TOTAL PAGES : 28

ALCATEL
SPACE

HERSCHEL / PLANCK

EMC/ESD CONTROL PLAN
H-P-1-ASPI-PL-0038

Product Code : 000000

	Responsabilité – Service – Société Responsibility – Office - Company	Date	Signature
Rédigé par / *Written by*			
J. GALLAGHER	EMC engineer	09/07/04	
A. LUC	EMC Engineer	09/07/04	
Vérifié par / Reviewed by		13/07/04	
K. HIBBERD	Electrical Interfaces manager		
P. COUZIN	Electrical Architecture manager	13/7/4	
Approuvé par / *Approved by*			
P. RIDEAU	Engineering manager	13/7/04	
C. MASSE	PA manager	13/07/04	
Released by			
J.J. JUILLET	Project Manager	17/07/04	

Entité Emettrice : Alcatel Space - Cannes
(détentrice de l'original) :

DISTRIBUTION / DISTRIBUTION RECORD

HERSCHEL/PLANCK		DISTRIBUTION RECORD	
DOCUMENT NUMBER : H-P-1-ASPI-PL-0038		Issue: 3 Rev.: 1 Date: 09/07/2004	
EXTERNAL DISTRIBUTION		INTERNAL DISTRIBUTION	
ESA	X	HP Team	X
ASTRIUM	X		
ALENIA	X		
		Clt. Documentation	Orig.

ENREGISTREMENT DES EVOLUTIONS / CHANGE RECORDS

ISSUE	DATE	§ : DESCRIPTION DES EVOLUTIONS § : CHANGE RECORD	REDACTEUR AUTHOR
1	03/11/2000	Initial issue (FP-ASPI-PL-1006)	
2	24/07/2001	Update before SRR	
3	27/05/2002	Update before PDR	
3.1	09/07/2004	Modification of §6.3.1 in accordance with H-P-ASP-CR-0535	J. Gallagher

TABLE OF CONTENTS

1. SCOPE

The EMC/ESD control plan defines methods, means and rules which will be used all along the HERSCHEL/PLANCK project to comply with the EMC-related requirements of the HERSCHEL/PLANCK System Requirements Specification and of the IID-B's.

It also summarises the general strategy adopted to demonstrate the System EMC margins, avoiding excessive testing while leaving as few uncertainties as possible.

This control plan is applicable to Instruments and to all sub-contractors.

2. INTRODUCTION

2.1 Aim of the control plan

The EMC control plan is aimed to define methods and rules which must be followed all along HERSCHEL/PLANCK programme to ensure the compatibility of all the subsystems with each other and the fulfilment of the EMC requirements.

It is then establishing a programme of control of emission, susceptibilities and coupling paths of the various units, subsystems, Instruments, modules and of the integrated spacecrafts all along the design, development, integration/tests and launch phases.

This document provides to each unit/subsystem supplier the design, test and control rules that the Prime intends to implement in order to avoid practices/applications which could lead to EM non compatibility.

2.2 General

The control of HERSCHEL and PLANCK EMI generated inside or from outside (launch vehicle, space environment) will be insured :

- by using “classical techniques” of EMI reduction ;
- by adopting a test philosophy which will allow to insure the platform internal compatibility (between units and subsystems of SVM mainly), the compatibility of the platform with the Instruments mounted on PLMs and the compatibility of each of the complete satellites with the environment it will encounter during the mission phases.

The control of EMI will be achieved at various levels by different means :

- the implementation of design rules to minimise EMI
- analyses performed at equipment, Instrument subsystem, Instrument, Module and System levels
- review of design implementation
- tests at equipment, Instrument subsystem, Instrument, Module and System levels
- the analysis of the test results and compliance justifications by the prime as soon as they are available

2.3 Application

This control plan is applicable to all subsystems, including Instruments. Each Module Contractor and Instrument Supplier shall issue an EMC Control Plan, based on concepts defined at system level in this document and make it applicable to its subcontractors.

At the time the present issue 3 is written, all 5 Instruments have issued at least a Draft Control Plan, cf. § 2.5.3.

2.4 Applicable documents

AD-01.1 : First/Planck System Requirements Specification (SRS)
SCI-PT-RS-05991

AD-04.1 : IID Part A
SCI-PT-IIDA-04624

AD-04.2 : IID Part B, Bolometer Instrument
SCI-PT-IIDB/SPIRE-02124

AD-04.3 : IID Part B, Heterodyne Instrument
SCI-PT-IIDB/HIFI-02125

AD-04.4 : IID Part B, Photoconductor Instrument
SCI-PT-IIDB/PACS-02126

AD-04.5 : IID Part B, HFI
SCI-PT-IIDB/HFI-04141

AD-04.6 : IID Part B, LFI
SCI-PT-IIDB/HFI-04142

AD-06.1 : Ariane 5 user manual
Issue 03/Rev. 00 - March 2000

- HERSCHEL/PLANCK Design & Development Plan (DDP)
  H-P-1-ASPI-PL-0009

2.5 Reference documents

2.5.1 Essential System documents

- HERSCHEL/PLANCK EMC Specification
  H-P-1-ASPI-SP-0037
- HERSCHEL/PLANCK General Design and Interface Requirements
  H-P-1-ASPI-SP-0027
- AVM Requirements and Design
  H-P-1-ASPI-TN-0164

