FIRST/SPIRE

Detector Readout Control Unit

and Warm Interconnect Harness

Development Plan

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DOCUMENT STATUS and CHANGE RECORD

Date	Issue	Affected pages or sections
14/04/00	Draft 0.1	Creation
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29/01/03	4.0	AIV updates Impact of the Power Supply development plan

SUMMARY

DOCUMENTATION

Applicable Documents:

A1	Intrument Development Plan	Last agreed Issue		SPIRE-RAL-PRJ-0035
A2	Major Milestone List	Last Agreed Issue		SPIRE-RAL-PRJ-00455
A3	PA Requirements	Last Agreed Issue		
A4	Standard Product Asssurance Plan	Issue: 1.0	07/11/00	SAp-GERES-FLo-436-00
A6	Product Tree	Last agreed Issue		SPIRE-RAL-PRJ-00030
A7	Configurable Document Tree	Last agreed Issue		SPIRE-RAL-PRJ-00033
A8	Product Assurance Plan	Last agreed Issue		BOL/RAL/D/0017.01
A9	Convention SAp/LAM (CEA/CNRS/CNES)	Draft 2	21/12/00	00.xxx/SAp.JLA

Reference Documents:

R1	Herschel/Planck IID-A	SCI-PT-IIDA-04624
R2	SPIRE IID-B	SCI-PT-IIDB/SPIRE-02124
R3	Instrument Requirement Document	SPIRE-RAL-PRJ-000034
R4	Instrument Model Philosophy	BS-12/07/00 - Note
R5	Liste des documents SPIRE	SAp-SPIRE-FLo-0028-00
R6	DRCU Electrical ICD	SAp-SPIRE-CCa-0024-00
R7	DRCU Subsystem Specification	SAp-SPIRE-CCa-0025-00
R8	DRCU AIV Plan	SAp-SPIRE-HT-0082-02
R9	FPU Simulator Specifications	SIG-SPIRE-PdA-0030-01
R10	Herschel/Planck delivery of Scientific Instrument Models	SCI-PT/012993
R11	Herschel Management Plan at CEA	SAp-FIRST-JLA-0038-01
R12	SPIRE OBS (part of Herschel SAp OBS)	SAp-FIRST-DR-0046-01
R13	SPIRE Schedule (part of Herschel SAp Schedule)	SAp-FIRST-DR-0047-01
R14	SPIRE WBS	SAp-FIRST-DR-0045-01
R15	SPIRE OBS (part of Herschel SAp OBS)	SAp-FIRST-DR-0046-01
R16	SPIRE Product Tree	SAp-SPIRE-DR-0045-01
R17	SPIRE Risk Analysis	SAp-SPIRE-DR-0046-01

LIST of USED ACRONYMS

AIV	Acceptance, Integration and Validation
AVM	AVionic Model
BB	BreadBoard
BSM	Beam Steering Mirror
CDMS	Command and Data Management Subsystem
CDR	Critical Design Review
CEA	Commissariat à l'Energie Atomique
CQM	Cryogenic Qualification Model
DCU	Detector Control Unit
DDR	Detailed Design Review
DPU	Data Processing Unit
DRCU	Detector Readout Control Unit
DTU	DRCU Test Unit
EM	Engineering Model
FCU	Focal plane Control Unit
FIRST	Far InfraRed Submillimetre Telescope *(renamed as Herschel)*
FM	Flight Model
FPU	Focal Plane Unit
FS	Flight Spare model
FSE	Factory Support Equipment
FTS	Fourier Transform Spectrometre
GSFC	Goddard Space Flight Centre
H/K	HouseKeeping
I&T	Integration and Test
I/F	Interface
ICD	Interface Control Document
IID	Instrument Interface Document
IRD	Instrument Requirement Document
JPL	Jet Propulsion Laboratory
LAM	Laboratoire d'Astrophysique de Marseille
LTU	Local Test Unit
MCU	Mechanism Control Unit
OBS	Organisation Breakdown Structure
PDR	Preliminary Design Review
PFM	Proto Flight Model
PSU	Power Supply Unit
QMW	Queen Mary and Westfield College
RAL	Rutherford Appleton Laboratory
SAp	Service d'Astrophysique (CEA/DAPNIA)
SCU	Subsystem Control Unit
SEDI	Service d'Électronique, des Détecteurs et d'Informatique (CEA/DAPNIA)
SIS	Service d'Ingénierie des Systèmes (CEA/DAPNIA)
SMEC	Spectrometer MEChanism
SPIRE	Spectral and Photometric Imaging REceiver
STM	Structure and Thermal Model
SVM	SerVice Module
TBD	To Be Defined
TBW	To Be Written
TC	Telecommand
WE	Warm Electronics
WIH	Warm Interconnect Harness (harness between the DPU and the DRCU)

