HERSCHEL - SPIRE

Spectrometer Mirror Mechanism subsystem specifications

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Document change record

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
26 June 2000	5	Adjustements according to systems budgets, optical error budget and IID-A Subsystem description and product tree suppressed, see reference document
20 Dec 2000	6	Filtering bandwidth added to the P10 specification Number of cycles for the on ground lifetests added Specifications for SMECm and MCU separated
12 Apr 2001	7	FIRST replaced by HERSCHEL Reference of documents updated Adjustments on the on-ground lifetime Shocks suppressed.

Glossary

AD	Applicable Document
AVM	Avionic Model
BOL	Begin Of Life
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
EOL	End Of Life
ESA	European Space Agency
FPU	Focal Plane Unit
FS	Flight Spare model
FTS	Fourier Transform Spectrometer
GSFC	Goddard Space and Flight Center
H/K	House Keeping
H/W	Hardware
I/F	Interface
JPL	Jet Propulsion Laboratory
LAM	Laboratoire d'Astrophysique de Marseille
MAC	Multi Axis Controller
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
S/C	Spacecraft
S/W	Software
SMEC	Spectrometer mirror MEChanism
SMECm	SMEC cryogenic mechanism
SPIRE	Spectral and Photometric Imaging REceiver
TBC	To Be Confirmed
TBD	To Be Defined
TBU	To Be Updated
TBW	To Be Written
TC	TeleCommands
TM	TeleMetry
WE	Warm Electronics

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 1.0	23 Nov 2000
AD2	ICD Structure - Mechanical I/F	B.Winter	SPIRE/MSS/PRJ/000617 Issue 1.0	Apr 2001
AD3				
AD4	Optics / SMEC Interface		SPIRE 1.2/1.5.2	
AD5	SMEC / DRCU Interface		SPIRE 1.5.2/2.2	
AD6	Systems budgets	C.Cunningham	SPIRE/ATC/DOC/000450 1.0	11 Jun 2000
AD7	Optical error budgets	K.Dohlen	LOOM.KD.SPIRE.2000.002-DRAFT	22 May 2000
AD8	FIRST/Planck IID-A	ESA	PT-IID-A-04624 Iss1 Rev0	1 Sep 2000
AD9	SPIRE Product assurance plan	RAL	SPIRE-RAL-PRJ-000017 Issue 1.0	11 Apr 2001

2.2. Reference documents

	Title	Author	Reference	Date
RD1	MCU Design description	D.Ferrand, M.Jevaud, P.Levacher	LAM.ELE.SPI.NOT.000619 Iss 2 Rev 0	12 Apr 2001
RD2	SMECm design description	D.Pouliquen	LAM.PJT.SPI.NOT.200008 Ind 3	12 Apr 2001

3. The SMEC Subsystem

3.1. General overview

The Spectrometer mirror MEChanism subsystem (SMEC) is a major part of the SPIRE Spectrometer. It is in charge of the movement of the FTS corner cubes 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.

3.2. Description of the spectrometer mirror mechanism subsystem

The SMEC is made of 2 main parts :

- **The cryogenic mechanism** (SMECm)
- **The Mechanisms Control Unit** (MCU)

See RD1 and RD2 for details

3.3. 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.

3.3.1. SMECm mission profile

Operation	Where	Duration	Note
Bakeout	LAM	1 week	
Control and integration	LAM	TBD	
Warm Vibrations	LAM	1 week	Including correlated controls
Transport	From LAM to RAL (TBC)	2 days	
Cold vibrations	RAL (TBC)	3 weeks	Including correlated controls There will be no 4K vibrations test facility at LAM.
4K control test	RAL (TBC)	1 week	Including correlated controls There will be no 4K test facility at LAM.
Transport	Back to LAM	2 days	
Thermal cycles	LAM	4 weeks	Including correlated controls
Characterisation	LAM	4 weeks	
Transport	From LAM to RAL	2 days	
Integration in the FPU	RAL	1 week	Including correlated controls
FPU Bakeout	RAL	1 week	
FPU 300K vibrations	RAL	1 week	
FPU Transport	From RAL to ?	TBD	
FPU Cold vibrations	?	3+ weeks	Including correlated controls
FPU Transport	Back to RAL	TBD	
FPU Thermal cycles	RAL	TBD	Including correlated controls
FPU Transport	From RAL to ESA	TBD	
SPIRE integration in HERSCHEL	ESA	TBD	Including correlated controls
Satellite tests	ESA	TBD	Including correlated controls

