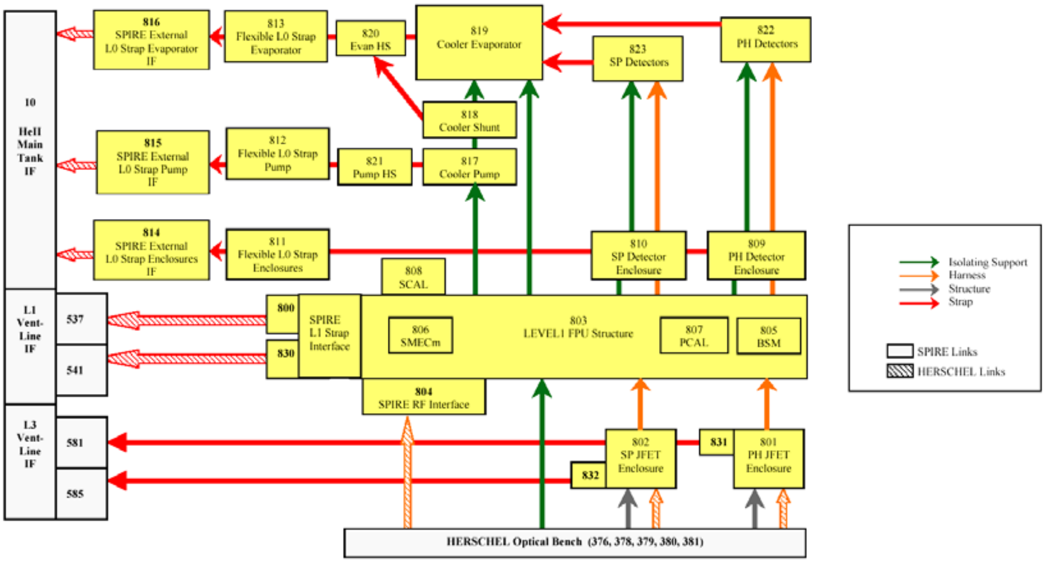


Figure 1: SPIRE ITMM OVERVIEW

The SPIRE reduced TMM Issue 2.5 is given by the pages here after:

Formatted: Bullets and Numbering

Formatted

A3 . ANNEX 3: DESCRIPTION OF THE OPERATIONS OF THE 3HE SORPTION COOLER

Description of the Operation of the ^3He Sorption Cooler

The ^3He cooler is produced for Spire and PACS by SBT/CEA, Grenoble, who own the intellectual information in this annex. The cooler is specified in SBT documents HSO-SBT-SP-001-3-3 and HSO-SBT-TNS-2; its interfaces internal to Spire are controlled via HSO-SBT-ICD-012-1-3.

The cooler's internal thermal configuration is as follows:

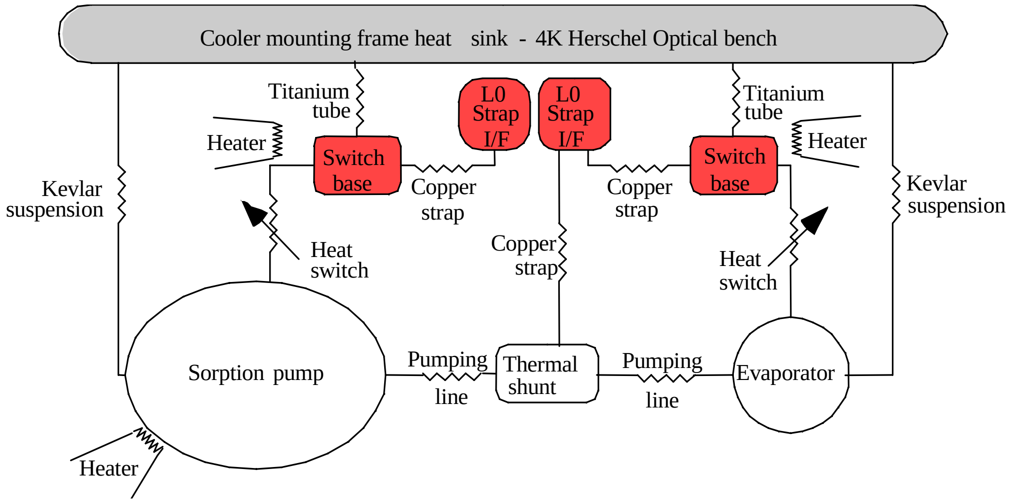


Figure 1: SPIRE Sorption cooler

The cooler is hermetically closed and does not have a lifetime limited by its cryogen boil-off. However it cannot cool continuously but rather it needs to be re-generated regularly. This regeneration energy cycle is a small but significant contribution to the total dissipation within the Herschel cryostat.

