Long, JA (Judy)

Subject: FW: Action: AI-DET-0000-18

SPIRE_Subs_Analysis
_d02.doc

-----Original Message-----
From: AUGUERES Jean-Louis DAPNIA [mailto:AUGUERES@DAPNIA.CEA.FR]
Sent: 10 April 2000 09:20
To: 'King Ken'
Cc: 'Griffin M.'; 'Swinyard Bruce'; 'Cunningham Colin'; 'Vigroux L.'
Subject: Action: AI-DET-0000-18

Hi Ken,

Here is the Draft 0.2 of the Subsystem Definition
template.

<<SPIRE_Subs_Analysis_d02.doc>>

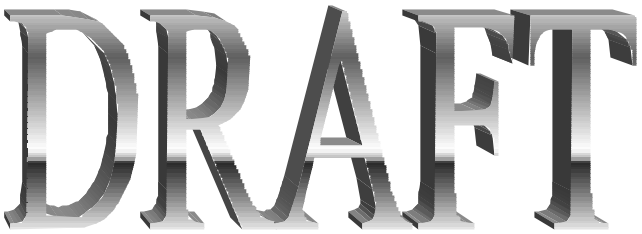
Unless there are comments this should close the
action:

AI-DET-0000-18 Augueres April 7

Provide document template to Ken King for
the Subsystem Definition Document based on the
viewgraph template

Cheers,

Jean-Louis



FIRST/SPIRE

WE Subsystem Specification Template

PROPOSAL

Reference: SPIRE-SAp-xxxx-99
Issue: Draft 0.2
Date: 7 - April - 2000
Author: J-L.Auguères

TABLE OF CONTENT

DOCUMENTATION

Applicable Documents

Reference Documents

[R1] SPIRE Warm Electronics Subsystem requirements - Draft - Sept. 19, 1999 - L.Vigroux.

[R2] FIRST/SPIRE Warm Electronics Requirement Document - Draft 0.2 - Aug. 10,1999

[R2] FIRST/SPIRE WE Subsystem Analysis Plan and Guidelines for the WE review - Draft 0.1 – 8 – October – 2000.

ACRONYM LIST

AIV	Acceptance, Integration and Validation
BSM	Beam Steering Mirror
CEA	Commissariat à l'Energie Atomique
DPU	Data Processing Unit
DRCU	Detector Readout Control Unit
FIRST	Far InfraRed Submillimetre Telescope
FTS	Fourier Transform Spectrometre
H/K	HouseKeeping
ICD	Interface Control Document
IID	Instrument Interface Document
IRD	Instrument Requirements Document
LAM	Laboratoire d'Astrophysique de Marseille
PDR	Preliminary Design Review
QMW	Queen Mary and Westfield College
RAL	Rutherford Appleton Laboratory
SADT	Structured Analysis Design Technique
SAp	Service d'Astrophysique
SMEC	Spectrometer MEChanism
SPIRE	Spectral and Photometric Imaging REceiver
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
WE	Warm Electronics
WERD	Warm Electronics Requirement Document

FOREWORDS

Purpose of the template.

The purpose of this template is to propose a standardised layout for the WE subsystem specification documents to be produced for each subsystems. This template is broadly identical to the one provided as viewgraph presentation guidelines for the Dec. 99 WE review. These documents are intended to be used as:

- presentation material for the SPIRE delta PDR.
- subsystem specification for the Warm Electronics.
- inputs for the specification of the DRCU simulator.

This template is applicable for the following SPIRE WE Subsystems:

Subsystems	**Resp. Institute**
- Beam Steering Mirror	ATC/LAM
- FTS	LAM
- Cryo-Cooler.	SBT/SAp
- Calibrators	GSFC
- House keeping	SAp
- Feed horn	JPL/SAp

Scope.

The Scope of this document concerns only the Warm Electronics view of the considered SPIRE Subsystems. However the WE part of each Subsystem has to be presented along with its respective environment (as a part of a whole SPIRE Subsystem).

Two aspects are addressed in this document:

- the WE Subsystem Analysis which concern the Subsystem requirements and functionality.
- the WE Subsystem Architecture and Design.

Notification.

In order to illustrate the application of the guidelines, an example using the Cryo-Cooler WE Subsystem has been set. However the information given on this Subsystem are only to be considered as illustration of the principles and do not reflect the reality (in particular, the temperature regulation of the head of the cryo-cooler is no longer considered).

1 INTRODUCTION.

1.1 Purpose.

1.2 Scope.

2 Subsystem Analysis *(Cryo-Cooler example)*

This Section is intended to provide a comprehensive description for each WE Subsystem with regard to their respective WE requirements and functionality. It aims to allow the identification of all the parameters (Settings, H/K, Control Lines) as well as the Monitoring and Control actions. The implementation itself is out of the scope of this section. However, the implementation sharing between the various implementation level is considered (Tele-Commands, S/W task, dedicated electronics). Finally this section should provide rather comprehensive specifications for the use of S/W implementation.