Lock of launch latch	ESA	TBD	Including correlated controls
Storage	ESA	2 years (TBC)	
Launch	CNES Kourou	TBD	
Power on	Orbit		Including correlated controls
Unlock of launch latch	Orbit	1/2 day	Including correlated controls
Beginning of operation	Orbit	TBD	Health assessement of the subsystem
Operations	Orbit	4.25 years	The SMECm will not be operated along the complete 4.25 years of HERSCHEL 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	TBD	

3.3.2. MCU Mission profile

Operation	Where	Duration	Note
Bakeout	LAM	1 week	
Control and integration	LAM	TBD	
Warm Vibrations	LAM	1 week	Including correlated controls
Transport	Form LAM to CEA	2 days	
Integration in the DRCU	CEA	1 week	Including correlated controls
DRCU transport	From CEA to INTESPACE	TBD	
DRCU Warm vibrations	INTESPACE (TBC)	1 week	Including correlated controls
DRCU Thermal cycles	INTESPACE (TBC)	TBD	Including correlated controls
DRCU EMI EMC	INTESPACE (TBC)	TBD	Including correlated controls
DRCU transport	Back to CEA	TBD	
DRCU transport	From CEA to RAL	TBD	
SPIRE Calibrations	RAL	TBD	
SPIRE Transport	From RAL to ESA	TBD	
SPIRE integration in HERSCHEL	ESA	TBD	Including correlated controls
Satellite tests	ESA	TBD	Including correlated controls
Lock of SMECm and BSMm launch latches	ESA	TBD	Including correlated controls
Storage	ESA	2 years (TBC)	
Launch	CNES Kourou	TBD	
Power on	Orbit		Including correlated controls
Unlock of SMECm and BSMm launch latches	Orbit	1/2 day	Including correlated controls
Beginning of operation	Orbit	TBD	Health assessement of the subsystem

Operations	Orbit	4.25 years	The MCU will not operate during the complete 4.25 years of HERSCHEL on orbit but approximately 1.4 year (non contiguous).
End of operations	Orbit	TBD	

3.4. Product trees

TBW

4. SMEC Performances Requirements

#	Requirement	IRD [AD1]	Note
SMEC_P1	Scientific Travel = -3.2 / +3.2 mm	SMEC-R01	w.r.t. ZPD position goal : -3.2 to +32 mm
SMEC_P2	Minimum movement sampling interval = 5µ	SMEC-R02	
SMEC_P3	Sampling interval = 5 to 25µ	SMEC-R03	2 to 26µ with 2µ steps 13 values selectable in the range.
SMEC_P4	Scan length = Start and stop anywhere in the travel range	SMEC-R04	
SMEC_P5	Deadtime = Less than 10% of the useful time	SMEC-R05	Allocation of the 10% will be made by technical team
SMEC_P6	Velocity range = 0.2 to 1 mm/s	SMEC-R06 & 07	any value selectable in the range 0 to 5 mm/s with a 1µ/s resolution
SMEC_P7	Velocity stability = 10 µ/s RMS in the velocity range, filtering bandwidth = 0.03 to 25Hz	SMEC-R08	
SMEC_P8	Velocity stability duration = 24 consecutive hours	SMEC-R08	
SMEC_P9	Mirrors position measurement range = -3.2 / +3.2 mm		Goal : -3.2 to 32 mm (see SMEC-P1)
SMEC_P10	Mirrors position measurement accuracy = 0.1µ in the +/- 3.2 mm travel range, +/- 0.3µ elsewhere, filtering bandwidth = 0.03 to 25Hz	SMEC-R09	The postion is measured relatively to fiducial mark position