When operational, Spire runs a 48 hour ^3He cooler cycle, 46 hours with Spire's detectors cooled to «300mK» and 2 hours recycling. This fits in with Herschel ground commanding periods.

When at «300mK», the temperature at the cooler's evaporator is to a very good approximation a single valued function of gross applied load on its evaporator, i.e. available/net cooling power PLUS the cooler's internal parasitics. The cooling is simply due to the physical process of evaporation along the cooler's «pumping line» geometry(see above figure). The function is shown below in figure 2) which is derived by offsetting curves of tip temperature v. load that have been measured at different L1 and hence parasistics. A puzzling factor is that the TRP 4 litre contract showed this characteristic to be independent of attitude but under test the function for the 6 litre units shows some dependency on attitude.

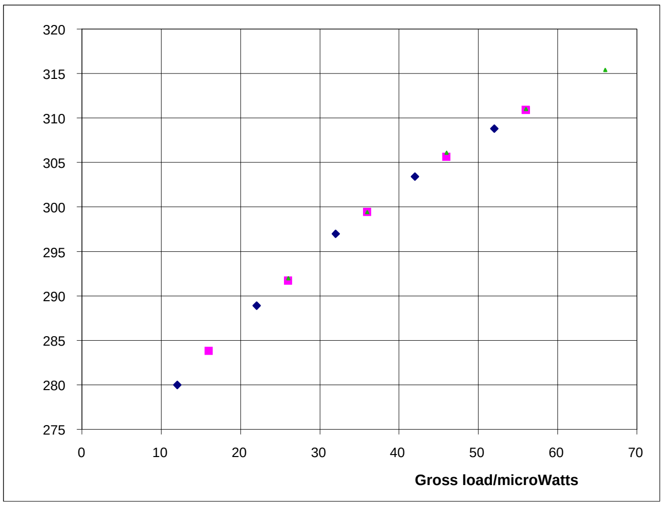


Figure 2: Evaporator temperature vs total load

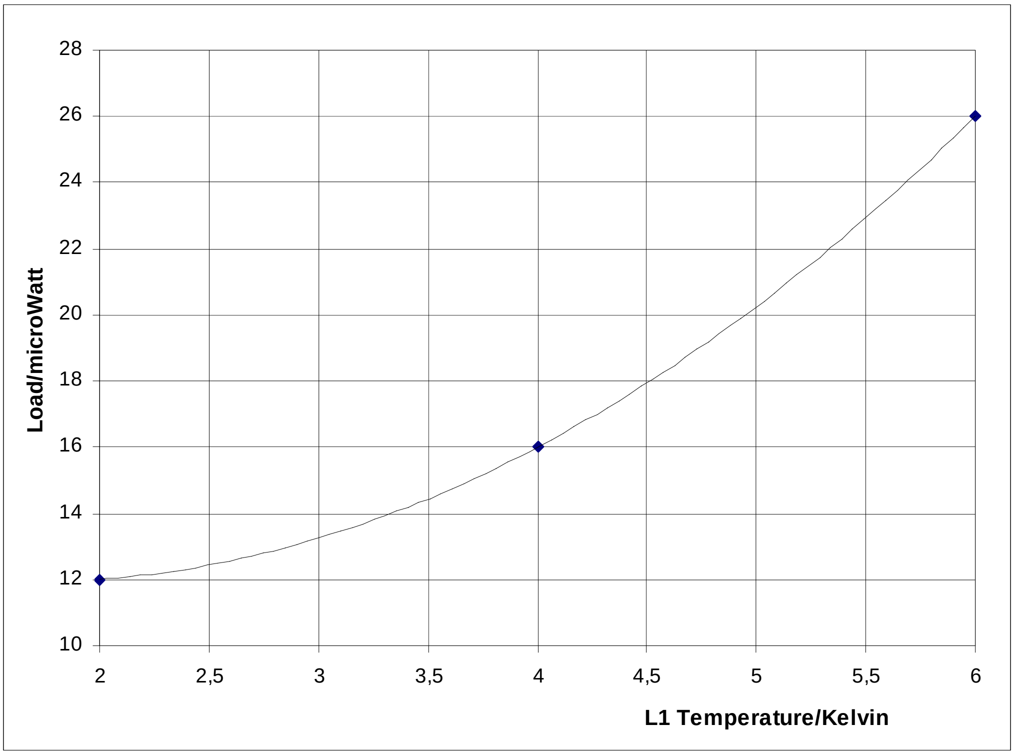


Figure 3: Cooler parasitic loads vs level 1 temperature

The baseline parasitic of 280mK shown in figure 2 of 12microwatts for L1 = 2K is indirectly derived, but the data plotted in figure 3 are the shifts needed to superimpose the curves at different L1 in

2a, They suggest a stronger dependence of cooler parasitics on L1 temperature than is often assumed.

