FIRST/SPIRE

Detector Readout Control Unit

and Warm Interconnect Harness

Development Plan

Reference: SPIRE-SAP-PRJ-000471
Issue: 2.0
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	Function	Name	Date	Visa
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DOCUMENT STATUS and CHANGE RECORD

Date	Issue	Affected pages or sections
14/04/2000	Draft 0.1	Creation
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15/12/00	2.0	

TABLE OF CONTENT

DOCUMENTATION

Applicable Documents:

A1	Intrument Development Plan	Issue: 1.0	20/06/00	SPIRE-RAL-PRJ-0035
A2	Major Milestone List	Issue: 1.1	02/08/00	SPIRE-RAL-PRJ-00455
A3	PA Requirements	Issue: 1	xx/09/97	
A4	Standard Product Asssurance Plan	Issue: 1.0	07/11/00	SAp-GERES-FLo-436-00
A6	Product Tree	Issue: 1.0	09/11/99	SPIRE-RAL-PRJ-00030
A7	Configurable Document Tree	Issue: 0.4	17/10/00	SPIRE-RAL-PRJ-00033
A8	PAP	Draft 1	05/02/98	BOL/RAL/D/0017.01
A9	Convention SAp/IAM (CEA/CNRS/CNES)	Draft 2	21/12/00	00.xxx/SAp.JLA

Reference Documents:

R1	IID-A	Issue 1.0	01/09/00	SCI-PT-IIDA-04624
R2	IID-B	Issue: 1.0	01/09/00	SCI-PT-IIDB/SPIRE-02124
R3	Instrument Requirement Document	Issue: 1.0	23/11/00	0034
R4	Instrument Model Philosophy	Note	12/07/00	
R5	Liste des documents SPIRE	Draft 0.2	15/12/00	SAp-SPIRE-FLo-0028-00
R6	DRCU Electrical ICD	Draft 0.3	21/11/00	SAp-SPIRE-CCa-0024-00
R7	DRCU Subsystem Specification	Draft 0.5	15/12/00	SAp-SPIRE-CCa-0025-00

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
FIRST	Far InfraRed Submillimetre Telescope
FM	Flight Model
FPU	Focal Plane Unit
FS	Flight Spare model
FSE	Factory Support Equipment
FTS	Fourier Transform Spectrometre
GSFC	Goddard Space Flight Centre
I&T	Integration and Test
ICD	Interface Control Document
IID	Instrument Interface Document
IRD	Instrument Requirements Document
LAM	Laboratoire d'Astrophysique de Marseille
MCU	Mechanism Control Unit
OIRD	Operation Interface Requirement Document
PDR	Preliminary Design Review
PDU	Power Distribution Unit
PFM	Proto Flight Model
QMW	Queen Mary and Westfield College
RAL	Rutherford Appleton Laboratory
SAp	Service d'Astrophysique (CEA/DAPNIA)
SCU	Subsystem Control Unit
SEI	Service d'Electronique et d'Informatique (CEA/DAPNIA)
SIG	Service d'Instrumentation Générale (CEA/DAPNIA)
SMEC	Spectrometer MEChanism
SPIRE	Spectral and Photometric Imaging REceiver
SVM	SerVice Module
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
WERD	Warm Electronics Requirement Document
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 FIRST 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:

- the AVM which concerns mainly the electronics interface with the S/C.
- the CQM which shall be flight representative but could be not fully detector populated. The CQM aims to demonstrate that the whole instrument chain fulfil the instrument requirements.
- the PFM.
- the FS Model which depending on the considered subsystem will consists in FM replica or spare units.

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.
- The FPU simulator.

1.1 Purpose of the document.

This document is the development plan related to the above mentioned sub-systems.

This plan shall be compliant with the SPIRE Instrument Development Plan [A1].

It is intended to be used:

- by the SPIRE Project Manager for integration in 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, 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, which is developed under the responsibility of the LAM [A9].
- the design and development of the required Facility Support Equipment.
- the design, development integration and test of the FPU simulator: with the exception of the FPU simulator sub-units which will be developed by other labs (see work-sharing table below).

