Rutherford Appleton Laboratory	DOCUMENT / ENGINEERING CHANGE REQUEST (ECR)	PRODUCT ASSURANCE Space Science and Technology Department

DCR / ECR Number:	HR-SP-RAL-ECR-009

Spacecraft / Project	Herschel-Planck	**Originator's Name**	JD
System / Experiment / Model	**SPIRE**	**Signature**	*John Delderfield.*
Sub-System	Instrument level I/F	**Date**	19th November 2001
Assembly		**Classification**	**Urgent**
Sub-Assembly		**Ref. Doc. / Drwg No.**	Spire IID-B 2/0
Item		**Reference**	SCI-PT-IIDB/SPIRE-02124

ECR Title	SPIRE IID-B UPDATE, #5

ECR Description

Required SPIRE detailed temperatures and heatflows at I/F.

Need /Justification For "Change"

The Spire thermal model has been evolved to better fit in with the ESA cryostat modelling since the values in IID-B 1/0.

The various versions of text describing Spire's thermal accommodation have been slowly added to with piecemeal minimised changes. They have also tended to incorporate engineering background on the HERSCHEL side of the interface which is not an optimum form of I/F statement.

Earlier change proposals were complicated multipart text updates.

So to address all these points, this ECR is now formulated to just replace sections 5.7start to 5.7.1.2.

Affected Items / Work package (Title, Number, Issue, Para)

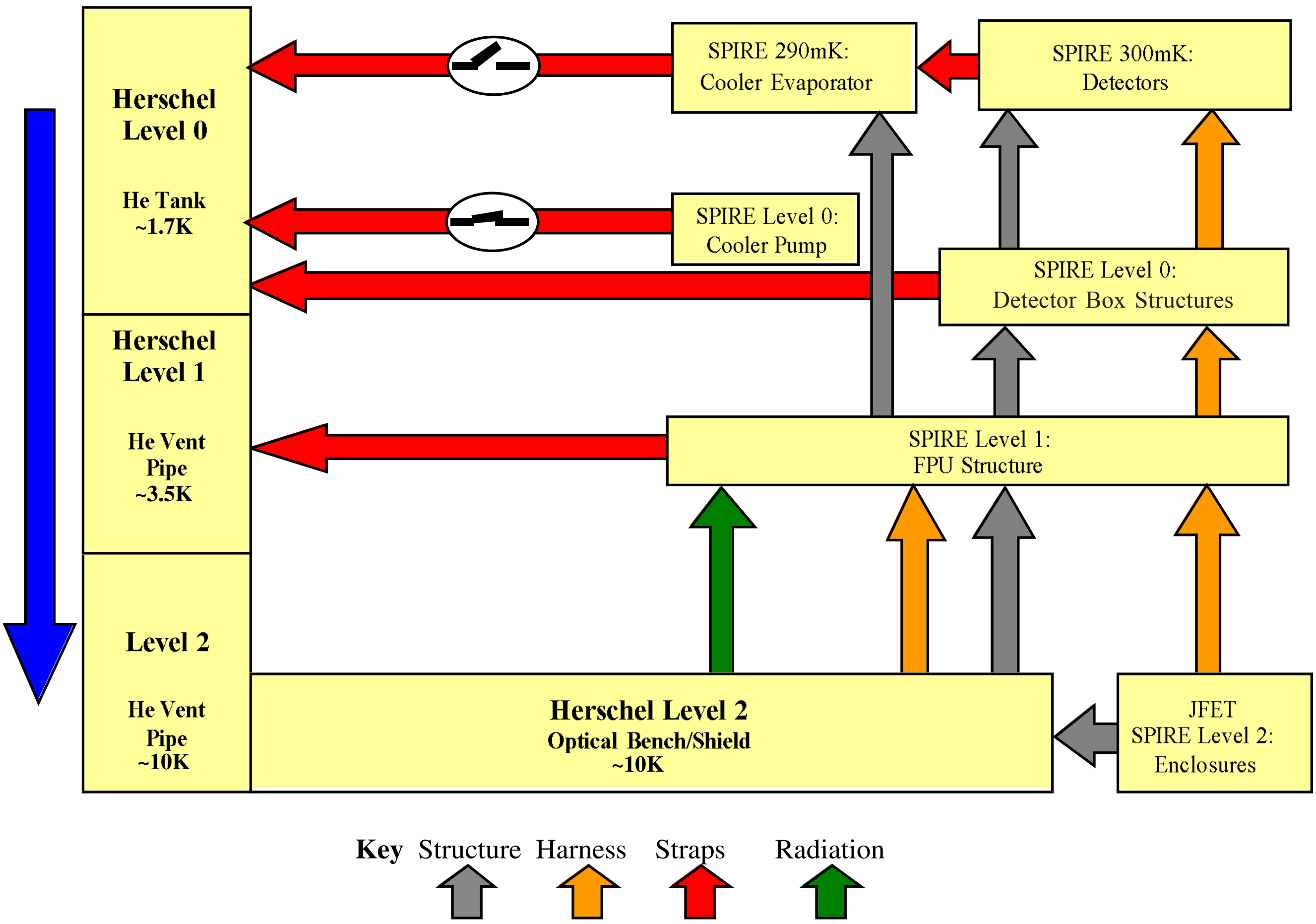
Incorporate the following replacement sections:

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.

