Spectrometer Calibrator

Failure Modes Effects & Criticality Analysis (FMECA) Report

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31/08/01	1.0	First Issue for DDR
15/11/01	1.1	Minor corrections

List of Acronyms

Term	Meaning	Term	Meaning
AD	Applicable Document	IR	Infrared
ADC	Analogue to Digital Converter	IRD	Instrument Requirements Document
AIV	Assembly, Integration and Verification	IRTS	Infrared Telescope in Space
AME	Absolute Measurement Error	ISM	Interstellar Medium
AOCS	Attitude and Orbit Control System	JFET	Junction Field Effect Transistor
APART	Arizona's Program for the Analysis of Radiation Transfer	ISO	Infrared Space Observatory
APE	Absolute Pointing Error	LCL	Latching Current Limiter
ASAP	Advanced Systems Analysis Program	LIA	Lock-In Amplifier
ATC	Astronomy Technology Centre, Edinburgh	LVDT	Linear Variable Differential Transformer
AVM	Avionics Model	LWS	Long Wave Spectrometer (an instrument used on ISO)
BDA	Bolometer Detector Array	MAC	Multi Axis Controller
BFL	Back Focal Length	MAIV	Manufacturing, Assembly, Integration and Verification
BRO	Breault Research Organization	MCU	Mechanism Control Unit = HSMCU
BSM	Beam Steering Mirror	MGSE	Mechanical Ground Support Equipment
CBB	Cryogenic Black Body	M-P	Martin-Puplett
CDF	Cardiff, Department of Physics & Astronomy	NEP	Noise Equivalent Power
CDMS	Command and Data Management System	NTD	Neutron Transmutation Doped
CDMU	Command and Data Management Unit	OBS	On-Board Software
CDR	Critical Design Review	OGSE	Optical Ground Support Equipment
CEA	Commissariat a l'Energie Atomique	OMD	Observing Modes Document
CMOS	Complimentary Metal Oxide Silicon	OPD	Optical Path Difference
CoG	Centre of Gravity	PACS	Photodetector Array Camera and Spectrometer
CPU	Central Processing Unit	PCAL	Photometer Calibration source
CQM	Cryogenic Qualification Model	PFM	Proto-Flight Model
CVV	Cryostat Vacuum Vessel	PID	Proportional, Integral and Differential (used in the context of feedback control loop architecture)
DAC	Digital to Analogue Converter	PLW	Photometer, Long Wavelength
DAQ	Data Acquisition	PMW	Photometer, Medium Wavelength
DCU	Detector Control Unit = HSDCU	POF	Photometer Observatory Function
DDR	Detailed Design Review	PROM	Programmable Read Only Memory
DM	Development Model	PSW	Photometer, Short Wavelength
DPU	Digital Processing Unit = HSDPU	PUS	Packet Utilisation Standard
DSP	Digital Signal Processor	RAL	Rutherford Appleton Laboratory,
DQE	Detective Quantum Efficiency	RD	Reference Document
EDAC	Error Detection and Correction	RMS	Root Mean Squared
EGSE	Electrical Ground Support Equipment	SCAL	Spectrometer Calibration Source
EM	Engineering Model	SCUBA	Submillimetre Common User Bolometer Array
EMC	Electro-magnetic Compatibility	SED	Spectral Energy Distribution
EMI	Electro-magnetic Interference	SMEC	Spectrometer Mechanics
ESA	European Space Agency	SMPS	Switch Mode Power Supply
FCU	FCU Control Unit = HSFCU	SOB	SPIRE Optical Bench
FIR	Far Infrared	SOF	Spectrometer Observatory Function
FIRST	Far Infra-Red and Submillimetre Telescope	SPIRE	Spectral and Photometric Imaging Receiver
FOV	Field of View	SRAM	Static Random Access Memory
F-P	Fabry-Perot	SSSD	SubSystem Specification Document
FPGA	Field Programmable Gate Array	STP	Standard Temperature and Pressure
FPU	Focal Plane Unit	SVM	Service Module
FS	Flight Spare	TBC	To Be Confirmed
FTS	Fourier Transform Spectrometer	TBD	To Be Determined
FWHM	Full Width Half maximum	TC	Telecommand
GSFC	Goddard Space Flight Center	URD	User Requirements Document
HK	House Keeping	UV	Ultra Violet
HOB	Herschel Optical Bench	WE	Warm Electronics
HPDU	Herschel Power Distribution Unit	ZPD	Zero Path Difference
HSDCU	Herschel-SPIRE Detector Control Unit		
HSDPU	Herschel-SPIRE Digital Processing Unit		
HSFCU	Herschel-SPIRE FPU Control Unit		
HSO	Herschel Space Observatory		
IF	Interface		
IID-A	Instrument Interface Document - Part A		
IID-B	Instrument Interface Document - Part B		
IMF	Initial Mass Function		