1 INTRODUCTION.

SPIRE is one of the three instruments to be embarked aboard the Herschel spacecraft satellite, which will be launched in 2007. SPIRE consists in a Photometer and a Spectrometer respectively equipped with infrared detector focal planes. The wavelength operation range of SPIRE is 200µ – 600µ.

It is planned to build and deliver to ESA 4 models of the instrument:

1. **AVM** : Concerns mainly the electronics interface with the S/C.
   On SPIRE this model consists in the DPU and a DRCU Simulator.
2. **CQM** : Flight representative but could be not fully detector populated. The CQM aims to demonstrate that the whole instrument chain fulfil the instrument requirements.
3. **PFM** : fully compliant.
4. **FS** : consists in FM replica or spare units, depending on the considered subsystem.

The CEA/SAp is committed to develop and deliver to the SPIRE Consortium the following Warm Electronics sub-systems:

- The Detector Readout and Control Unit (DRCU) models.
- The Warm Interconnect Harness (WIH) models.
- An FPU simulator.

1.1 Purpose of the document.

This document is the development plan related to the above-mentioned sub-systems in compliance with the SPIRE Instrument Development Plan [A1].

It is intended to be used:

- by the SPIRE Project Manager consolidation of the overall SPIRE development plan.
- by the SAp Local Manager as a reference document for managerial purpose.
- by the members of review boards all along the project for assessment purpose.
- by the CEA developers as a guide line.

1.2 Scope of the plan.

This Plan starts from the SPIRE Preliminary Design Review (June 2000).

This document deals with:

- the design, development, qualification, integration and test of the DRCU with the exception of the Mechanism Control Unit (MCU) (see §2.1), which is a sub-unit of the DRCU developed under the responsibility of the LAM [A9].
- the design, development integration and test of the FPU simulator: with the exception of the FPU simulator sub-units which will be developed by the LAM.
- the design and development of the required test equipment.

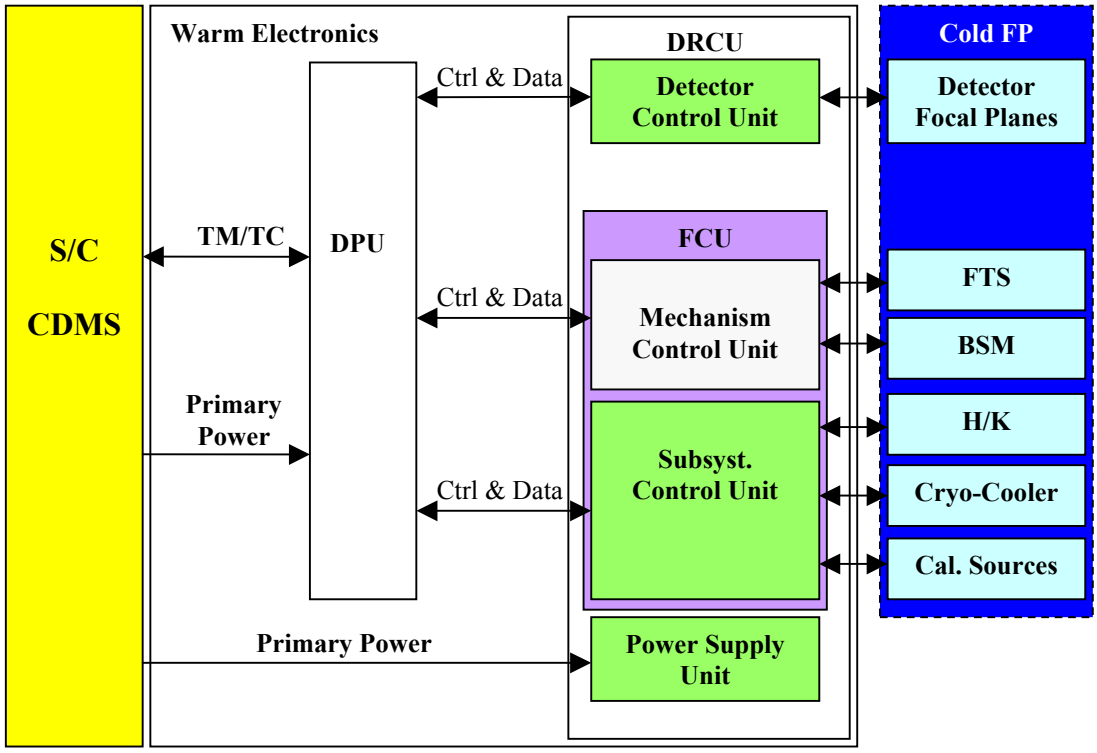
1.3 Document Overview.