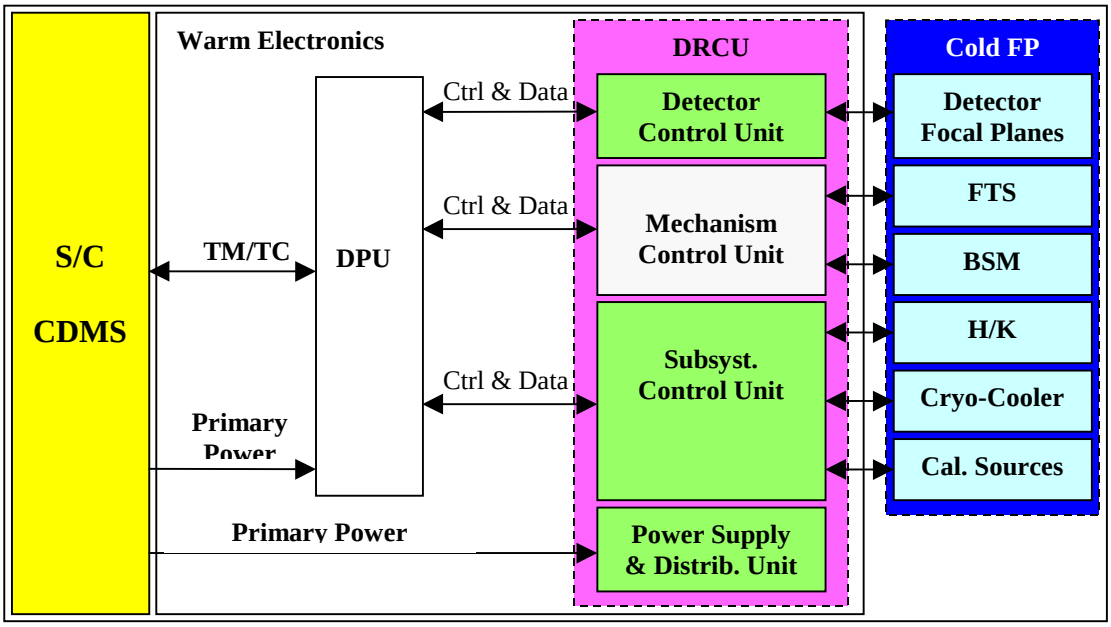
1.3 Document Overview.

This document addresses the following topics:

- Instrument overview and general description of the DRCU and its interfaces with other SPIRE subsystems.
- Organisation and worksharing
- Model definitions.
- Development
- Product tree.
- AIV overall plan.
- Development schedule.

2 Overall description.

2.1 SPIRE and SPIRE Warm Electronics Architectures.



The above block diagram shows the overall SPIRE instrument architecture. The SPIRE instrument consists of a cold Focal Plane which is linked through 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:

a) 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.
b) The FTS mirror moving system (SMEC) developed by the LAM.
c) The BSM actuator system developed by ATC.
d) The H/K unit which is mainly constituted of distributed temperature probes of various nature.
e) The Cryo-cooler used to cool down the detector focal planes which is controlled by the DRCU by the means heaters and temperature sensors situated on the thermal switches the pump of the cryo-cooler.
f) 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 the low level commands provided by the DPU and reporting on their execution.
b) Generation of the necessary digital control lines: detector addresses.
c) Carrying out of the necessary 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 Interfaces.

The DRCU Interfaces are described in the following documents:

R2	IID-B	Issue: 1.0	01/09/00	SCI-PT-IIDB/SPIRE-02124
R6	DRCU Electrical ICD	Draft 0.3	21/11/00	SAp-SPIRE-CCa-0024-00

2.2.2.1 Electrical I/F.

The DRCU is electrically interfaced with:

a) the DPU by the means of 3 sets of 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 harness.
c) the S/C which provides the DRCU power supply and monitors a couple of box temperatures.

2.2.2.2 S/W I/F.

The DRCU is interfaced with the DPU s/w via the above described serial link.

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

2.2.2.3 Mechanical and Thermal I/F.

The DRCU is physically 2 boxes which are interfaced:

- with the S/C: it is bolted to the SVM, this ensuring the mechanical fastening, and the thermal dissipation.
- with the various harnesses: to the DPU, the FPU and the S/C.