Table of Contents

1. Scope

This document presents the results of the FMECA carried out on the SCAL design.

2. Documents

2.1. Applicable documents

All applicable documents are listed in the AD chapter of the CIDL (HSO-CDF-LI-029).

2.2. Reference documents

3. Details of the analysis

A failure modes effects and criticality analysis has been performed on all functional elements of SCAL (excluding structural elements whose integrity has been assessed with stress analysis and fracture mechanics analysis as necessary) which can cause failure effects within the experiment or cause damage to or interfere with, the proper functioning of the SPIRE instrument or Herschel spacecraft.

Each failure effect identified has been given a criticality category according to the definition below:

- Category 1**:** The failure effect is not confined to the subsystem. When this failure results also in loss or degradation of the instruments function this shall be stated.

- Category 2: The failure results in loss or degradation of the subsystems function but the effect is confined to the subsystem.

- Category 3: Minor internal subsystem failures.

The following attributes have been added to the criticality category as appropriate:

- "R", if the design contains a redundant item which can perform the same function
- "SH", if the failure effect causes a safety hazard
- "SPF" if the failure is caused by a single point failure.

The following failure modes have been considered: -

Premature operation
Failure to operate (at the prescribed time)
Failure to cease operation (at the prescribed time)
Failure during operation
Degradation or out of tolerance operation
For failure at component level e.g. hardware interface
- short circuit
- open circuit
- incorrect function e.g. from single event upset - ex: latch-ups.

Incorrect commands or sequence of commands
Incorrect software functions
Mechanical failure

Design specifications, descriptions functional diagrams etc. used in the preparation of the FMECA shall be attached or referenced.

Table 1 Results of FMECA of SCAL subsystem.

FAILURE MODES EFFECTS AND CRITICALITY ANALYSIS (FMECA)

Product: SPIRE Instrument
Project/Phase: Herschel
System/Subsystem/Equipment: SCAL
Mission phase/Operational Mode: Space Flight
Prepared by: P.Hargrave
Approved by:
Date: 25/08/01
Document reference:
Issue:

Id number	Item/ block	Function	Failure mode	Failure cause	Failure effects a. Local effects b. End effects	Severity	Failure detection method/ observable symptoms	Compensation provisions	Correction actions	Remarks
000.001	SCAL Assembly		Input power short to ground (source A or B)	Connector Failure	a. Loss of SCAL_A or SCAL_B sources b. Degraded dynamic range for spectrometer detectors	2R	No source heating for one of the prime sources	Switch to redundant side	Can run second prime source – impaired telescope nulling	There are two prime sources with full redundancy. Running the other prime source will still allow some degree of telescope nulling with perhaps increased power dissipation
000.002	SCAL assembly		Input power open circuit (source A or B)	Connector Failure	a. Loss of SCAL_A or SCAL_B sources b. Reduced dynamic range for spectrometer detectors	2R	No source heating for one of the prime sources	Switch to redundant side	Can run second prime source – impaired telescope nulling	There are two prime sources with full redundancy. Running the other prime source will still allow some degree of telescope nulling with perhaps increased power dissipation
000.003	SCAL assembly		Thermometry short (source A or B)	Connector Failure	a. Inability to monitor SCAL_A or SCAL_B temperatures b. Loss of thermometry data for source	3R	Low impedance reading on source thermometer	Switch to redundant side	Can still run source “blind” based on experimental data until we maximise the central peak in the interferogram	

