HERSCHEL / PLANCK

AVM Requirements and Design
H-P-1-ASPI-TN-0164

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02.02	08/12/2003	Update of AVM testing - Sharing of reponsibilities Addition of FOG as a Planck CFE Update of AVM WU HW matrices Addition of I&T definition in §6.1.3 Update of the S/C modes tables §6.1.3	C.MONTFORT

TABLE OF CONTENTS

1. SCOPE

This document describes the overall approach of the AVionics Model (AVM).

The contents of the AVM note has been established to provide clear view of the selected approach:
§ 2 lists the applicable & reference documents
§ 3 sums up the Herschel & Planck flight avionics definition;
§ 4 reminds the reader of the AVM requirements as specified by ESA;
§ 5 defines the expected objectives of the AVM as the ESA requirements have been understood;
in order to meet the AVM objectives, § 6 presents the ensuing tests plan;
§ 7 describes the AVM design which enable to perform the AVM tests plan;
§ 8 deals with the responsibility aspect;
§ 9 presents the AVM activities during the FM integration;
§ 10 describes the relations between AVM activities and ISV activities;
§ 11 presents the risks analysis

2. DOCUMENTS, DEFINITIONS & ACRONYMS

2.1 Applicable Documents

AD1 System AIV Requirements [reference SCI-PT-RS-07430]
AD2 SVM AIV Requirements Specification [reference H-P-1-ASPI-SP-0007]

2.2 Reference Documents

RD1 Design & development Plan (DDP) [reference H-P-1-ASPI-PL-0009]
RD2 Verification Control Plan [reference H-P-PL-AI-0003]
RD3 Hardware Matrix [reference H-P-1-ASPI-LI-0058]

2.3 Definitions from applicable & reference documents

CCS: Central Checkout System is the core of the system EGSE, from which all testing is prepared, controlled and results archived.

EM: the Engineering Model is fully equivalent in form, fit and functions to the Flight Model unit, including mechanical and thermal aspects. EM can be used as integration spare for functional test but not as flight spare. The EM EEE parts are not Hi-Rel, but from the same type and from the same manufacturer as the FM unit.

EQM: The Engineering Qualification Model is an EM that is also devoted to partial qualification testing at equipment and subsystem level. EQM can be used as integration spare but not as flight spare.

FUMO : Functional Unit or part of Unit which uses generic items and commercial components to investigate performances or interface characteristics. This unit shall be identical to an EM from the performances required in the unit/subsystem specification and interfaces control documentation point of view, but it is not mechanically, EMC or thermally representative.
FUMO_1 = unit without internal redundancy
FUMO_2 = unit with internal redundancy
This definition from RFQ of SAAB is limited to ACC & CDMU.

The Unit Simulation Modules (intended when necessary for ACMS units) shall consist of a software functional model and a hardware simulator of the electrical data exchange interfaces

2.4 Acronyms

ACC	Attitude Control Computer
ACMS	Attitude Control and Measurement Subsystem
AVM	AVionics Model
CCS	Control Check-out System
CDMS	Command and Data Management Subsystem
CDMU	Central Data Management Unit
CQM	Cryogenic Qualification Model
DM	Dynamic Model
EGSE	Electrical Ground Support Equipment
EM	Engineering Model
EMC	Electromagnetic Compatibility
EPLM	Electrical Payload Module
EQM	Engineering Qualification Model (of spacecraft)
ESA	European Space Agency
FDIR	Failure Detection Isolation and Recovery
FM	Flight Model
FOG	Fiber Optic Gyroscope
FUMO	FUnctional MOdel
H/W	Hardware
HFI	High Frequency Instrument (Planck)
HIFI	Heterodyne Instrument (Herschel)
HRNS	Harness
I/F	Interface
I/O	Input/Output
I&T	Integration and Test
IST	Integrated Satellite Test
ISV	Independent Software Validation
LFI	Low Frequency Instrument (Planck)
MTL	Mission TimeLine
N/A	Not Applicable
OBCP	On-Board Control Procedure
OBDH	On Board Data Handling
OBSW	On-Board SoftWare
P/L	Payload
PACS	Photo-conductor Array Camera Spectrometer (Herschel)
PCDU	Power Conditioning and Distribution Unit
PCS	Power Control Subsystem
RCS	Reaction Control Subsystem
RF	Radio Frequency
S/C	Spacecraft
S/S	Subsystem
S/W	Software
SCOE	Specific Ckeckout Equipment
SIT	System Integration Test
SPIRE	Spectral Photometer Imaging Receiver (Herschel)
SVF	Software Validation Facility
SVM	Service Module
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
TC	Telecommand
TCS	Thermal Control Subsystem
THR	Thruster
TM	Telemetry
UFT	Unit Function Test
WU	Warm Unit

3. HERSCHEL / PLANCK FLIGHT AVIONICS DEFINITION

The flight Avionics is made up with:

- Command & Data Management Subsystem
- Attitude & Control Measurement Subsystem
- Power Control Subsystem
- Telemetry / Telecommand Subsystem

The flight Avionics architecture is similar between Herschel and Planck.

The flight Avionics architecture is characterised by a decentralised architecture, that means ACMS (Attitude Control & Monitoring Subsystem) and CDMS (Command & Data Management Subsystem) have their own computer.

- CDMS is composed of its computer unit (CDMU) and performs :
  - TM/TC management;
  - FDIR management;
  - Thermal control;
  - Battery management;
  - Other subsystems I/F management :
    - ACMS I/F management;
    - PCS I/F management;
    - TTC-RF I/F management;
    - P/L I/F management.

- ACMS is composed of its computer unit (ACC) and its equipment units. The ACC interfaces with the sensors and actuators, and with the RCS.

The maximum level of commonality has been taken as a driver:

- between Herschel and Planck ACC : Herschel and Planck ACCs are identical;
- between Herschel and Planck CDMU : Herschel and Planck CDMUs are identical;
- between ACC and CDMU : some modules (Processor Module, Reconfiguration Module, Data Bus) are identical;
- between Herschel and Planck RF subsystem: Herschel and Planck RF subsystem are very similar
- between Herschel and Planck Power subsystem: Herschel and Planck Power subsystem are identical.
- Between Herschel and Planck ACMS subsystem: common ACMS units are STR, SAS, AAD, CRS

ACMS equipment units and P/L instruments differentiate Herschel and Planck missions as follows:

- For Herschel :
  - ACMS units : 2 Coarse Rate Sensor, 1 Gyroscope, 4 Reaction Wheel System
  - Herschel ACMS software
  - Interface with 12 x 10N Thrusters.
  - Payload Module units: HIFI, PACS, SPIRE, Cryostat Control Electronics (connected via 1553 bus).

– For Planck Avionics :
  - ACMS units : 3 Coarse Rate Sensor
  - Planck ACMS software
  - Interface with 12 x 10 N Thr + 4 x 1 N Thr
  - Payload Module units: LFI, HFI (connected via 1553 bus)
  - FOG connected to the ACMS 1553 bus (CFE)

The Herschel and Planck avionics hardware matrixes are:

	Herschel	Planck
CDMS	CDMU	
PCS	PCDU	
	Battery	
	Solar Array	Solar Array
RF	TRSP1	
	TRSP2	
	TWTA	
	RFDN	
ACMS	ACC	
	Attitude Anomaly Detector (AAD)	
	Coarse Rate Sensor (CRS)	
	Sun Acquisition Sensor (SAS)	
	Star Tracker (STR)	
	Gyroscope (GYR)	Fiber Optic Gyroscope (FOG)
	Reaction Wheel System (RWS)	
RCS	Interface with 12 x 10N Thr	Interface with 12 x 10 N Thr + 4 x 1 N Thr
Payload	HIFI	LFI
	PACS	HFI
	SPIRE	
	Cryostat Control Electronics	

4. AIV REQUIREMENTS

4.1 AIV Requirements Specification

As required in the "System AIV Requirements" document [reference SCI-PT-RS-07430; Issue 1.0], the AVM Requirements specification is worded as follows:

> The AVM should be used to verify the electrical and functional interfaces of the satellite. This model should also provide a test bed for on-board software testing as well as for testing the Electrical Ground Support Equipment including its software. The AVM should be also used for operation procedures development and testing.

In the IIDA 2.1 documentation, the AVionic Model is specified as follow:

The AVM system test objectives are:

- verification of all electrical and software interfaces,
- verification of subsystem and instrument functional performance within system environment,
- full validation of on-board software,
- verification of system performance,
- verification of operational procedures.

The instrument AVM units therefore have to have the following built standard:

- electronics flight standard except for parts. The build standard of AVM units EEE parts that will be used in the qualification program, have to be identical in form, fit and function to the flight 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.

5. AVM OBJECTIVES

With regard to the proposed model philosophy, AVM consists of **a SVM (Avionics and payload warm units) EM test bench** which allows to reach the following objectives:

- to verify electrical and functional interfaces and compatibility (electrical I/F between avionics units, compatibility between avionics and payload warm units);
- to validate Avionics OBSW in system environment (payload warm units software excluded);
- to validate EGSE and CCS;
- to perform EMC pre-qualification (conducted tests only);
- to validate tests procedure for AIT.

These tests will be conducted for the two configurations of the AVM: Herschel and Planck.

The main avionics validation activity consists in performing over the different stages of the spacecraft development at units, S/S and SVM levels, the necessary set of tests to demonstrate the compliance of the avionics with all the Herschel and Planck functional and operational requirements.
In addition, as part of the AVM testing, the instruments Warm Units are integrated. Tests are limited to the demonstration of the compliance of the SVM interfaces, both electrical and functional (protocol), with the warm units.

