SPIRE

SUBJECT: **EQM test plan**

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Glossary

SPIRE	Spectral and Photometric Imaging REceiver

References

Applicable Documents

AD1	SPIRE-RAL-DOC-001799 SPIRE DRCU Integration Test Specification
AD2	SPIRE-RAL-DOC-001652 SPIRE Functional Test Specifications
AD3	HP-2-ASED-PL-0021
AD4	SPIRE-RAL-DOC-000768 Operating the SPIRE instrument

Reference Documents

1. SCOPE

This document describes the integration and test activities to be conducted at Astrium after delivery of the SPIRE CQM.

2. INTRODUCTION

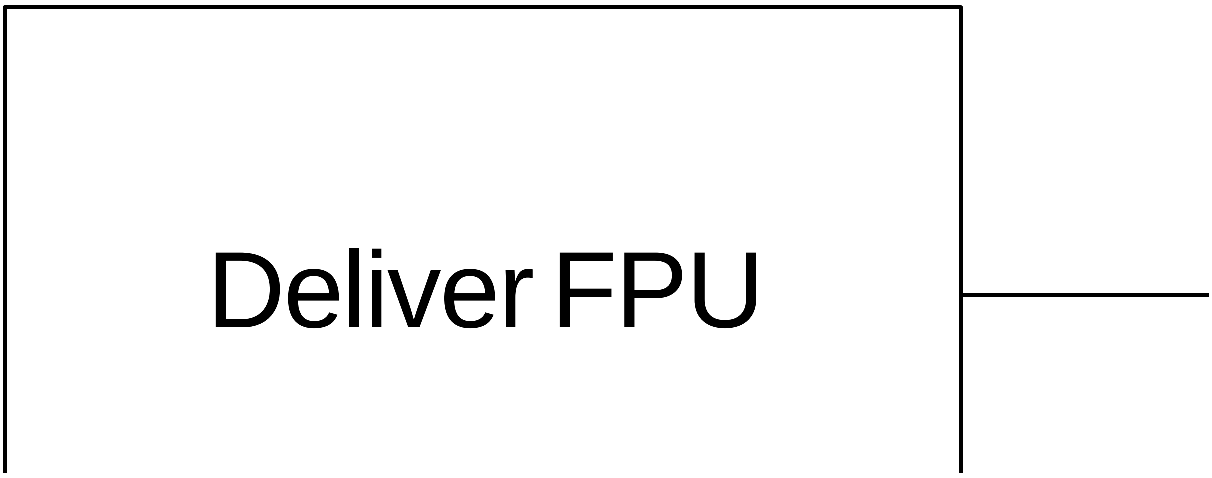
Development of the FPU and warm electronics are to some extent decoupled and therefore these two subsystems are not always available at the same time. The DRCU (QM1) is also required to support the PFM test programme at RAL.
Several scenarios can be considered for delivery of the CQM units to Astrium depending on availability and the requirements of the spacecraft AIV planning.

Scenario 1, FPU required for integration, no warm electronics required.
In this case SPIRE can deliver the FPU only, minimum stand alone testing and then integrate into the cryostat. Testing with Warm electronics can be done later.

Scenario 2, FPU required for integration, warm testing in the cryostat to be carried out immediately.
In this case the FPU and warm electronics together with GSE will be delivered and the testing described below carried out. The warm electronics will remain with the FPU for the cold test programme.

Scenario 3, FPU required for integration, warm testing in the cryostat to be carried out immediately.
In this case the FPU and warm electronics together with GSE will be delivered and the testing described below carried out. The warm electronics will then be returned to SPIRE to support the PFM programme at RAL, and then returned at a later date to support the cold test programme.

Below is an overview of the test flow envisaged.



3. DELIVERY

The following equipment will be delivered to Astrium by the SPIRE project. It will be delivered by road in one or more shipments.

FPU
FPU, JFETS and JFET harness in a dedicated container
MGSE
Lifting equipment

Warm electronics
DPU
DCU
FCU
Separate Power supply
WIH (test harness)

EGSE
CDMS simulator – loan for stand alone integration checks only
Test harness
FPU simulator – loan for stand alone warm electronics checkout only. This unit does NOT interface to the cryoharness
Stand alone "Cross talk" unit for checkout of Astrium detector side harness

The following equipment will already be at Astrium:
IEGSE (Instrument Electrical GSE). This is the common equipment for all Instruments

4. PRE INTEGRATION TESTS

A series of stand-alone tests will be conducted by SPIRE personnel to ensure that no damage has occurred during transit.

4.1 FPU testing.

Testing on the FPU is very limited and consists of visual inspection, continuity and isolation tests only.