2.5.2 System EMC analyses

- Herschel/Planck EMC analyses
  H-P-1-ASPI-AN-0202
- Cryostat Shielding Efficiency Assessment Consolidation
  H-P-2-ASPI-TN-0177

2.5.3 Instruments EMC Control Plans

- HIFI EMC Control Plan
  SRON-U/HIFI/PL/2000-002, Issue 2.0, 21/02/2002
- HIFI LO ESD/EMC Test Plan
  JPL/HIFI/PL/2001-001, Draft 2, 18/09/2001
- PACS EMC Control Plan & Frequency Plan
  PACS-ME-PL-015, Draft 0.2, 14/01/2002
- SPIRE EMC Control Plan
  SPIRE-RAL-PRJ-852, Draft 0.2, 03/02/2002
- Draft Planck HFI EMC Control Plan
  PL-PH251-200168-IAS, Issue 0, Rev 0, 19/04/2002
- PLANCK LFI – EMC Control Plan
  PL-LFI-PST-PL-006, Issue 1.0, 03/12/2001

2.5.4 EMC/Power Working Group minutes

[WG-11] EMC/Power WG meeting #11, H-P-ASPI-MN-306, 29/08/2001
[WG-H1] EMC WH Herschel/Cryostat, H-P-ASPI-MN-311, 30/08/2001
[WG-12] EMC/Power WG meeting #12, H-P-ASPI-MN-534, 06/11/2001
[WG-13] EMC/Power WG meeting #13, H-P-ASPI-MN-810, 16/01/2002
[WG-P1] Dedicated Planck EMC WG meeting, H-P-ASPI-MN-811, 17/01/2002
[WG-14] EMC/Power WG meeting #14, H-P-ASPI-MN-1360, 23/04/2002
[WG-HFI] HFI EMC meeting, H-P-ASPI-MN-1361, 24/04/2002

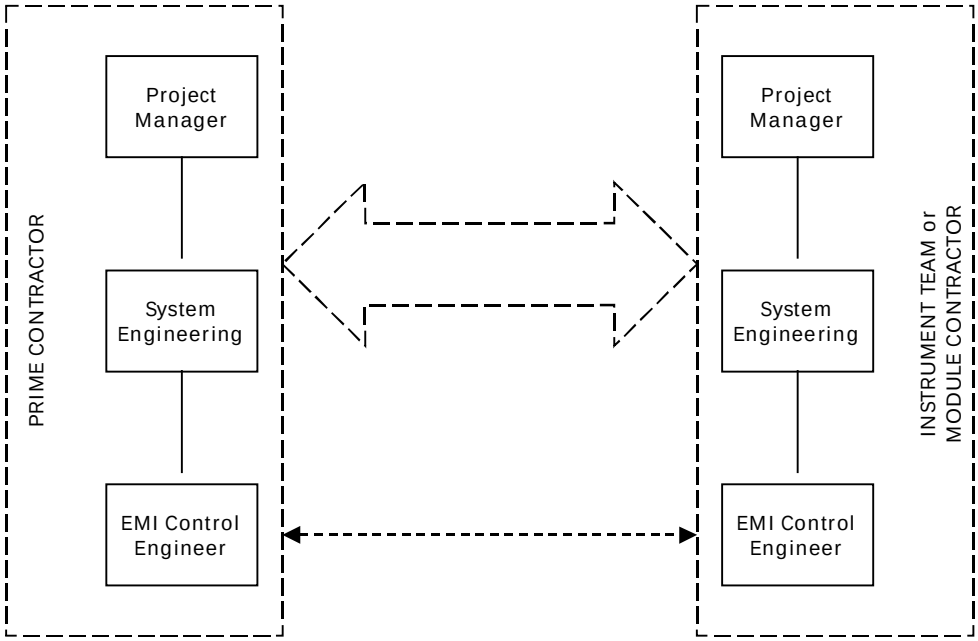
3. EMC CONTROL MANAGEMENT

3.1 Organisation description

The EMI control will be managed by the System EMC engineer who will :

- Provide technical support to the project team for all EMC related activities
- Provide technical support to the Instrument Teams
- Co-ordinate the EMI control activities of the 5 Instrument Teams, of the HPLM contractor, and of the SVM contractor

The proposed EM control organisation is shown here below :



3.2 Management of activities

Together with the electrical architect, the EMC engineer will be responsible for the management of all EMI control activities. This implies an active participation in the following areas :

- Participation, for EMI control related activities, to the main design reviews at unit/subsystem levels
- Control of suitable EMC requirements, defined at System level, in the related Instruments, HPLM contractor and SVM contractor documentation
- Permanent monitoring of coherence between EMI control and design activities
- Technical support for system/subsystem design, analysis and verification of EMC testing

3.3 Subcontractor management

The EMI control engineer will ensure that suitable EMI control requirements are injected in the related Subcontractor documentation. He will verify that an adequate EMI control organisation is implemented at Subcontractor level.