This document addresses the following topics:

- Instrument overview and general description of the DRCU and its interfaces with other SPIRE subsystems.
- Model definition.
- Test Equipment.
- AIV Philosophy.
- Safety Analysis.
- Development Monitoring.

2 Overall description.

2.1 SPIRE Warm Electronics Architecture.



The above block diagram shows the overall SPIRE instrument architecture.

The SPIRE instrument consists in a cold Focal Plane which is linked via suitable harnesses to the Warm Electronics (300K) situated on the S/C Service Module.

The Warm Electronics ensures the electrical and functional I/F between the S/C CDMS and the Cold Focal Plane.

As far as the electronics is concerned, the Cold Focal plane encompasses 6 sub-units, which are:

1. The Detector Focal Planes Unit: this unit encompasses the 5 Detector Focal Planes (3 for the Photometer and 2 for the Spectrometer) connected trough a JFET and R/F filter box situated at Cold Focal Plane level. The Photometer and the Spectrometer are working in an exclusive way.
2. The FTS mirror moving system (SMEC) developed by the LAM.
3. The BSM actuator system developed by ATC.
4. The H/K unit which is mainly constituted of distributed temperature probes of various nature.

5. The Cryo-cooler used to cool down the detector focal planes which is controlled by the DRCU by heaters and temperature sensors situated on the thermal switches of the cryo-cooler pump.
6. The Calibration Sources which are basically heaters coupled with temperature probes.

2.2 Definition and description of the DRCU.

2.2.1 Role of the DRCU.

The DRCU provides the electrical and functional interfaces between the DPU and the Cold Focal Plane Sub-units:

a) Interpretation and execution of the low level commands provided by the DPU and reporting on their execution.
b) Generation of the suitable digital control lines: detector addresses.
c) Carrying out of the suitable analog to digital and digital to analog : detector signal readout, bias generations, temperature acquisition, analog control.
d) Cold unit power supply.

2.2.2 DRCU Architecture and Subsystems.

The DRCU consists in three subsystems:

1. the Detector Control Unit (DCU).

2. the FCU which encompasses:

    a) the MCU which is built by the LAM.
    b) the Subsystem Control Unit (SCU).

3. the PSU.

    The design and realisation of the PSU will be sub-contracted to the industry.

2.2.3 DRCU Interfaces.

The DRCU Interfaces are described in the following documents:

R1	Herschel/Planck IID-A	SCI-PT-IIDA-04624
R2	SPIRE IID-B	SCI-PT-IIDB/SPIRE-02124
R6	DRCU Electrical ICD	SAp-SPIRE-CCa-0024-00

2.2.3.1 Electrical I/F.

The DRCU is electrically interfaced with:

a) the DPU by the means of 3 sets of redundant serial links, each set including a bi-directional low rate link and an mono-directional (DRCU to DPU) high rate link.
b) the Cold Focal Plane units by the mean of the harnesses.
c) the S/C which provides the DRCU power supply and monitors a couple of box temperatures.

2.2.3.2 S/W I/F.

The DRCU is interfaced with the DPU s/w via the above-mentioned serial links.

This I/F concerns the S/W communication protocol related to the TC and Acknowledgement as well as the Science and H/K data sending out.

2.2.3.3 Mechanical and Thermal I/F.

The DRCU is physically made of 3 boxes: the DCU box, the FCU box and the PSU box, the PSU box being located under the FCU box.

