HERSCHEL / PLANCK

CLEANLINESS TEAM REPORT
H-P-1-ASPI-RP-0314

Product Code:00000

Written by	HERSCHEL / PLANCK CLEANLINESS TEAM	Date	Signature
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JJ.JUILLET	ALCATEL Project Manager	11/12/02	

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

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ENREGISTREMENT DES EVOLUTIONS / *CHANGE RECORDS*

ISSUE	DATE	§ : DESCRIPTION DES EVOLUTIONS *§ : CHANGE RECORD*	REDACTEUR *AUTHOR*
1	14/06/2002	Initial issue	
1 Rev 1	08/11/2002	Modification in pages 9,10 ,12 ,14, 15, 16, 17, 18, 34 according to Rids PDR N° 8349 and 8365.	C.MASSE

1°)Introduction

Cleanliness requirements included in the System Requirement Specification are very stringent.
At the starting of the programme and based on the ISO lessons learned it has been decided to settle a cleanliness working group in order to define the cleanliness requirements and to provide apportionment of budget to each subsystem. The working group was composed by the experimenters , ALCATEL and ESA .
The outcomes of this working group led ASPI to issue a cleanliness requirement spec which was part of the SRR documentation .

During the review nine RIDs have been submitted (RID PAS 01-1 to PAS 01-9) and the disposition of the review board was to restart a working group (called cleanliness team) with the following mandate:
" The purpose is to work out a correct cleanliness operations on ground and assure the cleanliness requirements for instrument at end of life under worst case conditions and agree a cleanliness specification and apportionment. The participants from ESA/ASPI/Astrium will be PA manager plus specialists."

The objectives of this document is to present a synthesis of the work performed by this "cleanliness team".

2°)Documentation

2-1:Applicable documents:

AD-01:HERSCHEL/PLANCK SYSTEM REQUIREMENTS SPECIFICATION (SRS)
SCI-PT-RS-05991

AD-02:SRR Rids PAS 01-1 to PAS 01-9

2-2:Reference documents:

RD-01:Cleanliness team MoM N°1
H-P-ASPI-MN-546

RD-02:Cleanliness team MoM N°2
H-P-2-ASED-MN-0044

RD-03:Cleanliness team MoM N°3 ,
H-P-2-ASED-MN-0062

RD-04:Cleanliness team MoM N°4 ,
H-P-2-ASED-MN-0080

RD-05:Cleanliness team MoM N°5 ,
H-P-2-ASED-MN-0103

RD-06:Cleanliness end of life needs
H-P-1-ASPI-TN-0197

RD-07:ISO Cleanliness policy
ISO AS 1300 TN 0429

RD-08:Cleanliness team MoM N°6
H-P-ASPI-MN-1321

RD-09:Permeation through CVV sealings
H-P-2-ASED-TN-0034 issue 2 31-10-2002

RD-10: Contamination and cleanliness control
ECSS-Q70-01

RD-11: Measurements at ESTEC facilities
YTO/REP/ALL/0474/C

RD-12: Application to Use Ariane (DUA)
H-P-1-ASPI-IF-0066

RD-13: HIFI particulate contamination evaluation
SRON-U/HIFI/TN/2002-002 issue 1 21-02-2002

RD-14: HIFI contamination degradation analysis
SRON-U/HIFI/TN/2000-002 issue 2 02-02-2002

RD-15: SPIRE Cleanliness plan
SPIRE-RAL-PRJ-1070 issue 1

RD-16: Contamination risk analysis for PACS
PACS-ME-TN-020 issue 1

RD- 17: Planck straylight evaluation of the carrier configuration
PT-TN-05967 issue 2

RD- 18: Contamination working group session 5 (minutes)
PT-09164

RD- 19: Planck HFI Instrument cleanliness control plan
PL-PH191-100033-IAS issue 2