This management of Subcontractor activities and provision of EMC support / co-ordination to Instruments will apply particularly through planned regular meetings during design, development and test phases in order to :

- Identify and solve EMI problems which could appear during the program at subsystem or unit level
- Verify the correct implementation of the requirements as defined in the subsystem control plan

3.4 Subcontractor control plan

Each sub-contractor and Instrument responsible shall issue a control plan to define and describe in detail the planned EMI control activities and to show how compliance to the requirements given in IID-A, in the HERSCHEL/PLANCK EMC specification, in the GDIR and in the present document is achieved.

That document (subsystem control plan) will be written by the Subsystem / Instrument EMI control engineer.

This engineer will be directly involved for all related to :

- theoretical evaluation (EMC wise) of present signals
- EMC impacts of the chosen concept
- proper implementation of the EMC requirements into the subsystem
- release of EMC test procedures
- evaluation of EMC test results
- control of EMC activities at its Subcontractors
- processing of subsystem associated Non-Conformance (NC) and propose design/hardware modification if necessary.

Such proposed organisation should allow a good visibility and a correct transmission of essential information.

3.5 Main steps of control management

Figure 3.5-1 presents the different steps of the EMI control program which should result in a final product that will function with an adequate margin.

The final design of units, subsystem and system shall be achieved at the dedicated CDR.

The initial crucial step consists in the assessment of :

- the potential EMI sources,
- the potential coupling paths
- the Instruments sensitivity,
- their compatibility with the standard EMC rules and test levels.

An EMC working group has been established with the following objectives :

- to justify through analysis the adequacy of the requirements and test levels specified in IID-A and EMC Specification on the basis of the Instruments sensitivity
- to elaborate a coherent EMC test plan which allows to verify the Instruments/Spacecraft/environment compatibility.

Members of the working group have been nominated by :

- ESA
- Instruments suppliers
- HERSCHEL/PLANCK Prime Contractor
- HERSCHEL PLM architect