The DRCU interfaces:

- with the S/C: the two boxes (DCU and FCU+PSU) are bolted to the SVM, ensuring the mechanical fastening, the electricazl grounding and the thermal dissipation.
- with the S/C and the FPU via harnesses.

3 Development.

3.1 DRCU Model Definition.

3.1.1 DCU Breadboard.

The Detector Control Unit breadboard aims to validate the electronics design concepts: this Breadboard Model designed jointly by SAp and JPL/Caltech and realised and tested at JPL.

3.1.2 STMs.

a) DRCU STM:

   Mechanical Structure Prototypes: for testing & qualification (Vibration and Thermal tests) purpose of the mechanical structures (box and board stiffeners).

   This Model is common with the PACS project (BOLC Mechanical Structure).

b) PSU STM:

   The PSU is located under the FCU box.

   The PSU manufacturer provides a PSU STM. It will be used to check the mechanical and thermal design, as mechanical I/F for the FCU.

3.1.3 EMs.

a) DCU EM:

   A Detector Control Unit Engineering Model will be built at JPL based on a common (SAp/JPL) design validated by the DCU breadboard model.

   This EM Model will be integrated to the QM1 Model.

b) PSU EM:

   The PSU manufacturer will built a PSU EM. This model will only electrically representative. It will be used to check the electrical compatibility between the DRCU and the PSU.

3.1.4 Qualification Models.

Two DRCU Qualification Models will be developed:

QM1 : Validation of the Design Concepts and Functionality as well as the electrical I/Fs and budgets.
QM2 : Full Qualification.

3.1.4.1 DRCU QM1

- This Model is functionally representative and as representative as possible compared to the Flight Model as far as its electrical and mechanical properties are concerned. Cold redundancies are NOT implemented on this model (see Annex 1).
- DRCU QM1 specifications: Cf. the Model summary characteristics table in §3.2.
- This model is deliverable to RAL for I&T on the WE QM. It will be delivered by RAL to ESA as a test means for the Instrument CQM.
- A separate Power Bench powers the DRCU QM1.

3.1.4.2 DRCU QM2

- This Model is intended to undergo the qualification tests.
- This model is almost fully representative of the Flight Model.
- Mechanical and Thermal test will be performed by using the PSU STM. The PSU EM will be used to carry out the performance tests.
- DRCU QM2 specifications: Cf. the Model summary characteristics table in §3.2.
- A separate Power Bench powers the DRCU QM2.
- This Model is NOT deliverable to ESA. It will be delivered to RAL for the pre-integration of the Instrument FM (awaiting for the delivery of the DRCU FM). Then, it will be shipped back to SAp.

3.1.5 Flight Model.

- This Model will be integrated to the WE FM.
- DRCU FM specifications: Cf. the Model summary characteristics table in §3.2.
- PSU FM delivered by the PSU manufacturer will be integrated to the FCU.
- A separate Power Bench powers the DRCU FM as long as the PSU FM is not available.
- This model is deliverable to RAL for I&T to the WE FM. Ground Calibration will be performed by RAL with this Model. RAL will in turn deliver it to ESA as part of the instrument FM.

3.1.6 Flight Spare Model.

- This Model is NOT yet specified: Spares or fully complete FM like Model.
- All FS units are equivalent to the FM ones.
- This Model is deliverable to RAL.

3.2 DRCU Model characteristics.

			FCU				
DRCU	**Mechanics**	**DCU**	**MCU**	**SCU**	**PSU**	**Part Grade**	**Perform.**
BB	N/A	Yes	Yes	Yes	-	Standard	NNP
STM	Yes					N/A	N/A
QM1	Simplified -	EEq(*) NCR	EEq NCR	EEq NCR	PB NCR	EEq	NNP
QM2	F -	FEq CR	FEq CR	FEq CR	STM,EM,PB CR	FEq	NNP
FM	F -	F CR	F CR	F CR	F	F	NoP
FS	F ?	F ?	F ?	F ?	F ?	F	NoP

Ext : External (Power Supply only)
EEq : Electrically Equivalent
FEq : Flight Equivalent (any grade but nominal size, consumption and performances)
F : Flight
NCR : Cold Redundancy Not implemented
CR : Cold Redundancy implemented
DeP : Degraded Performance acceptable
NNP : Near Nominal Performance
NoP : Nominal Performance
(*) : The number of readout channels implemented shall at least correspond to the number of detectors of the instrument CQM (photometer and spectrometer).