Contributions to the cooler's internal evaporator parasitics are heat-switch off-state leakage to L0, tube conduction to the thermal shunt, wiring conduction, and Kevlar suspension leakage to L1, presuming the lack of unwanted effects inside the cooler. For details see Annex 3.

In the 46hr. operating/observing mode only the sorption pump sieve heat-switch heater is on. The following confirms a sieve switch-over temperature of 12-13K.

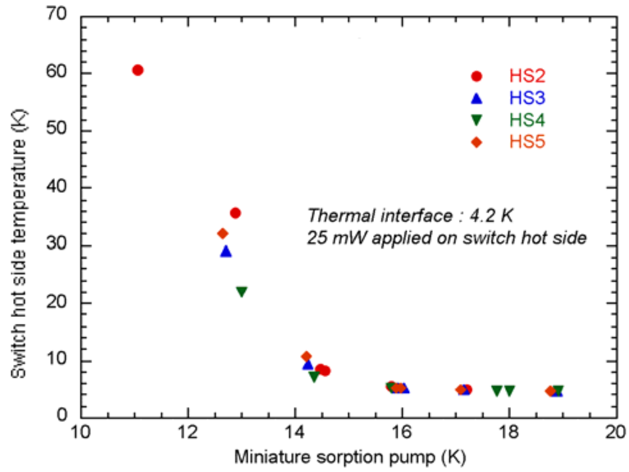


Figure 4: Heat switch "switching temperature" (vs switch pump temperature)

The power needed to raise the switch's sieve to ~14K is ~200 µW. To have margin, ~400 µW has been demonstrated to run the pump switch and to speed up the switch-over phase the sieve is heated at 800 µW for an initial limited time.

As helium evaporates, heat is pumped. There is an amplification factor between the heat load at the evaporator and the resulting adsorption heat load on the pump which is sunk down the turned-on pump switch and its strap. The following curves are from an experiment to measure this.

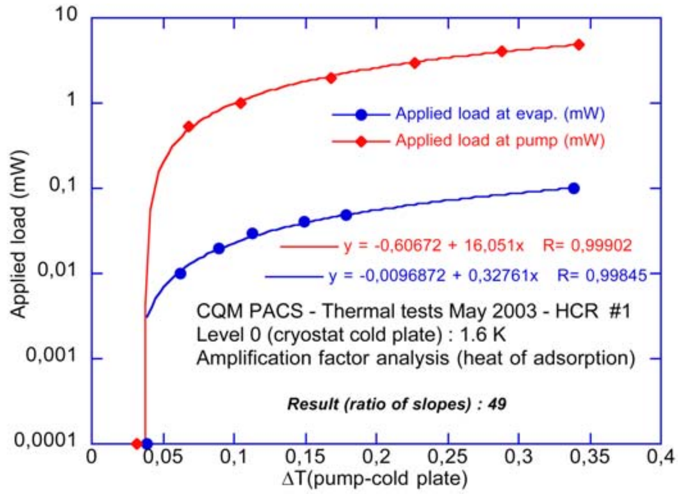


Figure 5 : Measurement of adsorption heat on pump vs heat applied on evaporator

A ratio between these heat loads of 46-49 is typical for ^3He coolers, and such a test result shows that the cooler is pumping properly according to the expected thermodynamics.