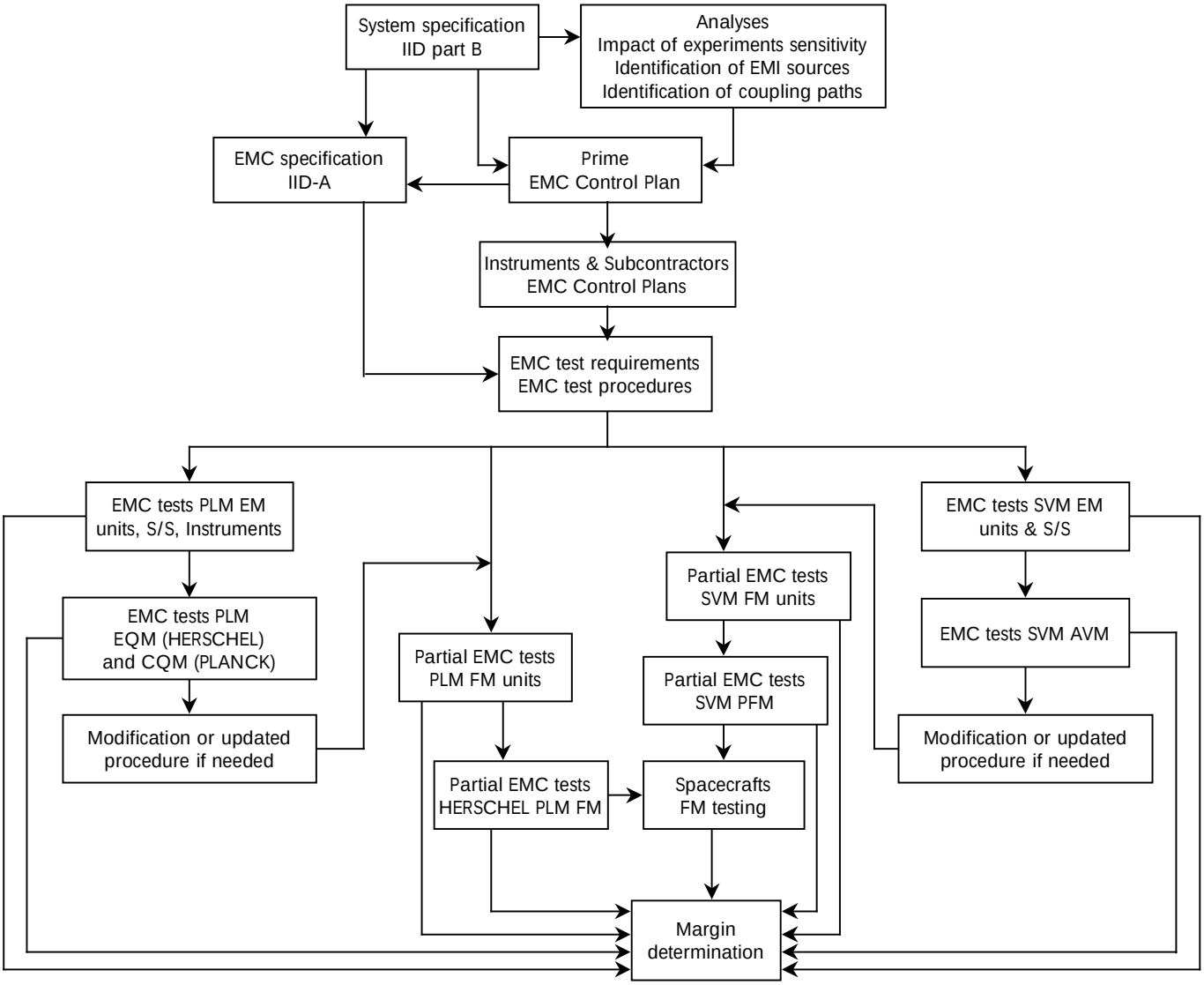


Figure 3.5 - 1

4. DESIGN REQUIREMENTS

To achieve a System which :

- is compatible with itself from an EMI point of view and with the environment it will encounter during the specified mission time extended to ground testing
- does not involve EMC/EMI related Instrument performance degradation
- shall operate and function with the required performances with an EMC safety margin of at least 6 dB between emission and susceptibility

A set of design and construction rules which aim to minimise EMI shall be implemented at unit, subsystem and system levels.

Those rules are defined in :

- GDIR (H-P-1-ASPI-SP-0027) : § 6 : Electrical Design and Interface Requirements
- and IID part A for Instruments :
  - § 5.10 : Connector, harness, grounding, bonding
  - § 5.14 : EMC

5. ANALYSES

5.1 EMC analyses

5.1.1 General

The test levels (emission limits and susceptibility thresholds) are defined in the EMC specification and in the IID-A § 5.14.

System level EMC analyses have been carried out (H-P-1-ASPI-AN-0202) in order to prove the consistency of the EMC requirements, i.e. to demonstrate that they imply sufficient positive system margins (> 6dB), taking into account, particularly, the grounding concepts and the critical coupling paths and modes (i.e. conducted, radiated, E field, H field, field to cable coupling, CM-induced DM, etc.).

This analysis shall be updated periodically throughout the program development whenever new inputs are available and shall take into account the EMC test results as soon as available.

A System frequency plan has been established (H-P-1-ASPI-PL-0201). It shall be maintained as part of the EMC programme.

The most critical EMC issues of the Instruments shall be identified, examined and solved by the "EMC Working Group", or in the frame of dedicated EMC meetings involving the Prime and one or several Instruments EMC engineers/teams.

The aim of this Chapter 5 is to propose a way by which the Prime can demonstrate that the specified emission and susceptibility levels :

- involve sufficient positive margins (i.e. covering uncertainties)
- are compatible with the Instruments design and susceptibility

The rationale for the planning of those activities can be outlined as follows :

Phase B1	Questionnaire to Instruments EMC specification Identification of Instruments EMC critical areas Preliminary System bonding/shielding concepts
Phase B2	Instruments detection chains / bias lines grounding diagrams First analyses at Instruments level First analyses at System level assessing EMC margins Final choice of System bonding/shielding concepts
Beginning Phase C/D	Updated analyses at Instrument level Assessment/processing of possible RFWs Updated analyses at System level demonstrating EMC margins

5.1.2 Instruments EMC models

EMC analyses will be conducted by each Instrument team, in contact with the Prime.
They will concentrate especially on the detection and bias lines susceptibility to common mode and to the so-called “ground loop coupling” (GLC), cf. H-P-1-ASPI-AN-0202.

The effects of E, H fields will be converted into CM voltages/current sources. These CM voltages/current sources will be applied to the model in order to assess the resulting noise at the Instrument receivers inputs, where the sensitivity will be defined, if relevant as a function of frequency.

The models used for the analyses will consist essentially of :

- Instruments return and grounding diagrams
- Instruments DM and CM impedances and gains
- models of the cryo-harness after properties characterisation
- differential links parasitic dissymetries

Simulation software (e.g. PSPICE, CNES-EMC) will be used allowing to compute currents and voltages in the different parts of an RLC network when either a lumped or distributed perturbation is applied.

5.1.3 RF compatibility

As far as PLANCK is concerned, the coupling between the X-band antenna and LFI horns has been assessed as soon as ASPI proposal and is recalled in the EMC analyses (H-P-1-ASPI-AN-0202).

