FIRST/SPIRE

Detector Readout Control Unit

and Warm Interconnect Harness

Development Plan

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TABLE OF CONTENT

DOCUMENTATION

Applicable Documents:

[A1]	SPIRE	SPIRE Instrument Development Plan

Reference Documents:

[R1]	ESA	FIRST/Planck Instrument Interface Document - Part A PT-IID-A-04624 - Sept 30, 1997 - Draft 0
[R2]	ESA	FIRST/Planck Instrument Interface Document - Part B - Instrument "SPIRE" PT-SPIRE-02124 - Feb. 28, 2000 - Issue 0-1
[R3]	SPIRE	SPIRE Instrument Requirements Document SPIRE/RAL/N/0034 - Feb. 16, 1998 - Issue .00
[R4]	SPIRE	SPIRE Warm Electronics Requirements Document
[R5]	SPIRE	SPIRE DRCU Requirements Document
[R6]	SPIRE	DPU to DRCU Interface Control Document. (TBW)
[R7]	SPIRE	DRCU to FPU Interface Control Document. (TBW)
[R8]	ESA	OIRD

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.

1.1 Scope of the document.

This document is the development plan related to the Detector Readout Control Unit and the DPU/DRCU Warm Interconnect Harness, which are subsystems of the SPIRE Warm Electronics. The development of the Mechanism Control Unit (MCU) (see §2.1), which is a sub-unit of the DRCU, is developed under the responsibility of the LAM and is therefore out of the scope of this document.

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

It deals with all the managerial information related to the development, integration and test of all the Models (*) until their delivery to RAL for integration within the SPIRE instrument. This Plan starts from the SPIRE Preliminary Design Review (June 2000).

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.

(*) FS excepted due to the current lack of definition.

1.2 Purpose of the project.

1.2.1 SPIRE framework overview.

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.

1.2.2 DRCU development.

This development consists in building and providing all the models of the Detector Readout Control Unit of the SPIRE instrument. The DRCU shall meet the specification stated in the DRCU Requirement Document [R5] and be compliant with the interface described in the respective ICDs [R6], [R7], [R8].

1.2.3 Warm Interconnect Harness development.

This development consists in building and providing all the models of the Warm Interconnect Harness. The specification of this harness is stated in the DPU/DRCU Interface Control Document [R6].

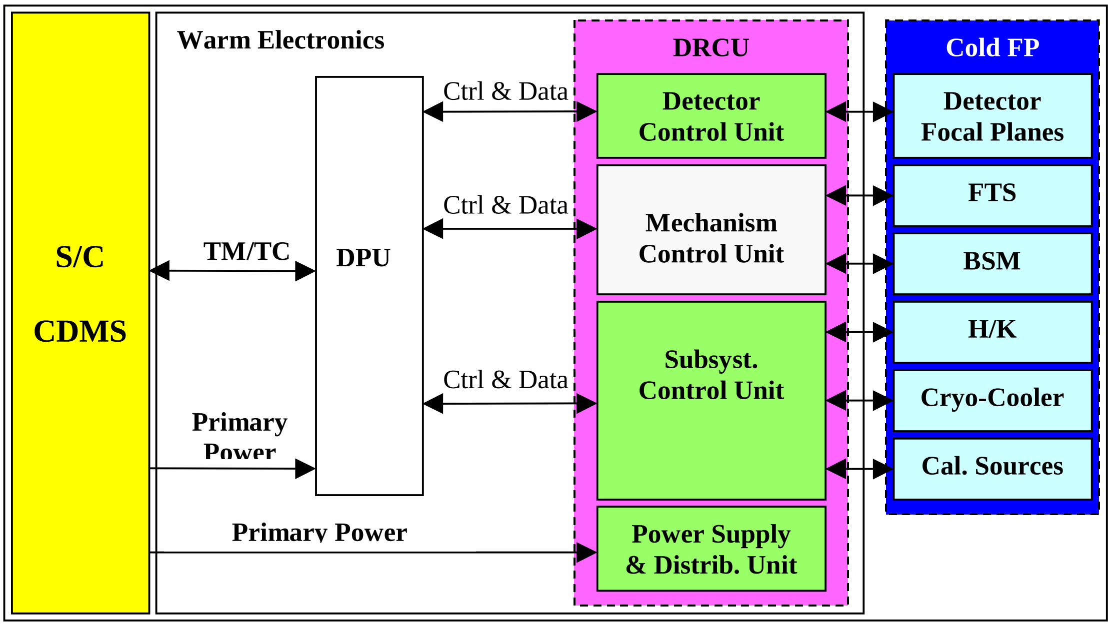
1.3 Document Overview.