5.7.1 Inside the cryostat

The various instrument stages require straps to 3 different temperature levels. An overview of the heatflows in the system is:



5.7.1.1 Description of Interfaces for the ^{3}He Cooler

Operation of the **Spire** ^{3}He cooler requires that it is recycled by heating the sorption pump to ~40-K whilst the evaporator is kept at 1.7K, thus condensing the ^{3}He into the evaporator. The sorption pump will still operate properly even if the "hot" end of its strap rises momentarily to as much as 10 K.

The temperature of the evaporator during condensation is critical to the overall efficiency of the cooler, required to get the best HERSCHEL **Spire** science return from a given amount of cryogen. Its manufacturer stipulates a conductance of >0.1Watts/Kelvin to ^{3}He. The efficiency of the cooler also determines 300mK hold time, and **Spire** has no excess margin w.r.t to achieving its specified 48hour operating cycle.

At the end of the condensation phase of the cooler's regeneration, the heat switch on the sorption pump is turned ON and the switch on the evaporator is turned OFF. There is a substantial peak power from the sorption pump to the cryostat as it re-cools via the strap. This peak power and associated energy should not have any significant impact on the cryostat ^{3}He tank. However it will have a significant temporary impact on the thermal gradient along the strap.

There are thus two straps from the cooler, one for the sorption pump and one for the evaporator. In this way, during normal operation, the temperature of the evaporator strap will remain at T_{bath}+DT (as small as possible), leading to a good condensation efficiency and less ^{3}He lost during the cooldown from 1.7 K to 0.3K. Note that the cooler has an internal heat shunt between its pump and evaporator, but the braid from this shares an external cooler I/F with the evaporator braid.

Spire has two 1.8K optical box structures on isolating mounts inside the HSFPU. As shown in the overall scheme above, these provide a low temperature mounting for the detector assemblies. The photometer box and the spectrometer box are thermally linked internally to the FPU, and provide just one instrument external strap I/F to level 0.

5.7.1.2 Thermal Requirements

Spire interfaces require to be adequately cooled by HERSHEL Level 0 straps. At the **Spire** I/F plane, the thermal links the straps shall provide at least the following cooling at the **Spire** I/F:

Strap	Temperature	Heatflow
Detector Enclosures	1.8K	5mW
Cooler Pump	1.74K	2mW
Cooler Evaporator	1.71K	1mW

Spire is being designed to require as little cooling as possible, to maximise mission lifetime and minimise its own operating temperatures. The following heatflows at the interfaces are calculated by the most recent coupled models and should be used (scaled adjusted for operating cycle) when assessing mission lifetime:

Strap	Heatflow Operating	Heatflow Non-Operating
Detector Enclosures	3mW	1mW
Cooler Pump	1.8mW	0.25mW
Cooler Evaporator	0.6mW	0.25mW

The A-frame strap supports are the S/C side of this interface and provide a thermal path between the level 0 braids and level 1 HSFPU. **Spire** shall ensure than that each puts <25mW into its strap provided that the Level 1 strap cools the HSFPU as required.

During recycling, the cooler connects its 40K pump back to the level 0 cooling path via a gas switch. At high heatflow, the switch's impedance is expected to limit the pulse to 1000mW, TBC, but the strap's thermal capacity and other system design details shall prevent cavitation at the ^{3}HE liquid/aerogel to cryostat wall.

The Level 1 strap shall provide at least the following cooling at the **Spire** I/F:

Strap	Temperature	Heatflow
HSFPU SOB	5K	18.25mW
	4.25K	9.12mW

The HOB level 2 shall provide at least the following cooling at the **Spire** I/F:

Interface	Temperature	Heatflow
Three HSFPU Feet	12K	50mW

The level 2 to level 1 non-bolometer ESA cryo-harness shall not input more than 0.2mWatts into the HSFPU.

No HSJFS or HSJFP straps are listed because the present design uses direct mounting conduction to the HOB, so they are not fitted, TBC.

To provide the required overall thermal balance boundary, since the inner instrument shield is nominally black at level 2, the effective temperature seen from any point on the surface of the HSFPU when integrated over an outward hemisphere shall not exceed 16K. This surface of course includes the areas around **Spire**'s input aperture.

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INDUSTRY ASSESSMENT / IMPACT OF CHANGE			
System design			
Schedule			
Cost			
Industry Assessor Signature			
Related Factors			
Spacecraft	Performance	Power	Others (Specify)
Ground Segment	Elect. Interfaces	Weight	I/F.
Launch Vehicle	Mech. Interfaces	Schedule	
Payload	Test/Verification	Cost	
Attachments		**Distribution**	
None		See covering Sheet	

Change Approved		**Signature / Date**	