2.1 Overall description.

Description of the subsystem and its functionality (Cf. Laurent's logical block diagrams in the SPIRE WE subsystem requirement document).

The cryo-cooler provide the appropriate temperature to the detector. Its equilibrium temperature is about 300 mK. The cooler is based on He3 sorption on charcoal. The system must be recycled every 48 hours. The recycling time duration is 2 hours, including cooling time after the recycling. The temperature of the detector is determined by fixed thermal impedance between the cryo-cooler and the detector base plate. The equilibrium temperature of the system is determined by changing the thermal conduction of the heat switches which connect the cryo-cooler to the LHe tank of FIRST. These Heat Switches are based on small tube filled with He3 and containing a small amount of coal. When heated, the charcoal outgas He3 and the conduction of the switch increases. Cooling the charcoal create vacuum inside the tube, making the thermal conduction very low.

2.2 Requirements.

List of the requirements related to the WE Subsystem. They shall be consistent with the WE Subsystem requirements (see the WERD).

7	**Shall be able to monitor the Cryo-cooler system.**
7.1	Shall be able to control the regeneration cycle
7.2	Shall be able to regulate the temperature stability better than TBD mK at 0.015 Hz at a maximum power dissipation.

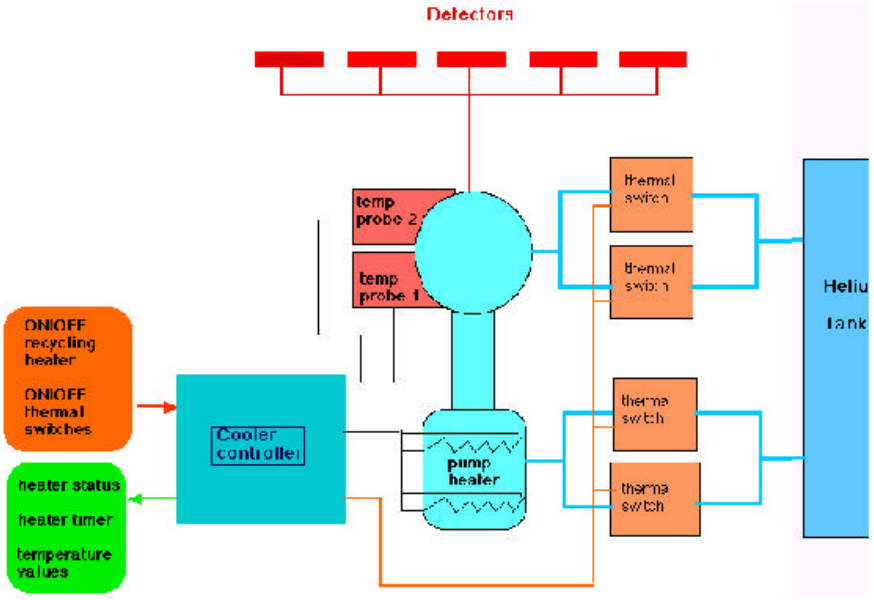
2.3 WE Subsystem I/F.

List of the I/F requirements between the WE Electronics and the proper Subsystem. Only the logical and functional aspects have to be considered here. Implementation details as number, type or impedance of wires and connector type and pin-out will be considered in the respective ICDs.

I/F	Type	Nb.	I/O	Min.	Max.	Constraints
Sorption Pump Heater	Analog Current	2	Out	0 mA	20 mA	400 Ω load
Thermal Switch Control	Analog Current	4	Out	0 mA	TBD	load?
Cold Finger Temperature	Temp. Sensor (TBD)	2	In			
Pump Heater Current	Analog	2	In			

2.4 Block Diagram.

Logical block diagram representing the subsystem considered together with its WE parts. (Cf. Laurent's logical block diagrams in the SPIRE WE subsystem requirement document).



2.5 Criticality Analysis.

Demonstrate that the proposed subsystem design fulfil the reliability requirements mainly:

- *No single point failure.*
- *No propagation failure.*

2.6 Functional Diagrams.

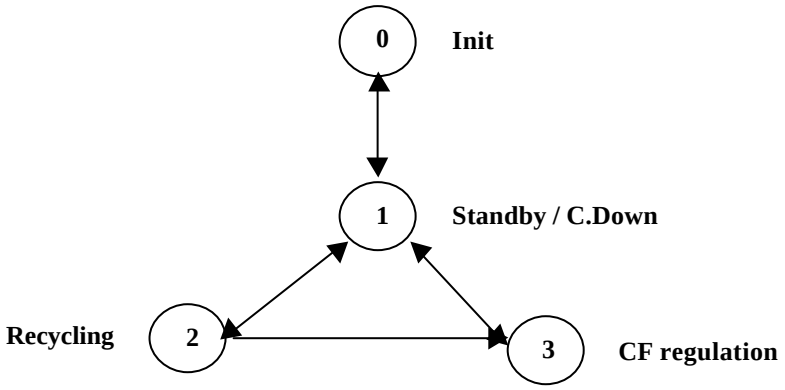
To illustrate the various functionality of the subsystem, a description by the mean of functional chart can be provided (e.g. SADT[1] functional diagrams).

