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SPIRE Spectrometer Mirror Mechanism Subsystem Specification

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Update

Date	Indice	Remarks
11 Feb 2000	1	Creation of the document
14 Apr 2000	2	Update of performances specifications following an internal meeting at LAM with JP Baluteau.
25 Apr 2000	3	Design description added.
9 May 2000	4	Adjustements after LAM reading Mission profile added Product tree added

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Table of contents

1. Scope of the document

This specification defines the requirements applied to the performances, the design and the qualification of the SPIRE spectrometer mirror mechanism. It is applicable to the PFM and the FS.

2. Documents

2.1. Applicable documents

	Title	Author	Reference	Date
AD1	Instrument Requirements Document	B.M.Swinyard	SPIRE-RAL-PRJ-000034 Issue 0.21	30 nov 1999
AD2	Structure/SMEC Interface		SPIRE 1.1/1.5.2	
AD3	Thermal / SMEC Interface		SPIRE 1.1.1/1.5.2	
AD4	Optics / SMEC Interface		SPIRE 1.2/1.5.2	
AD5	DMEC / DRCU Interface		SPIRE 1.5.2/2.2	

2.2. Glossary

AD	Applicable Document
BSM	Beam Steering Mirror
BSMm	BSM cryogenic mechanism
CEA	Commissariat à l'Energie Atomique
CDR	Critical Design Review
CNES	Centre National des Etudes Spatiales
CoG	Center of Gravity
CQM	Cryogenic Qualification Model
DDR	Detailed Design Review
DESPA	Département des Etudes SPAtiales
DM	Development Model
DPU	Digital Processing Unit
DRCU	Digital Read-out and Control Unit
DSP	Digital Signal Processor
EGSE	Electrical Ground Support Equipment
EM	Electrical Model
FIRST	Far InfraRed Submillimeter Telescope
FPU	Focal Plane Unit
FS	Flight Spare model
FTS	Fourier Transform Spectrometer
GSFC	Goddard Space and Flight Center
JPL	Jet Propulsion Laboratory
LAM	Laboratoire d'Astrophysique de Marseille
MCU	Mechanism Control Unit
MGSE	Mechanical Ground Support Equipment
MM	Mechanical Model
MSSL	Mullard Space Science Laboratory
NA	Not Applicable
OGSE	Optical Ground Support Equipment
PDR	Preliminary Design Review
PFM	Prototype Flight Model
RAL	Rutherford Appleton Laboratory
RD	Reference Document
SMEC	Spectrometer mirror MEChanism
SMECm	SMEC cryogenic mechanism
SMECp	SMEC cold preamplifier
SPIRE	Spectral and Photometric Imaging REceiver
TBC	To Be Confirmed
TBD	To Be Defined
TBU	To Be Updated
TBW	To Be Written
WE	Warm Electronics

3. The SMEC Subsystem

3.1. Subsystem description

The Spectrometer mirror MEChanism subsystem (SMEC) is a major part of the SPIRE Spectrometer. It is in charge of the movement of the rooftop mirrors inside the SPIRE spectrometer.
The critical performances of SMEC [AD1] are the mirror velocity and its stability, the mirror movement around its travel axis and the required accuracy of the mirror position measurements.

The SMEC is made of 3 main parts and is controlled by the MCU:

- **The cryogenic mechanism** (SMECm)

The SMECm is the mechanism which moves the mirrors, The mirrors are considered a part of SMECm.
Basically, the movement of the mirrors is a translation only, obtained through the action of a linear actuator. The position of the mirrors along their travel is measured by an incremental optical sensor coupled to a rule. This sensor is coupled with three magentoresistive position sensors for the ZPD position and travel limits measurements.
The mechanical design is based on the GSFC design for a balloon project. A base plate supports the mechanism and is mounted on the SPIRE Optical Bench (Structure). On the baseplate are mounted the fixed part of the actuator and the optical encoder. A moving plate supports the rooftop mirrors and the rule for the optical encoder. The base plate and the mirror moving plate are linked by four "legs". Each leg has two arms, one arm linking the base plate and the intermediate moving plate, the other linking the intermediate moving plate and the mirror moving plate. The articulations at both extremities of the legs use Bendix pivots. A synchronisation device ensures that the mirror plate moves parallel to the base plate. The stiffness of the articulation is very low to keep the actuator power consumption within the specified limits. Consequently, for SPIRE, a launch latch item is added to allow the mechanism to sustain the launch vibrations without damage. The latch is placed between the baseplate and the mirror moving plate.