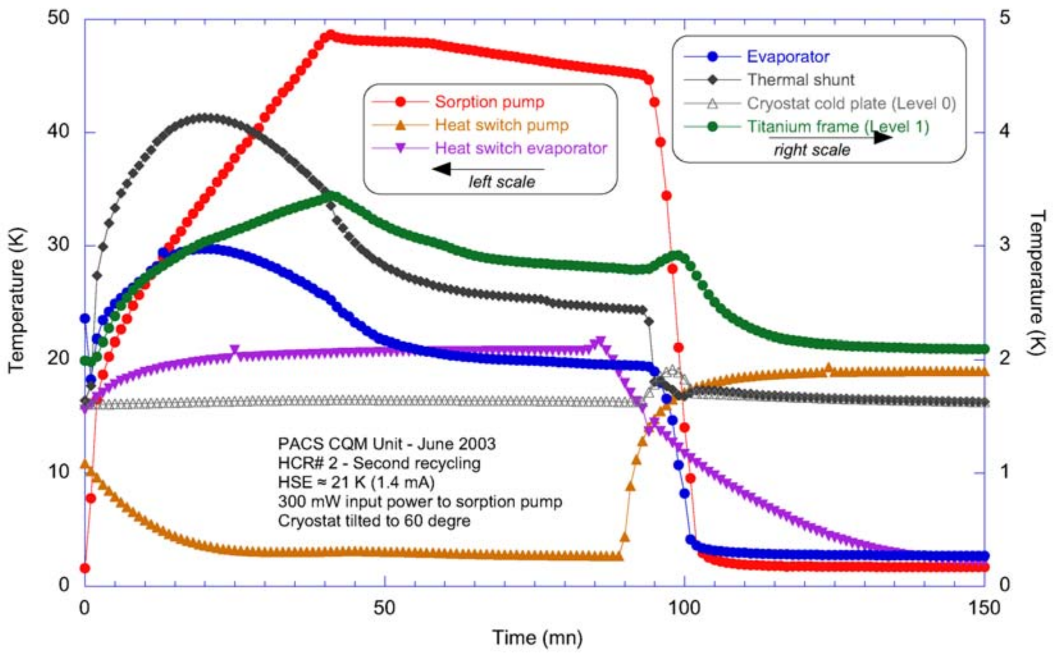
In practise the whole system must be able to cope with the 2 hour recycling heat mode. This is in many respects is more demanding than the 46hour hold-time.

During the first phase of recycling, i.e. condensation, the evaporator heat-switch is closed and the pump's switch opened. The evaporator strap needs extremely low thermal impedance and 800W heat-switch sieve power is baselined. The cooler's sorption pump is heated to 40-45K and a lower power is then used to keep it hot. Condensation occurs in the evaporator. Almost all the cooler's ^3He charge needs to be condensed so Spire can meet the hold-time for its subsequent 46 hours at 300mK. The temperature of the evaporator itself at the end of condensation is critical. This is a parameter internal to Spire, even being internal to one of its subsystems, and it needs to be <2K for the last few minutes of this phase. We may need to apply 1mW to the evaporator's heat-switch sieve the end of the condensation phase to help to achieve this <2K

During this condensation phase the shunt has to extract nearly all the heat from the hot gas travelling from the pump to the evaporator; it should typically stay below 6K. More than >80% of the enthalpy of the hot gas should be thus removed. throughout the condensation phase. The overall shunt strap actually needs a tuned conductance because during the condensation phase its temperature needs to go and stay above Tevap to avoid ^3He condensing on it instead of in the evaporator.

At the end of the condensation phase there is a cooling phase when and the cooler heat switches are swapped over to their normal (operating) positions: the pump switch is on and the evaporator's off. Timings for this have to be optimised by test. This cooler requires that its pump and evaporator have separate straps back to Herschell's main ^4HeII because otherwise the heat-pulse that occurs at this switch-over could heat the evaporator and waste much of the available ^3He liquid charge.

Recycling of a flight type 6 litre coolers is sdhown below, but with a warning that it has been obtained at unit level with 200mW/K conductances for both the straps from the cooler heatswitch interfaces (which are not Spire/Herschel Interfaces) to the ^4HeII (at <1.7K). When later results with flight type conductances are available, these results will need updating. For instance when the cooler is accommodated inside Spire the 350J pump power spike is likely to peak at only ~500mW and of course therefore to last longer.