The direct coupling between the TWTA RE and the BEU shall be confirmed on the basis of the following test results :

- Measurement of the X-band transponder EQM RE in Planck configuration up to 40 GHz
- Measurement of the TWTA EQM RE up to 40 GHz
- Measurement of the TWTA output spectral content in conducted mode on the SVM AVM (with X-band transponder EQM in Planck configuration) up to 40 GHz

As far as HERSCHEL is concerned, the compatibility of the Heterodyne Instrument with spurious emissions from the SVM in the Instrument Intermediate Frequency band shall be assessed early considering :

- HIFI units susceptibility
- HIFI units expected/measured shielding efficiency
- SVM units expected/measured RE (especially the X-band transponder)
- HIFI warm units expected/measured RE
- Coupling analyses

A preliminary assessment has been done by ASPI (cf. H-P-1-ASPI-AN-0202) taking into account HIFI preliminary RS tests on Mixer Units.

5.2 ESD analyses

A charging analysis will be carried out in the PDR timeframe in order to determinate the areas/materials susceptible to get charged during the transfer orbit. It will be used as input for the selection of the most suitable PPLM external paint.

In parallel, the Instruments will assess their survival to a typical ESD current propagating on the external cryo-harness (derived from System requirement SENV-155). These analyses will take H-P-1-ASPI-AN-0202 § 5.9 as reference.

In particular, a sufficient protection (filtering…) of the RF components bias interfaces (HIFI and LFI), shall be demonstrated by the Instruments.

6. EMC TEST PLAN

The aim of the test plan is to describe which EMC tests shall be performed in the frame of the HERSCHEL/PLANCK program to support the overall EMC demonstration.

Test levels and set-ups are defined in the HERSCHEL/PLANCK EMC Specification (H-P-1-ASPI-SP-0037) for the SVM and PLM units, for the whole modules, and for the whole spacecrafts. For the test plan, cf. § 6.1.

The test levels and set-ups applicable to the Instruments units/subsystems as well as to the integrated Instruments are defined in the IID-A. For the test plan, cf. § 6.2.

6.1 Tests at Unit/Subsystem level

Three cases are considered concerning the EMC qualification at unit/subsystem level :

- EMC representative EM model planned : full EMC qualification on EM
- Non EMC representative EM model planned : limited tests on EM (submitted to PRIME agreement) and full EMC qualification on PFM
- No EM (recurrent unit) : Delta EMC qualification on PFM

The following tests shall be performed :

Test type	Applicable document and relevant section	Applicable to
Bonding	GDIR GDEL-080	All units
Isolation	GDIR GDEL-660	All units (where applicable)
RE-E NB 14kHz - 1GHz (resp. 18 or 40 GHz)	EMC spec. §3.2.4.6.1.1	All units and S/S
RE-E 420MHz - 480MHz	EMC spec. §3.2.4.6.1.1	All units on at launch
RE-E TC Rx band	EMC spec. §3.2.4.6.1.1	All units and S/S
RE-H	EMC spec. §3.2.4.6.1.2	All units interfacing with 28 V bus and S/S
RS-E 14kHz - 18GHz	EMC spec. §3.2.4.6.2.1	All units and S/S
RS-E TM Tx band	EMC spec. §3.2.4.6.2.1	All units and S/S
RS-E launcher/launch site bands	EMC spec. §3.2.4.6.2.1	All units and S/S on at launch and RF receivers
RS-H	EMC spec. §3.2.4.6.2.2	All units and S/S
ESD	EMC spec. §3.2.4.7	All units and S/S
CE of 28V	EMC spec. §3.2.4.8.1	PCDU
CS of 28V	EMC spec. §3.2.4.8.3	PCDU
CE of users of power lines (including inrush current with relay & LCL)	EMC spec. §3.2.4.8.2	All units interfacing with 28 V bus and S/S
CS of users of power lines	EMC spec. §3.2.4.8.4	All units interfacing with 28 V bus and S/S
CE/CS on TM/TC and Data lines	EMC spec. §3.2.4.9	All units and S/S

CE and CS tests shall be repeated on FM units (as well as grounding/bonding and isolation tests, before and after environmental tests).
Radiated tests shall be reperformed on FM in case EM is non compliant or marginal or the design has been updated significantly between EM and FM.

Specific case :

The X-band transponder EQM shall be tested in RE in both Planck and Herschel configurations.

6.2 Specific case of Instruments

Concerning the Instruments, one must distinguish :

- The warm units (including preamplifier)
- The cold units

And various integration levels :

- Instrument unit (enclosure containing electronics connected with other units through cables and/or waveguides)
- Instrument subsystem
- Integrated Instrument

The applicability of the tests to a particular deliverable model (AVM, CQM, FM) shall be analysed considering the representativity of the model for each unit and the criticality of the performance versus the expected susceptibility.

For most Instruments, only testing an integrated detection chain can be relevant to assess the susceptibility. If so, such tests shall be performed before the PLM CQM program, either at ambient if dummy detectors allow to reproduce the correct impedance and/or noise level, or at cold, or both. Indeed the electrical behaviour of cryogenic detectors, the noise levels and sensitivity are fundamentally dependant on the temperature of operation.