- **The preamplifier** (SMECp)

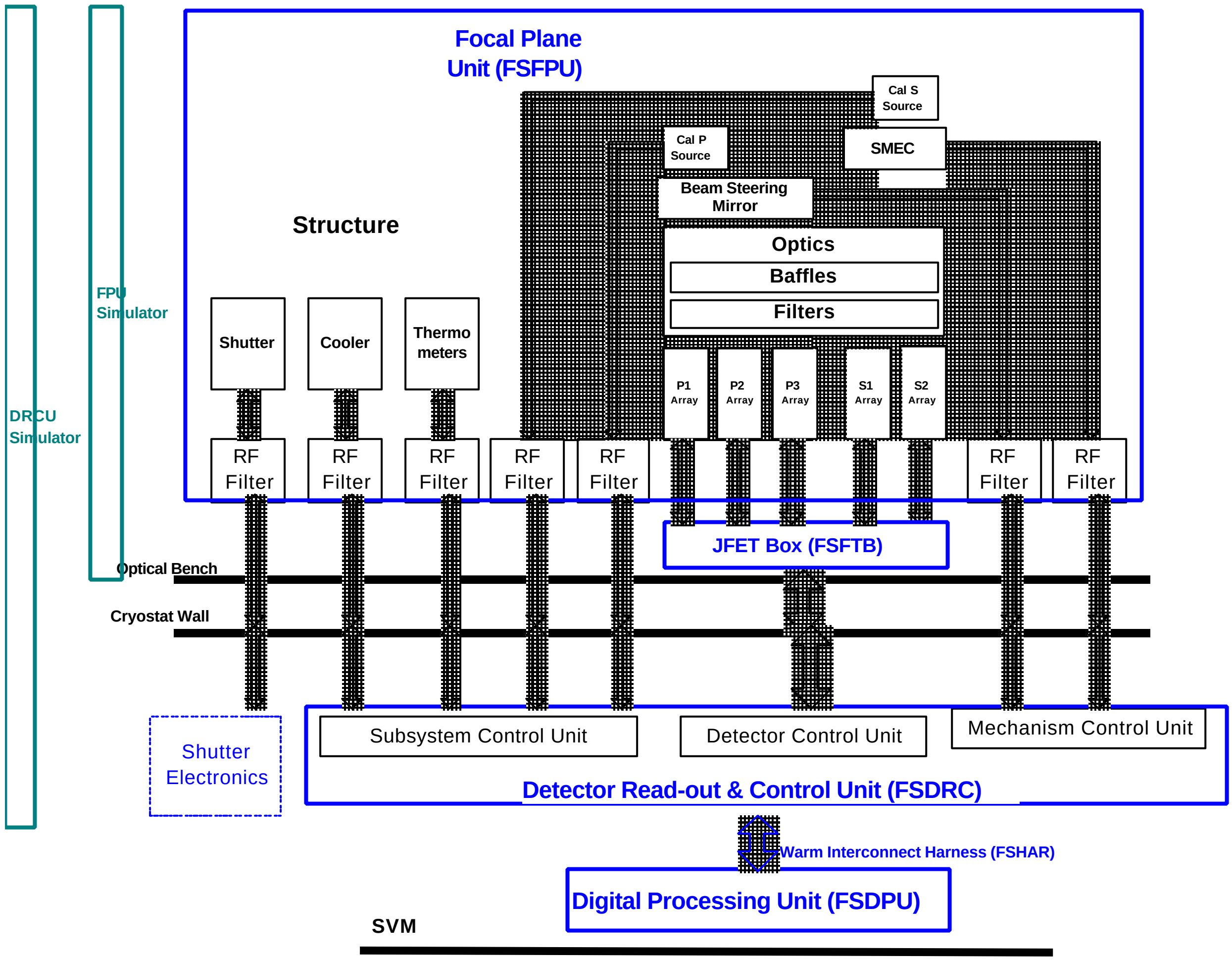
Due to the loss of current on the output signals of the optical encoders when they are cooled down to 4K, a preamplifier is necessary (TBC). The electronic components (JF4s, etc..) are implemented on a card integrated in a box mounted on the SPIRE optical bench (TBC). The temperature of the components is set around 100K.