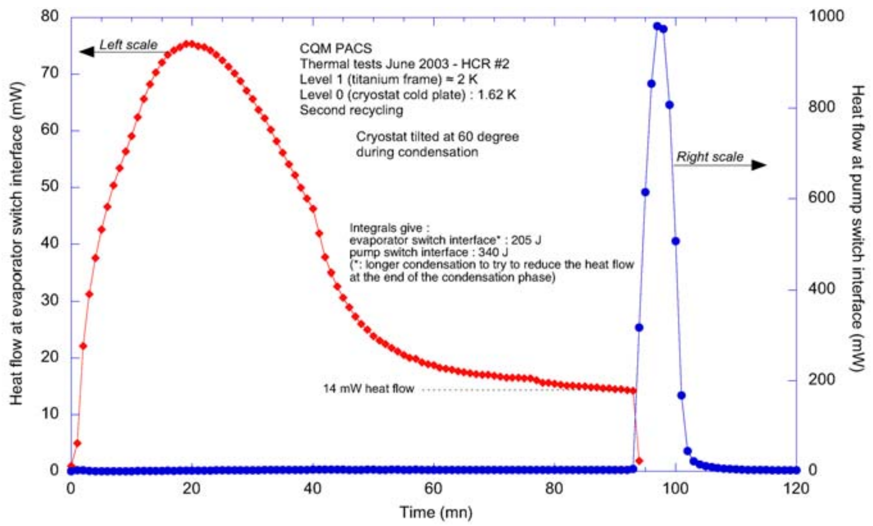


Figure 6: Cooler Recycling: Characteristics above and estimated heat-flows below

We see that during test, and probably in flight also, the cooler's titanium frame alters temperature during re-cycling. This is even with the cooler chassis fixed all along one side (PACS style) to the L1 test plate.

Generally the faster the whole regeneration process the better, both in terms of the minimising the total single recycle energy and in terms of the fraction of time available for science. By searching for efficient operation, in Spire we have set the initial pump heater power to 300mW. If the heat shunt and evaporator strap could take the load as a high flow-rate of warm ^{3}He leaves the pump, we could heat the pump with some 600mW to 40K very quickly, keep it there for just a few minutes, turn off and let everything cool down again, which would achieve a very energy efficient regeneration. In practise, strap impedance both limits the initial power that can be applied and causes us to need to wait an appreciable time before the evaporator comes back down to <2K, the point at which «cool down» can be commenced.

The time taken for the 6 litre flight cooler's sorption pump to be heated up to ~40-45K is expected to be ~30minutes. SBT/CEA have put considerable effort into developing the heat straps inside the cooler to cut down the wait time for evaporator itself to get back down to <2K at the end of the condensation phase.

The shunt and the evaporator share an L0 strap, the latter via a heat-switch. The energy to be transported during recycling from the evaporator itself is expected to be 50 Joules with the profile shown, peaking at a power of 45mW. However the total energy through this strap per cycle is ~205 Joules when the shunt's contribution is also added in, peaking at 75mW. Although evaporator power may drop to <2mW at the end of the condensation phase, there is still ~13mW from the shunt added into the strap to give a total power along it of ~15mW.

Achieving the 46 hours lifetime requires a minimised total load on the 300mK evaporator, and also on the cooler achieving its full 6 litre latent heat energy rating. Spire should only place an external load on the cooler such that the total load remains below ~29μWatts

Not achieving an evaporator temperature of <2K at the end of the condensation phase would cause an unacceptable reduction in the amount of condensed helium in the evaporator available for next operation phase. This is computed to be:

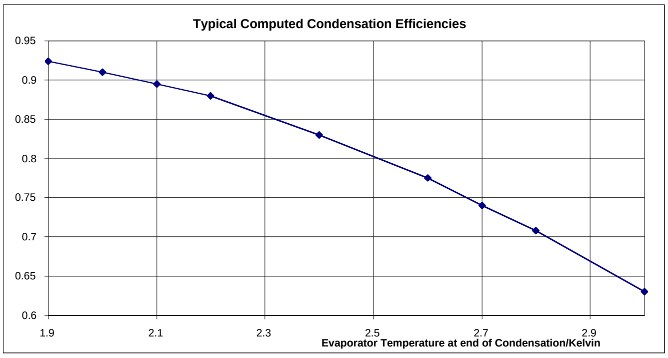


Figure 7 : Estimated Condensation efficiency (% ^{3}He liquefied) vs evaporator temperature

A fraction of the ^{3}He charge is expended cooling both itself and the evaporator/detectors down to 300mK, which is taken as the end of recycling. This leaves an amount of ^{3}He available to keep the Spire 300mK section cooled for the next 46 hrs. The evaporator temperature at the end of the previous phase is again critical to minimising He usage for this pre-cooling process, and <2K is required.