Note: a) See IID-B for Model Performance Requirements.
b) FS policy TBD.

3.3 Warm Interconnect Harness Model definition.

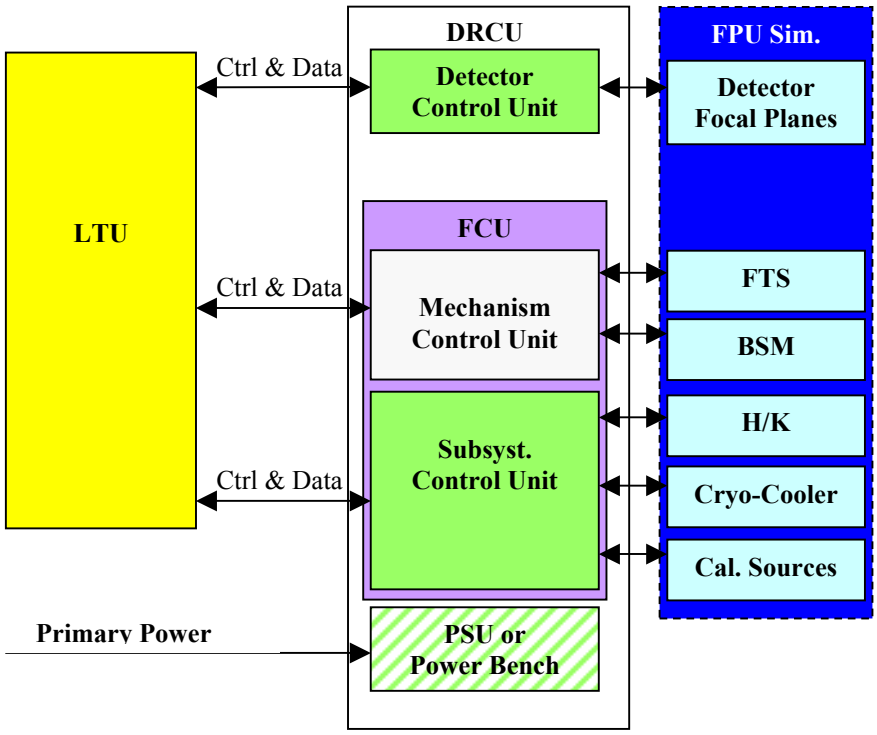
DPU/DRCU H. Models	Qty	Wires	Connectors	Perform.	Comments
Test	1	Pro	Std	NNP	
QM1	1	Pro	Std	NNP	
QM2	1	F	F	NoP	
FM	1	F	F	NoP	
FS	?	F	F	NoP	

Pro : Prototype
Std : Standard component (commercial grade)
F : Flight
NNP : Near Nominal Performance
NoP : Nominal Performance

3.4 Ground Test Equipment.

The DRCU Ground Test equipment consist in:

- a Local Test Unit (LTU).
- an FPU simulator.
- a set of test harnesses: DPU/DRCU, DRCU/FPU, PDU/DRCU.
- a Power bench (used when the PSU is not available (or not necessary)).



The above block diagram shows a typical DRCU full test configuration

3.4.1 Local Test Unit (LTU).

The DRCU Local Test Unit generates the DPU command flow, records incoming data and provide data display capabilities. It is made up of a PC equipped with the suitable serial I/Fs. The PC is running dedicated test S/W modules. The MCU test sequence run by the DRCU test unit is provided developed by the LAM.

3.4.2 FPU Simulator.

The FPU Simulator is designed to simulate:

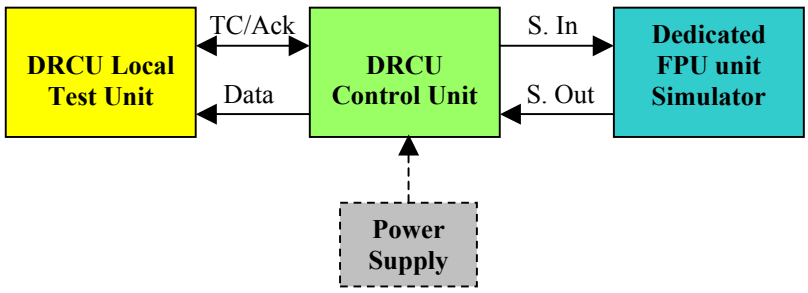
- the FPU electrical I/F.
- the behaviour of the FPU up to a certain extent (cf. FPU Simulator specification [R9].