- **The warm electronic** (SMECe)

The SMEC warm electronic comprises the SMEC analog electronic i.e. the power amplifier for the actuator, the position acquisition electronics and interface unit and the ZPD and limit position sensors conditioning. The main and redundant circuitry are implemented on one board.
This board is a part of the Mechanism Control Unit (MCU).

- **The mechanism control unit** (MCU)

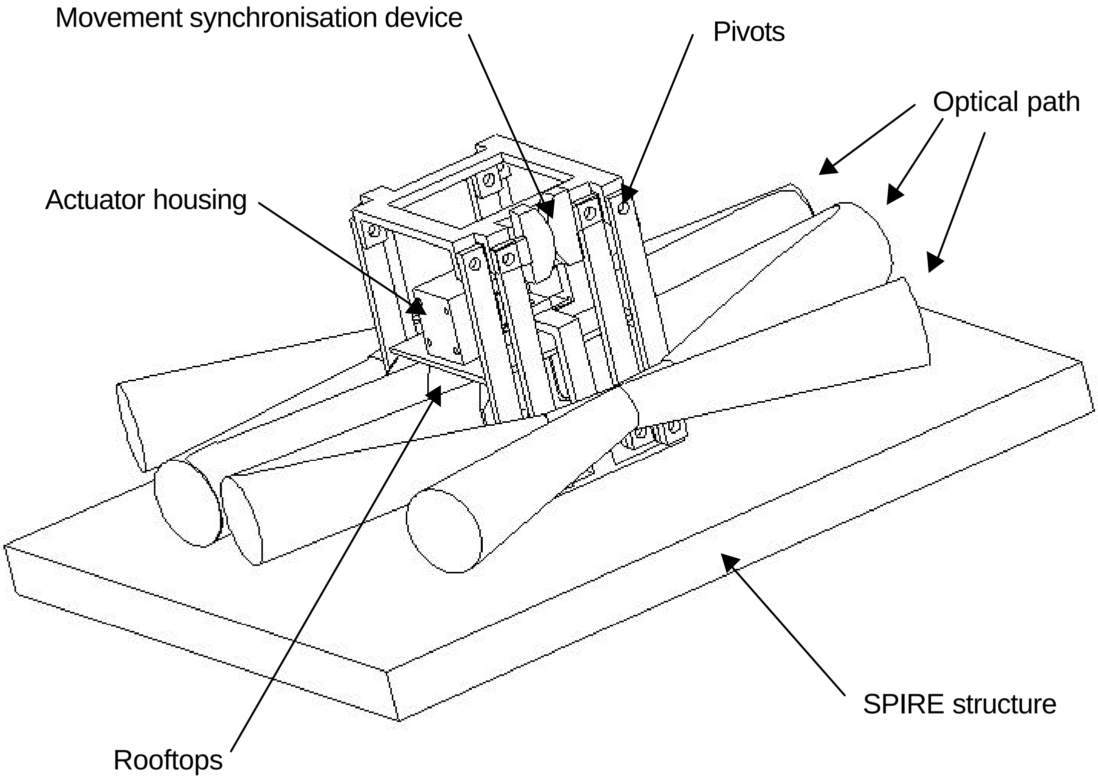
The MCU comprises the SMEC board, the BSM board and the Multi Axis Controller (MAC) board which houses the interface electronics (FPGA) and the mechanism control electronics (DSP based). The MAC board takes charge of the commands sent by SPIRE Digital Processing Unit (DPU) via the Digital Read-out Control Unit (DRCU), controls the movement of the mechanisms via the relevant analog board, delivers the position measurements and transmits the housekeeping data to SPIRE DPU via the DRCU.
The power is provided by the DRCU in which the MCU is integrated.