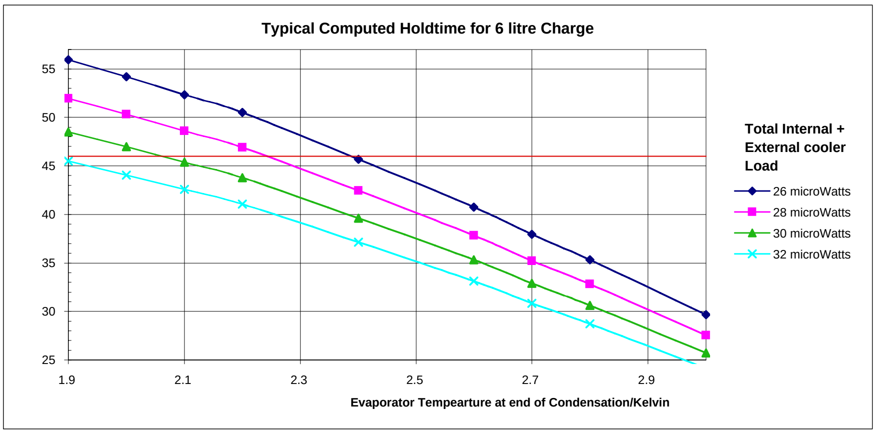


Figure 8 : Cooler hold time ve evaporator temperature at end of condensation, and average total load on evaporator.

Figure 8 is the same as one from the IHDR but with the above condensation efficiencies also included.

These curves are an approximation in that they ignore the small extra demands on the cooler from all loads during the 2K to 300mK cooldown and the heat capacity during this period of all 300mK components besides that of the helium itself. However, these effects are small and the approximation is good.

Note:

There is one cooler variation still under consideration by **Spire**. The requirement that the evaporator itself be <2K at the end of the condensation phase [typically 1.85K at the cooler's heat-switch interface inside the instrument] is sufficiently challenging to achieve that we were considering putting the shunt on the pump's strap rather than on the evaporator's, see thermal overview drawing at the start of this section. This would avoid ~15mWatts from the shunt travelling down the evaporator strap at this stage in the recycling, thus avoiding its contribution to the temperature drop along the strap. Caveat: it's not clear yet if this alteration has other significant disadvantageous side-effects, and the project has seriously run out of time to put such a change into the programme.

- END OF DOCUMENT -

(*) FPU and MGSE ICD's and drawings listed in this table and included in this annex 1 shall be updated by SPIRE according here under ASED comments and SPIRE answer and agreement here after:

1. ASED comments:

Extract from fax ASED HP-ASED-FX-0316-04 dated 10/05/04: Fast Loop Assessment HP-SP-RAL-ECR-068 IID-B SPIRE Mechanical Interface Drawings, SPIRE-RAL-DWG-001409, Update to Issue 11

SPIRE FPU:

Sheet 1: Mass properties (mass, CoG and MOI) updated. Updates acceptable, but note that update of the FPU MTD design is considered to be not necessary. The SPIRE FPU MTD will be provided with mass properties, as in Issue 18.

Sheet 5: L0 thermal strap interfaces updated as agreed with one exception. L0 flexstrap clearance holes shall be 5.0mm and not 4.5mm. See also ASED comments in HP-ASED-EM-0740-03, dated 28/11/03

Sheet 5: L1 thermal strap interfaces: Agreed interface may be changed to implement electrical insulation at FPU side. Updated IF drawings are urgently awaited by ASED.

Sheet 6: Harness stay-out areas updated. Updates acceptable to ASED.

FPU/JFET MGSE:

It shall be noted that the proposed MGSE is a deviation from the current baseline, which assumed that the SPIRE FPU and the JFETs are integrated independently. EADS Astrium reserves the right to raise ECP, if the detailed analysis revealed an increased required effort.