RD-20: Email of J-M Lamarre of 19-12-2001 in annex

RD-21: Cleanliness team MoM N°7
H-P-ASPI-MN-1488

RD-22: End of life cleanliness analysis
H-P-ASPI-AN-0269

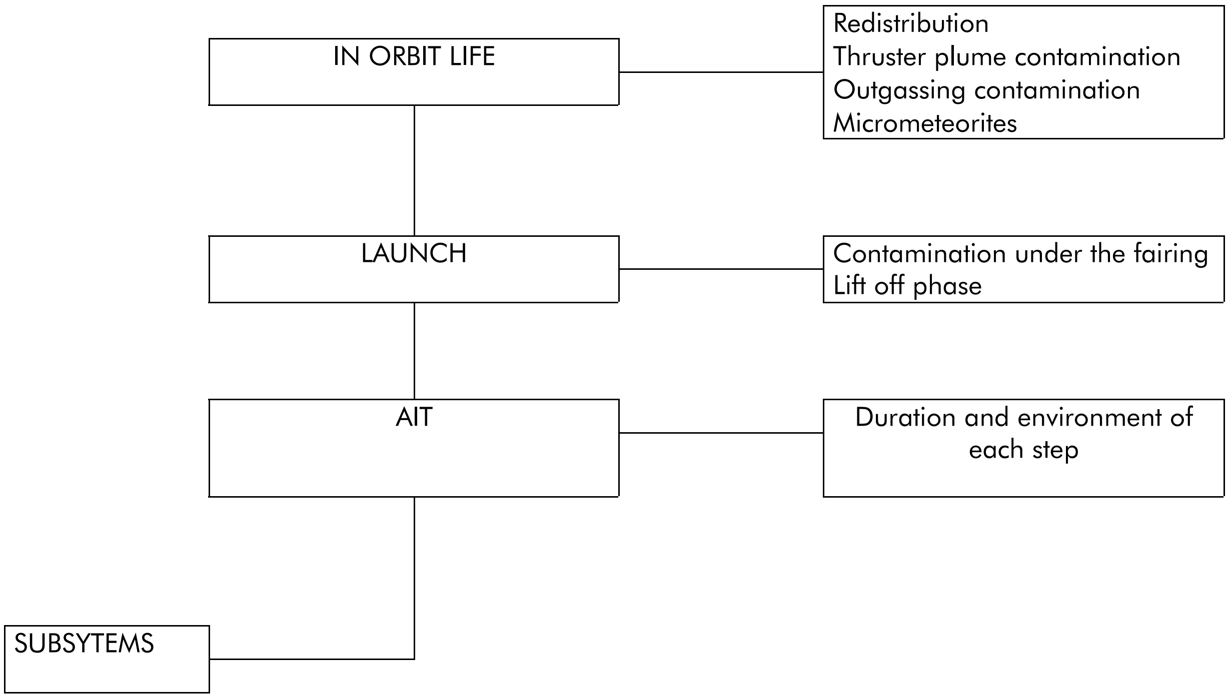
RD-23:Herschel contamination Control Plan
H-P-2-ASED-PL-0023 issue 1.1

RD-24:Planck Contamination Control Plan
H-P-3-ASPI-PL-0253 issue 1

3°)Influent parameters on cleanliness

3-1 Life cycle

The life cycle of each satellite is simply described here after with in front of each phase the actors involved in cleanliness.



3-2 Lift off phase

For this phase it is considered in a first approach that both satellites are exposed in an identical way to potential contamination. The information provided by Arianespace concerning the particulate and organic deposits for the launch phase from the beginning of the spacecraft encapsulation up to the separation from the launcher are (see RD 08) :
Particulate :lower than 5000 ppm from encapsulation to séparation.
Molecular: lower than 4 10-7g/cm^2
For particulate, the ALCATEL specified figure is 1000 ppm to be negotiated with Arianespace.

3-3 Thruster plume

This molecular contamination is induced by the gas released by the thrusters during the satellite manoeuvres. With respect to the working wavelength of both satellites the critical elements to be considered are vapour water and NH 3. A mathematical modelling is performed in Alcatel to determine what are the potential affected surfaces in order to assess the criticality. The analyses have started, the results are detailed in the document RD 22. A summary is presented in this report in the chapter end of life figure.

3-4 Outgassing

This molecular contamination is induced by the outgassing of organic materials which are included in the satellite's constituent. An accurate identification off those material is made, quantity in mass, location in the satellite, outgassing properties are identified (see annex 4 and annex 5). These data completed by temperature repartition are entered in a dedicated mathematical model to evidence where these vapours can condense and in which quantity. These analyses have started in Alcatel for Planck and for Herschel telescope, the results are detailed in the document RD 22. A summary is presented in this report in the chapter end of life figure.

For Herschel, as far as the internal cryostat is concerned a dedicated analysis taking into account the organic materials inside the CVV has been performed by ASTRIUM, the results are provided in annex 2-3.