SPIRE Block Diagram

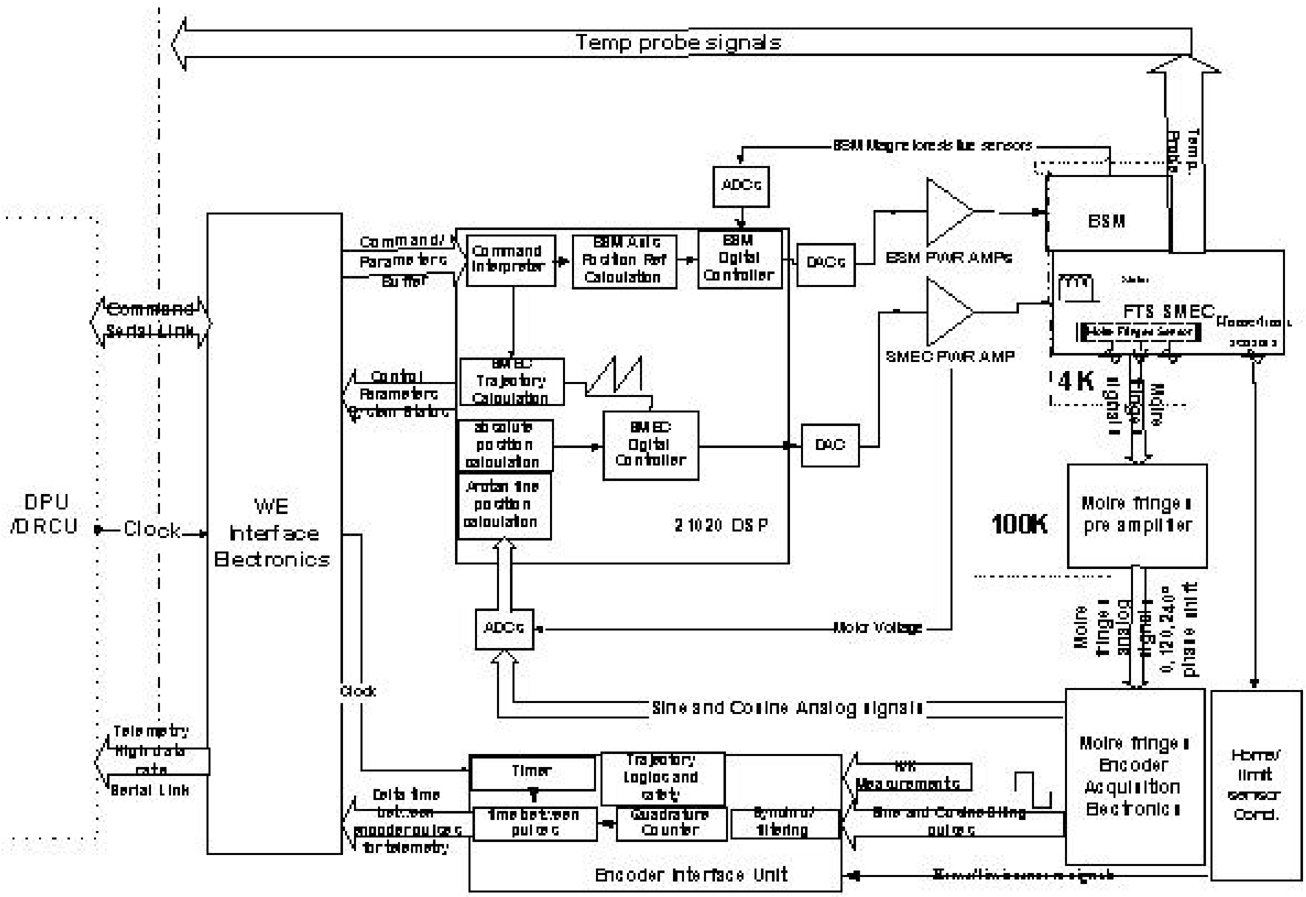
This diagram shows the links between the SMEC, the BSM, the MCU, the DRCU and the DPU.

View of the GSFC mechanism
The optical path has been symbolized for show.



MCU schematics

The 21020 DSP is the heart of the control system. It controls both the SMEC and the BSM FPU subsystems. It is integrated in the DRCU.