5. SMECm Requirements

5.1. Technical requirements

#	Requirement	Ref	Note
SMECm_Tm1	Axis definition = X is the direction of the travel and of the launch direction Y is perpendicular to the interface SMECm fixation plane Z is the third direction	AD2	The XZ plane is the interface plane between the structure and SMECm
SMECm_Tm2	SMECm Alignment tolerances = <1° (TBC) all directions w.r.t. optical path	AD7	
SMECm_Tm3	Dimensions = 140 mm x 140 mm x 165 mm	AD2	Plus a 24 mm deep pocket under the XZ plane
SMECm_Tm4	Center of gravity = TBD		
SMECm_Tm5	Mass = 1100 g + 200 g excluding margins, mirrors, harness	AD6	In the actual design, 1100 g for SMECm and 200 g for the preamplifier.
SMECm_Tm6	Inertia = TBD		
SMECm_Tm7	Emitted vibrations = TBD		
SMECm_Tm8	Power consumption =< 2.4 mW	AD6	
SMECm_Tm9	EMC = TBD		
SMECm_Tm10	Fiducial mark position = inside the +/- 0.32 mm subtravel		
SMECm_Tm11	Fiducial mark position accuracy = +/- 50 µ w.r.t. ZPD theoretical position, goal +/- 25µ		
SMECm_Tm12	Operational position = SMECm must be in the specs only in 0g conditions or simulated 0g. with the travel axis within TBD degrees from the horizontal plane.		Operation will be possible with the travel axis within TBD degrees from the horizontal plane.
SMECm_Tm13	Stray light = Must be as IR light tight as possible		
SMECm_Tm14	Number of thermometers = 2 Nominal and one redundant	AD1	Location TBD
SMECm_Tm15	Movement = No friction allowed, no shocks allowed		For optimum movement control
SMECm_Tm16	Resonance frequency = None in the 0.03 – 25 Hz that cannot be notched by the control		

5.2. Operational requirements

5.2.1. Relialibility

Cold redundant hardware shall be provided wherever practicable within the SMECm design.

5.2.2. Lifetime

#	Requirement	Ref	Note
SMECm_OL1	Ground Storage lifetime = 2 years cumulated time		A guess
SMECm_OL2	Ground Integrated lifetime = 4 years cumulated time		About
SMECm_OL3	Ground operational lifetime = 3 months cumulated time		1 month for subsystem acceptance 1 month for SPIRE acceptance 1 month for HERSCHEL acceptance Under 1g conditions The distribution will be : 1 month : SMECm travel = -0.32 to +0.32 mm => 1.8^{E}6 cycles 1 month : SMECm travel = -3.2 to +3.2 mm => 1.8^{E}5 cycles 1 month : SMECm travel = -3.2 to +32 (goal) mm => 3.7^{E}4 cycles Number of cycles calculated assuming a speed of 0.5 mm/s plus 10% deadtime (*)
SMECm_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 => 5.2^{E}6 cycles 85 days : SMECm travel = -3.2 to +3.2 mm => 5.2^{E}5 cycles 85 days : SMECm travel = -3.2 to +32(goal) mm => 1^{E}5 cycles Number of cycles calculated assuming a speed of 0.5 mm/s plus 10% deadtime (**)
SMECm_OL5	On orbit non operational lifetime = 3.5 years cumulated time		

(*) The qualification factor for on ground operational lifetime is 4

(**)As the number of on orbit cycles is always greater than 1E5, the qualification factor to be applied during lifetime tests is 1.25 (see AD8)

5.2.3. Operating modes

The SMECm has only one operating mode which is moving along the trajectory and back.

5.2.4. Telemetry

NA

5.2.5. Telecommands

NA

5.3. Interface requirements

The interfaces are defined in the relevant applicable documents.

Interface	With	Document
Mechanical	SPIRE Structure	[AD2]
Thermal	SPIRE Structure	[AD2]
Optics	SPIRE Optics	[AD4] SPIRE 1.2 / 1.5.2
Electronic	MCU	RD1

5.4. Design and manufacture requirements

5.4.1. Design requirements

LAM design procedures are adopted where applicable

5.4.2. Manufacture requirements

These are requirements on accessibility, dismountability, testability and manufacturing processes.
As a general rule, the manufacture and cleaning processes will be compatible with class 100 specifications and with the SPIRE PA plan (AD9)
Materials and processes will be declared in the relevant Declared Materials List.

5.5. 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

5.6. Environment requirements

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

5.6.1. Natural environement

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

#	Requirement	Ref	Note
SMECm_EN1	Vacuum = Less than 10-4 Pa		During tests, launch and in operation
SMECm_EN2	• Operating temperature during system qualif and on orbit = 4K • during subsystem qualification = 300K and 20K, (4K for specific tests) • during SPIRE bake out = +80°C (353K)		Components at 100K inside the preamplifier
SMECm_EN3	Storage and handling temperature = -20 to +30 °C Humidity = Less than 45% Cleanliness = Class TBD		Under atmospheric pressure, on ground In clean room In clean room
SMECm_EN4	Radiations = Less than 3.5 kRAD	AD8	On orbit

5.6.2. Operating environment

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

#	Requirement	Ref	Note
SMECm_ON1	Vibrations • quasi static level : 37.5 g along X (launch directin), 21g along Y and Z • sine vibrations level : TBD • random vibrations level = 110 g RMS along X (launch direction), 125g RMS along Y and 50 gRMS along Z	AD2	At 4K
SMECm_ON2	Shocks = NA		At 4K
SMECm_ON3	Microvibrations = TBD		On orbit
SMECm_ON4	Acoustic = NA	AD8	launched under vacuum
SMECm_ON5	Electrostatic = TBD		
SMECm_ON6	EMC = TBD		

5.7. Verification requirements

The verification requirements is in AD1.