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 represents the overall instrument architecture. The SPIRE instrument consists of a cold Focal Plane situated in the S/C cryostat which is linked to the Warm Electronics (300K) situated on the S/C Service Module.

The Warm Electronics ensures the electrical I/F between the S/C CDMS and the Cold Focal Plane. The Warm Electronics is linked to the CDMS and the Cold Focal Plane by the mean of harnesses. Power supply (28V) is provided by the S/C.

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 with the JFET box. 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 the LAM.
d) The H/K unit which is mainly constituted of distributed temperature probes of various nature.
e) The Cryo-cooler which is controlled by the means of thermal switches and temperature.
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 reports on their execution.
b) Generation of the necessary digital control lines: detector addresses.
c) Performance of the necessary analog to digital and digital to analog correspondences: detector signal readout, bias generations, temperature acquisition, analog control.
d) Cold unit power supply.

2.2.2 DRCU Interfaces.

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 being constituted of a bi-directional low rate I/F (typically 100 kbps) and an mono-directional (DRCU to DPU) high rate I/F (typically 1 Mbps).
b) the Cold Focal Plane by the mean of cold unit dedicated I/F.
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 a box which is 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 Architecture.

The DRCU consists of several subsystems:

a) The DRCU box(es) (including backplanes and connectors) which contains the other DRCU units (boards, power supply).
b) The Detector Control Unit (DCU).
c) The MCU which is built by the LAM. Its development is described in a separate document compatible with the DRCU development plan.
d) The Subsystem Control Unit (SCU).
e) The Power Supply and Power Distribution Unit.

3 Managerial Considerations.

3.1 SAp's Responsibilities.

a) Local Development management.

b) DRCU System and Architecture Design.

c) Design, Manufacturing and test of all 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.

d) Design, Manufacturing and test of the Warm Interconnect Harness.

e) Design, Manufacturing and Testing of the following DRCU test equipment:
- DRCU Local Test Unit.
- FPU Simulator.

f) Integration and Test of all the DRCU Models (with respect to the Model definition given in §4.1.1).