3.2. Mission profile

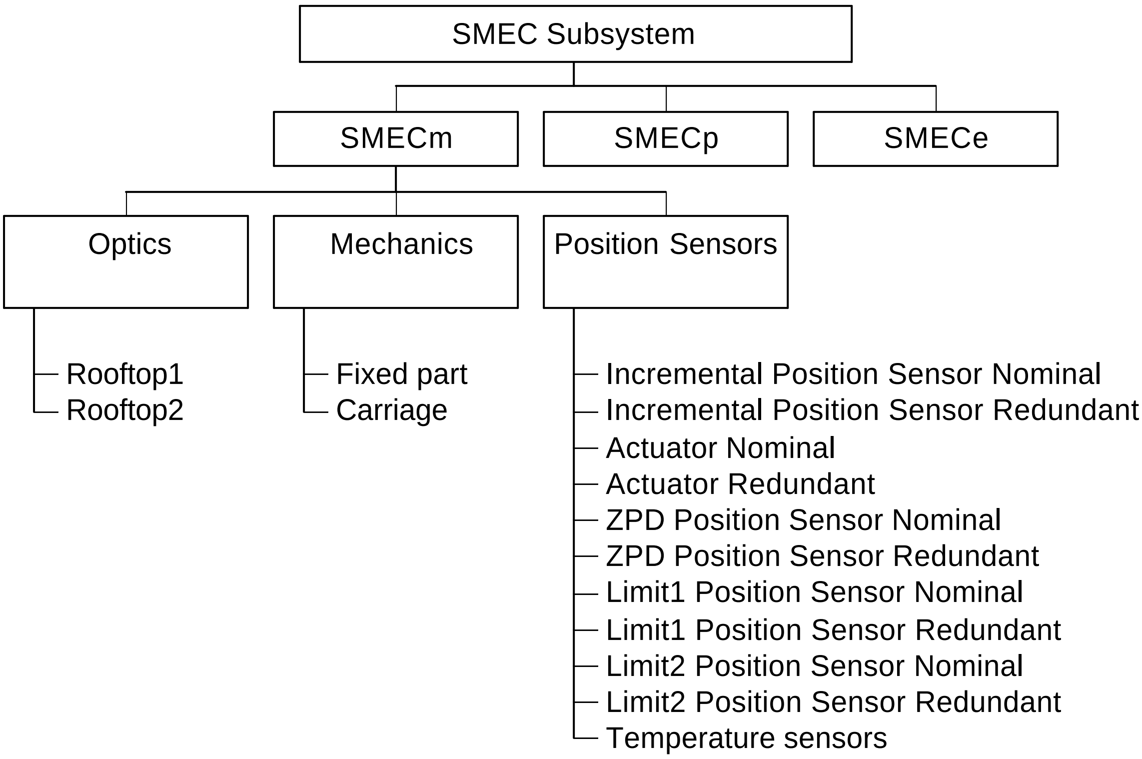
Here are the successive phases of the subsystem life from the end of manufacturing to the end of life.
These are for information only. Discrepancies with actual AIV and operation plan are allowed.
Durations are TBC.

Operation	Where	What	Duration	Note
Bakeout	LAM	Everything	1 week	
Control and integration	LAM	Everything	2 weeks	
Warm Vibrations	LAM	SMECm and SMECp Ok SMECe and MCU : TBD	1 week	Including correlated controls
Transport	From LAM to RAL (TBC)	SMECm and SMECp	2 days	
Cold vibrations	RAL (TBC)	SMECm and SMECp	3 weeks	Including correlated controls There will be no 4K vibrations test facility at LAM.
4K control test	RAL (TBC)	SMECm and SMECp	1 week	Including correlated controls There will be no 4K test facility at LAM.
Transport	From RAL(TBC) to LAM	SMECm and SMECp	2 days	
Thermal cycles	LAM	Everything	4 weeks	Including correlated controls
Characterisation	LAM	Everything	4 weeks	
Transport	From LAM to RAL and CEA	SMECm and SMECp	2 days	
Integration in the SPIRE Structure	RAL	SMECm and SMECp	1 week	Including correlated controls
Integration in the DRCU	CEA	SMECe and MCU	1 week	Including correlated controls
Bakeout	RAL	SMECm and SMECp integrated	1 week	
Warm vibrations	RAL and CEA	Everything integrated	1 week	Including correlated controls
Transport	From RAL to ?	SMECm and SMECp integrated	TBD	
Cold vibrations	?	SMECm and SMECp integrated	3+ weeks	Including correlated controls
Transport	From ? to RAL	SMECm and SMECp integrated	TBD	
Thermal cycles	RAL	Everything integrated	TBD	Including correlated controls
Calibrations	RAL	Everything integrated	TBD	
Transport	From RAL to ESA	Everything integrated	TBD	
Satellite tests	ESA	Everything integrated	TBD	Including correlated controls
Lock of launch latch	ESA	SMECm integrated	1/2 day	Including correlated controls
Storage	ESA	Everything integrated	2 years (TBC)	