6. AVM TESTS PLAN

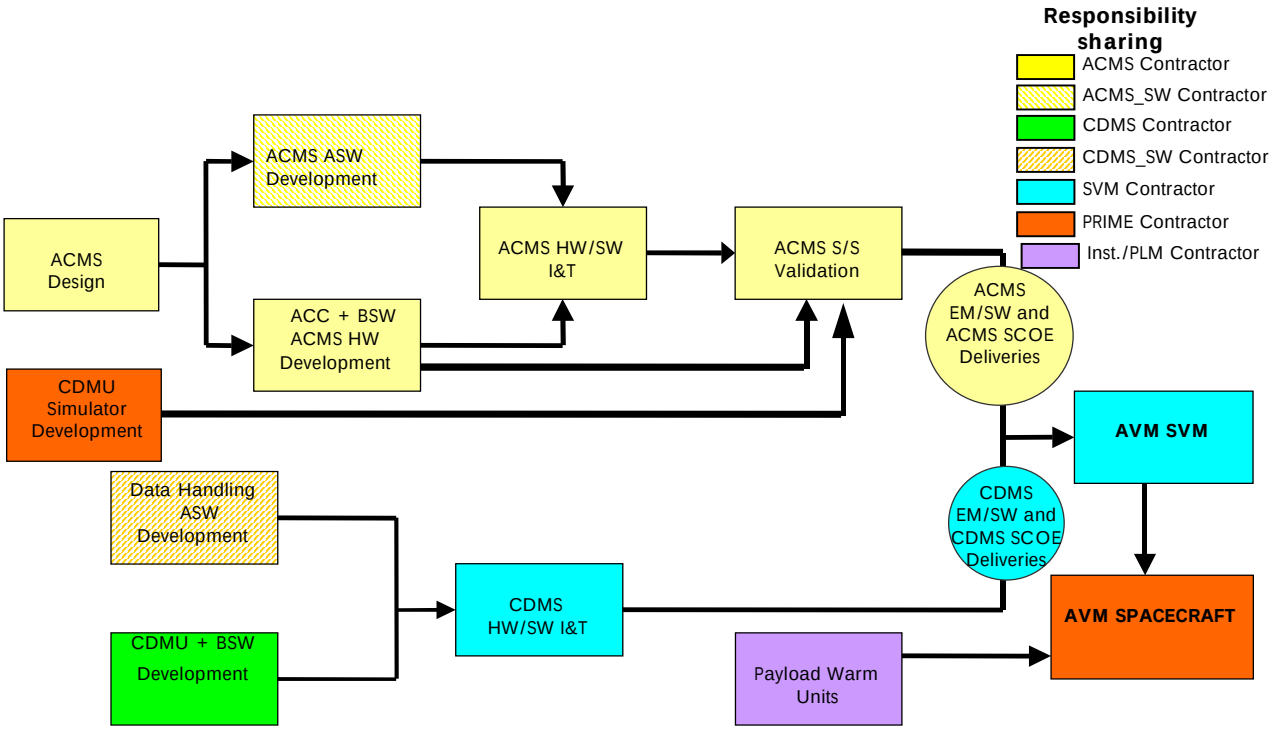
6.1 AVM Tests Sequence

6.1.1 General logic

ACMS and CDMS are developed and validated under different responsibilities, the Avionics validation approach is incremental in order to adapt to the successive deliveries of the basic elements.

The different steps of the Herschel and Planck Avionics validation process are:

- Herschel & Planck ACMS development and validation;
- delivery of the ACMS EM units to the SVM responsible;
- delivery of ACMS SCOE;
- CDMS development and validation;
- delivery of the CDMS EM units;
- delivery of CDMS SCOE;
- integration and functional validation of AVM SVM in Herschel and Planck configurations;
- integration of instruments warm units and functional validation of AVM spacecraft in Herschel and Planck configurations.



6.1.2 AVM logic

The AVM tests sequence consists of the main following stages:

- Common part Herschel/Planck configuration :
  When test bench & EGSE & CDMS available, I & T and tests sequence of common part of Herschel/Planck flight avionics;

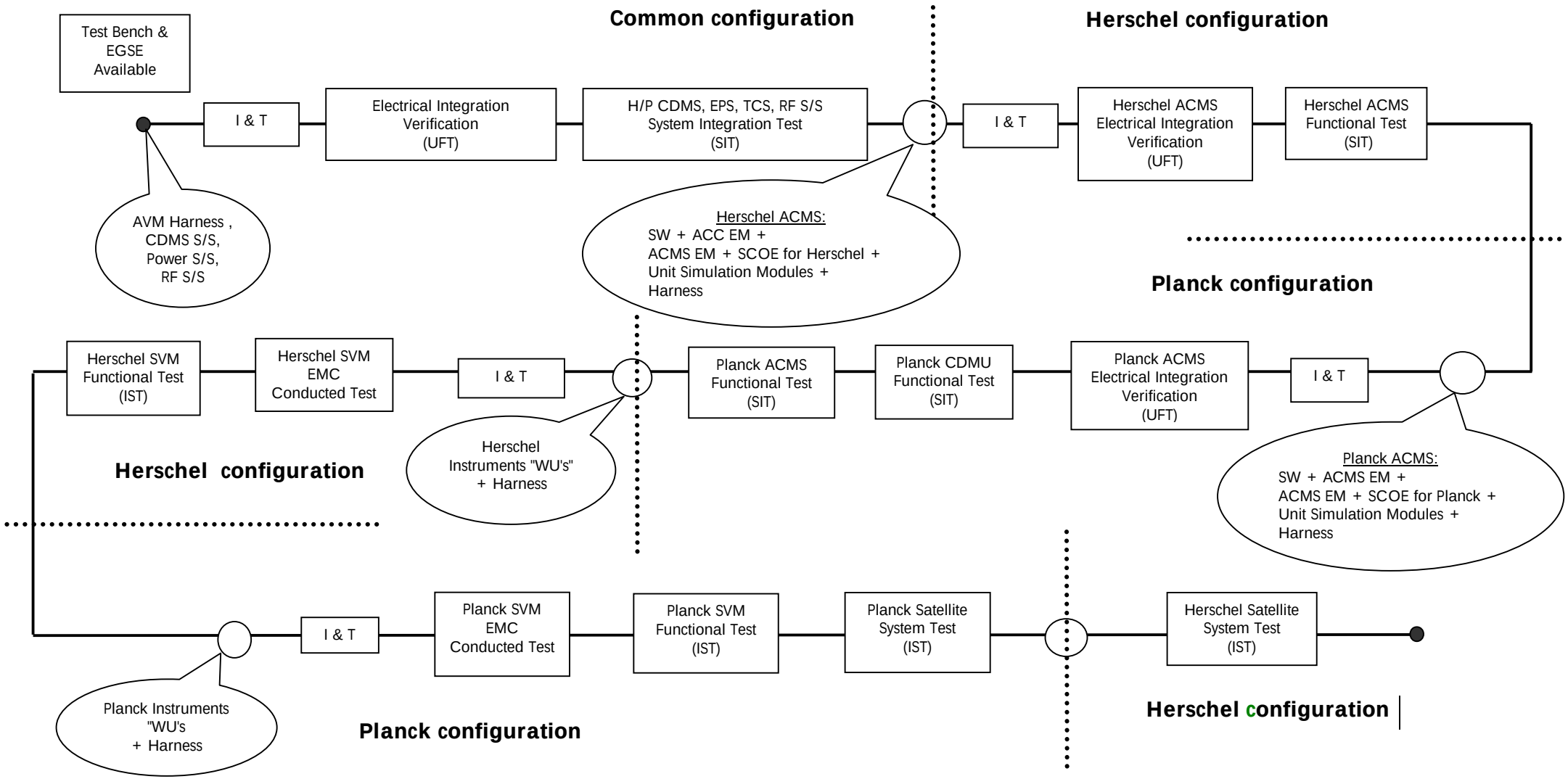
- Herschel configuration :
  - when ACC and expected ACMS EM units available, I & T and ACMS tests sequence for Herschel;

- Planck configuration:
  - when ACC and expected ACMS EM units available, I & T and ACMS & CDMU tests sequence for Planck;

- Herschel configuration :
  - when P/L warm units available, I & T and Herschel SVM tests sequence (including EMC and IST).

- Planck configuration :
  - when P/L warm units available, I & T and Planck SVM tests sequence (including EMC and IST);

The detailed sequence is shown on the diagram hereafter:



6.1.3 AVM Types of tests

The AVM tests sequence will carry out tests as defined in the "System AIV Requirements" document [reference SCI-PT-RS-07430] :

- The Integration and Tests (I&T): these tests are including the mechanical mounting of a unit on the test bench, the electrical interface check before the connection, and the connection itself of a unit or subsystem;

- the Unit Function Tests (UFT): this is a short low level electrical and functional test to verify the interfaces with the S/C and to ensure the successful integration of the unit on the S/C. These tests are a subset of the IST;

- the System Integration Tests (SIT) : to verify the interaction of equipment and subsystems between themselves. The baseline adopted for the programme is however to minimise the number and complexity of SITs*;*

- the Integrated Satellite Tests (IST): to verify correct operation of the fully integrated module or satellite in a series of representative mission modes including autonomous (Mission Timeline (MTL) and On-Board Control Procedures (OBCPs)) and backup modes. This test is an automated test using combination of test procedures developed from units or subsystem level electrical test sequences;

- the Short Functional Test (SFT): to verify system electrical integrity following local movement of the spacecraft. It's a subset of the IST sequences;

- the EMC conducted Test: to preliminary check the conducted electromagnetic compatibility of the satellite AVM units. The conducted emission tests will demonstrate that levels measured in the most emissive modes do not exceed the specified limits. The conducted susceptibility tests will demonstrate that the AVM will perform within its specifications. During these tests the AVM will not exhibit spurious or inadvertent response to any combination of operational modes and conditions that are tested;

Concerning the instruments warm units tests, the project definition is limited as follows:
- the instruments warm units tests: to verify the communication and functional compatibility within the avionics units limited to checking the 1553B bus and I/O communication with the CDMS and the power compatibility with the PCDU.

Concerning the IST at Satellite level, the definition is as follow:
- The main objective of the IST is to verify the correct operation of the satellite in a fully integrated environment and with mission representative test sequences.

  It therefore assumes that all unit and subsystem level tests have been successfully carried out. Functionally, the IST will be organized in a number of sequences, each of them aiming to represent a phase of the mission, including the transition. It is proposed, for the definition of the sequences, to refer to the different satellite modes stated in the document "System Operation and FDIR requirements" H-P-1-ASPI-SP-0209:

  * Launch Mode,

  * HK1,

* HK2,
* Science Mode,
* Survival Mode.