6. MCU Requirements

6.1. Technical requirements

#	Requirement	Ref	Note
MCU_Tm1	Axis definition = TBD		
MCU_Tm2	Dimensions = TBD		Cards fromat is eurodouble or a little more
MCU_Tm3	Center of gravity = TBD		Only for the boards
MCU_Tm4	Mass = TBD		Only mass of the boards. Mechanical box in the DRCU mass budget.
MCU_Tm5	Inertia = TBD		Only for the boards
MCU_Tm6	Power consumption = 13.9W mean, 22.5W peak	RD1	
MCU_Tm7	EMC = TBD		

6.2. Operational requirements

6.2.1. Relialibility (see AD1)

IRD-REL-03 : Cold redundant hardware shall be provided wherever practicable within the MCU design.
IRD-REL-04 : As far as possible, all control loops shall be implemented through the use of on board software
IRD-REL-05 : It shall be possible to break all control loops implemented in hardware..

6.2.2. Lifetime

Based on AD8

#	Requirement	Ref	Note
MCU_OL1	Ground Storage lifetime = 2 years cumulated time		A guess
MCU_OL2	Ground Integrated lifetime = 4 years cumulated time		About
MCU_OL3	Ground operational lifetime = 1.5 years cumulated time		6 months for subsystem acceptance 6 months for SPIRE acceptance 6 months for HERSCHEL acceptance Under 1g conditions
MCU_OL4	On orbit operational lifetime = 8.5 months cumulated time		Operating during 1/6 of the mission duration (4.25 years)
MCU_OL5	On orbit non operational lifetime = 3.5 years cumulated time		

6.2.3. Operating modes

TBW

6.2.4. Telemetry

The telemetry interface link has a rate of 1 Mbits/s, based on 16 bits words. Data may be provided in 32 bits format in two words.

6.2.5. Telecommands

The MCU shall receive a 32 bits word for each command. The 32 bit word shall include (i) 2 or 3 bits for subsystem id (ii) 7/8 bits for command type (e.g. set scan_length), (iii) the rest for the parameter itself. There are 2 registers (for command receipt and command reply) in interface with MCU DSP.
There is a specific broadcast @ a dedicated address.

6.3. Interface requirements

The interfaces are defined in the relevant applicable documents.

Interface	With	Document
Mechanical	DRCU	[AD5] SPIRE 1.5.2 / 2.2
Thermal	DRCU	[AD5] SPIRE 1.5.2 / 2.2
Electronics	DRCU DPU SMECm BSMm	[AD5] SPIRE 1.5.2 / 2.2 ? TBW TBW
TM/TC	DPU	?

6.4. Design and manufacture requirements

6.4.1. Design requirements

All electronics will be mounted on double eurocards.

6.4.2. Design rules

TBD

6.4.3. Manufacture requirements

These are requirements on accessibility, dismountability, testability and manufacturing processes.
As a general rule, the manufacture and cleaning processes will be compatible with the SPIRE PA plan (AD9)

6.5. Logistic requirements

The subsystem wil be transported to and from CEA-SAp under LAM responsibility.
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

6.6. Environment requirements

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

6.6.1. Natural environement

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

#	Requirement	Ref	Note
MCU_EN1	Vacuum = Less than 10-4 Pa		During tests, launch and in operation
MCU_EN2	Operating temperature = TBD	AD8	
MCU_EN3	Storage and handling temperature = TBD Humidity = Less than 45% Cleanliness = Class TBD		Overall, on ground In clean room In clean room
MCU_EN4	Radiations = Less than 12 kRAD	AD8	On orbit

6.6.2. Operating environment

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

#	Requirement	Ref	Note
MCU_ON1	Vibrations = TBD		At 300K, atmospheric pressure
MCU_ON2	Shocks = TBD		At 300K, atmospheric pressure
MCU_ON3	Acoustic = TBD		At 300K, atmospheric pressure
MCU_ON4	Electrostatic = TBD		
MCU_ON5	EMC = TBD		

6.7. Verification requirements

The verification requirements is in AD1.