2.2.3 DRCU Physical Architecture.

The DRCU consists of several subsystems integrated into two boxes:

- A box containing the Detector Control Unit (DCU).

- A box containing the rest of the DRCU:

    a) The MCU which is built by the LAM.
    b) The Subsystem Control Unit (SCU).
    c) The Power Supply and Power Distribution Unit.

3 Managerial Considerations.

3.1 SAp's workpackages.

WP n°	WP description	Comments
SAp-01	Local management.	
SAp-02	QA	
SAp-03	DRCU System and Architecture Design.	
SAp-04	Design, Manufacturing and test of the following DRCU units: - Mechanics (box & Board stiffeners). - Detector Control Unit (with the active participation of JPL at the design and test stage). - Subsystem Control Unit. - Power Supply and Power Distribution Unit.	
SAp-05	Design, Development and test of the Warm Interconnect Harness.	
SAp-06	Design and development of the test harnesses	Test harnesses are defined by SAp but will be procured by RAL.
SAp-07	Design, Development and test of the FPU Simulator	
SAp-08	Test equipment Design, Development and Test	- DRCU Local Test Unit. - Test harnesses
SAp-09	Design and Development of the Transport containers.	
SAp-10	Integration, Test and Qualification of the DRCU Models (with respect to the Model definition given in §4.1.1).	
SAp-11	Qualification and Acceptance tests of the WIH models	
SAp-12	Maintenance of the delivered products (Except the sub-units provided by other labs).	

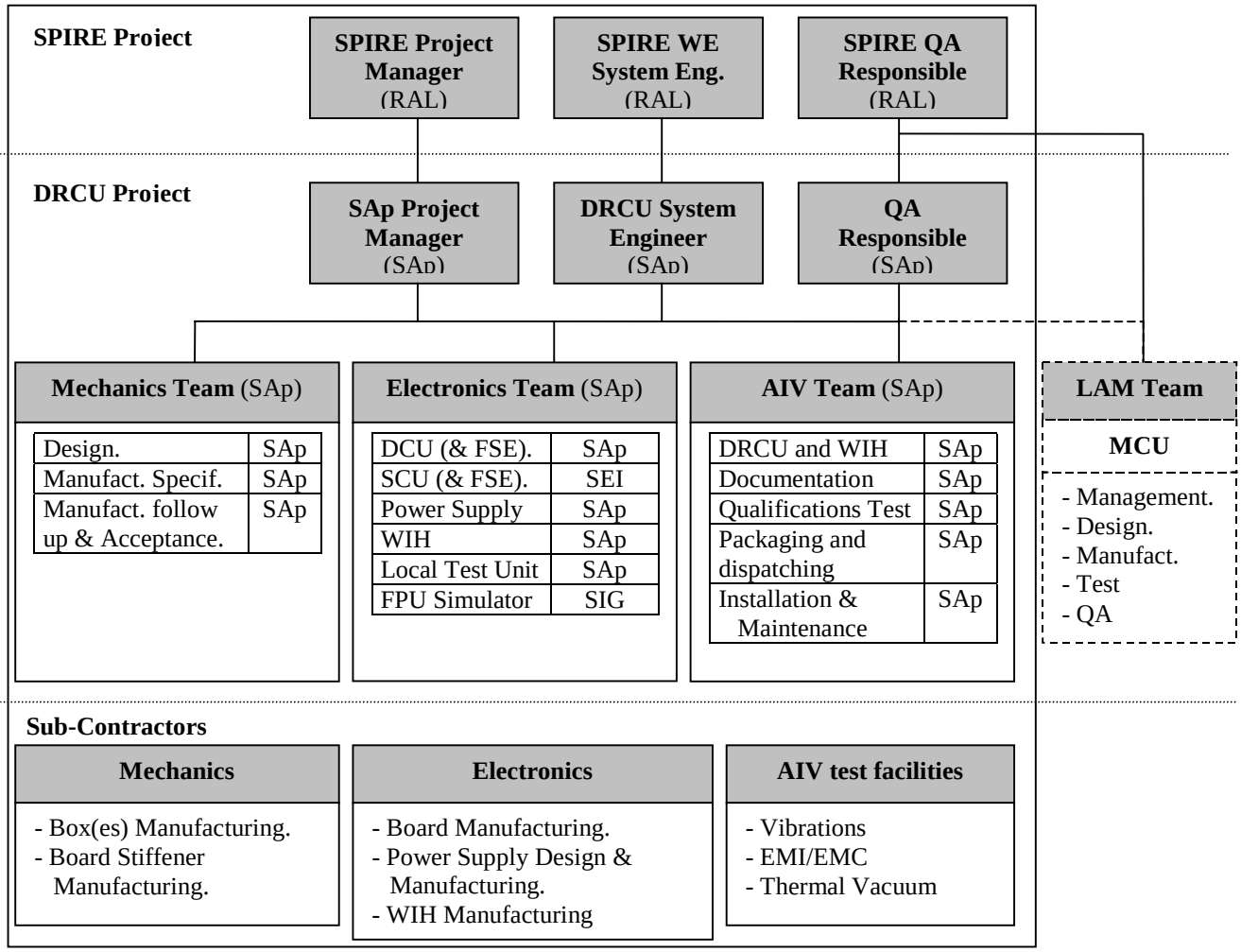
3.2 Worksharing.