Each of these satellites modes is defined as a set of subsystem, unit and instruments elementary modes (see Fig 6.1.3-1, 6.1.3-2 and 6.1.3-3), which, at the stage of the IST, will have been already verified, one by one, at the level of UFT / SIT tests.

To this respect, the IST sequences will be essentially composed of a set of validated individual sequence.

In a preliminarily way, the IST will then comprise:

* IST_Test Seq'1: launch mode simulation + transition to HK1 + HK1
* IST_Test Seq'2: HK1 + transition to HK2 + HK2
* IST_Test Seq'3: HK2 + transition to Science Mode + Science Mode
* IST_Test Seq 4: HK1 + transition to Survival Mode + Survival Mode
* IST_Test Seq 5: HK2 + transition to Survival Mode + Survival Mode
* IST_Test Seq 6: Science Mode + transition to Survival Mode + Survival Mode
* IST_Test Seq 7: Spacecraft Maintenance

The sequences 2, 3, 5, 6 are anticipated to be somehow complex sequences considering the number of subsystem configurations involved. They will be further broken down into subsequences. It may be desirable, however, to reduce the total number of configuration for each sequence; this will be achieved by restricting them to the sizing cases in terms of performance and stress to the design.

It shall be printed out that the vast majority of the above tests will be run as part of the "SVM IST" since basically involving only SVM functions.

Spacecraft Mode	TTC mode		MTL Mode	ACMS Mode	EPS Mode	Instruments Mode
	Antennae conf : Nominal branch (*backup branch*)	TM/TC Configuration				
Launch Mode	Rx : LGA +Z (*MGA*)	Low rate	Disabled	SBM	Battery Discharge	OFF
	Tx : LGA +Z	OFF				
Sun Acquisition Mode	Rx : LGA +Z (*LGA –Z* when initiated by separation) (*MGA* otherwise)	Low rate (Nominal rate after separation)	Disabled	SAM or SM	Battery Charge or SA	OFF or Standby
	Tx : LGA +Z	Low2 Rate (5kbps) when initiated by separation Low1 Rate (500bps) otherwise				
Nominal Mode	Rx : MGA (*LGA+Z*)	Nominal rate	Enabled	NOM,OCM	BatteryCharge /discharge or SA	OFF, standby or Science
	Tx : MGA	Medium Bit Rate (transition to High Bit Rate by TC)				
Earth Acquisition Mode	- Rx MGA (*LGA+Z*)	Nominal rate	Disabled	NOM	Battery Charge/discharge or SA	OFF or Standby
	- Tx MGA	Medium Bit Rate				
Survival Mode	- Rx : LGA+Z (*LGA-Z*)	Low rate	Disabled	SAM, SM	Battery Charge/discharge or SA	OFF
	- Tx : LGA+Z	Low1 rate (500bps)				

TABLE 6.1.3-1 HERSCHEL OPERATION MODES

NOM : Normal Mode – SAM : Sun Acquisition Mode – SM : Survival Mode – SBM : Stand By Mode – OCM : Orbit Correction Mode

Spacecraft Mode	TTC mode		MTL Mode	ACMS Mode	EPS Mode	Instruments Mode
	Antennae conf : Nom (*backup*)	TM/TC Configuration				
Launch Mode	Rx : LGA -X (*MGA*)	Low rate	Disabled	SBM	Battery Discharge	OFF except 4K cooler in Launch Lock
	Tx : LGA -X	OFF				
Sun Acquisition Mode	Rx : LGA -X (*LGA –Z/+Z* when initiated by separation) (*MGA* otherwise)	Low rate (Nominal rate after separation)	Disabled	SAM or SM	Battery Charge or SA	OFF or Standby
	Tx : LGA -X	Low2 Rate (5kbps) when initiated by separation Low1 Rate (500bps) otherwise				
Nominal Mode	Rx : MGA (*LGA -X*)	Nominal rate	Enabled	SCM, HCM, OCM	BatteryCharge/ discharge or SA	OFF, standby or Science
	Tx : MGA	Medium Bit rate (transition to High Bit Rate by TC)				
Earth Acquisition Mode	- Rx: MGA (*LGA -X*)	Nominal rate	Disabled	OCM, HCM, SAM	Battery Charge/ discharge or SA	OFF or Standby
	- Tx: MGA	Medium rate				
Survival Mode	- Rx : LGA -X (*LGA +Z/-Z*)	Low rate	Disabled	SAM, SM, OCM, HCM	Battery charge/ discharge or SA	OFF
	- Tx : LGA -X	Low rate (500bps)				

TABLE 6.1.3-2 PLANCK OPERATION MODES

SCM : Science Mode – SAM : Sun Acquisition Mode – SM : Survival Mode – SBM : Stand By Mode – OCM : Orbit Correction Mode – HCM : Angular Momentum Correction Mode

Satellite Modes	AFS	AFO	N/A
Launch Mode	(*)		
Sun Acq Mode	❐ X	X	
Survival Mode	(*)		
Nominal Mode	X	❐ X	
Earth Acq Mode	❐ X	X	

TABLE 6.1.3-3 RELATION BETWEEN SATELLITE AND FDIR MODES

For each satellite mode, the authorised FDIR Modes are marked by a **X**. The FDIR mode at entry into the satellite mode is marked ❐.
(*) Launch Mode and Survival Mode are specific cases; the reconfiguration strategy associated to these Modes is strongly linked to the satellites configuration.

6.2 Integration &Validation phases

The process is composed of 6 steps:

– The first step consists of the integration and the validation of the CDMS & PCS

– The second step consists of the integration and the validation of the CDMS & PCS & TTC RF.

– The third step consists of the integration and the validation of second step + Planck ACMS after Planck AVM configuration set up

– The fourth step consists of the integration and the validation of third step + Planck P/L Warm units after Planck AVM configuration set up.

– The fifth step consists of the integration and the validation of second step + Herschel ACMS after Herschel AVM configuration set up

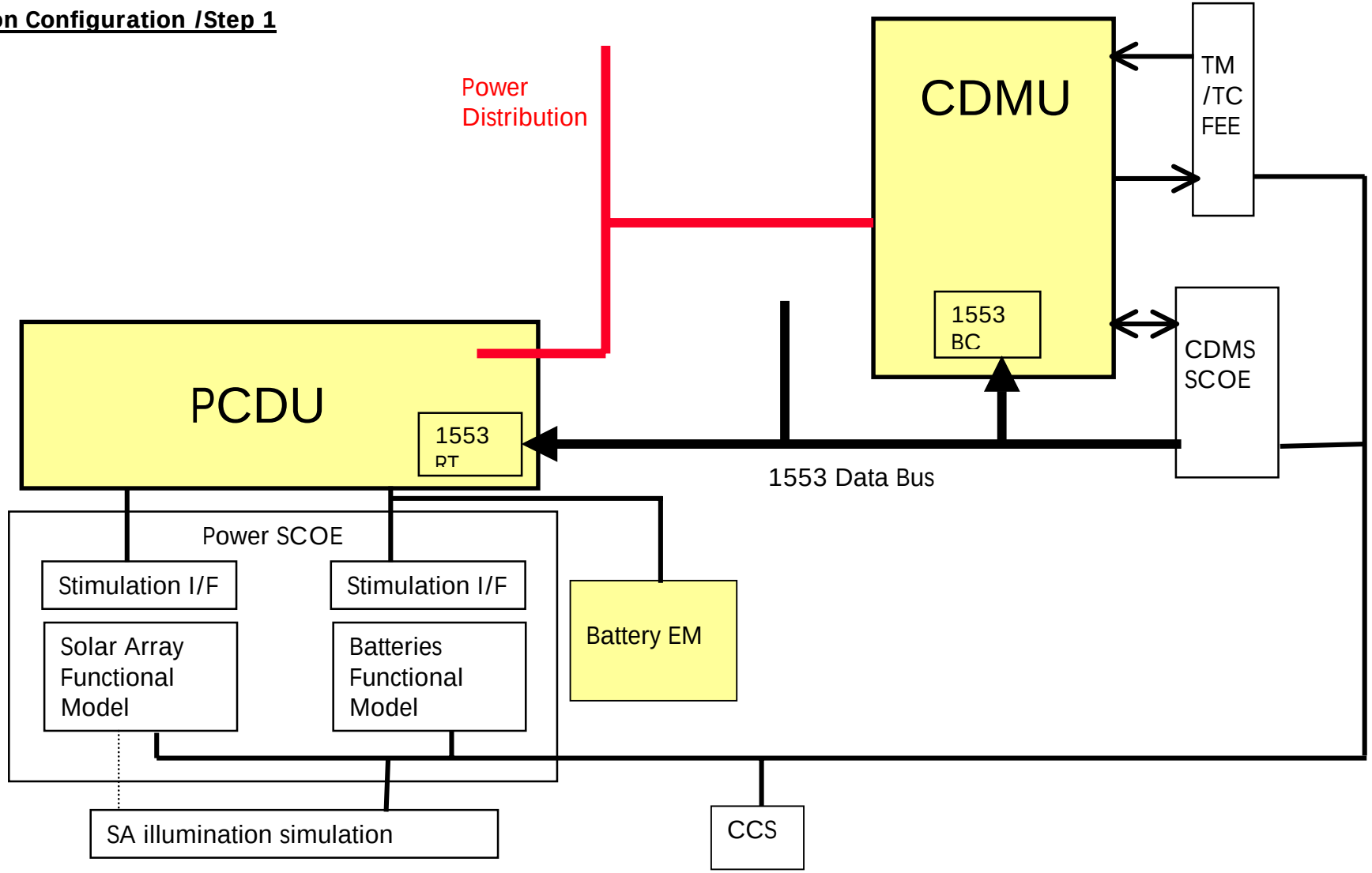
– The sixth step consists of the integration and the validation of fifth step + Herschel P/L Warm units in Herschel AVM configuration

Four reconfigurations of the AVM are foreseen, and consist in:
- connecting to CDMU and PCDU the Herschel / Planck payload equipment,
- connecting to ACC and PCDU the Herschel / Planck ACMS equipment,
- using the dedicated TTC harness if it is different between Herschel and Planck configuration,
- changing the CCS configuration,
- changing the ASW code on ACC , CDMU and STR.

