HERSCHEL/SPIRE

Synthesis note about DRCU FMEA and reliability

	Function	Name	Date	Visa
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DOCUMENT STATUS and CHANGE RECORD

Date	Issue	Affected pages
10/02/2003	0.1	Creation

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1 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to amend the "DRCU – Architecture and reliability analysis report"[RD1], because the architecture has been defined more precisely since the architecture analysis was performed; main changes are :

- Powering on/off of various parts of DRCU is no more performed through relays on the secondary supply lines (see [RD2]),
- SCU design has been refined,
- DCU backplane now includes independent current limiters on LIA boards supply lines.

This document does not include any analysis relative to MCU architecture analysis. [RD1] only covers DCU, SCU and PSU sub-units.

1.2 REFERENCE DOCUMENTS

RD1	DRCU – Architecture and reliability analysis report	SAp-SPIRE-Flo-0039-01	Issue 2-27/11/2001
RD2	SPIRE Power supply unit cahier des charges technique	Sap-SPIRE-DS-012-02	Issue 1.1 11/12/2002
RD3	Spire Harness definition document	SPIRE-RAL-PRJ-000608	Issue 1.0 08/07/2002
RD4	SPIRE-PACS Declared component list	--	Issue 1.3

2 FMEA

2.1 Reliability critical items

The reliability critical item are those mentioned in [RD1] § 7.1)

2.1.1 Overheating of a bias board

This failure can be detected in DCU box temp. housekeeping channels, and a switch off can be performed. The need of a quick switch-off leads to recommend an automatic switch-off by spacecraft s/w.

Critieria concerning overheating of boards have to be included in the switch-off strategy.

2.1.2 Overheating of a temperature probe by SCU

The temperature probe electronic module of the SCU may send a non-adapted signal to a FPU temperature sensor, and thereby leads to miss-operation of the FPU as temperature rises.
This would lead to unusual values in the HK channels:

A strategy should be defined here to ensure that such an event can be detected.

2.2 Inopportune setting on of a PSU module

This may lead to power on both Photometer and Spectrometer part, and to exceed the maximum allocated power, and thus to switch DRCU off. Care will be taken on PSU (FMEA) to ensure that no failure propagation occurs to the on/off commands of the redundant chain.
However the SCU provides hardware security to guarantee that both photo and spectro are not both powered on, even in case of a wrong command issued by DPU.

2.3 Failure propagation

Internal failure propagation from LIA board to another LIA board is avoided by using independent current limiter on each LIA's supply line.

In order to avoid (thermal) failure propagation from BIAS or DAQ board to other boards, it is necessary to switch-off quickly (Criteria concerning overheating of boards have to be included in the switch-off strategy).

2.4 Single point failure

No other single point failures than those already mentioned in [RD1] are identified.

3 Quantitative reliability evaluation

3.1 Optimisation of LIA boards configuration

According to [RD3], the configuration chosen for LIAP is :
4xPSW/PSW (LIAP n°1 to LIAP n°4)
3xPMW/PMW (LIAP n°7 to LIAP n°9)
1xPLW/PSW (LIAP n°5)
1xPLW/PLW (LIAP n°6)

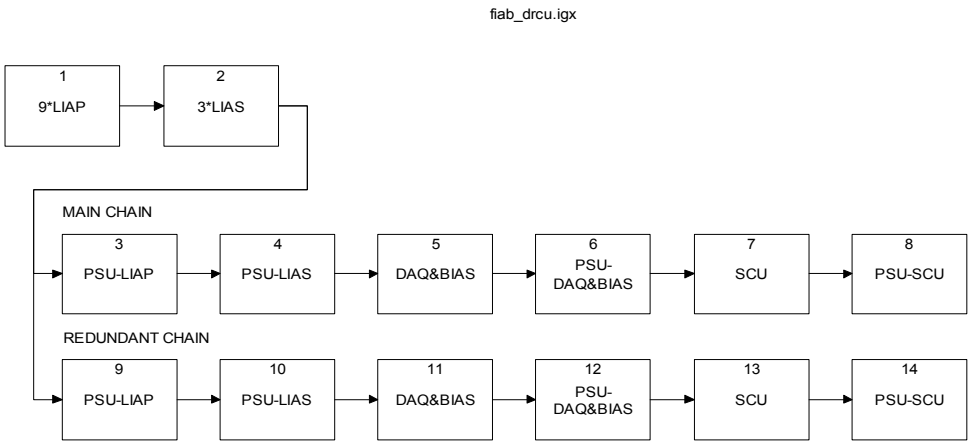
This configuration, according to [RD1] presents a good compromise if degraded mode is acceptable. However, loss of LIAP n°6 leads to a loss of 2/3 of PLW channels (The other configuration proposed in [RD1] § 7.2 leads to a loss of 1/3 of PLW channels in case of 1 LIAP board failure).