The following equipment will be required for this test, and supplied by SPIRE:
The spacecraft EGSE is not required.

FPU and JFETS
Test leads
Breakout boxes.

Expected duration ½ day.

4.2 Warm electronics testing

Limited function testing can be carried out on the warm electronics.

The following equipment will be required for this test, and supplied by SPIRE:
The spacecraft EGSE is not required.

DPU
DCU
FCU
Separate power supply
IEGSE (already at Astrium)
CDMS simulator
FPU simulator
WIH (test harness)
Test harness

Tests:
SPIRE DRCU Integration Test specified in AD1.
SPIRE warm Short Functional Test – this will be a TBD sub-set of the full Warm Functional Test specified in AD2

Expected duration ½ day.

4.3 Detector harness cross talk checkout

The Astrium cryoharness can be connected between the SPIRE DCU and a SPIRE provided piece of GSE that simulates the JFET units with resistor networks. This unit provides a 1 Hz oscillating signal on 4 out of 24 signal channels and allows the cross talk between channels to be assessed. It also allows the function of the harness to be checked safely checked before integration onto the FPU.

We have carried out this test at RAL and will provide the specification in the near future.

4.4 Warm Electronics Integration with Spacecraft EGSE

Following the stand alone test using the SPIRE EGSE (see section 6 below) we will wish to connect the SPIRE warm units to the spacecraft EGSE and repeat the integration tests.

The test to be carried out are as a minimum those specified in AD1.

5. INTEGRATION

The FPU and JFETS will be integrated onto the PLM following the SPIRE handling and integration procedure. This will be provided in the near future.

6. WARM POST INTEGRATION TESTS

A series of functional tests will be carried out to test the system when the FPU is integrated into the cryostat, but before cool down.

The following SPIRE supplied equipment is required for this test.
The spacecraft EGSE is not required.

FPU and JFETS, integrated into the cryostat
DPU Mounted on the SVM, TBD
DCU Mounted on the SVM, TBD
FCU Mounted on the SVM, TBD
Separate power supply, mounted remotely from the SVM
IEGSE (already at Astrium)
CDMS simulator
FPU simulator
WIH (test harness)
Test harness

We will carry out a full Warm Functional Test at this time as specified in AD2. We will carry out these tests independently of the spacecraft EGSE

These tests will take approximately 1 day

7. COLD TESTS

A series of functional and performance tests will be carried out to test the system when the FPU is integrated into the cryostat, and is cold.
During these tests the Instrument will be controlled via the spacecraft and its associated EGSE.

Dependent on the circumstances – i.e. whether we have already carried out the integration of the warm electronics with the spacecraft EGSE, we could either carry out these tests with the SPIRE CDMS simulator (as per section 6) or using the spacecraft EGSE.

The following SPIRE supplied equipment is required for this test.
The spacecraft EGSE is not required but can be used if the integration tests specified in section 4.4 has been carried out.

FPU and JFETS, integrated into cryostat
DPU Mounted on the SVM
DCU Mounted on the SVM
FCU Mounted on the SVM
Separate power supply, mounted remotely from the SVM
CDMS simulator (if required)

The test sequence is as follows:
At He-I
Short Cold Functional Test – a TBD sub-set of the full functional test (see next item) to ensure instrument integrity
This will take 1 hour
At He-II
Full Cold Functional Test will be carried as specified in AD2
This will take 4 hours

A cooler recycle (CREC mode see AD4) will be carried out as part of this test – this will allow SPIRE to carry out the performance tests as outlined in AD3. Appendix A of the present document gives the test specification sheets proposed by SPIRE and replaces SPIRE-RAL-NOT-000982 iss 0.2

APPENDIX A

Here are the test case forms as used in AD3 – for completeness I include forms for tests specified above.

Title:
Flight Operations Thermal Balance Test
Cooler Recycle

Experiment:
Herschel/SPIRE

Objectives:
To verify the temperature stability and balance of the SPIRE instrument during and after cooler recycle mode operations
To prepare the instrument for operation with the photometer or spectrometer detectors

Test Description:
The cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions i.e. the mass flow rate and shield temperatures must be those expected in flight. The SPIRE cooler recycle sequence (CREC see AD4) will be carried out and the temperatures of the various stages monitored.
The results will be compared to those from the SPIRE Instrument Thermal Model (ITMM) and ILT.

Instrument Configuration:
CQM

Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):
At least 17 degrees tilted around Z-axis towards +Y
This operation can be carried out with the PLM rotated to 90 degrees in same direction.

Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):
Mass flow rate as close as possible to that expected in flight
Shield temperatures as close as possible to expected in flight temperatures certainly as follows
L0 < 1.8 K
L1 < 6 K
L2 < 15 K
These should be maintained for the duration of the test and thereafter for the start of the follow on photometer test.

Success Criteria:
Cooler is successfully recycled and temperatures settle to within operational limits as predicted by the SPIRE ITMM and ILT

Duration:
~3 hours

Applicable: EPLM EQM

Title:
Warm Functional Test

Experiment:
Herschel/SPIRE

Objectives:
To check out the functionality of the SPIRE instrument following integration at payload module level before cooldown commences.

Test Description:
See SPIRE-RAL-DOC-001905 and associated AD's

Instrument Configuration:
CQM

Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):
None

Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):
None

Success Criteria:
Instrument housekeeping data monitored via SCOS2000 and QLA. Comparison with values obtained during ILT shows no change in function.

Duration:
~4 hours

Applicable: EPLM EQM

Test Case Form

Title: Cold Functional Test	*Experiment:* Herschel/SPIRE

Objectives:
To check out the functionality of the SPIRE instrument following integration at payload module level after the instrument has been cooled down.

Test Description:
See SPIRE-RAL-DOC-001905 and associated AD's

Instrument Configuration: CQM	*Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):* None

Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):
Temperatures need to be as follows for the test to be valid.
Level 0 – <1.8 K
Level 1 - < 6 K
Level 2 < 15 K

Success Criteria:
Instrument housekeeping data monitored via SCOS2000 and QLA. Comparison with values obtained during ILT shows no change in function.

Duration: ~4 hours	*Applicable:* EPLM EQM ☒

Title:
Flight Operations Thermal Balance Test – **Photometer Chop Mode**

Experiment:
Herschel/SPIRE

Objectives:
To verify the temperature stability and balance of the SPIRE instrument during simulated photometer chopped mode operations.

Test Description:
The EQM cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions i.e. the mass flow rate and shield temperatures must be those expected in flight.
The ambient background in the instrument is such as to allow meaningful signals from the detectors to be seen. This will be verified by a dedicated measurement
The SPIRE cooler has been recycled and the instrument is at nominal temperature
The photometer JFETs are switched on and the instrument temperatures allowed to settle
A simulated photometer chop observation is carried out – this will include operation of the photometer calibrator and a simulated operation of the beam steering mirror using the "backup" operational mode to provide current to the dummy motor coils.
The results will be compared to the ILT and the SPIRE ITMM

Instrument Configuration:
CQM

Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):
No restriction on the tilt

Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):
Mass flow rate as close as possible to those expected in flight
Shield temperatures as close as possible to those expected in flight temperatures certainly as follows
L0 < 1.8 K
L1 < 6 K
L2 < 15 K
These conditions should be maintained following the cooler recycle (see Cooler Recycle sheet)
Photon background on the detector in the 420-580 μm band within x5 (TBC) of that expected in flight – this equivalent to a blackbody of <~ 20 K in the beam of SPIRE

Success Criteria:
The instrument temperatures stay within pre-defined limits as predicted by the SPIRE ITMM
No excess background is seen on the detectors during operations

Duration:
~1 hour

Applicable: EPLM EQM

Title:
Flight Operations Thermal Balance Test – **Ambient Background Verification**

Experiment:
Herschel/SPIRE

Objectives:
To check the photon background on the photometer detectors after cooler recycle and before all other tests

Test Description:
The EQM cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions i.e. the mass flow rate and shield temperatures must be those expected in flight.
The SPIRE cooler has been recycled and the instrument is at nominal temperature
The photometer JFETs are switched on and the instrument temperatures allowed to settle
Load curves are taken on the photometer detectors by varying the bias voltage

Instrument Configuration:
CQM

Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):
No tilt requirements

Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):
Mass flow rate as close as possible to those expected in flight
Shield temperatures as close as possible to those expected in flight temperatures certainly as follows
L0 < 1.8 K
L1 < 6 K
L2 < 15 K
These conditions should be maintained following the cooler recycle (see Cooler Recycle sheet)

Success Criteria:
Data analysed in real time to calculate the background flux on the detectors. Background should be within limits defined for the follow on test

Duration:
~1 hour (TBC)

Applicable: EPLM EQM

Title:
Flight Operations Thermal Balance Test – **Spectrometer Mode Simulation**

Experiment:
Herschel/SPIRE

Objectives:
To verify the temperature stability and balance of the SPIRE instrument during simulated spectrometer mode operations