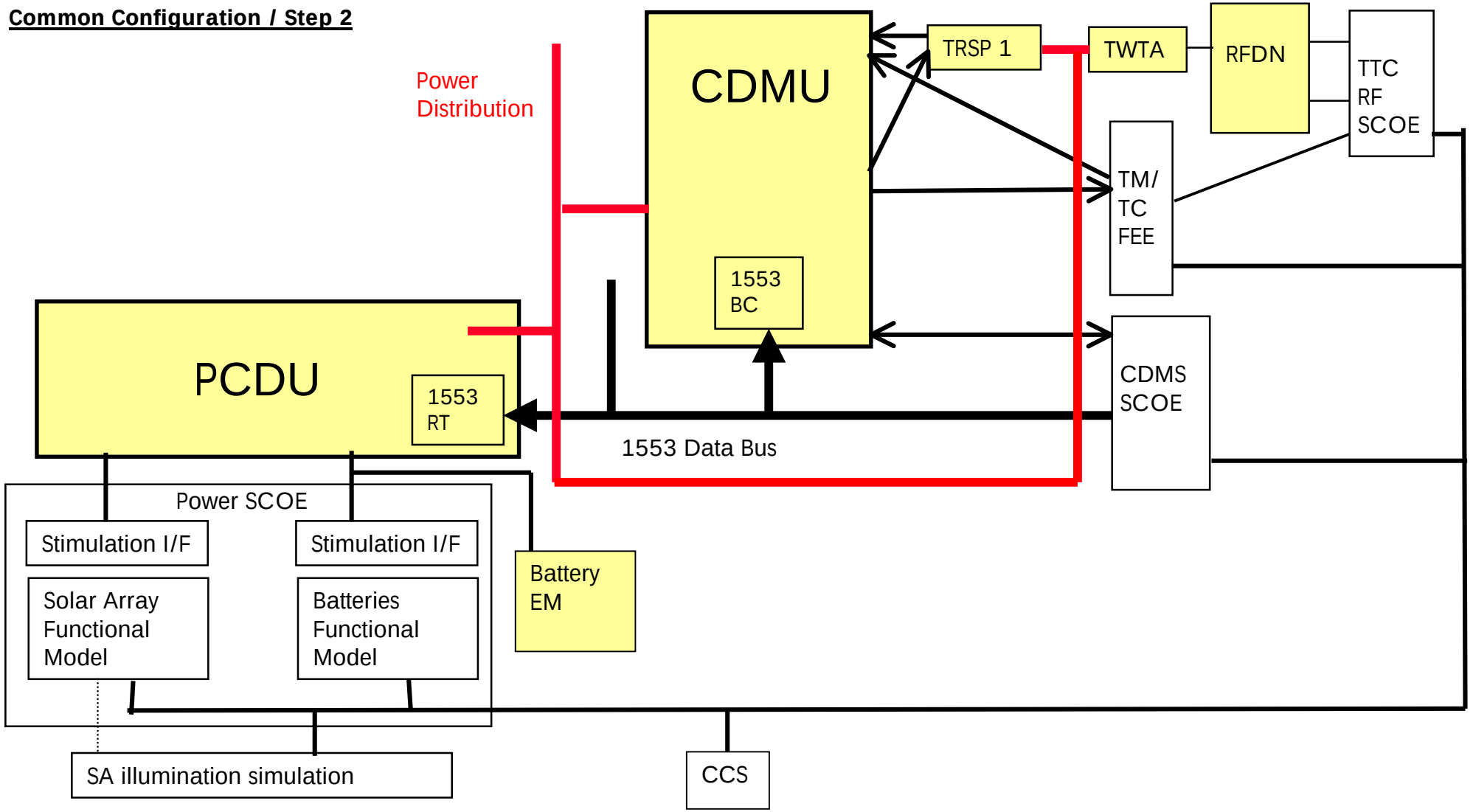
The evaluated time for change is 48 hours.

The following diagrams illustrate these six steps:

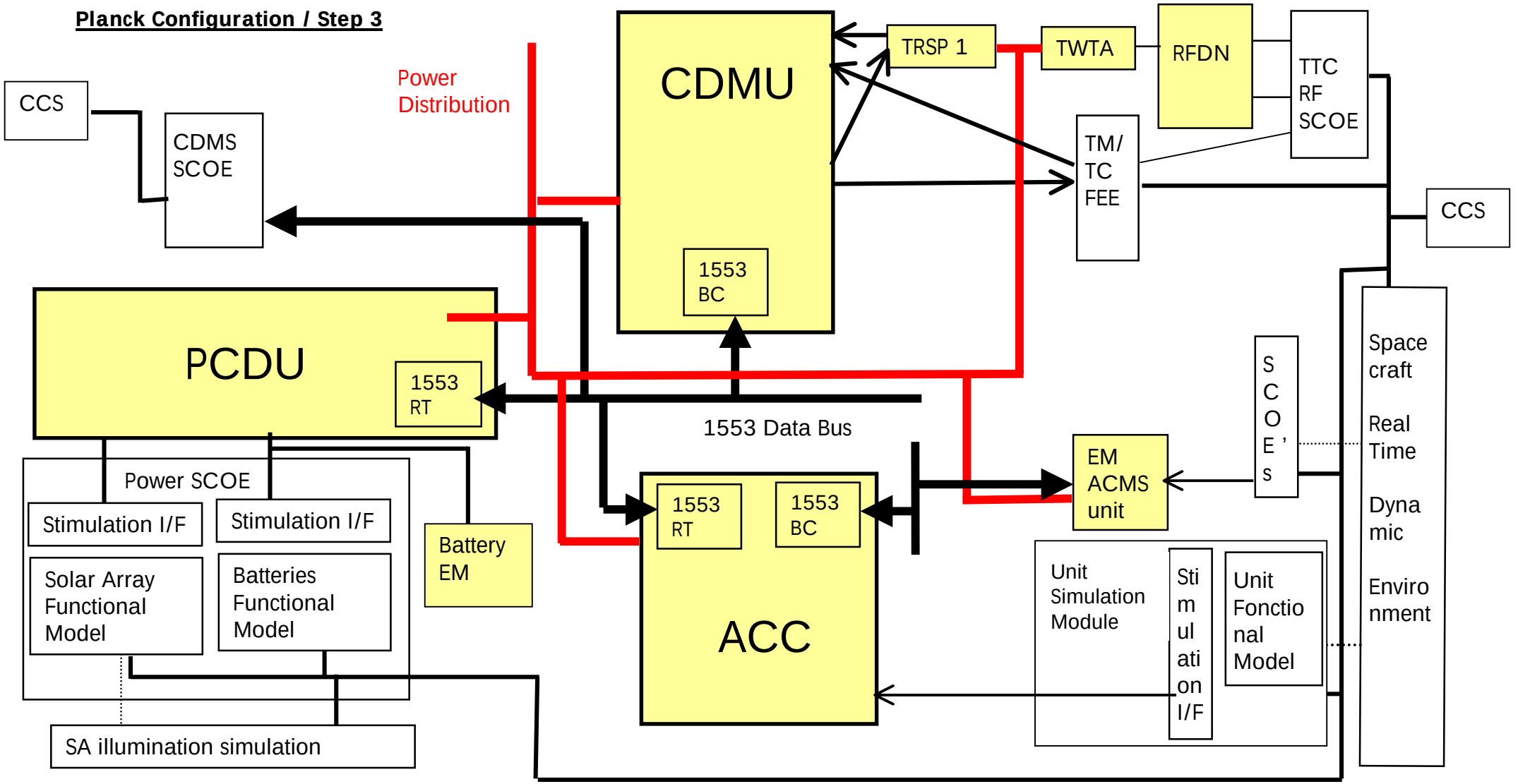
Common Configuration /Step 1



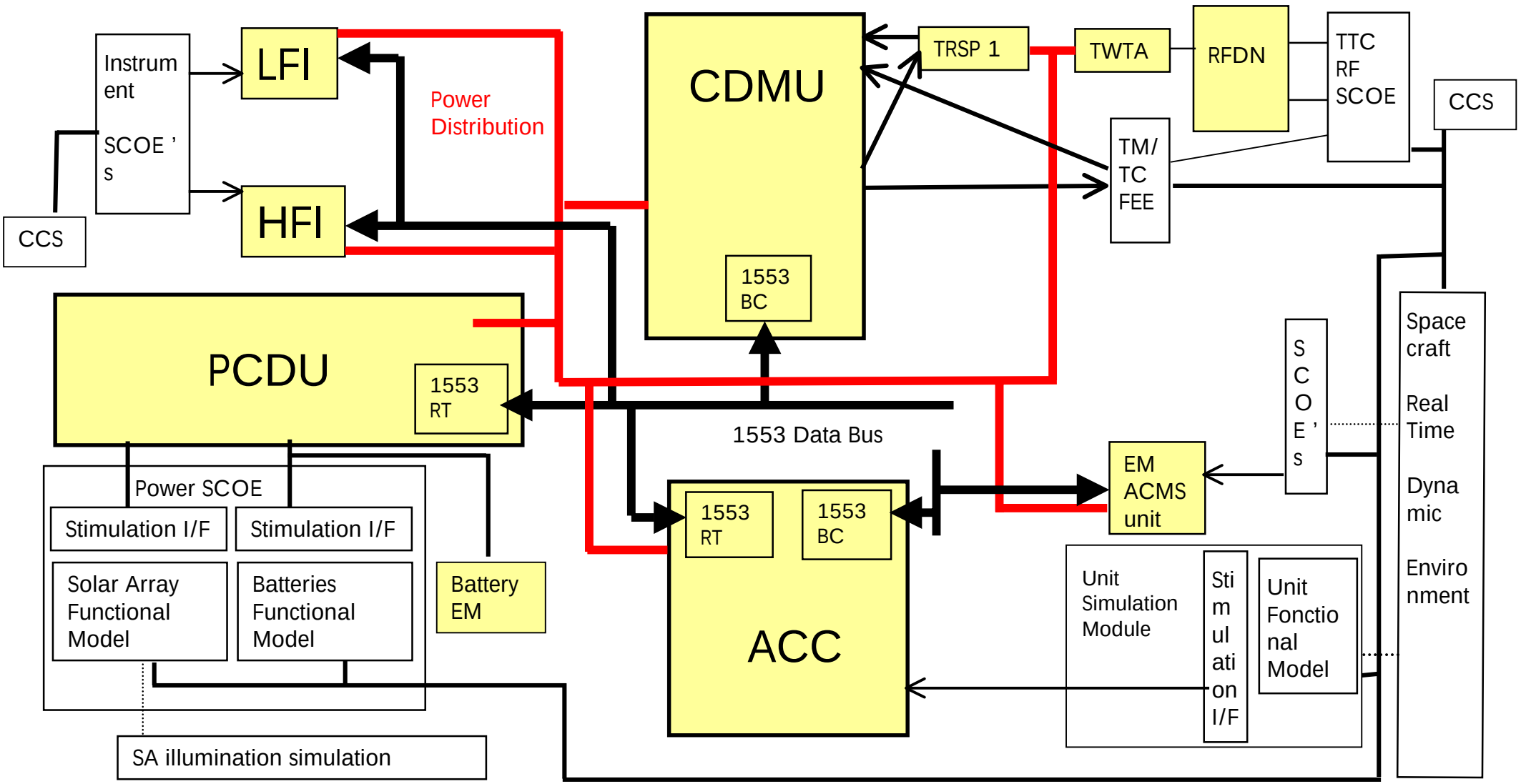
Common Configuration / Step 2



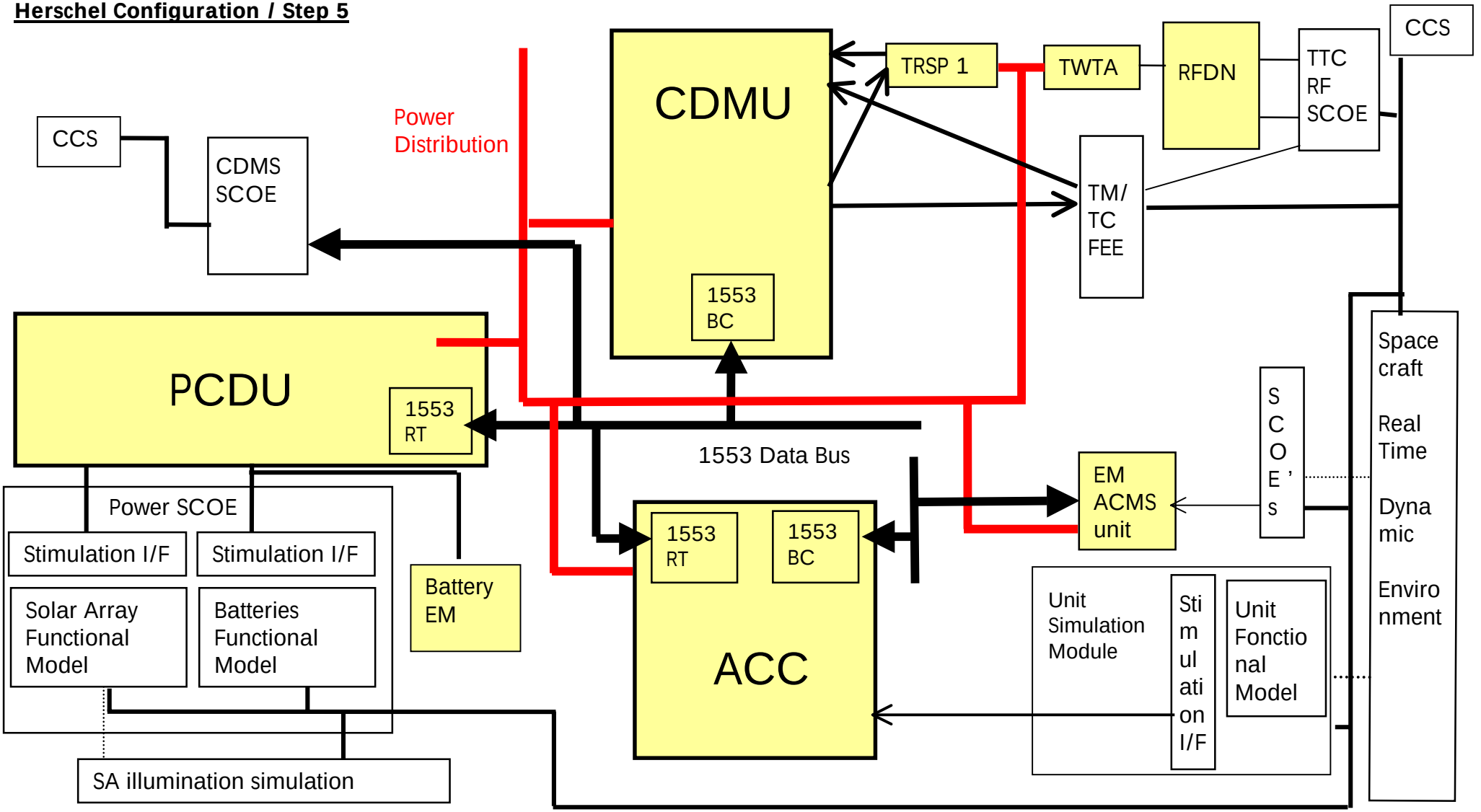
Planck Configuration / Step 3



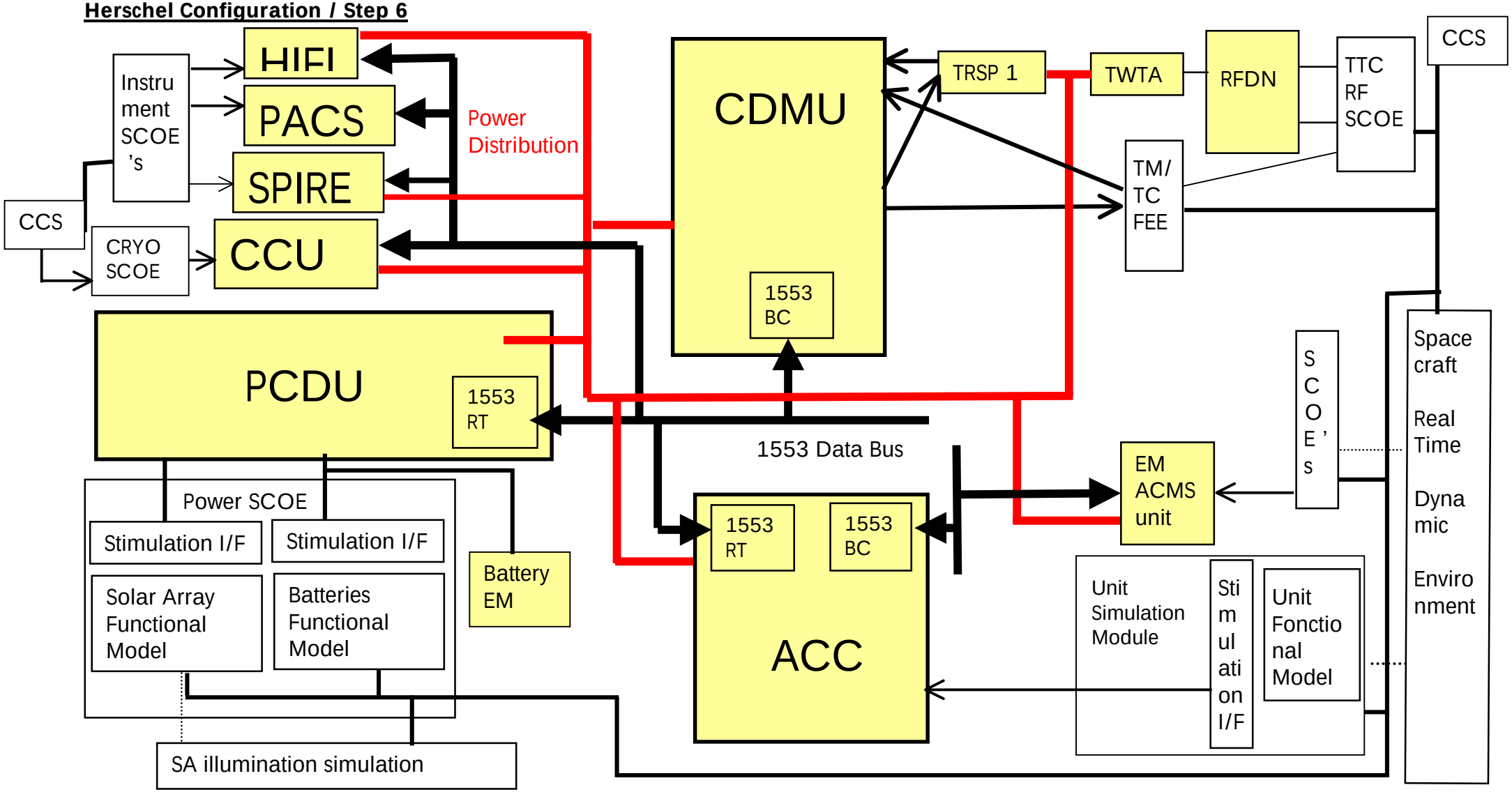
Planck Configuration / Step 4



Herschel Configuration / Step 5



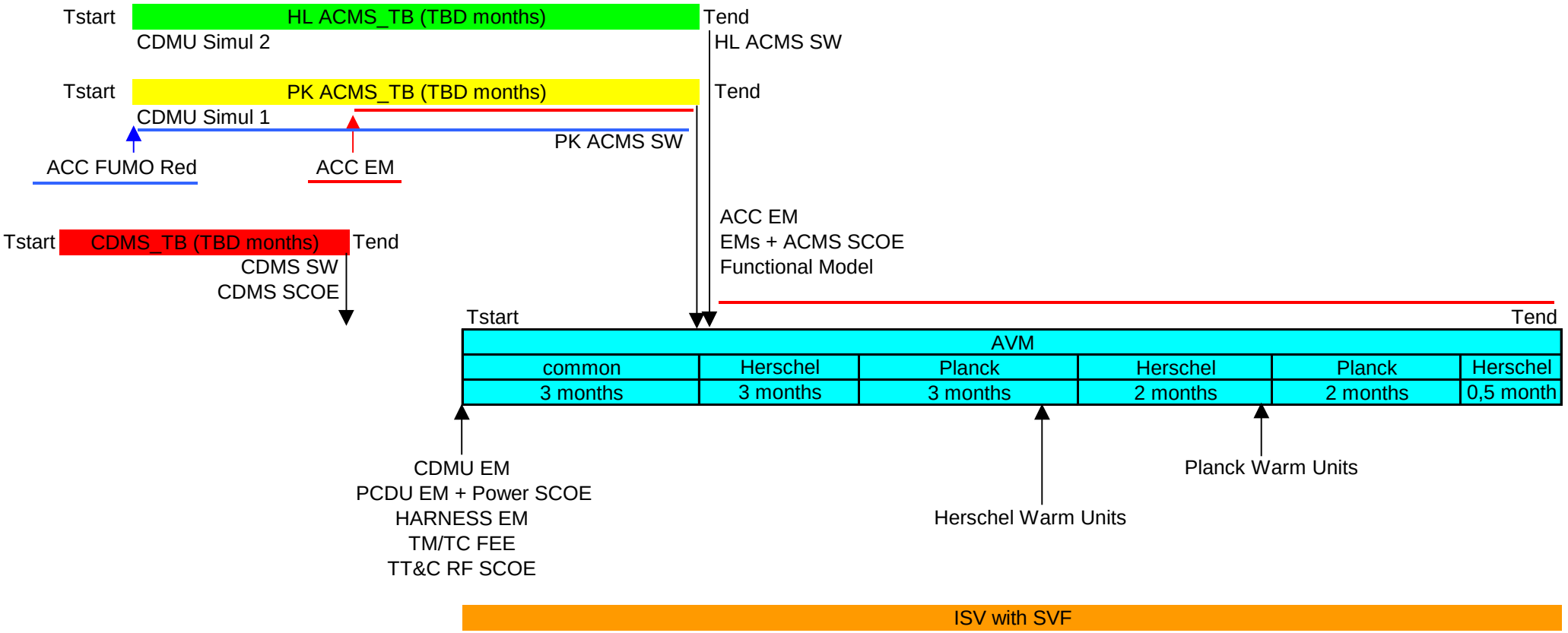
Herschel Configuration / Step 6



6.3 AVM configurations switching sequence

The AVM configurations switching sequence is illustrated by the following diagram to show:

- the successive configurations;
- the number of switchings;
- the different uses of ACC & ACMS units EMs between AVM and ACMS_Test Beds;
- the estimated and expected milestones.



6.4 Tests Families

AVM Config. Steps	AVM Tests Steps	TEST	Type
1, 2	1	Herschel / Planck Harness, EPS, CDMU , TT&C	I & T + UFT
2	2	Herschel / Planck EPS	SIT
2	3	Herschel CDMU	SIT
2	4	Herschel / Planck TT&C	SIT
5	5	Herschel ACMS (ACC EM + EM units)	I & T + UFT
5	6	Herschel ACMS	SIT
	7	Switch configuration from Herschel to Planck	switch conf.
3	8	Planck ACMS	I & T + UFT
3	9	Planck CDMU	SIT
3	10	Planck ACMS	SIT
	11	Switch Configuration from Planck to Herschel	switch conf.
6	12	Herschel Instrument Warm Units	I & T
6	13	Herschel EMC conducted Test	EMC
6	14	Herschel SVM	IST
	15	Switch configuration from Herschel to Planck	switch conf.
4	16	Planck Instrument Warm Units	I & T
4	17	Planck EMC conducted Test	EMC
4	18	Planck SVM	IST
4	19	Planck Satellite System Test	IST
	20	Switch configuration from Planck to Herschel	switch conf.
6	21	Herschel Satellite System Test	IST

7. AVM DESIGN

7.1 Definition

The AVionics Model is a bench model on which will be installed the electrical equipment of Herschel/Planck SVM subsystems and the Herschel/Planck Instruments "Warms" Units.

To simplify, it can be said like that :

SVM AVM = Satellite avionics & Harness & SCOEs & CCS

Satellite AVM = SVM AVM & Interconnected Harness & P/L Warm units with their SCOEs

Only one AVM will be used either in the Herschel configuration (equipped with Herschel ACMS and with Herschel instruments AVM) or in the Planck configuration (equipped with Planck ACMS and with Planck instrument AVM).

[I-CQM] Instruments CQM

The [I-CQM] are the models of instruments delivered for assembly tests at PLM EQM (Herschel) and PLM CQM (Planck) levels.

[I-FPU-CQM] Focal Plane Units (FPU) of Instruments

The [I-FPU-CQM] are