Working areas	Responsibility	Comments
Local Management	CEA/SAp	
DRCU System design	CEA/SAp	
Quality Assurance / Product Assurance	CEA/SAp	Except for the MCU development
Integration	CEA/SAp	
Qualification	CEA/SAp	
DRCU		
Mechanics	CEA/SAp	
Power Supply	CEA/SAp	
Detector Control Unit	CEA/SAp	
Subsystem Control Unit	CEA/SAp&SEI	
Mechanism Control Unit	LAM	Development under LAM's control
Warm Interconnect Harness	CEA/SAp	Done by CEA but Cost shared with IFSI
Local Test Unit	CEA/SAp+SIG	SIG provides Operator I/F S/W
FPU Simulator	CEA/SIG	Specification written by SAp
Detector Focal Plan Sim.	JPL	
BSM+SMEC Sim.	LAM	
H/K Sim.	CEA/SAp	
Cryo-Cooler Sim.	CEA/SAp	
Calibration Source Sim.	GSFC	
FPU Test Harnesses and connectors	RAL	Procurement by RAL, but paid by CEA
Transport Containers	CEA/SAp	Only for Integrated Products.
Provision of a Cryogenic test facility for the JPL detectors	JPL	This test facility will be provided along a detector prototype

3.3 Working Organisation.

The SAp has set up a team to deal with all FIRST activity at SAp (SPIRE & PACS).

The Following diagram shows only the organisation related to the SPIRE project.



4 Development.

4.1 DRCU Development.

4.1.1 DRCU Model Definition.

4.1.1.1 Breadboards.

The Detector Control Unit breadboard aims to validate the electronics design concepts: this Breadboard Model will be conceived by SAp and realised and tested at JPL.

4.1.1.2 STMs.

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

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

4.1.1.3 EMs.

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.

4.1.1.4 Qualification Models.

Two DRCU Qualification Models will be developed:

As mentioned in §4.1.1 and summarised by the table in §6.2 below the Model objectives are as follow:

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

4.1.1.4.1 DRCU QM1

- This Model is to be integrated with the WE QM.
- It shall be as representative as possible compared to the Flight Model for what concern its thermal, electrical and mechanical properties and its functionality. Cold redundancies are NOT implemented.
- DRCU QM1 specifications: Cf. the Model summary characteristics table in §4.1.1.7.
- This model is deliverable to RAL for I&T with the WE QM. RAL will in turn deliver it to ESA as part of the CQM.

4.1.1.4.2 DRCU QM2

- This Model is intended to undergo the qualification tests under Saclay's supervision.
- This model has the same characteristics as the QM1 but all redundancies are implemented.
- DRCU QM2 specifications: Cf. the Model summary characteristics table in §4.1.1.7.
- 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.