It is made up of the assembly of Unit simulators: DCU, SCU and MCU). The MCU simulator is provided by the LAM (see §4.1).

3.5 Subsystem tests.

Each DRCU Control Unit (DCU, SCU, MCU) has to be tested separately prior to their integration. This requires the following equipment:

- a DRCU Test Unit (*): H/W + dedicated test s/w)
- a dedicated FPU unit simulator.
- a LTU/DRCU test harness.
- a DRCU/FPU Unit test harness.
- an external power supply if required.



(*) A full LTU is not required as only one set of communication lines is needed.

Only the s/w necessary to test the specific DRCU Control Unit is required as well.

Similarly to the whole DRCU test configuration, the above configuration allows to carry out:

- DRCU Control Unit electrical and S/W (communication protocol) I/Fs test and validation.
- DRCU Control Unit functional test (to some extent).

3.6 AIV Philosophy.

See the DRCU AIV Plan [R8].

All the Models delivered to RAL are fully tested and ready for their integration with the corresponding instrument WE models.

AIV steps are summarised as follow:

a) Unitary test and validation of the sub-units.
b) Successive Integration of the sub-units in the DRCU Boxes.
c) Full Validation (functionality, performance,…)
d) Carrying out of the Qualification or Acceptance tests.

The following table summarises the validation, qualification and acceptance policy:

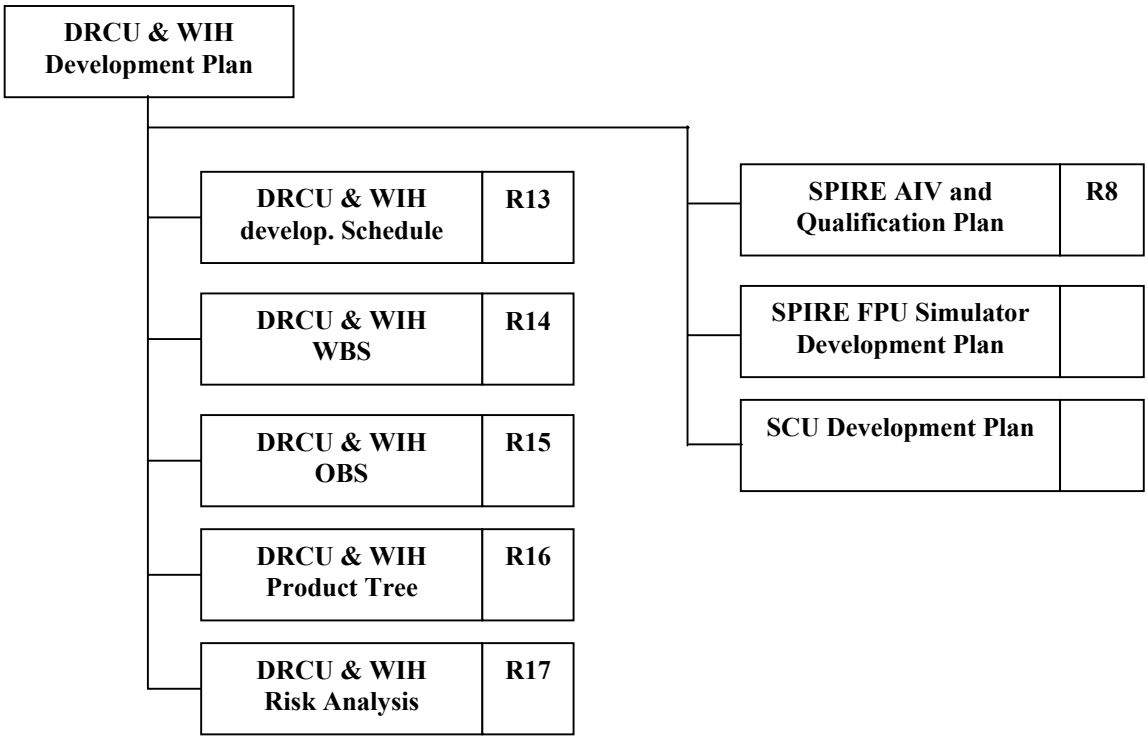
DRCU	Electrical	Mechanical & Thermal I/F	Performance Level	Vibration	Themal Vaccum	EMI	EMC
STM		**X**	**X**	**Q**			
QM1	**X**	**X**	**X**				
QM2	**X**	**X**	**X**	**Q**	**Q**	**Q**	**Q**
FM	**N**	**N**	**N**	**A**	**A**	**A**	**A**
FS	**N**	**N**	**N**	**A**	**A**	**A**	**A**

X : Nominal or Near Nominal
N : Nominal
Q : Qualification Level
A : Acceptance Level

4 Development Monitoring.

4.1 Documentation.

The main development activities are monitored by the means of a set of documents linked to the present plan.