Herschel Focal plane Units (HIFI, PACS and SPIRE) to be accommodated on the Optical Bench inside the cryostat and the HIFI LOU and PACS BOLA to be accommodated outside the CVV. Planck Focal Plane Units and Coolers (HFI and LFI).

[I-WU-AVM] Warm Units (WU) of Instruments

The [I-WU-AVM] are the functional electrical units able to operate the [I-FPU-CQM] during PLM EQM (Herschel) and PLM CQM (Planck) testing. **They are part of the relevant PLM** but they are accommodated inside the SVM. They are the interface between PLM and SVM.

[AVM] Dedicated electrical model

The [AVM] is a bench "system" model on which will be installed the electrical equipment of Herschel/Planck.

The purpose of the [AVM] is to gain early confidence of the correct interactions and interfacing of the elements of the system, including the units of instruments which interface the various spacecraft subsystems (IIDA §9.2.1.1). For that the [AVM] will have the following configurations.

[CS-AVM] Common SVM electrical model

The [CS-AVM] includes the common Herschel/Planck avionics subsystems like CDMS, Power S/S (batteries and PCDU), RF S/S and the common ACMS units (i.e. ACC computer and sensors units).

[HS-AVM] Herschel SVM electrical model

The [HS-AVM] is the [CS-AVM] plus the specific units of Herschel in order to reach the related full SVM configuration, namely : specific ACMS Sensors and Actuators.

[PS-AVM] Planck SVM electrical model

The [PS-AVM] is the [CS-AVM] plus the specific units of Planck in order to reach the related full SVM configuration, namely : specific ACMS Sensors and Actuators.

[H-AVM] Herschel Satellite electrical model

The [H-AVM] is the [HS-AVM] on which will be installed the Herschel [I-WU-AVM] and the simulators.
For what concerning Instrument Warm Units I & T, the tests are under Astrium responsibility with ALENIA and Instrument supports.

[P-AVM] Planck Satellite electrical model

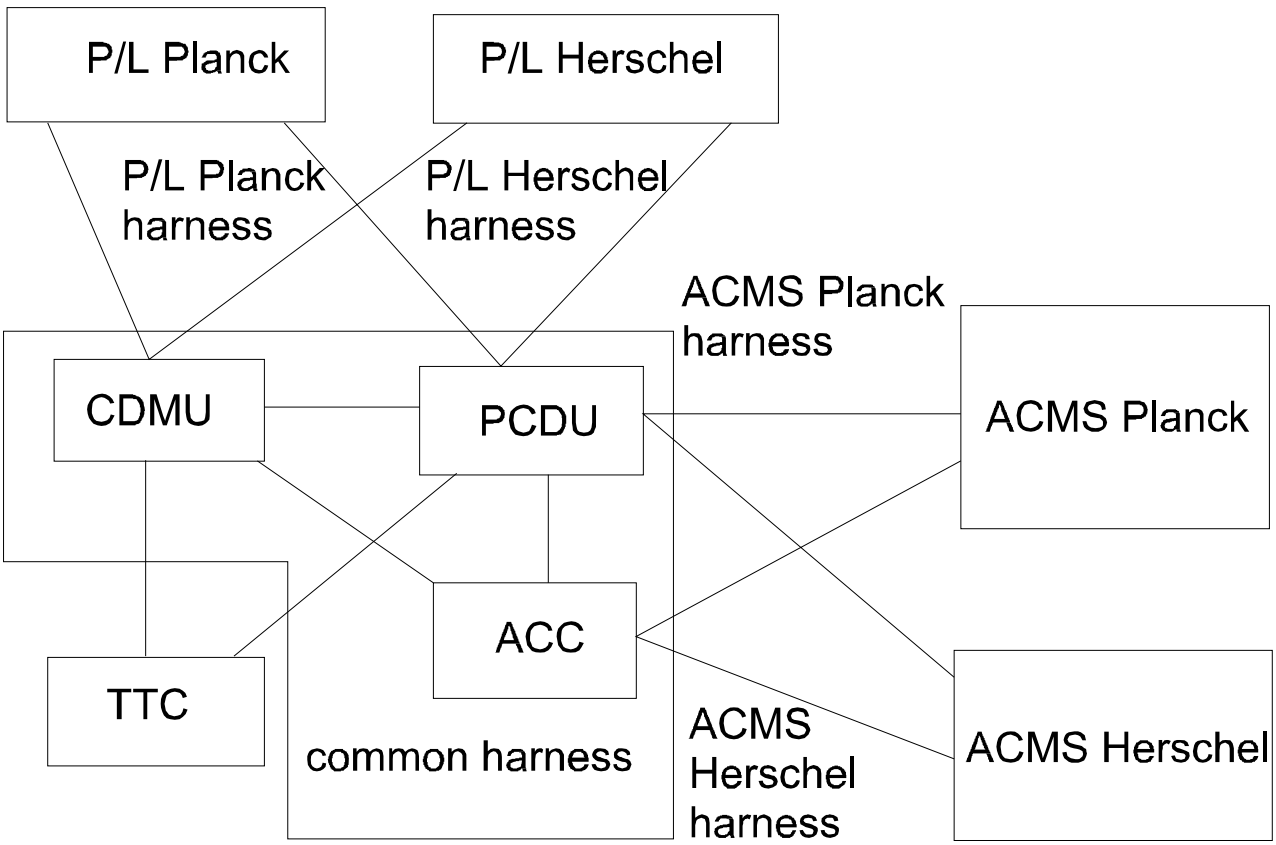
The [P-AVM] is the [PS-AVM] on which will be installed the Planck [I-WU-AVM] and the simulators.
For what concerning Instrument Warm Units I & T, the tests are under ALCATEL responsibility with ALENIA and Instrument supports.

7.2 How representative

The units used on AVM will be, (as defined at § 3.3):
- EM for CDMU;
- EM for ACC;
- unit simulation modules or EM units for ACMS sensors/actuators;
- breadboards, simulators, CQM for Herschel and Planck instruments.