4.1.1.5 Flight Model.

- This Model will be integrated with the WE FM.
- DRCU FM specifications: Cf. the Model summary characteristics table in §4.1.1.7.
- This model is deliverable to RAL for I&T with 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.

4.1.1.6 Flight Spare Model.

- This Model is NOT yet specified: Spares or fully complete FM like Model.
- All units constituting the FS (whatever they are) will have the same characteristics as the corresponding FM units.
- This Model is deliverable to RAL for I&T and delivery to ESA.

4.1.1.7 DRCU Model characteristics.

DRCU	Mechanics	DCU	MCU	SCU	DC/DC	Part Grade	Perform.
BB	N/A	Yes	Yes	Yes	-	Standard	NNP
STM	Yes					N/A	N/A
EM	N/A	Yes(*)	Yes	Yes	Yes	FEq	NNP
QM1	FEq -	FEq(*) NCR	FEq NCR	FEq NCR	Ext. P.Sup. NCR	FEq	NNP
QM2	FEq -	FEq CR	FEq CR	FEq CR	FEq 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)
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).

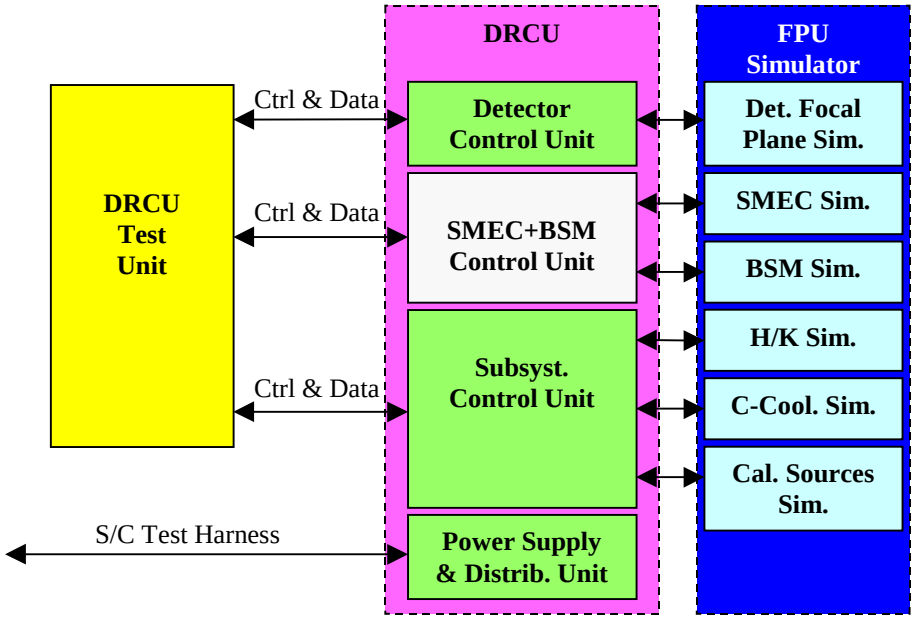
Note: a) See IID-B for Model Performance Requirements.
b) FS policy TDB.

4.1.2 DRCU testing and Test Equipment.

To test the whole DRCU subsystem the following test equipment are needed:

- a DRCU Test Unit (DTU).
- an FPU simulator.
- a DPU/DRCU test harness.
- a DRCU/FPU test harness.
- a PDU/DRCU test harness (28V.)

In addition, External Power Supplies may be required to supply the DRCU as long as a Power Supply & Distribution Unit is not integrated in the DRCU (likely for the QM1).



The above configuration allows to carry out:

- DRCU electrical and Communication protocol I/Fs test and validation.
- DRCU functional & Performance tests and validation (to some extent).

4.1.2.1 DRCU Test Unit (DTU).

The DRCU Test Unit shall simulate 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 S/W run by the DRCU test unit will be developed by the LAM.

The DTU shall be developed in parallel with the development of the QM1 of the DRCU Control Units.

4.1.2.2 FPU Simulator.

The FPU Simulator is designed to simulate:

- the FPU electrical I/F.
- the behaviour of the FPU in a TBD limited way.