Test Description:
The EQM cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions i.e. the mass flow rate and shield temperatures must be those expected in flight.
The ambient background in the instrument is such as to allow meaningful signals from the detectors to be seen. This will be verified by a dedicated test.
The SPIRE cooler has been recycled and the instrument is at nominal temperature
The spectrometer JFET simulators (heaters in the STM JFET modules) are switched on and the instrument temperatures allowed to settle
The spectrometer calibrator is switched on
A simulated spectrometer observation is carried out using the "backup" mode operation to provide current directly to the fixed motor coils.
This will include operation of the photometer calibrator and beam steering mirror simulator
The results will be compared to the ILT and the SPIRE ITMM

Instrument Configuration:
CQM

Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):
None

Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):
Mass flow rate as close as possible to those expected in flight
Shield temperatures as close as possible to those expected in flight temperatures certainly as follows
L0 < 1.8 K
L1 < 6 K
L2 < 15 K
These conditions should be maintained following the cooler recycle
There are no spectrometer detectors fitted to the SPIRE CQM so there are no background restrictions.

Success Criteria:
The instrument temperatures stay within pre-defined limits as predicted by the SPIRE ITMM

Duration:
~1 hours

Applicable: EPLM EQM

Title:
EQM EMC Test
EMC Most Sensitive Mode

Experiment:
Herschel/SPIRE

Objectives:
To set the instrument into its most sensitive mode to allow the effects of EMI to be verified

Test Description:
The EQM cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions i.e. the mass flow rate and shield temperatures must be those expected in flight.
The ambient photon background in the instrument is low enough such that meaningful noise measurements can be made on the detectors. The background shall be verified by a dedicated test
The SPIRE cooler has been recycled and the instrument is at nominal temperature
The photometer JFETs are switched on and the instrument temperatures allowed to settle.
Noise traces are taken from the detectors at the highest data sampling frequency allowed by the electronics before and during **conducted** and **radiated** EM testing.
The results will be compared to the ILT and the SPIRE EMC model.

Instrument Configuration:
CQM

Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):
No tilt requirement.

Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):
Mass flow rate as close as possible to those expected in flight
Shield temperatures as close as possible to those expected in flight temperatures certainly as follows
L0 < 1.8 K
L1 < 6 K
L2 < 15 K
These conditions should be maintained following the cooler recycle (see Cooler Recycle sheet)
Photon background as low as practically possible to attempt to have the noise dominated by the intrinsic detector noise. This shall at least be such as to meet the expected background in flight in the 420-580 µm band – this is equivalent to a black body of <~12 K in the beam of SPIRE.

Success Criteria:
No excess noise is seen on the detectors during **conducted** and **radiated** EMC testing. Noise levels should be lower than those set by the SPIRE project (TBD).

Duration:
TBD

Applicable: EPLM EQM

Title: EQM EMC Test **EMC Most Noisy Mode**	*Experiment:* Herschel/SPIRE

Objectives:
To set the instrument into its most EMC noisy mode to allow the effects of EMI to be verified

Test Description:
The EQM cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions i.e. the mass flow rate and shield temperatures must be those expected in flight.
The SPIRE cooler has been recycled and the instrument is at nominal temperature
The photometer JFETs are switched on and the instrument temperatures allowed to settle.
The spectrometer calibrator is switched on
A simulated spectrometer observation is carried out using the “backup” mode operation to provide current directly to the fixed motor coils.
This will include operation of the photometer calibrator and beam steering mirror simulator
Noise traces are taken from the photometer detectors at the highest data sampling frequency allowed by the electronics to confirm self compatibility
Data taken on other instruments used to confirm instrument/instrument compatibility

Instrument Configuration: CQM	*Specific Requirements on PLM (e.g. PLM tilted about 30° around z-axis):* No tilt requirement.

Particular Environmental Constraints (e.g. level 0-2 temperatures, mass-flow - during what time):
Mass flow rate as close as possible to those expected in flight
Shield temperatures as close as possible to those expected in flight temperatures certainly as follows
L0 < 1.8 K
L1 < 6 K
L2 < 15 K
These conditions should be maintained following the cooler recycle (see Cooler Recycle sheet)
Photon background as low as practically possible to attempt to have the noise dominated by the intrinsic detector noise. This shall at least be such as to meet the expected background in flight in the 420-580 μm band – this is equivalent to a black body of <~12 K in the beam of SPIRE.

Success Criteria:
No excess noise is seen on the SPIRE detectors during simulated spectrometer operation. Noise levels should be lower than those set by the SPIRE project (TBD).
No excess noise seen on other instrument’s detectors during simulated spectrometer operation.

Duration: TBD	*Applicable:* EPLM EQM