7.2.1 Harness decomposition

The harness is composed of an AVM part and P/L harness for what concern the Warm Units on SVM
- a common part for Planck & Herschel : CDMU/PCDU; ACC/PCDU;CDMU/ACC
- an ACMS harness for Planck
- an ACMS harness for Herschel
- a Warm Unit P/L harness for Planck
- a Warm Unit P/L harness for Herschel
- a TTC harness for Planck
- a TTC harness for Herschel (if the geometrical layout of the 2 panels (TTC, CMDU/PCDU/ACC/Battery) is not the same for Planck & Herschel)



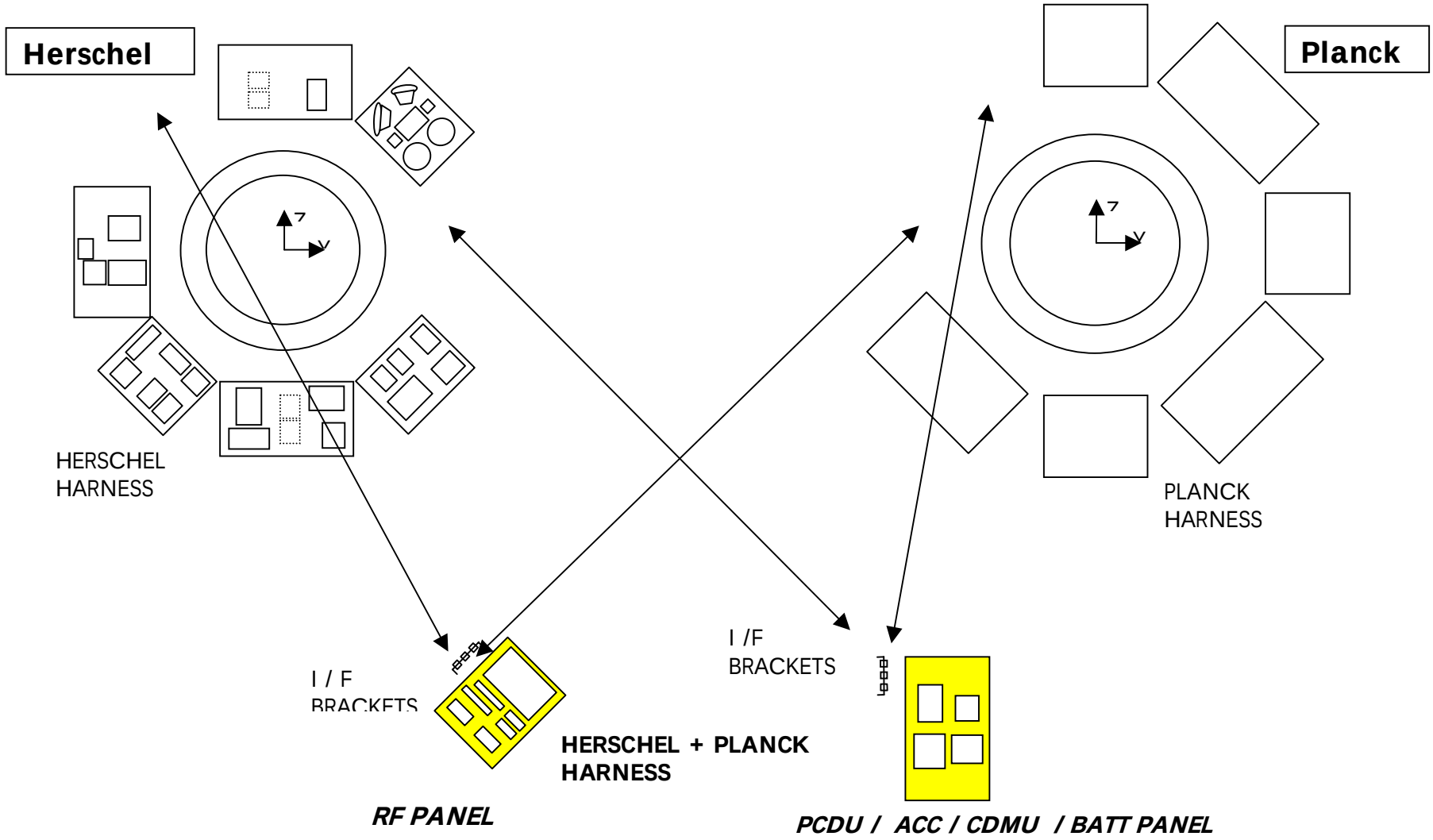
7.2.2 AVM Mechanical Design

The following diagram shows the mechanical principle:

- 1 central table for HERSCHEL;
- 1 central table for PLANCK;
- specific panels : 6 for both spacecraft;
- common panels : 2 that can be dismounted from one bench to the other.

In order to have a representative structure for the EMC tests, the panels will be made of wood table coated with a fine aluminum plate.

The instruments units will be delivered on their panels after the CQM tests (in the same configuration as during CQM tests). TBC.



7.2.3 Hardware matrix

Hereafter the AVM H/W matrix for Herschel & Planck is presented (the detail of S/W Test Bed and ACMS Test Bed is not listed for ACMS is not yet designed).

Let's notice that:

1) *the yellow parts mean the units which are used are the same for both Hershel and Planck on the AVM.*
2) *The TCS is not present in this HW matrix, but tests will be performed on AVM to validated the TCS SW with representative loads.*
3) *Additional harness/adaptator to connect the WU to the AVM harness (when not form and fit unit, or external power supply, for example) will be procured by ALCATEL, from the Instruments contractors.*

Herschel AVM H/W MATRIX		S/W Test Bed	ACMS Test Bed				AVM				Remarks
			Unit Simulation Module	FUMO	EM	SCOE	FUMO	Unit Simulation Module	EM	SCOE	
CDMS	CDMU	Core processor BB	N/A	N/A	N/A	1	N/A	N/A	1	N/A	
	CDMU SCOE	1 TBC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	
ACMS	ACC	Core processor BB	N/A	1	1	CDMU simulator	N/A	N/A	1	N/A	
	Attitude Anomaly Detector (AAD)	N/A	1	N/A	1	N/A	N/A	1	1	N/A	
	Coarse Rate Sensor (CRS)	N/A	2	N/A	1	N/A	N/A	2	1	N/A	
	Sun Acquisition Sensor (SAS)	N/A	2	N/A	1	N/A	N/A	2	1	N/A	
	Star Tracker (STR)	N/A	2	N/A	1	N/A	N/A	2	1	N/A	
	Gyroscope (GYR)	N/A	1	N/A	1	N/A	N/A	1	1	N/A	
	Reaction Wheel System (RWS)	N/A	4	N/A	1	N/A	N/A	4	1	N/A	
	ACMS SCOE	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	1	Including Dynamics Environment + RCS simu
PCS	PCDU	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1*	N/A	*EQM
	Battery	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1*	N/A	*EQM
	Solar Array	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	Included in Power SCOE
	Power SCOE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	Including SA illumination simulation
RF	TT&C-RF SCOE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	
	TM/TC FEE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	
	TRSP1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1*	N/A	*EQM
	TWTA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1*	N/A	*EQM
	RFDN	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1**	N/A	**EM partiel
HARNESS	HARNESS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	

Herschel AVM H/W MATRIX		AVM				
		Breadboard	Unit Simulation Module	EM	SCOE / EGSE	Remarks
PL (warm units)						
HIFI	HIFI Focal Plane Unit (FHFPU)	N/A	N/A	N/A	N/A	
	Focal Plane Control Unit (FHFCU)	N/A	N/A	N/A	N/A	
	Local Oscillator (FHLOU)	N/A	N/A	N/A	N/A	
	Local Oscillator Control Unit (FHLCU)	N/A	1*	N/A	N/A	* Dummy load only
	Local Oscillator Control Source (FHLSU)	N/A	N/A	N/A	N/A	
	High Resolution Spectrometer Horizontal Polarization (FHHRH)	N/A	1*	N/A	N/A	* Dummy load only
	HRS Vertical polarization (FHHRV)	N/A	1*	N/A	N/A	* Dummy load only
	Wide Band Spectrometer Electronics for Horizontal Polarization (FHWEH)	N/A	1*	N/A	N/A	* Dummy load only
	WBS Electronic for Vertical Polarization (FHWEV)	N/A	1*	N/A	N/A	* Dummy load only
	Wide Band Spectrometer Optics Horizontal Polarisation (FHWOH)	N/A	N/A	N/A	N/A	
	WBS optics Vertical Polarisation (FHWOV)	N/A	N/A	N/A	N/A	
	Instrument Control Unit (FHICU)	N/A	N/A	1*	N/A	* DM, no redundancy
	Warm Interconnection Harness (FHWIH)	N/A	N/A	1	N/A	
	HIFI EGSE	N/A	N/A	N/A	1	(SCOS 2000 + HIFI database + PC) + (HCSS+ database + PC) + (QLA + PC) + Power supplies
PACS	PACS Focal Plane Unit (FPFPU)	N/A	1	N/A	N/A	might be either a PC with simulator, or additional boards inside decmec and bolc
	Detector (spectro) & Mechanism Control (FPDECMEC)	1	N/A	N/A	N/A	Baseline is 19 inches rack, but may fit with envelope (tbc) for accommodation on SVM, and may have external power supply
	Bolometer (photometer) & Cooler Control (FPBOLC)	1	N/A	N/A	N/A	same remark as FPDECMEC
	Buffer Amplifier (FPBOLA)	N/A	N/A	N/A	N/A	not delivered