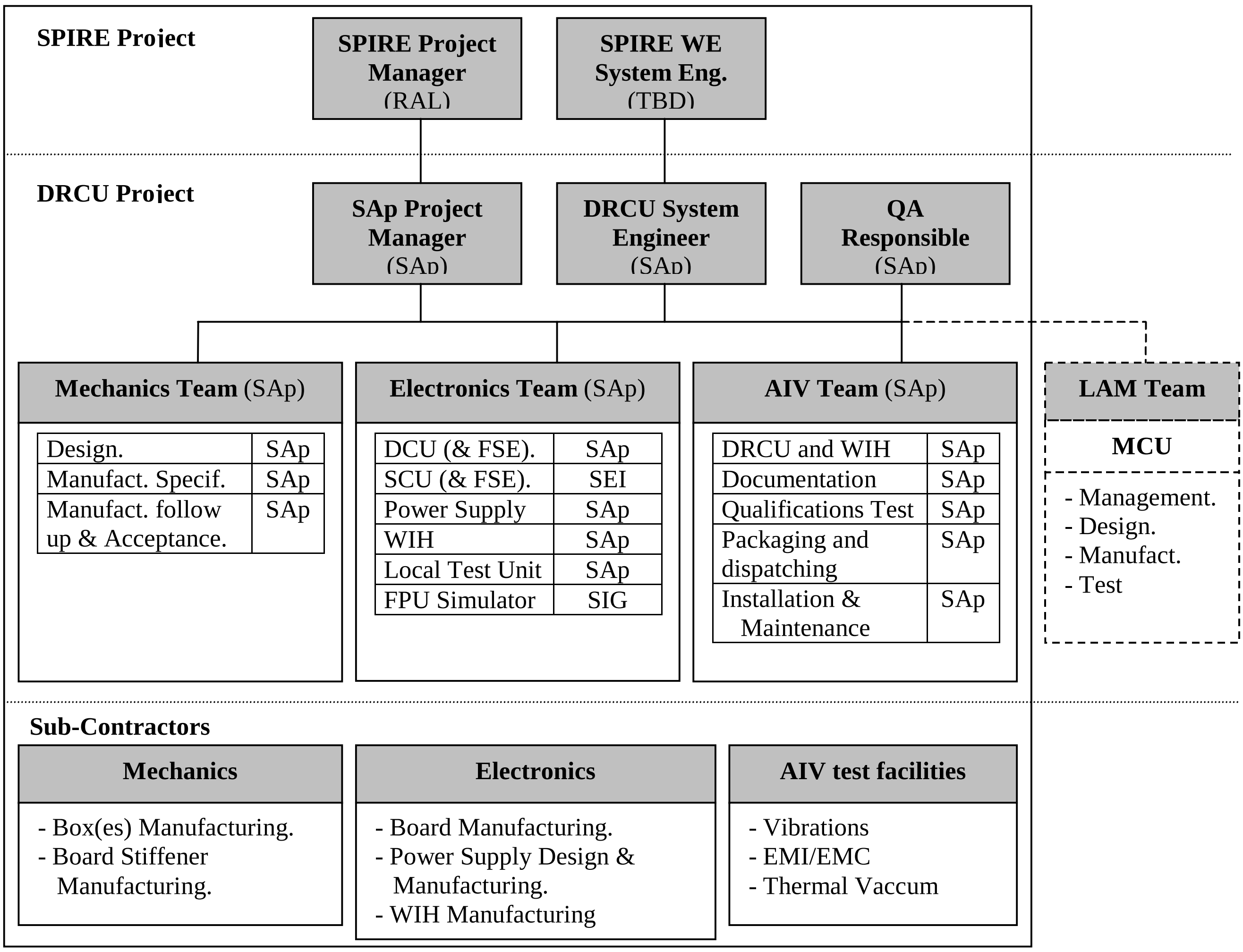
g) WIH Qualification and Acceptance tests.

h) Delivery to RAL of the DRCU and WIH harness Models including documentation.

i) Maintenance of the delivered products (*).

(*) Except the MCU provided by the LAM.

3.2 Working Organisation.



3.3 Worksharing.

Working areas	Responsibility	Comments
Local Management	CEA/SAp	
DRCU System design	CEA/SAp	
Quality Assurance / Product Assurance	CEA/SAp	
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	
BSM+SMEC Control Unit	LAM	
Warm Interconnect Harness	CEA/SAp	Done by CEA but Cost shared with IFSI
Local Test Unit	CEA/SAp+SIG	
FPU Simulator	CEA/SIG	
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

4 Development.

4.1 DRCU Development.

4.1.1 DRCU Model Definition.

4.1.1.1 Breadboards.

The following Breadboard or Prototypes are foreseen:

- The Detector Control Unit breadboard: this Breadboard Model will be conceived by SAp and realised and tested at JPL.
- Mechanical Structure Prototypes: for testing & qualification (Vibration and Thermal tests) purpose of the mechanical DRCU structures (box and board stiffeners).

4.1.1.2 Qualification Models.

Two DRCU Qualification Models will be developed:

4.1.1.2.1 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 §4.1.1.5.
- 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.

4.1.1.2.2 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 §4.1.1.5.
- 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).

4.1.1.3 Flight Model.

This Model will be integrated with the WE FM.

DRCU FM specifications: Cf. the Model summary characteristics table in §4.1.1.5.

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.

4.1.1.4 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.