Launch	Kourou	SMECm and SMECp integrated, at 4k under vacuum SMECe and MCU, integrated, at 300K at atm pressure	TBD	
Power on	Orbit	Everything integrated		Including correlated controls
Unlock of launch latch	Orbit	SMECm integrated	1/2 day	Including correlated controls
Beginning of operation	Orbit	Everything integrated	TBD	Health assessement of the subsystem
Operations	Orbit	Everything integrated	4.25 years	The SMEC subsystem will not be operated along the complete 4.25 years of FIRST on orbit but approximately 8.5 non contiguous months. The subsystem will be stored (power off) during TBD months and powered on but non operating during TBD months.
End of operations	Orbit	Everything integrated	TBD	

3.3. Product tree

This product tree is for information only.



4. Requirements

4.1. Functional requirements

4.1.1. Performance requirements

The performance requirements are listed in [AD1]

#	Parameter	Value	IRD	Note
P1	Scientific Travel	-3.2 / +3.2 mm	IRD-SMEC-R01 et R02	w.r.t. ZPD position goal : -3.2 to +32 mm
P2	Movement minimum sampling interval	5µ	IRD-SMEC-R02	
P3	Sampling interval	5 to 25µ	IRD-SMEC-R03	TBD values selectable in the range.
P4	Scan length	Start and stop anywhere in the travel range	IRD-SMEC-R04	
P5	Deadtime	Less than 10% of the useful time	IRD-SMEC-R05	Allocation of the 10% will be made by technical team
P6	Velocity range	0.2 to 1 mm/s	IRD-SMEC-R06 & 07	TBD values selectable in the range
P7	Velocity stability	0.01 mm/s RMS in the velocity range, filtering bandwidth = 0.03 to 25Hz, Filter shape TBD	IRD-SMEC-R08	
P8	Velocity stability duration	24 consecutive hours	IRD-SMEC-R08	
P9	Position measurement range	-3.2 / +3.2 mm	TBD	Goal : -3.2 to 32 mm (see P1)
P10	Position measurement accuracy	0.1µ in the +/- 3.2 mm travel range, +/- 0.3µ elsewhere	IRD-SMEC-R09	The postion is measured relatively to fiducial mark position

4.1.2. Technical requirements

4.1.2.1. SMECm

#	Parameter	Value	IRD	Note
Tm1	Axis definition	TBD		
Tm2	Alignment tolerances			
Tm3	Dimensions	TBD		
Tm4	Center of gravity	TBD		
Tm5	Mass	1 kg including margin		Excluding mirrors
Tm6	Inertia	TBD		
Tm7	Stiffness along travel axis	TBD		
Tm8	Emitted vibrations	TBD		
Tm9	Power consumption	TBD		
Tm10	EMC	TBD		
Tm11	Fiducial mark position	TBD		As near as possible to ZPD
Tm12	Fiducial mark position accuracy	+/- 32µ		To be refined according to P5
Tm13	Operational position	SMECm can operate only in 0g		To have it operate in any

		conditions or with the travel axis within TBD degrees from the horizontal plane.		condition would lead to a non acceptable thermal leak and very bad nominal conditions.

4.1.2.2. SMECp

#	Parameter	Value	IRD	Note
Tp1	Axis definition	TBD		
Tp2	Dimensions	60 x 60 x 60 mm3 (TBC)		
Tp3	Center of gravity	TBD		
Tp4	Mass	0.2 kg		Including box
Tp5	Inertia	TBD		
Tp6	Power consumption	TBD		
Tp7	EMC	TBD		
Tp8	Position	Less than 1m (TBC) from Optical Encoder		
Tp9	Stray light	TBD		Must be as IR light tight as possible if mounted inside SPIRE Structure.