Examples :

- Dummy detectors composed of 5 MΩ exist in SPIRE Bolometer Detector Assemblies that feed out through the warm electronics in the same way as the standard detectors
- 500 pF or 10 MΩ bolometer detector simulators (simulating bolometer at 100 mK) for HFI CQM testing at room temperature, as well as 500 Ω (bolometer + JFET) simulators (output impedance of the JFET box at 120 K)

For example, it can be envisaged to test at the same time the warm units and the preamplifier loaded by a “FPU simulator” including the dedicated cryo-harness (at least the most critical lines as defined by the Instruments and their loads).
Other EMC tests than only detection chain susceptibility tests can be performed at such stage if relevant for time saving and better EMC characterisation.

Such strategies if adopted shall be detailed in the Instrument EMC Control Plan.

One shall take advantage as far as possible of the functional and performance tests performed at Instrument level (before delivery) to perform EMC testing.

It is essential that each Instrument EMC programme allows, through the tests performed at the various levels, to get a sufficient knowledge of the Instrument Emission and Susceptibility characteristics, and a reasonable confidence in the compliance with the applicable requirements (especially as far as the detection chains susceptibility is concerned), so as not to :

- jeopardise the goals of the subsequent PLM CQM programs
- discover a major susceptibility problem at a late development stage

6.2.1 Warm units

For warm units, standard EMC testing as defined in the HERSCHEL/PLANCK EMC specification shall be carried out, namely :

- CE and CS on the power lines (including plug-in and inrush current)
- CE/CS on signal lines
- RE-E, RE-H, RS-E, RS-H

They are detailed in the following table.

Test type	Applicable document and relevant section	Applicable to
Bonding	IID-A §5.10.4.9/10 IID-A §5.14.2.11/12/15	All units
Isolation	IID-A §5.10.3.4/5/9 IID-A §5.14.1.2	All units (where applicable)
RE-E NB 14kHz - 18GHz	IID-A §5.14.3.9	All Instrument units/subsystems and Instruments
RE-E 420MHz - 480MHz	Ariane 5 User Manual	All Instrument units/subsystems on at launch
RE-E TC Rx band	IID-A §5.14.3.9	All Instrument units/subsystems and Instruments
RE-H	IID-A §5.14.3.11	All Instrument units/subsystems and Instruments
RS-E 14kHz - 18GHz	IID-A §5.14.3.10	All Instrument units/subsystems and Instruments
RS-E launcher/launch site bands	Ariane 5 User Manual	All Instrument units/subsystems on at launch and RF receivers
RS-H	IID-A §5.14.3.12	All Instrument units/subsystems and Instruments
ESD	IID-A §5.14.3.13	All Warm Units including preamplifiers Herschel Cold Units : N/A Planck Cold Units : TBD - no FM hardware to be tested -
CE of users of power lines	IID-A §5.14.3.1	All units/subsystems interfacing with 28 V bus
Plug-in and inrush current	IID-A §5.14.x	All units/subsystems interfacing with 28 V bus
CS of users of power lines	IID-A §5.14.3.3/4/8	All units/subsystems interfacing with 28 V bus
CE CM on signal bundles	IID-A §5.14.3.2	All Instrument units/subsystems and Instruments
CS CM on signal bundles	IID-A §5.14.3.5	All Instrument units/subsystems and Instruments
CS CM voltage on signal reference	IID-A §5.14.3.6/7	All Instrument units/subsystems and Instruments

Concerning the RE-E, the specific requirement in the range 420 – 480 MHz is not applicable to Instrument units off at launch.

6.2.1.1 AVM Warm Units

The built standard for the AVM units is detailed in IID-A § 9.2.2.1 and is recalled hereafter :

- electronics flight standard except for parts ; commercial parts have to be of same technology, same supplier as FM parts ;
- mechanisms flight representative for electrical actuators ;
- software flight standard ;
- form, fit and function of the flight model ;
- software of flight quality must be able to be run.

In order to save cost the AVM hardware contents may be reduced by reducing redundancy:

- cold redundant units or channels may be deleted if no automatic switch-over function is involved
- multiple redundancy of hot redundant units or modules may be reduced by electrical dummies (to e.g. dual redundancy) if compatible with the AVM test objectives
- simulators may be supplied of units not directly interfacing with spacecraft subsystems. The level of these simulators, to be agreed with ESA, will allow verification of the correct execution of the flight procedures.

For all AVM units complying with this built standard, for the minimum the inrush current shall be measured and the CE/CS tests on the power lines shall be performed.

Note : according to their EMC Control Plan, SPIRE have foreseen so-called “EQM” models for the DCU and FCU Warm Units that are EMC representative and meant to allow, among other things, for unit level CE/CS qualification)

6.2.1.2 CQM Warm Units

Most of the Instruments units/subsystems EMC qualification shall be performed at CQM unit/subsystem level according to table § 6.2.1.

6.2.1.3 FM Warm Units

At FM units level, partial EMC testing is to be carried out on all FM units (including internal redundancy), namely :

- Grounding/bonding and isolation tests
- Applicable CE and CS tests

Radiated tests shall be reperformed the FM unit each time the corresponding CQM (resp. AVM, “EQM”) unit is significantly non compliant or the design has been updated significantly between CQM (resp. AVM, “EQM”) and FM.