4.1.1.5 DRCU Model characteristics.

DRCU	Box(es)	DCU	MCU	SCU	DC/DC	Part Grade	Perform.
QM1	FEq -	FEq(*) NR	FEq NR	FEq NR	FEq NR	FEq	NNP
QM2	FEq -	FEq RE	FEq RE	FEq RE	FEq RE	FEq	NNP
FM	F -	F RE	F RE	F RE	F	F	NoP
FS	F ?	F ?	F ?	F ?	F ?	F	NoP

Ext : External (Power Supply only)
Pro : Prototype
FEq : Flight Equivalent (any grade but nominal size, consumption and performances)
F : Flight
NR : Cold Redundancy Not implemented
RE : 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).

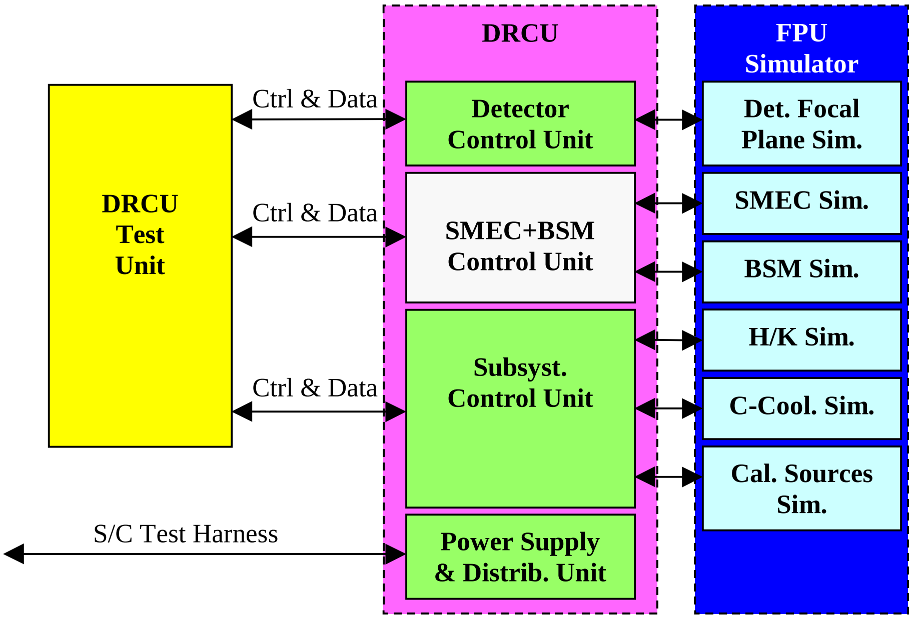
Note: a) See IID-B for Model Performance Requirements.
b) FS policy TDB.

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.



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 is made up of a PC equipped with the suitable serial I/Fs. The PC is running dedicated test S/W modules.

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.

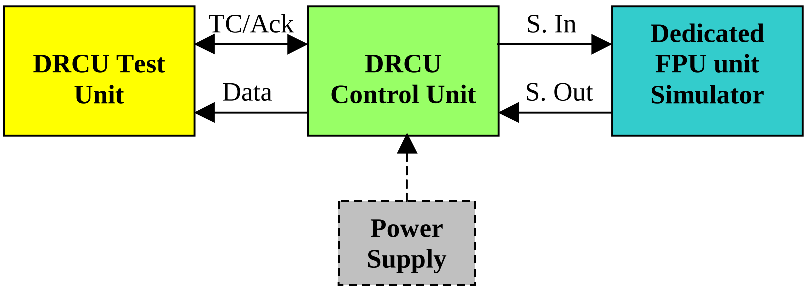
It is made up of the assembly of Unit simulators to be provided by the various institutions as stated in the "Worksharing" section (§3.3)

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							
	DRU						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				
	Subsystem Sim.	SAp	1				
	Calibration Sources Sim.	GFSC	1				
	MCU 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				
	Test Detector Set	JPL	1				
	Detector Test Cryostat	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.

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

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 Box.
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
Mechanics		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	
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.