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000.004	SCAL assembly		Thermometry open circuit (source A or B)	Connector Failure	a. Inability to monitor SCAL_A or SCAL_B temperatures b. Loss of thermometry data for source	3R	Open circuit reading for thermometer	Switch to redundant side	Can still run source "blind" based on experimental data until we maximise the central peak in the interferogram	
100.001	SCAL_A(P) – prime 4% source assembly	Radiant source for telescope nulling	Heater body breaks off strut	Manufacturing error. Part failure.	a. Loss of SCAL_A(P) source b. Degraded dynamic range for spectrometer detectors. Possible damage to other subsystem and instrument components (e.g. SM8B, beam splitter)	1R	Open circuit reading for thermometer and heater	a. Switch to redundant side b. None	Can run second prime source – impaired telescope nulling	
101.001	SCAL_A(P) – heater body		Loss of black coating	Manufacturing error.	a. Reduced emissivity of source – increased power dissipation to achieve required level of nulling. Impaired nulling. b. Possible damage to other subsystem and instrument components (e.g. SM8B, beam splitter) from coating fragments	1R		a. Switch to redundant side b. None	Can run second prime source – impaired telescope nulling	May not be possible to match spectrum within requirements
102.001	SCAL_A(P) – strut	Supports heater body – provides thermal isolation	Breaks	Material failure	a. Loss of source b. Reduced dynamic range for spectrometer detectors. Possible damage to other subsystem and instrument components (e.g. SM8B, beam splitter)	1R		a. Switch to redundant side b. None	Can run second prime source – impaired telescope nulling	

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103.001	SCAL_A(P) – sapphire plate	Provides electrical isolation for heater resitor & good thermal path to heater body	Cracks	Manufacturing error. Differential thermal contraction	a. Impaired thermal path to heater body – increased warm-up time b. Longer warm-up	3R		Switch to redundant side		May be detectable by performing cross-calibration with redundant side sources.
104.001	SCAL_A(P) – thermometer	Monitors source temperature	Short	Manufacturing error. Part failure.	a. Inability to monitor SCAL_A temperature b. Loss of thermometry data for source	3R	Low impedance reading on source thermometer	Switch to redundant side	Can still run source “blind” based on experimental data until we maximise the central peak in the interferogram	
104.002			Open	Manufacturing error. Part failure.	a. Inability to monitor SCAL_A temperature b. Loss of thermometry data for source	3R	Open circuit reading for thermometer	Switch to redundant side	Can still run source “blind” based on experimental data until we maximise the central peak in the interferogram	
104.003			Erratic output	Manufacturing error. Part failure.	a. Inability to monitor SCAL_A temperature b. Loss of thermometry data for source	3R		Switch to redundant side	Can still run source “blind” based on experimental data until we maximise the central peak in the interferogram	

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Id number	Item/ block	Function	Failure mode	Failure cause	Failure effects a. Local effects b. End effects	Severity	Failure detection method/ observable symptoms	Compensation provisions	Correction actions	Remarks
104.004			No output	Manufacturing error. Part failure.	a. Inability to monitor SCAL_A temperature b. Loss of thermometry data for source	3R		Switch to redundant side	Can still run source "blind" based on experimental data until we maximise the central peak in the interferogram	
105.001	SCAL_A(P) – Heater resistor	Heater for source	Open	Manufacturing error. Part failure.	a. Loss of source b. Reduced dynamic range for spectrometer detectors	2R	No source heating	Switch to redundant side	Can run second prime source – impaired telescope nulling	There are two prime sources with full redundancy. Running the other prime source will still allow some degree of telescope nulling with perhaps increased power dissipation
105.002			Short	Manufacturing error. Part failure.	a. Loss of source b. Reduced dynamic range for spectrometer detectors	2R	No source heating	Switch to redundant side	Can run second prime source – impaired telescope nulling	There are two prime sources with full redundancy. Running the other prime source will still allow some degree of telescope nulling with perhaps increased power dissipation
105.003			Changed value	Manufacturing error. Part failure.	a. Change in drive requirements b. None	3R	Monitor I/V values for heater (4 wire configuration)	Change drive current Switch to redundant side?	Change drive current	