[1] SADT: Structured Analysis Design Technique.

2.7 Subsystem States.

2.7.1 Status Diagram.

The behaviour of most of the subsystems can be described by the mean of Status Diagrams showing the various states in which the Subsystem could be and the relationship between these States. Transition between states are triggered by Events (or any combination of them).



2.7.2 State Definition.

List of each state along with their respective definition.

N°	States	Definition
0	Init	C.Cooler elect. is Switched On, H/K Monitoring Active.
1	St-by/C.down	Waiting State or Cooling Down waiting State.
2	CF regulation	Cryo-Cooler Cold Finger Temp. within the regulation limit. Regulation algorithm Active.
3	Recycling	Pump Heater(s) Activated.

2.8 Status / Event relationship.

2.8.1 Event Definition.

The Events which when arising could modify the State of the Subsystem have to be defined.

Events	Definition	Origin
Activate Subsystem	Electronics Power On / Active Subs. Control	TC
De-Activate Subsystem	Electronics Power Off / De-Active Subs. Control	TC
Pump Heater 1/2 On	Pump Heater 1/2 switch on	TC
Pump Heater 1/2 Off	Pump Heater 1/2 switch off	TC or Time-Out or Current Overload
Temp. Regul. On	Temperature regulation of the Cooler head activated	TC
Temp. Regul. Off	Temperature regulation of the Cooler head de-activated	TC
CC. T. Out of Limit	Temperature on the Cryo-Cooler Cold Finger cross the max. limit.	Self-diagnostic
Subs. Fault	Cryo-cooler subsystem fault detected on the Subsystem	Self-diagnostic

2.8.2 Status Table.

This table shows the various events which could arise and their impacts on the evolution of the Subsystem current State. The various possible States are those described in the previous section

N°	States	Fault	Activ.	De-Activ	P.Heat. On	P.Heat Off	T.Reg. On	T.Reg. Off	CC T. Out	
0	Init	0	1	0	Error	-	Error	-	-	
1	Standby	0	1/Error	0	3	-	2/1	-	1	
2	FP regul.	0	1/Error	0	3	-	-	1	1	
3	Recycling	0	1/Error	0	-	1	Error	-	-	

2.8.3 State Transition Actions.

This section provides the list and the respective description of all the actions to be carried out when stepping from one State to another.

N°	States	Fault	Activ.	De-Activ	P.Heat. On	P.Heat Off	T.Reg. On	T.Reg. Off	CC T. Out	
0	Init	A	B	A	-	-	-	-	-	
1	Standby	A	B/-	A	C	-	D/-	-	B	
2	FP regul.	A	B/-	A	C	-	-	B	B	
3	Recycling	A	B/-	A	-	B	-	-	-	

Actions	Descriptions
A	
B	
C	
D	

2.9 States vs. Controls.

For each state, the status of the various internal or external Controls (WE output, internal flags,...) could be defined by a dedicated table.

N°	States	CC head Th. Sw.	CC Pump Th. Sw.	Pump Heater Sw.						
0	Init	Off	Off	Off						
1	Standby	Off	On	Off						
2	FP regul.	Regul.	On	Off						
3	Recycling	Off	Off	On						

2.10 Internal control algorithms.

Dedicated complex functionality have to be described independently from their possible implementation (Tele-commands, Pure S/W, Electronics or any combination of them.

For each of such functionality, it is proposed to describe them using the following Plan:

- *List of the States in which the functionality is Active.*
- *List of the Input Parameter (H/K, Setting, Computed Value,...)*
- *List of the Output Parameters.*
- *Description of the Algorithm.*

2.10.1 Cold Finger temperature regulation.

Activ. State(s)	2

Input Parameters:

Label	Parameter	Origin	Type	Unit.	Min	Max	Accur
T_CC-HEAD	Temp. on the head of the Cryo-Cooler	H/K	Real	mK			
T_REGUL_CF	Regul. Temp. of the head of the CC	Setting	Real	mK	290	350	10
T_FING_MAX	Maximum temp. on the Cold Finger	Setting	Real	mK		350	
D_CF_REGUL	Max. Regulation Gap	Setting	Real	mK		2.5	

Output Parameters:

Label	Parameter	Type	Unit.	Min	Max	Accur
CC_HD_T_SW_1	Thermal Switch on Cryo-Cooler's Head n°1	On/Off				
CC_HD_T_SW_2	Thermal Switch on Cryo-Cooler's Head n°2	On/Off				

Algorithm Description:

The algorithms can be described by the means of either a Chart or Pseudo-language or by a simple formulae. Depending on the kind of "algorithm" to be considered, 3 sequences could have to be described:

- *an "Init sequence" which is to be run when starting the "algorithm" activity (e.g. when the State transition to one of the active State occurs) (see 2.8.3).*
- *a Periodic sequence which is run at a determined rate.*
- *a Closing sequence which is run when leaving from one of the active State (see 2.8.3).*

Init Sequence:

Begin;

End;

Periodic Sequence: Activation rate 1s.