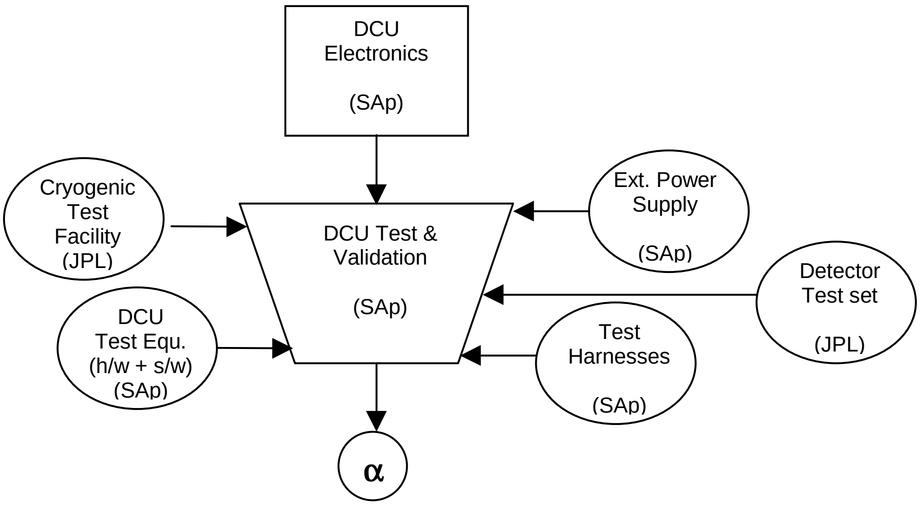
Internal Delivery Milestones	From	Date	Comments
DRCU User Requirements	System	Oct. 2000	Validated document
DRCU related ICDs	System	Oct. 2000	Validated documents
DCU EM	JPL	March 2001	
JPL Detector Prototypes	JPL	March 2001	
Detector Test Cryostat	JPL	March 2001	Equipped with JFet box
FPU Unit Simulators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

7.1.4 Critical Items.

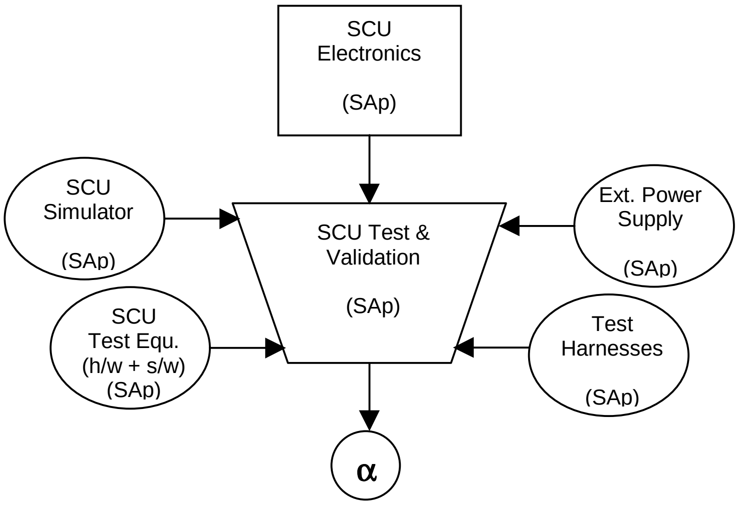
Risk	Preventive Action	Impact
Late definition the S/C interface (mainly due to the late involvement of the S/C Prime Contractor)	ESA to make early commitment on S/C I/F specification	Could have dramatic impact on the Detector Readout feasibility and instrument performance.
Delay on availability and consistency 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	The DRCU SSD cannot be completed on time. Development Schedule shift. Concerns for long lead items which will be subcontracted (e.g.: DC/DC Power Supply)
Delay on availability of Internal Deliveries	None	Delays will have at least equal repercussions on further Delivery Models
Too tight delivery date to RAL mainly due to the tight delivery dates imposed by ESA.	ESA to relax the Instrument Model delivery dates (especially the FM).	- there is no time left for the development of an Engineering Model. - FM manufacturing starts before the Qualification is completed and before the CDR. Verification and Qualification results may lead to modify and/or redesign part of the QM. - Big cost overhead and big delay at the best. Overall instrument feasibility at the worse.