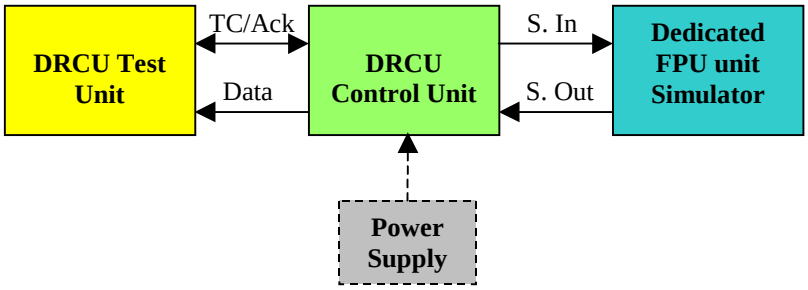
It is made up of the assembly of Unit simulators to be provided by the various institutions as stated in the "Worksharing" section (§3.2)

4.1.2.3 DRCU Control Unit testing.

The DRCU Control Units are: the Detector Control Unit (DCU), the Subsystem Control Unit (SCU) and the Mechanism Control Unit (MCU).

Each DRCU Control Unit has to be tested separately prior to their integration. This is requiring the following equipment:

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



(*) A full DTU 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).

4.2 Warm Interconnect Harness Development.

4.2.1 WIH Model Definition.

The WIH have to be delivered along with each DRCU Models.

4.2.2 DPU/DRCU Harness Model characteristics.

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	

(*) : The WIH is a single cable encompassing Prime and Redundant interconnections.

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

5 Product Definition.

5.1 Product Tree

See the product tree is given in Annex 2.

5.2 Product Summary Table

		Resp.	QM1	QM2	FM	FS	Comments
DRCU							
	DCU						BB & EM Dev. & Test in collab. with JPL
	Digital Unit	SAp	1	2	2	?	
	JFet Supply + Bias Unit	SAp	1	2	2	?	
	LIA	SAp	1	2	2	?	
	Backplane	SAp	1	2	2	?	
	SCU						
	H/K Readout	SAp	1	2	2	?	Thermometry
	Cryo-Cooler Control	SAp	1	2	2	?	
	Calib. Sources Control	SAp	1	2	2	?	
	Power Dist. Control	SAp	1	2	2	?	
	Backplane	SAp	1	2	2	?	
	MCU	LAM	1	2	2	?	See LAM Dev. PLan for Details
	Power Supply						
	DC/DC	SAp	1	2	2	1?	
	Distribution Unit	SAp	1	2	2	1?	
	Mechanics						
	DRCU Box	SAp	1	1	1	?	FS could use QM1 or QM2 box
	Board Stiffeners	SAp	x	x	x	?	
	Connectors	SAp	x	x	x	?	
Harnesses							
	WIH	SAp	1	1	1	1	Main & Redundant wires in one harness
	Power Supply Test H.	RAL	1				
	Test Harnesses						
	DTU to FPU Test H.	RAL	1				
	DCU to Test Det. Warm H.	JPL	1				
	DCU to Test Det. Cold H.	JPL	1				
Simulators							
	FPU Simulator						
	H/W	SIG	1				
	S/W	SIG	1				
	FPU Unit Simulators						
	Detector FPU Sim.	JPL	1				
	H/K Sim.	SAp	1				
	Cryo-Cooler Sim.	SAp	1				
	Calibration Sources Sim.	GFSC	1				
	DEC/MEC Sim.	LAM	1				FTS and BSM Mechanism Simulator
Test Equip.							
	DRCU Test Unit						
	H/W	SAp	1				PC + DRCU I/Fs
	Data presentation S/W	SIG	1				
	R-Time & D. Analysis S/W	SAp	1				MCU part provided by LAM
	Test Detector Set	JPL	1				
	Det. Cryo. Test Facility	JPL	1				

6 AIV.

6.1 AIV Philosophy.

All the Models delivered to RAL shall be fully tested and ready for their integration in the instrument WE models.

The AIV Flowchart given in Annex 1 is describing the AIV steps which 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.