6.2.2 Cold units

Susceptibility cannot be tested in a standard way because units can only operate at cold temperature. For conducted susceptibility, two areas must be distinguished : detectors and mechanisms :

- For detectors the test philosophy is TBD with ESA and Instruments. At least a good characterisation should be acquired in the frame of elementary testing
- For most sensitive mechanisms, susceptibility tests will be performed at elementary level which will be compared to the emission measured on command lines during warm unit testing

6.2.3 Tests at Instrument level

Whenever compatible with the Instruments development program, the applicable conducted susceptibility tests shall be performed at full CQM Instrument level (using a test cryostat), with a test harness representative of the flight one.

Additionally, CS simulating RS on the cold harness on warm units side shall be performed (TBC) with a level to be defined by the Instruments based on the RS specification and on a worst case field to cable coupling analysis.

Alternatively, genuine RS testing can be performed. If such a option in chosen the test set-up limitations in terms of representativity shall be identified and assessed in the relevant documentation.

6.3 HERSCHEL PLM Testing

6.3.1 EQM testing in cold conditions

6.3.1.1 CE/CS on HPLM EQM in cold conditions

On the EQM (ISO upgraded cryostat integrating CQM Instruments and Warm Units on table) in cold condition, CE and CS tests shall be performed on the 28V power lines.
The CS tests on the 28V power lines will be the ones foreseen for subsystems and units in the EMC specification (§ 3.2.4.8.4) and in the corresponding chapters of the IID-A (5.14.3.3 & 5.14.3.4) (*).

Conducted susceptibility common mode current on signal bundles (IID-A § 5.14.3.5) shall be performed on detection and bias bundles on the warm units side (*).

CS simulating RS on the cryo-harness on the warm units side shall be performed (TBC) with a level to be defined between the Prime and the Instruments based on the RS specification and on a worst case field to cable coupling analysis (Cf. H-P-1-ASPI-AN-0202).

As far as possible the two previous tests shall be combined into one.

6.3.1.2 RS on HPLM EQM in cold conditions

As agreed in HPLM EQM meetings and in EMC Working Group meetings with the Instruments, RS shall be performed as well on the HPLM EQM in cold conditions with standard external antennas.

Up to 1 GHz, the RS antennas shall be pointed to the cryo-harness of the Instrument under test.

Above 1 GHz, the RS antenna shall be pointed to the feed-through connectors of the Instrument under test, and to the LO windows (*).

(*) Tests to be performed will be defined precisely as soon as HEPLM EQM configuration will be known and instruments EMC tests results will be available.

6.3.2 FM testing at ambient

On the FM, a CE test on the 28V power bus shall be performed in both differential and common modes (Narrow Band frequency domain current and time domain voltage) in order to verify that no significant unexpected difference exists with respect to the EQM.

6.4 PLANCK PLM Testing

6.4.1 CQM testing at ambient

On PLANCK CQM, CE and CS tests shall be performed on the 28V power lines.
The CS tests on the 28V power lines shall be the ones foreseen for subsystems and units in the EMC specification (§ 3.2.4.8.4) and in the corresponding chapters of the IID-A (5.14.3.3 & 5.14.3.4).

If success criteria can be defined for the detection chains in such conditions, CS simulating RS on the cold harness on warm units side shall be performed (TBC) with a level to be defined between the Prime and the Instruments based on the RS specification and on a worst case field to cable coupling analysis (Cf. H-P-1-ASPI-AN-0202).

6.4.2 CQM testing in cold conditions

Only conducted testing can be envisaged in cold conditions, because of the vacuum chamber.

Given the complexity and criticality of the CQM test campaign at CSL, one shall concentrate on CS tests, meaning that the applicable CE tests on the Instruments Warm Units need to have been performed in advance, e.g. at AVM level if representative units are available, in order not to jeopardise the CQM test objectives.

CS tests on the 28V power lines shall be performed (the ones foreseen for subsystems and units in the EMC specification, § 3.2.4.8.4) and in the corresponding chapters of the IID-A (5.14.3.3 & 5.14.3.4). They will be limited to the frequency where the injected level shall become tricky to control due to test harness resonance (10 MHz TBC).

Conducted susceptibility common mode current on signal bundles (IID-A § 5.14.3.5) shall be performed on detection and bias bundles (TBC) with injection probes of location TBD.

CS simulating RS on the cryo-harness shall be performed (TBC) with a level to be defined between the Prime and the Instruments based on the RS specification and on a worst case field to cable coupling analysis (Cf. H-P-1-ASPI-AN-0202).

As far as possible the two previous tests shall be combined into one.

6.4.3 FM testing at ambient

Three types of tests can be considered on the FM :

- « acceptance » type test which demonstrate that the FM has similar characteristics than the QM.
- A sub set of the conducted test (CE & CS) foreseen on the QM are then sufficient.
- delta qualification tests which would be necessary either resulting from a criticality highlighted by the QM tests or because of identified differences between the QM and the FM configurations.