Annex 1 - DRCU AIV.

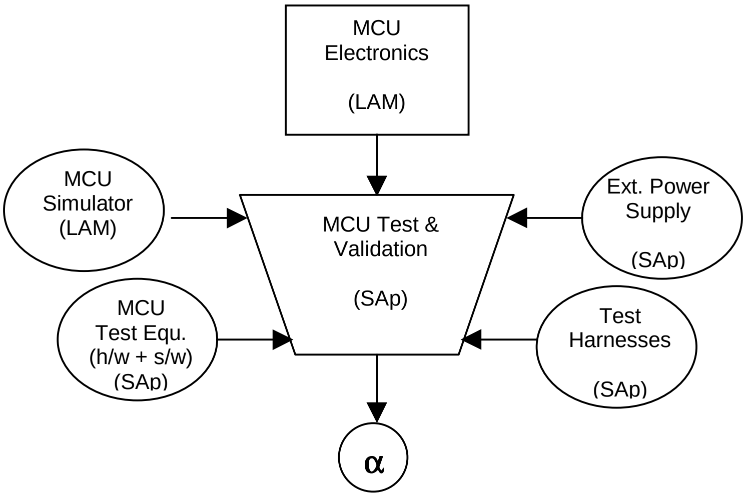
DCU Test & Validation



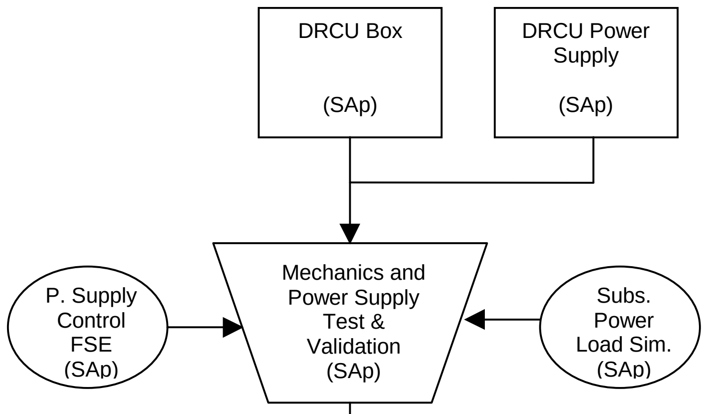
SCU Test & Validation



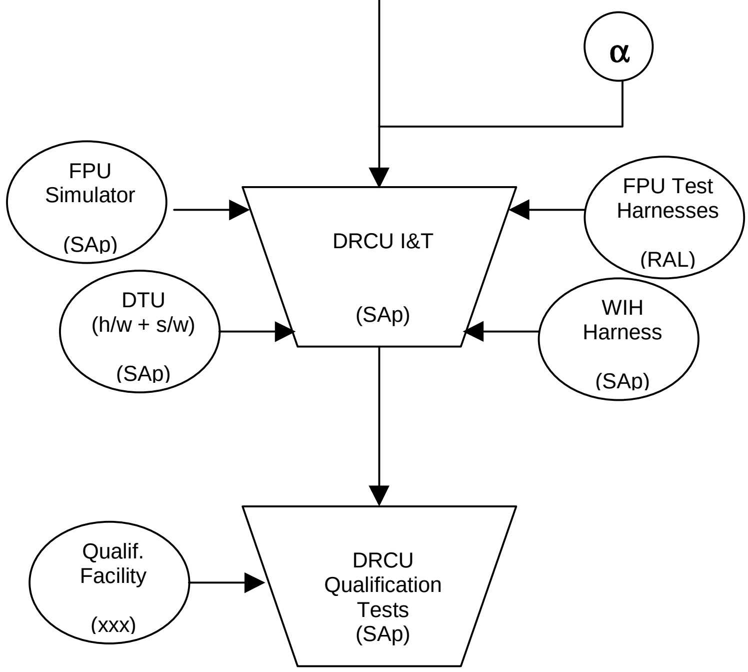
MCU Test & Validation



Mechanics & Power Supply I&T



DRCU I&T



Annex 2 – Product Tree

High Level