6.2 Performance, Qualification and Acceptance.

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

7 Schedule.

7.1.1 Project Main Milestones.

Project Milestones	Date	Comments
SPIRE Final PDR	June 2000	
SPIRE DDR	Oct. 2000	
DRCU QM1 Delivery to RAL	Oct. 2002	
FIRST CDR	Apr. 2003	
DRCU QM2 Delivery to RAL	Nov. 2003	Sept. 2003 (Note B.Swinyard dated 19/12/00)
DRCU FM Delivery to RAL	March 2004	
DRCU FS Delivery to RAL	Dec. 2005	

7.1.2 Development Schedule.

The DRCU development schedule is provided as a separate Microsoft Project document.

7.1.3 DRCU Development Internal Delivery Milestones.

Internal Delivery Milestones	From	Date	Comments
DRCU User Requirements	System	Oct. 2000	Validated document
DRCU related ICDs	System	Oct. 2000	Validated documents
DCU EM	JPL	March 2001	
JPL Detector Prototypes	JPL	March 2001	
Detector Test Cryostat	JPL	March 2001	Equipped with JFet box
FPU Unit Simulators	LAM, JPL, GFSC	Sept. 2001	
FPU Test Harnesses	RAL	Sept. 2001	
MCU – QM1	LAM	Sept. 2001	
MCU – QM2	LAM	Sept. 2002	
MCU – FM	LAM	Aug. 2003	

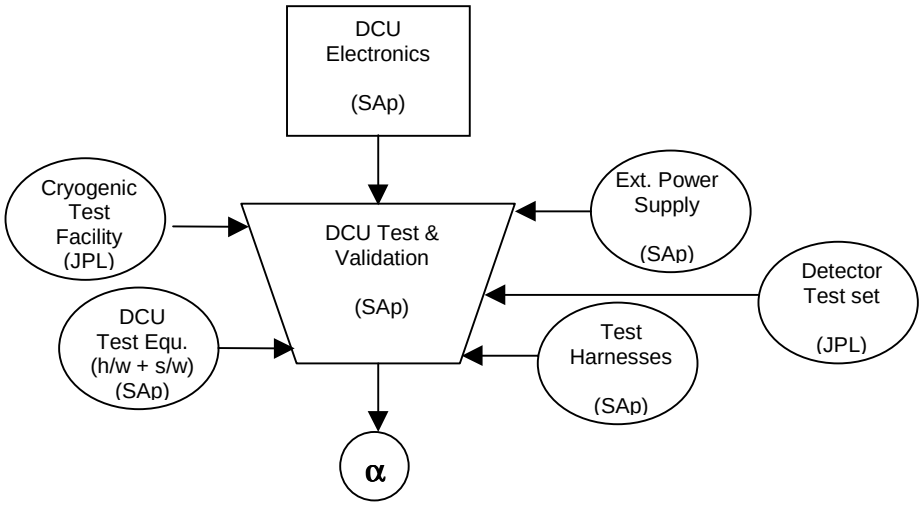
7.1.4 Critical Items.

Risk	Preventive Action	Impact
Late definition the S/C interface (mainly due to the late involvement of the S/C Prime Contractor)	ESA to make early commitment on S/C I/F specification	Could have dramatic impact on the Detector Readout feasibility and instrument performance.
Delay on availability and consistency of the WE inputs documents (Requirements and ICDs)	SPIRE Project to set up of an operational System Team and a QA team. Start early documentation configuration control	Development Schedule delay. Concerns for long lead items which will be subcontracted (e.g.: DC/DC Power Supply)
Administrative delay related to place the purchase orders for the part procurements.	CNES to foresee a simplified part procurement procedure (e.g. dedicated CNES-ESA agreement).	Development schedule delay.
Long lead item procurement	Early definition and ordering.	Development schedule delay.
Internal Deliveries delay	Setting up of Memorandum of Understanding between the SAp and the other institutions.	Development schedule delay.
Integration issues	Writing of clear ICDs. Setting up of a system team including representative of the other institution.	Degraded performance. Development schedule delay Cost increase