Begin;
If the "Temp. on CC's Head" < "CF Max Limit"
Then
If the "Temp. on CC's Head" - "Regul. Temp" > 2 mK
Then Switch On the "Head Thermal Switch";
Else Switch Off the "Head Thermal Switch";
Else
Flag the CF "Out of Limit" event;
Switch Off the "Head Thermal Switch";
End If;
End;

Closing Sequence:

Begin;

End;

2.10.2 Cryo-Cooler Recycling.

Activ. State(s)	3

Input Parameters:

Label	Parameter	Origin	Type	Unit.	Min	Max	Accur

Output Parameters:

Label	Parameter	Type	Unit.	Min	Max	Accur

Algorithm Description:

Init Sequence:

Begin;

End;

Periodic Sequence: Activation rate 1s.

Begin;

If the "Pump Heater Current" > "Pump Heater Current limit" Then generate a "Fault" event;
If the recycling time is over Then generate a "Time-Out" event;

End;

Closing Sequence:

Begin;

End;

2.11 Setting Parameter list.

List of all the Setting Parameters to be set up (basically by the means of Tele-commands).

Label	Parameter	Unit	Comment
T_FING_MAX	Maximum temp. on the Cold Finger	mK	No temp. regul. above this temp.
T_REGUL_CF	Temp. regulation setting on Cold Finger	mK	
CC-REC-TIME	Recycling Time	sec.	
CF-REG-DELT	Max Regulation Gap for the Cold Finger	mK	
HEAT_CUR-L	Current Limit in the Pump Heaters	mA	
HEAT_CUR_P1	Setting value for the Heater Current of Pump 1	mA	
HEAT_CUR_P2	Setting value for the Heater Current of Pump 2	mA	

2.12 H/K list.

List of the H/K generated by the Subsystem apart from the Setting Values which should be systematically mirrored).

Label	Parameter	Type	Unit.	Min	Max	Rate	Accur
C_COOL_STATE	Current State Number	Int.					
C_COOL_FAULT	Fault Flag	Bin.					
CF_TEMP	Temperature on the Cold Finger	Analog	mK			1s.	1mK
HEAT_CUR_1	Current measured in the Pump Heater 1	Analog	mA			1s.	1mA
HEAT_CUR_2	Current measured in the Pump Heater 2	Analog	mA			1s.	1mA

2.13 WE Implementation.

This section aims to describe the way, the WE functions of the Subsystem are likely to be implemented
.

2.13.1 Subsystem Telecommands.

List of the Subsystem dedicated Tele-Commands (a part from the parameter setting commands which are handled independently).

Tele-Command	Function and Parameters
	Cryo-Cooler Subsystem Activation / De-activation (Flag setting)
	Pump Heater 1 Activation / De-activation (Flag setting)
	Pump Heater 2 Activation / De-activation (Flag setting)
	Temp. Regulation Activation / De-activation (Flag setting)

2.13.2 Subsystem S/W

List of the functions to be implemented by S/W either at DPU or DRCU level.

S/W Functions
All overall Monitoring & Control functionality
Cold Finger Temperature Regulation algorithm.
Cryo-Cooler Recycling algorithm.

2.13.3 Subsystem Dedicated Electronics.

List of the functions to be implemented by the means of dedicated electronics (H/W).

Electronics (H/W) Functions
Temperature Sensor measurement electronics.
Pump Heater Current generators.
Pump Heater Current measurement electronics.

3 WE Subsystem Dedicated Electronics implementation

This Section is intended to describe the features and the architecture of the Subsystem dedicated electronics (i.e. electronics circuitry and interconnection including complex circuits like FPGAs and/or dedicated micro-controllers. This Section is referring to the electronics items given in 2.13.3

3.1 Overall description.

3.2 Main Specifications.

3.3 Electronics Block-Diagram.

3.4 External I/F and Connection.

3.5 Detailed description.

3.5.1 Block 1.

3.5.2 Block 2.

.
.
.
.

3.5.3 Block n.

3.6 Power Supply.

3.7 Grounding Scheme.

3.8 Mechanical implementation.

3.9 Budgets.

3.10 Use of Special Components.