The assumptions and comments made in HP-ASED-EM-0231-04 are still valid concerning the provided MGSE drawings. As the MGSE I/F drawings are dated 2/02/04 and the comments (HP-ASED-FX-0231-04) are dated 27/02/04, it is assumed that they have not been implemented yet.

Tilting of FPU is required during the integration. Therefore please upgrade MGSE to allow tilting of assembly by 3 to 10 degrees, e.g. by including a turnbuckle (self-locking) on the +Z rope.

The wires holding the JFETs are not included, but the bolt holes in the MGSE plate indicate a potential conflict with the ventline. Please refer to HP-ASED-EM-0231-04 for details.

Flexibility of FPU/JFET harnesses: Note that it will be required to move the Photometer JFET to +y during the lowering of the FPU/JFET assembly, due to the conflict with the ventline on its -y side. Our initial estimates are that the Photometer JFET need to be moved by 10mm in +y direction. Please confirm that your internal harness can cope with move to Photo JFET by about 10mm (for details please see HP-ASED-EM-0231-04)

Removal of L0 Detector Strap before FPU integration:

At least the front part of the Lower A-frame of need to be removed before integration The top A-frame and the flex link on top of the strap need to be removed completely. Alternatively the top flex strap could stay, but SPIRE need to confirm that it can be moved by 10 to 15mm to in +z/-y direction

Please clarify your proposal for the partial or complete removal of the FPU L0 detector strap (see HP-ASED-EM-0231-04 for details).

Fixation of SPIRE L0 pump flex link to H-EPLM rigid pod:

There may be not sufficient clearance for the fixation of all 6 interface bolt at the L0 pump rigid pod with the torque wrench.

Please check provision of tool or removal of L0 pump strap lower A-frame for the fixation of all interface bolts (see HP-ASED-EM-0231-04 for details).
Furthermore, the following additional comments shall be considered:
Provision of a fixation of the MGSE JFET Lifting plate to FPU Optical Bench
Please confirm that the JFET lifting plate is stiff enough to reduce the potential vibrations of the JFET units during the lowering to the Herschel Optical Bench. It is assumed that the plate has a thickness of 2-3mm (not provided in the drawing).
In summary, the SPIRE change request HP-SP-RAL-ECR-068 is technically acceptable, assuming the implementation of the comments in this fax.

2. SPIRE answer to ASED comments:

Extract from Mail from Eric Sawyer dated 27/05/04

Objet : Response to fast loop assessment

Hi Horst, Here is our response to your fax HP-ASED-FX-0316-04. Dated 10/5/04
HP-SP-RAL-ECR-068 IID-B SPIRE mechanical interface drawings, update 11.

SPIRE FPU

Sheet 1, mass properties, ok
Sheet 5, agreed that L0 strap clearance holes shall be 5,00 mm, confirmed by e-mail from John Coker.
Sheet 5, Separate telecon held on L1 interface change, ECR 073 issued
Sheet 6, ok
Note, an updated ICD (issue 20) is not planned for 1st July, for next IIDB issue, the FPU ICD of last SPIRE pack v11 (CR 68 v1) will be used, with the list of agreed missing changes included in front page of IIDB-Annex 1.

FPU/JFET MGSE

It is not possible to integrate the JFETS before the FPU, the connectors are not accessible. The concept of lifting the FPU and JFETS has been tried successfully, e.g. at CSL on the shaker. Of course, the extra equipment like vent lines and other instruments were not present.
It is planned to incorporate all Astrium comments.
A turn buckle will be implemented.
Potential conflict with the vent lines will be evaluated. The position of the JFET support wire is not critical, so modification of the MGSE, if required is not thought to be a problem.
Flexibility of the JFET harness. - The JFETs when supported are flexible and repositioning by 10mm or so is not a problem.
Removal of L0 detector strap for integration .- The detector strap can be partially or completely removed for integration. It may be best to asses this when we do the first CQM integration. We can baseline complete removal, this is what I have put in the integration procedure.
Fixation of SPIRE L0 Flex link to H-PLM rigid pod.
SPIRE sees no problem with the removal of the lower A-frame for fixation of the interface bolts.
Additional comments.
The JFET MGSE is rigidly attached to the FPU lifting plate, they form one unit.
SPIRE confirms that the JFET lifting plate id thick enough to prevent vibrations, proved by test.