4.1.2.3. SMECe

TBD

4.1.2.4. MCU

TBD

4.2. Operational requirements

4.2.1. Relialibility

4.2.2. Lifetime

#	Parameter	Value	IRD	Note
OL1	Ground Storage lifetime	2 years		A guess
OL2	Ground Integrated lifetime	4 years		About
OL3	Ground operational lifetime	1.5 years		6 months for subsystem acceptance 6 months for SPIRE acceptance 6 months for FIRST acceptance Under 1g conditions
OL4	On orbit operational lifetime	8.5 months cumulated time		Operating during 1/6 of the mission duration (4.25 years) Distribution: 85 days : SMECm travel = -0.32 to +0.32 mm 85 days : SMECm travel = -3.2 to +3.2 mm 85 days : SMECm travel = -3.2 to +32(goal) mm
OL5	On orbit non operational lifetime	3.5 years cumulated time		

4.2.3. Operating modes

4.2.4. Telemetry

4.2.5. Telecommands

4.3. Interface requirements

The interfaces are defined in the relevant applicable documents.

Part	Interface	With	Document
SMECm	Mechanical	SPIRE Structure	SPIRE 1.1/1.5.2
	Thermal	SPIRE Structure	SPIRE 1.1.1/1.5.2
	Optics	SPIRE Optics	SPIRE 1.2 / 1.5.2
SMECp	Mechanical	SPIRE Structure	SPIRE 1.1/1.5.2
	Thermal	SPIRE Structure	SPIRE 1.1.1/1.5.2
SMECe	Mechanical	DRCU	SPIRE 1.5.2 / 2.2
	Thermal	DRCU	SPIRE 1.5.2 / 2.2
	Electronic	DRCU	SPIRE 1.5.2 / 2.2
	Electronic	MCU	TBW
MCU	Mechanical	DRCU	SPIRE 1.5.2 / 2.2
	Thermal	DRCU	SPIRE 1.5.2 / 2.2
	Electronics	DRCU	SPIRE 1.5.2 / 2.2

4.4. Design and manufacture requirements

4.4.1. Design requirements

TBD

4.4.2. Design rules

TBD

4.4.3. Manufacture requirements

These are requirements on accessibility, dismountability, testability and manufacturing processes.

- TBD fluids to be forbidden during manufacture to avoid pollution.
- TO BE COMPLETED

4.5. Logistic requirements

The subsystem wil be transported to and from RAL and CEA.
The containers will have to guarantee that:

- no shocks are greater than those defined for the launch.
- no pollution sneaks to the subsystem
- TO BE COMPLETED

4.6. Environment requirements

These requirements describe the environement in which the subsystem will live.

4.6.1. Natural environement

This is the description of the natural environment around the subsystem.

#	Parameter	Value	IRD	Note
EN1	Vacuum	Less than 10-4 Pa		During tests, launch and in operation
EN2	Operating temperature	SMECm : during system qualif and on orbit = 4K SMECm : during subsystem qualification = 300K and 20K, (4K for specific tests) SMECp : 4K (TBC) SMECe and MCU : -55 to +45°C (TBC)		Components at 100K inside
EN3	Storage and handling temperature	-20 to +30 °C		Overall, on ground
	Humidity	Less than 45%		In clean room
	Cleanliness	Class TBD		In clean room
EN4	Radiations	SMECm : Less than 3.5 kRAD SMECp : Less than 3.5 kRAD SMECe and MCU : Less than 12 kRAD		On orbit

4.6.2. Operating environment

This is the description of the environment imposed by the location of the subsystem in SPIRE and in FIRST.

#	Parameter	Value	IRD	Note
ON1	Vibrations	SMECm : TBD SMECp : TBD SMECe and MCU : TBD		At 4K At 4K (TBC) At 300K
ON2	Shocks	SMECm : TBD SMECp : TBD SMECe and MCU : TBD		At 4K At 100K (TBC) At 300K
ON3	Microvibrations	SMECm : TBD		On orbit NA for SMECp, SMECe and MCU
ON4	Acoustic	NA		SMECm and SMECp Launched under vacuum SMECe and MCU mounted inside the DRCU box provided by CEA.
ON5	Electrostatic	SMECm : TBD SMECp : TBD SMECe and MCU : TBD		
ON6	EMC	SMECm : TBD SMECp : TBD SMECe and MCU : TBD		

4.7. Verification requirements