4.2 Product vs. Model Summary.

See Annex I.

4.3 Project Main Milestones.

4.3.1 ESA main Milestones.

Instrument delivery date are given in [R10]

Milestones	Date	Comments
SPIRE IIDR	April 2001	Carried out
SPIRE IBDR	March 2002	Carried out
IHDR	June 2003	
Instrument AVM delivery to ESA	Oct. 2003	
Instrument CQM delivery to ESA	Oct. 2003	
Instrument FM delivery to ESA	January 2004	
Instrument FS delivery to ESA	January 2005	

4.3.2 SPIRE Main Milestones.

The following Milestones are extracted from the SPIRE Major Milestone list [A2].

Milestones
DRCU DDR
DRCU/WIH QM1 and FPU Simulator delivery to RAL
DRCU QM2 Delivery to RAL
DRCU PFM Delivery to RAL
DRCU FS Delivery to RAL

4.3.3 Internal Delivery/Availability Milestones.

Milestones	From
DCU EM	JPL
JPL Cryogenic Test Facility	JPL
MCU Simulator	LAM
LTU #1	SAp
FPU Simulator #1	SIS
SCU QM1	SEDI
MCU QM1	LAM
SCU QM2	SEDI
MCU QM2	LAM
LTU #2	SAp
FPU Simulator #2	SIS
SCU PFM	SEDI
MCU PFM	LAM
SCU FS	SEDI
MCU FS	LAM

4.4 Schedule.

The SPIRE development at CEA are monitored via schedules. SAp are maintaining:

- An overall schedule (one A4 page).
- A Master Schedule.
- Detailed schedule on demand.

4.5 Working Organisation.

Item		Resp.	Comments
DRCU	DCU	SAp	SEDI for DPU I/F (VHDL)
	SCU	SEDI	SAp for Temp. Measurement and cryo-cooler control.
	MCU	LAM	
	PSU	SAp	the realisation of this unit is sub-contracted
	Mechanic	SAp	
Harnesses	Flight H.	SAp	
	Test H.	SAp	
Test Equipment	FPU Sim.	SIG	LAM provide the MCU (BSM + SMEC) simulators
	LTU	SAp	

- Overall Herschel project organisation at CEA is given in [R11].
- The detailed working organisation is given in the OBS [R12].

ANNEX I – DRCU Product vs. Model Summary

S-Syst (N1)	S-Syst (N2)	S-Sys (N3)	Part n°	STM	EM	QM1	QM2	FM	FS	Comments
DCU										
	DAQ+IF			2 dum.	1	1	2	2	1	
	BIAS			2 dum.	1	1	2	2	1	
	LIA-TC			1 dum.	0	0	1	1	1	
	LIA-S			3 dum.	3	3	3	3	1	
	LIA-P			8 dum.	2	2	8	8	2	
	BP-DCU			1 dum	1 (QM1)	1	1	1	1	
	DCU Box			1	1 (QM1)	Light	1	1		
FCU										
	SCU									
		CCHK+IF		-	-	1	2	2	1	
		Temp+Heat		-	-	1	2	2	1	
		BP-SCU		-	-	1?	1	1	1	
	MCU			-	-	1	1	1	?	LAM Delivery
	SCU Box			-	-	Light	-	-	-	
	FCU Box			-	-	Light	1	1	-	
PSU				1	Lab.	PB	PB/EM	PB/1	Board	PB=Power Bench
Flight Harnesses										
	DRCU-DPU			-	-	1	2	2	-	
	PSU-DCU			-	-	1	2	2	-	
	PSU-FCU			-	-	1	2	2	-	
		PSU-SCU		-	-	1	2	2	-	
		PSU-MCU		-	-	1	2	2	-	