	Data Processing Unit (FPDPU)	N/A	N/A	1	N/A	
	Signal Processing Unit nominal (FPSPU)	1	N/A	N/A	N/A	same remark as FPDECMEC except for external power supply
	Warm Interconnection Harness (FPWIH)	N/A	N/A	1	N/A	
	PACS EGSE	N/A	N/A	N/A	1 TBC	(SCOS 2000 + HIFI database + PC) + (HCSS+ database + PC) + (QLA + PC) + Power supplies
SPIRE	SPIRE Focal Plane Unit (FSFPU) + JFET (FSFPJS, FSFJP)	N/A	1 (DRCU Simulator)	N/A	N/A	1 simulator for all 3 units (1 box) (PC connected to DPU)
	Detector Control Unit (FSDCU)	N/A		N/A	N/A	
	FPU Control Unit (FSFCU)	N/A		N/A	N/A	
	Digital Processing Unit (FSDPU)	N/A	N/A	1	N/A	
	Warm Interconnection Harness (FSWIH)	N/A	N/A	1	N/A	
	SPIRE EGSE	N/A	N/A	N/A	1	(SCOS 2000 + SPIRE database + PC) + (HCSS+ database + PC) + (QLA + PC) + Power supplies
CRYOSTAT CONTROL UNIT	Cryostat Control Unit (CCU)	N/A	N/A	1*	N/A	* EQM (flight spare)
	CCU EGSE (cryostat simulator)	N/A	N/A	N/A	1 TBC	
OTHER	Standard Radiation Environment Monitor (SREM)	N/A	1	N/A	N/A	
	Video Monitoring Camera (VMC)	N/A	1**	1**	N/A	**Simulator or EM (TBC)

Planck AVM H/W MATRIX		S/W Test Bed	ACMS Test Bed				AVM				Remarks
			Unit Simulation Module	FUMO	EM	SCOE	FUMO	Unit Simulation Module	EM	SCOE	
CDMS	CDMU	Core processor BB	N/A	N/A	N/A	1	N/A	N/A	1	N/A	
	CDMU SCOE	1 TBC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	
ACMS	ACC	Core processor BB	N/A	1	1	CDMU Simulator	N/A	N/A	1	N/A	
	Attitude Anomaly Detector (AAD)	N/A	1	N/A	1	N/A	N/A	1	1	N/A	
	Coarse Rate Sensor (CRS)	N/A	3	N/A	1	N/A	N/A	3	1	N/A	
	Sun Acquisition Sensor (SAS)	N/A	2	N/A	1	N/A	N/A	2	1	N/A	
	Star Tracker (STR)	N/A	2	N/A	1	N/A	N/A	2	1	N/A	
	ACMS SCOE	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	1	Including Dynamics Environment + RCS simulator
PCS	PCDU	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1*	N/A	*EQM
	Battery	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1*	N/A	*EQM
	Solar Array	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	Included in Power SCOE
	Power SCOE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	Including SA illumination simulation
RF	TT&C-RF SCOE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	
	TM/TC FEE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	
	TRSP1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1*	N/A	*EQM
	TWTA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1*	N/A	*EQM
	RFDN	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	
HARNESS	HARNESS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	

Planck AVM H/W MATRIX		AVM			
		Breadboard	Unit Simulation Module	EM	SCOE / EGSE
PL (warm units)					
LFI	Front End Unit RAA (PLFEU)	N/A	N/A	N/A	N/A
	DAE Back End Unit (DAE control box) (PL BEU)	N/A	N/A	1	N/A
	DAE Power Box RAA (PLCB)	N/A	N/A		N/A
	Back End Unit (BEU)	N/A	1	N/A	N/A
	Radiometer Electronics Box Assy Nominal (REBA - PL REN)	N/A	N/A	1(QM or rack)	N/A
	SC Compressor Nominal (SCC) PS M3	N/A	1	N/A	N/A
	SC Cold End (SCCE)	N/A	1(Dummy load)	N/A	N/A
	SC Electronics Nominal (SCE) PL M4	N/A	N/A	1(CQM)	N/A
	Warm Interconnection Harness (WIH)	N/A	N/A	1	N/A
	LFI EGSE	N/A	N/A	N/A	1 TBC
HFI	Focal Plane Unit (PH A)	N/A	N/A	N/A	N/A
	Data Processing Unit Nominal (DPU) (PH BA-N)	N/A	N/A	1(CQM)	N/A
	Pre-Amplifier Unit (PAU) (PH CBA)	N/A	1	N/A	N/A
	Readout Electronics Unit (REU) (PH CBO)	N/A		N/A	N/A
	4K Cooler Electronics Unit (4K CDE) (PH DO)	N/A	N/A	1(CQM)	N/A
	4K Cooler Compressor Unit (CCU) (PH DA)	N/A	1	N/A	N/A
	4K Cooler Ancillary Unit (CAU) (PH DB)	N/A		N/A	N/A
	4K Cooler Cold End (4K CCE)	N/A		N/A	N/A
	4K Cooler Current Regulator (CCR) (PH DJ)	N/A	N/A	1(CQM)	N/A
	0.1K Dilution Cooler Control Unit (DCCU) (PH EO)	N/A	1	N/A	N/A
	Valves commanded by DCCU	N/A		N/A	N/A
	Warm Interconnection Harness (WIH)	N/A	N/A	1	N/A
	HFI EGSE	N/A	N/A	N/A	1 TBC
OTHER	Standard Radiation Environment Monitor (SREM)	N/A	1	N/A	N/A
	Video Monitoring Camera (VMC) **(simulator or EM TBC)	N/A	1**	1**	N/A
	Fiber Optic Gyroscope (FOG) ***(EM lent for 3 months)	N/A	N/A	1***	N/A

8. AVM RESPONSIBILITY

8.1 Localisation

AVM will be located at ALENIA/TORINO premises.

8.2 Responsibility sharing

This part concerns the sharing of responsibility of tasks between various parties involved in AVM activities, that is to say: ASPI, ALS, ASTRIUM and ESA.

As prime Contractor ALCATEL Space has the overall responsibility of Herschel Satellite and Planck Satellites.
The SVM is under the overall responsibility of Alenia SPAZIO. It has to deliver fully integrated and electrically tested SVMs.
Astrium-ED has the overall responsibility of Herschel EPLM and it is responsible for AIT of Herschel satellite.
ALCATEL Space has also the overall responsibility for Planck EPLM.

The table and definitions hereafter are taken from the fax number HP-ASPI-LT-0791 and present the responsibility sharing during the AVM test campaign:

[AVM] Configuration	Tests	Specification	Procedure	Execution	Report	Evaluation
[CS-AVM]	SVM Common S/S I & T and UFT	ALENIA	ALENIA	ALENIA	ALENIA	ALENIA
	SVM Common VMC I & T and UFT	ALCATEL	ALENIA (2)	ALENIA	ALENIA	ALCATEL
	SVM Common SREM I & T and UFT	ESA (2)	ALENIA	ALENIA	ALENIA	ESA (2)
	SVM Common S/S SIT	ALENIA	ALENIA	ALENIA	ALENIA	ALENIA
[PS-AVM]	SVM Specific Planck ACMS units I & T and UFT	ALENIA	ALENIA	ALENIA	ALENIA	ALENIA
	FOG I & T and UFT	ESA (2)	ALENIA	ALENIA	ALENIA	ESA (2)
	SVM Specific Planck ACMS units SIT	ALENIA	ALENIA	ALENIA	ALENIA	ALENIA
[P-AVM]	Planck [I-WU-AVM] I & T	ALENIA	ALENIA	ALENIA	ALENIA	ALENIA
	Planck [I-WU-AVM] UFT	ALCATEL (1)	ALENIA (2)	ALENIA	ALENIA	ALCATEL (1)
	SVM Planck IST	ALENIA	ALENIA	ALENIA	ALENIA	ALENIA
	SVM Planck EMC Conducted Test	ALENIA (3)	ALENIA	ALENIA	ALENIA	ALENIA (3)
	Planck Satellite IST TBC	ALCATEL (1)	ALCATEL (4)	ALCATEL (4)	ALCATEL (4)	ALCATEL (1)
	Planck SVT-0	ESOC	ESOC (4)	ESOC (4)	ESOC (4)	ESOC
[HS-AVM]	SVM Specific Herschel ACMS units I & T and UFT	ALENIA	ALENIA	ALENIA	ALENIA	ALENIA
	SVM Specific Herschel ACMS units SIT	ALENIA	ALENIA	ALENIA	ALENIA	ALENIA
[H-AVM]	Herschel [I-WU-AVM] I & T	ALENIA	ALENIA	ALENIA	ALENIA	ALENIA
	Herschel [I-WU-AVM] UFT	ASTRIUM (1)	ALENIA (6)	ALENIA	ALENIA	ASTRIUM (1)
	Herschel CCU I & T and UFT	ASTRIUM	ALENIA (6)	ALENIA	ALENIA	ASTRIUM
	SVM Herschel IST	ALENIA	ALENIA	ALENIA	ALENIA	ALENIA
	SVM Herschel EMC Conducted Test	ALENIA (3)	ALENIA	ALENIA	ALENIA	ALENIA (3)
	Herschel Satellite IST TBC	ALCATEL (1)	ASTRIUM (4)	ASTRIUM (4)	ASTRIUM (4)	ALCATEL (1)
	Herschel SVT-0	ESOC	ESOC (4)	ESOC (4)	ESOC (4)	ESOC

(1) with Instrument support
(2) with ALCATEL support
(3) with ALCATEL approbation
(4) with ALENIA support
(5) with ESA support
(6) with ASTRIUM support

AVM Testing – Sharing of responsibilities

The warm Units integration is performed by ALENIA : mechanical, low level electrical (power distribution, compatibility with PS-ICD). No verification of Warm Units functions and performance is baselined. ALENIA is responsible up to the Warm Units tests (excluded) that are under ASPI responsibility

The SIT for WU, FOG, SREM and VMC will be performed during satellite IST, if necessary.

9. AVM ACTIVITIES DURING FM INTEGRATION AND UNTIL IOCR

AVM activities are planned to be finished before FM integration. It may be used however for trouble shooting, SW modification tests, … The AVM configuration is limited by the lack of many redundant units. The AVM will be kept operational all along the AIT sequence to be usable for potential failure analysis or for validation of software modification.
During this period, the SVT0 will also be performed, under ESA/ESOC responsibility.

10. AVM ACTIVITIES AND ISV

These activities (ISV and AVM tests) are in parallel. A case by case analysis should be done if software errors are found during ISV campaigns to determine if a delta AVM activity is necessary.

11. RISKS ANALYSIS

At system level, the AVM is by itself a risk mitigation item. The AVM has anyway some possibilities of replacing EM units by simulators (battery, ACMS units, …).

END OF DOCUMENT