HERSCHEL - SPIRE

SMECm Specifications

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Date	Issue	Revision	Modification	Pages affected
9 Sep 2004	1	0	Creation of the document *The origin of this document is the part of the document "Spectrometer Mirror Mechanism subsystem Specification", reference LAM.PJT.SPI.NOT.200002 related only to the mechanism, the MCU part being deleted. This document is no longer maintained.*	All

Distribution list

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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 1.1	10 Jan 2002
AD2	~~ICD Structure - Mechanical I/F~~	~~B.Winter~~	~~SPIRE/MSS/PRJ/000617 Issue 1.0~~	~~Apr 2001~~
AD3	Optics / SMEC Interface		SPIRE 1.2/1.5.2	
AD4	SPIRE Instrument Budgets	J.Delderfield	SPIRE-RAL-PRJ-000450 Issue 4.0	1 Jun 2003
AD5	Optical error budgets	K.Dohlen	LOOM.KD.SPIRE.2000.002 Issue 4	17 Jan 2002
AD6	Herschel/Planck IID-A	ESA	PT-IID-A-04624 Iss3 Rev0	1 Jul 2003
AD7	SPIRE Product assurance plan	RAL	SPIRE-RAL-PRJ-000017 Issue 1.0	11 Apr 2001
AD8	SOB mounted units random and sine specifications	B.Winter	Technote 20 Issue 2	2 Sep 2004
AD9	SMEC Interface control document	G. Rousset	LAM.SSP.SPI.DCI.040611_01	11/06/2004

2.2. Reference documents

	Title	Author	Reference	Date
RD1	SMECm design description	D.Pouliquen	LAM.PJT.SPI.NOT.200008 Ind 4	16 Oct 2001
RD2	Product Breakdown Structure	P.Dargent	SPI.PFM.00.PB.01.A	3 Oct 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 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.

Operation	Where	Duration	Note
Bakeout	LAM	1 week	At mechanical parts level, before integration
Control and integration	LAM	3 weeks	
Warm Vibrations	LAM	1 week	Including correlated controls
Transport	From LAM to RAL	1 week	
Cold vibrations	RAL (TBC)	3 weeks	Including correlated controls There is no 4K vibrations test facility at LAM.
Transport	Back to LAM	1 week	
Thermal tests	LAM	2 weeks	Including correlated controls
Transport	From LAM to RAL	1 week	
Integration in the FPU	RAL	3 days	Including correlated controls
FPU Bakeout	RAL	1 week	
FPU 300K vibrations	RAL	1 week	
FPU Transport	From RAL to CSL	TBD	
FPU Cold vibrations	CSL	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	FPU at 4K, under vacuum
Power on	Orbit		Including correlated controls
Unlock of launch latch	Orbit		Including correlated controls
Beginning of operation	Orbit	TBD	Health assessement of the subsystem

Operation	Where	Duration	Note
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	

3.4. Product trees

SMECm : Proto Flight Model (extracted from RD2)

- **10** : Base structure
- **20** : Linear guidance means
  - **21** : Rocking frames
  - **22** : Intermediate frames
  - **23** : Flex-pivots
  - **24** : Synchronization
- **30** : Carriage
- **40** : Mirrors
- **50** : Actuator
  - **51** : Stator
  - **52** : Coils
- **60** : Optical position Sensor
  - **61** : Sensor head
  - **62** : Sensor rule
- **70** : L.V.D.T. position sensors
  - **71** : Coils
  - **72** : Core
- **80** : Launch Latch
  - **81** : Coil
  - **82** : Core
  - **84** : Pin
  - **85** : Switch
- **90** : Harness

4. SMECm Performances Requirements

#	Requirement	IRD [AD1]	Note
SMEC_P1	Scientific Travel = -3.2 / +3.2 mm w.r.t. ZPD position	SMEC-R01	goal : -3.2 to +32 mm
SMEC_P2	Minimum movement sampling interval = 5µ	SMEC-R02	
SMEC_P4	Scan length = Start and stop anywhere in the travel range	SMEC-R04	Spec for the MCU
SMEC_P9	Mirrors position measurement range = -3.2 / +3.2 mm w.r.t. ZPD position		Goal : -3.2 to 32 mm (see SMEC-P1)

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	AD9	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	AD5	
SMECm_Tm3	Dimensions = 140 mm x 140 mm x 165 mm	AD9	Plus a 24 mm deep pocket under the XZ plane and without the volume of the preamplifier board
SMECm_Tm4	Left intentionally blank		
SMECm_Tm5	Mass = 1710 g including mirros and excluding margins and harness	AD4	The mass budget is 1300 g for SMECm excluding margins, mirrors.
~~SMECm_Tm6~~	~~Inertia = TBD~~		No value issued by the project
~~SMECm_Tm7~~	~~Emitted vibrations = TBD~~		No value issued by the project
SMECm_Tm8	Power consumption =< 2.4 mW	AD4	Required mean power consumption over the mission.
~~SMECm_Tm9~~	~~EMC = TBD~~		No value issued by the project
SMECm_Tm10	~~Fiducial mark position = inside the +/- 0.32 mm subtravel~~		No longer applicable
SMECm_Tm11	~~Fiducial mark position accuracy = +/- 50 µ w.r.t. ZPD theoretical position, goal +/- 25µ~~		No longer applicable
SMECm_Tm12	Operational position = SMECm must be in the specs only in 0g conditions or simulated 0g, with the travel axis within +/- 8 degrees from the horizontal plane.		Actuator power limits the inclination from horizontal.
SMECm_Tm13	Stray light = Must be as IR light tight as possible		
SMECm_Tm14	Number of thermometers = 2 Nominal and 2 redundant	AD1	1 main and 1 redundant are integrated on the mechanism itself, the 2 others put on a location to be agreed by the system team
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		
SMECm_Tm17	Corner Cubes decenter < 0.5 mm Corner cubes tilts < 10 arcmin		
SMECm_Tm17	First eigen frequency > 170 Hz		

5.2. Operational requirements

5.2.1. Relialibility

Cold redundant hardware shall be provided wherever practicable within the SMECm design. Every electrical components is duplicated. Two completely independant electric systems are implemented, one redundant, one nominal, without electrical crossing.
The mechanical system cannot be duplicated.

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		Total length of on ground testing of SPIRE = 6 months, distributed 3 months on the photometer, 3 months on the spectrometer. 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). 1/6 comes from: - 3 experiments on herschel (PACS, HIFI and SPIRE) - 2 sub instruments on SPIRE : the photometer and the spectrometer. 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 AD6)

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	[AD9]
Thermal	SPIRE Structure	[AD9]
Optics	SPIRE Optics	[AD3] SPIRE 1.2 / 1.5.2
Electronic	MCU	[AD10]

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 (AD7)
Materials and processes will be declared in the relevant Declared Materials List and Declared Processes 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

5.6. Environment requirements

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

5.6.1. Natural environment

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 100		Under atmospheric pressure, on ground In clean room In clean room
SMECm_EN4	Radiations = Less than 3.5 kRAD	AD6	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	Qualification levels Vibrations defined in AD8 Flight levels deduced from the qualification levels by applying the appropriate factor.	AD8	At 4K. Same levels at 300K for preliminary tests.
SMECm_ON2	Shocks = NA		
SMECm_ON3	Microvibrations = TBD		On orbit
SMECm_ON4	Acoustic = NA	AD6	launched under vacuum
SMECm_ON5	Electrostatic = TBD		
SMECm_ON6	EMC = TBD		

5.7. Verification requirements

The verification requirements is in AD1.