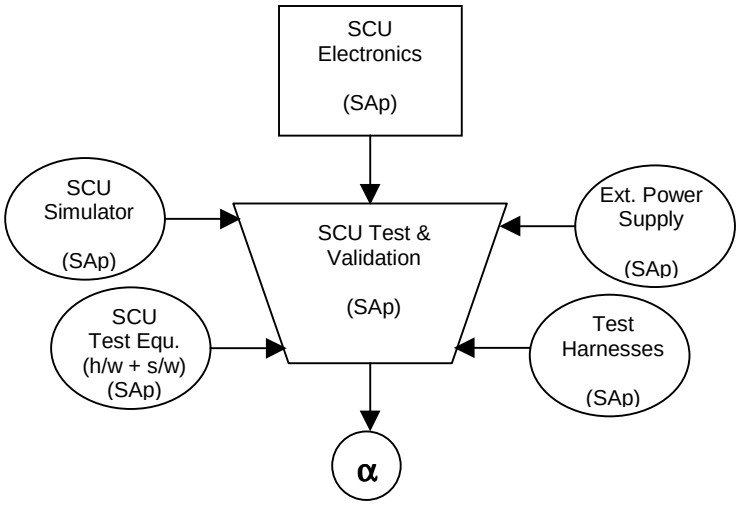
Risk	Preventive Action	Impact
Non adequate JPL detector electronics design	Setting up of a close collaboration between SAp and JPL	Degraded performance. Development schedule delay Cost increase
Too tight delivery date to RAL mainly due to the tight delivery dates imposed by ESA.	QM and FM development overlap or ESA to relax the Instrument Model delivery dates (especially the FM).	- EM/QM1. - FM manufacturing starts before the Qualification is completed and before the CDR. Verification and Qualification results may lead to need for heavy modification. - Big cost overhead and big delay at the best. Overall instrument feasibility at the worse.

Annex 1 - DRCU AIV.

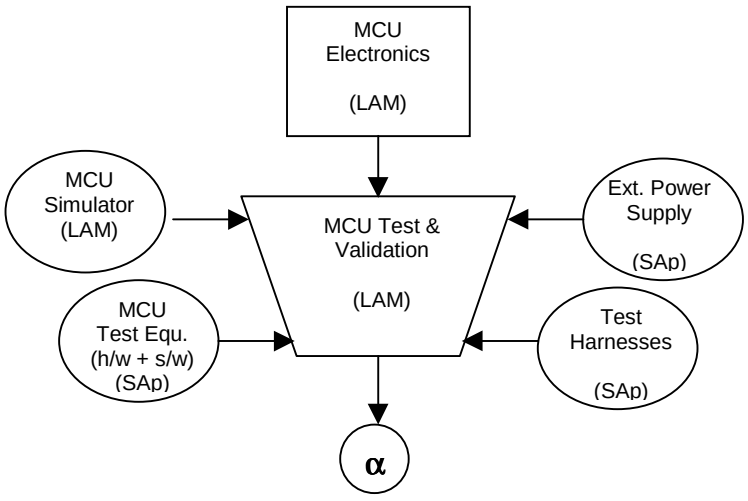
DCU Test & Validation



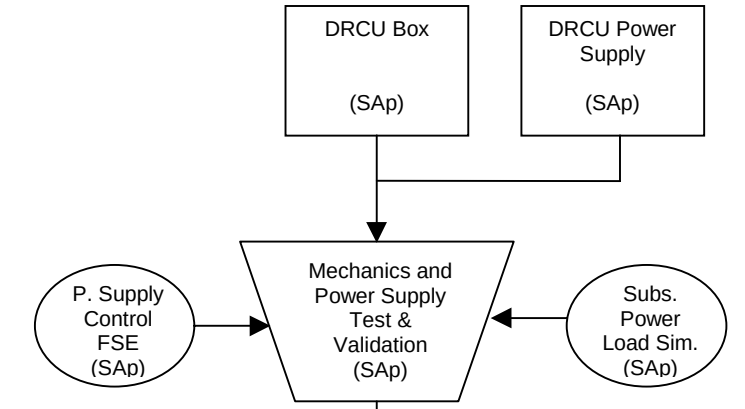
SCU Test & Validation



MCU Test & Validation



Mechanics & Power Supply I&T



DRCU I&T