6.4.4 FM testing in cold conditions

Except if required by a MRB decision of the QM or by a significant configuration change between the QM and the FM, no EMC in cold condition is foreseen on the FM.

6.5 SVM Testing

6.5.1 AVM testing

The SVM AVM shall be tested in EMC as required in the EMC Specification § 3.2.3.1.

On the AVM including the Instruments Warm Units, CE tests shall be performed on the power lines at PCDU output in both differential and common modes (NB frequency domain current and time domain voltage).

CE + (> 6 dB) shall then be injected (CS) in order to demonstrate the system margin.

The CE on the most noisy signal bundles (TBD) shall also be measured.

These tests shall be performed with the AVM in HERSCHEL configuration and with the AVM in PLANCK configuration.

The spectrum at the TWTA output shall be measured up to 40 GHz in “conducted” (guided) mode with the X-band transponder in Planck configuration.

6.5.2 PFM testing

On the PFM including the Instruments Warm Units, CE tests shall be performed on the power lines at PCDU output in both differential and common modes (NB frequency domain current and time domain voltage).

6.6 Satellite FM Testing

RE and RS tests shall be performed on the each FM satellite to cover the launcher interface EMC requirements and to confirm the system margin between RE and RS.

The EMC tests shall be performed as required in the EMC Specification § 3.2.2.

Conducted interference levels on interfaces between Service and Payload modules will be observed during satellite electrical integration.

7. HANDLING OF NON-CONFORMANCES / MARGIN DETERMINATION

7.1 Handling of non-conformances

The non-conformances raised at unit or subsystem level will be analysed by the PRIME, in accordance with standard PA routines.

The PRIME will assess the consequences, referring to the EMC specification and comparing :

- the measured emission exceeding to the specified (or better measured) susceptibility of the potential receptors
- the measured susceptibility to the specified or measured emission of the potential emitters

Of course, assessment of consequences and subsequent handling is depending on the program phases.

In the early phases of the program (non-conformance during EM unit EMC testing), reference will be made to specified levels, while non-conformance occurred during flight unit testing will be handled referring to measured levels.

7.2 Margin determination

The aim of the EMC control is to achieve a system which is compatible with itself and with the environment and which presents a minimum of 6 dB margin between emission and susceptibility in all EMC areas.

The main supports to achieve such a system and to demonstrate those margins are :

- an EMC specification which levels are adequately chosen and justified
- a test philosophy which shall allow to demonstrate the margin on all lines, in all EMC areas
- EMC analyses performed at System, Module and Instruments levels

Generally speaking, the margin will be determined by comparing :

- the susceptibility measured at unit or subsystem level
- the emissions measured at subsystem module or system level.

The margins will be assessed at intermediate steps of the projects and the potential critical areas will be identified.

In conjunction with the proposed test plan, the general philosophy of margin determination is depicted here below :

EMC AREA	SUSCEPTIBILITY	EMISSION
28V power lines	– Measured at Instrument CQM level and PLM CQM level for Instruments – Measured at Instrument unit/subsystem CQM (or EQM) level and FM – Measured at SVM unit E(Q)M level, and FM	– Measured at Instrument unit/subsystem AVM or CQM level, and FM – Measured at SVM AVM level for SVM units and PLM warm units – Measured at SVM unit E(Q)M level and FM
TM/TC and Data lines	– Measured at SVM unit E(Q)M level, and FM – Measured at Instrument unit/subsystem CQM (or EQM, or AVM) level and FM – Measured at Instrument CQM (or EQM or AVM) level	– Measured at Instrument CQM (or AVM) level – Measured at SVM unit level EM, FM Measured at SVM AVM level TBC
Inter S/S links (TBC)	– Measured at unit or subsystem level (EM and FM)	– Measured at module level (SVM AVM, PLM QM)
Intra S/S links (TBC)	– Measured at unit level EM, FM	– Measured at module level (SVM AVM, PLM QM)
Cryo-harness	– Common mode rejection measured at Instrument or Instrument S/S level , and PLM CQM level	– Common mode measured at PLM or System level
Field environment	– RS measured at Instrument CQM and PLM CQM levels (or/and CS simulating RS TBC at Instrument and PLM CQM levels) – RS measured at SVM unit E(Q)M level	– RE measured at satellite FM level – RE measured at Instrument unit/subsystem CQM level – RE measured at SVM unit E(Q)M level – Analysis (TBC) for B field emission from Herschel Solar Array
Compatibility with Launcher	– RS measured at units-on-at-launch level – RS performed at satellite FM level	– RE measured at units-on-at-launch level – RE in launcher critical bands measured at satellite FM level
Compatibility with environment	– ESD testing on SVM E(Q)M units – ESD testing on Instruments CQM units (or AVM or EQM, if representative)	– Charging analysis / Design requirements – Discharge analyses

END OF DOCUMENT