3.2 Reliability evaluation

Reliability evaluation is based on the following assessments:

Board	Failure rate (λ_{on})	T_{on} // T_{off}
DCU/LIA-P	0,7239 10^{-6} h^{-1}	8554h // 30326h
DCU/LIA-S	0,6175 10^{-6} h^{-1}	4277h // 34603h
DCU/BIAS	0,5780 10^{-6} h^{-1}	12830h // 26050h
DCU/DAQ+IF	0,7239 10^{-6} h^{-1}	12830h // 26050h
SCU/TEMP	0,4080 10^{-6} h^{-1}	12830h // 26050h
SCU/CCHK-IF	0,5090 10^{-6} h^{-1}	12830h // 26050h
PSU	2000 10^{-6} h^{-1}	--
1 PSU module[1]	0,4000 10^{-6} h^{-1}	Same as powered group of boards

Failure rate of the redundant chain (off) is $\lambda_{off} = \lambda_{on} /10$.



[1] See Figure 2.2.2.1 of [RD2] for PSU architecture; PSU specs requires that PSU has less than 2000 fits; this is spread into 400 fits per module.

Box #	λ_{on} (h^{-1})	λ_{off}	t_{on}	t_{off}	Fail probability	Reliability
Box #1 (9*LIA-P)	$6,5160.10^{-6}$	$6,5160.10^{-6}$	8554h	30326h	$75,498.10^{-3}$	R_1=0,92450
Box #2 (3*LIA-S)	$1,8525.10^{-6}$	$1,8525.10^{-7}$	4277h	34603h	$14,333.10^{-3}$	R_2=0,98567
Box #3 (PSU-LIAP-M)	$0,4.10^{-6}$	$0,4.10^{-7}$	8554h	30326h	$4,66346.10^{-3}$	R_3=0,99537
Box #4 (PSU-LIAS-M)	$0,4.10^{-6}$	$0,4.10^{-7}$	4277h	34603h	$3,0949.10^{-3}$	R_4=0,99691
Box #5 (DAQ&BIAS-M)	$1,357.10^{-6}$	$1,357.10^{-7}$	12830h	26050h	$20,945.10^{-3}$	R_5=0,97905
Box #6 (PSU-DAQ&BIAS-M)	$0,4.10^{-6}$	$0,4.10^{-7}$	12830h	26050h	$6,1740.10^{-3}$	R_6=0,99383
Box #7 (SCU-M)	$0,917.10^{-6}$	$0,917.10^{-7}$	12830h	26050h	$14,308.10^{-3}$	R_7=0,98569
Box #8 (PSU-SCU-M)	$0,4.10^{-6}$	$0,4.10^{-7}$	12830h	26050h	$6,1740.10^{-3}$	R_8=0,99383
Box #9 (PSU-LIAP-R)	--	$0,4.10^{-7}$	--	38880h	$1,5552.10^{-3}$	R_9=0,99844
Box #10 (PSU-LIAS-R)	--	$0,4.10^{-7}$	--	38880h	$1,5552.10^{-3}$	R_{10}=0,99844
Box #11 (DAQ&BIAS-R)	--	$1,357.10^{-7}$	--	38880h	$5,2760.10^{-3}$	R_{11}=0,99472
Box #12 (PSU-DAQ&BIAS-R)	--	$0,4.10^{-7}$	--	38880h	$1,5552.10^{-3}$	R_{12}=0,99844
Box #13 (SCU-R)	--	$0,917.10^{-7}$	--	38880h	$3,565.10^{-3}$	R_{13}=0,99643
Box #14 (PSU-SCU-R)	--	$0,4.10^{-7}$	--	38880h	$1,5552.10^{-3}$	R_{14}=0,99844
Main chain (box #3 to box #8)	--	--	--	--	--	R_M=0,94582
Redundant chain (box #9 to box #14)	--	--	--	--	--	R_R=0,98500
All DRCU	--	--	--	--	--	**R_A=0,91051**
Photo mode only[2]						**R_P=0,92386**
Spectro mode only[3]						**R_S=0,98501**

If a loss (failure) of one LIAP board is acceptable, LIAP (box #1) reliability can be estimated as an "8 among 9" redundant system.
$R_1=e^{-9\lambda t}+9(1-e^{-\lambda t})(e^{-8\lambda t})$, with $\lambda=\lambda_{on}.0,22+\lambda_{off}.0,78$, and t=38880h
This leads to R_1=0,99787, and R_A=0,98277.
-> This shows that if loosing an LIAP board is acceptable, the reliability of the mission is largely improved.

4 TODO

- Refine the reliability prediction of boards, including backplane and cables.
- Include MCU matters in this note.

[2] For "Photo mode only", SCU, DAQ&BIAS reliability is estimated with $t_{on}=t_{spectro}+t_{photo}$, not only t_{photo}.
[3] For "Spectro mode only", SCU, DAQ&BIAS reliability is estimated with $t_{on}=t_{spectro}+t_{photo}$, not only $t_{spectro}$.