3-5 Redistribution

On ISO the analyses based on " ANDREOZZI "concluded that this parameter was negligible (see RD07). The result of the contribution for redistribution for a satellite contaminated at 3000 ppm was 2.5ppm. These calculations are based on mission lifetime and on the ratio of the surfaces. A rough comparison of these parameters between ISO and Herschel /Planck indicates that the ISO analysis based on " ANDREOZZI" is still valid and shows that the ratio of the surfaces is favourable for the latter, the mission duration is equivalent for Planck and double for Herschel.
It can be concluded that the contribution for redistribution can be neglected (see RD02)

3-6 µmeteoroides

On ISO the analyses concluded that this parameter was negligible (see RD07). The result of the contribution was estimated at 6 ppm. The meteoroids prediction graph at L2 (source NGST) evidence, for Herschel/Planck, lower values than the ones used on ISO (see RD02 and ANNEXE 3). It can be concluded that the contribution for micrometeoroids, even with a larger Herschel telescope surface, can be neglected.

4°)Requirements

The cleanliness requirement of the System Requirements Specification (AD 01) is recalled here after:
SGEN-195 H/P : Maximum molecular contamination shall not exceed 2 10-7 g/cm² on ground.
Particulate contamination on ground shall be smaller than 300 ppm (TBC)
This requirement is very stringent.

The instrument consortia have provided the following information on their requirements End Of Life EOL on maximum allowable contamination levels as far as the FPU and the front optics are concerned:

Herschel

Item	Particulate ppm max	Molecular g/cm^2 max	Remarks
HIFI demand on Telescope M1	4650	$4x10^{-6}$	For particulate contamination the distribution between M1 and M2 can be changed provided the sum remains unchanged. See RD13 and RD14
HIFI demad on Telescope M2	4300	$4x10^{-6}$	
HIFI FPU	1200	$6x10^{-6}$	See RD13 and RD18
HIFI LOU CVV Window	1200	$8.5x10^{-6}$	See RD13 and RD14 For each face of the window
LOU inside	300	$4x10^{-6}$	See RD13 and RD14.Requires proper covers to avoid contribution from system AIT
PACS demand on telescope M1 and M2 each	5000	$4x10^{-6}$	See RD16. .In addition self emission specification applies if more restrictive
PACS FPU outside	1500	$6x10^{-6}$	See RD16
SPIRE demand on telescope M1 and M2 each	5000	10^{-5}	See RD15 In addition self emission specification applies if more restrictive
SPIRE FPU outside	NA	10^{-4}	See RD15
SPIRE FPU internal	500	$5x10^{-5}$	No contribution is expected from system AIT as SPIRE is closed by a shutter. See RD15

Planck

Item	Particulate ppm max	Molecular g/cm^2 max	Remarks
HFI demand on Telescope	5000	$4x10^{-6}$	On horizontal surfaces for particulate contamination. Correspondingly less on vertical surfaces factor 10. This is meant to meet straylight budget. See RD17 , RD19 and RD20
HFI FPU	5000	$7x10^{-6}$	See RD19, RD20
LFI demand on Telescope	5000	$4x10^{-6}$	On horizontal surfaces for particulate contamination. Correspondingly less on vertical surfaces factor 10. This is meant to meet straylight budget. See RD17 , RD18
LFI FPU	5000	$7x10^{-6}$	See RD17 and RD18.

Purging :A purging is requested by HIFI and LFI (see SCI-PT-IIDB/LFI-04142 and SCI-PT-IIDB/HIFI-02125) but not properly defined nor justified. This point has been raised during the system PDR and led to an action item in the frame of RID 8390. The action was to organise meeting (s) to define the purging requirements. As far as HIFI is concerned a first meeting has been held on 13 and 14 of November (H-P-1-ASP-MN-2241)

For thermal performances purpose the following requirements have to be taken into account (see RD 06).

EOL contamination level needs	Molecular (g/cm^2)			Particulate (ppm)
	H_20	NH_3	On ground contaminants	
Groove 1 (low emissivity surfaces)	$10\ 10^{-5}$	$1.4\ 10^{-5}$	$13\ 10^{-5}$	10 000
Groove 2	$15\ 10^{-5}$	$1.4\ 10^{-5}$	$13\ 10^{-5}$	10 000
Groove 3	$10\ 10^{-5}$	$10\ 10^{-5}$	$13\ 10^{-5}$	10 000
Groove 3 and baffle external side (high emissivity surfaces)	$3\ 10^{-5}$	$1.5\ 10^{-5}$	$3\ 10^{-5}$	15 000
Baffle (internal side)	$20\ 10^{-5}$	$5.6\ 10^{-5}$	$1\ 10^{-5}$	10 000

5°) PLANCK

5-1 AIT activities

The assembly integration and test sequence are performed in clean-room for which the cleanliness rate with respect to the cleanliness levels of the rooms are given in the ESA PSS 01 701 and recalled here after:

Particulate	Molecular
Class 100 000: 225 ppm / 24 working hours per day Class 10 000 :60 ppm / 24 working hours per day Class 1000 :12 ppm / 24 working hours per day Class 100 :1,5 ppm/24 working hours per day	Class 100 000: 1 10-6g/cm²/year=2,7 ng/cm²/day Class 10 000 : 1 10-6g/cm²/year=2,7 ng/cm²/day Class 1000 : 4 10-7g/cm²/year=1,1 ng/cm²/day Class 100 : 4 10-7g/cm²/year=1,1 ng/cm²/day

For test under vacuum, the sensitive sequences with respect to contamination are the pump-down, the cool down to cryo temperature the warm up and the pressure recovery. The particulate contamination rate is independent from the duration at cryo temperature it has been decided to take the fixed figure of 25 ppm per thermal vacuum sequence. As far as molecular is concerned the calculation is made according to the rate of 1 ng/cm²/day (see RD 21).

The budget is establish considering that the contribution of a thermal vacuum cycle is 25 ppm and 1ng/cm²/day.

For mechanical tests the assumption is the following based on previous programmes on a protected mode :
Vibration cycle: 25 ppm and 1 ng/cm²/day
Acoustic test : 25 ppm and 1 ng/cm²/day

For transports 25 ppm and 1 ng/cm²/day.

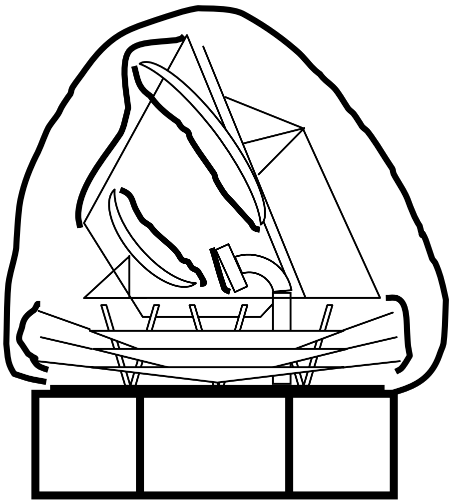
The installation of protections prevent an increase of the contamination level.

5-2 Launch campaign activities

The launch campaign activities are described in RD12. With respect to contamination the major events can be summarised as follow.
Both satellite arrive in CSG 15 weeks before launch, a complete cleaning is performed before their encapsulation. A first set of operation is performed in the S5C building (inspections, preparation validation) in a class 100000 clean-room, during that time the sensitive elements are protected. At the end of this period a final cleaning of the non protected areas is performed the protection are changed to ones compatible with safety rules. At launch date minus 3 weeks both satellite are transferred in S5A/B building for propellant loading this phase lasts 10 days in class 100000 with protection on, after both satellite are transferred in the BAF for final activities of integration on the launcher. The activities starts with Planck satellite, at launch minus 10 days Planck is installed under the Sylda the protections are removed the satellite is entirely exposed to class 10000 environment .On Herschel the activities of mating with Sylda and Helium tank filling start at launch minus 9 days up to launch minus 4 days when the protection are removed and the satellite entirely exposed to class 10000 environment. During this period the molecular rate is 2 10-7 g/cm²/week see RD 08. The installation of Planck under the Sylda is considered as the starting point of the phase " from encapsulation to separation"

5-3 Planck cleanliness budget

First assessment for the AIT sequence (TBC) of Planck satellite leads to the figure given in annex 1. This shows the results taking into the assumptions that the AIT is performed in clean room class 100000 using several types of protective covers, one on each reflector and on FPU, one to ensure the protection of the entire PLM, an other one for the grooves and one dedicated to the volume inside the baffle, this latter is called " cavity". These protections are assumed to be effective with respect to both type of contamination



The assumption that the hardware is protected during the non working hours can not be applied during all the operation. On an other hand some activities can last several days with only few hours of exposure time. To take this into account a coefficient has been applied in order to give the exact time while the surfaces are exposed in a clean room for which the contamination rate is the one given in chapter 5.1.This coefficient is calculated in the following way:
Coef = Nb of hours with sensitive surfaces exposed X 1.5 / Total duration of the operation
Exemples:
For an operation which lasts one day (8 working hours + 16 hours with protection) the coefficient is 0,5 the amount of contamination is 0,5X225: 112,5 ppm
For an operation which lasts 3 days (8 hours exposed + 64 hours with protection) the coefficient is 0,17 the amount of contamination is 114,75

The coefficient in the table budget is " # " in front of operation for which the amount is a fixed budgeted value.

A cleaning operation by mean of vacuum cleaning will lead to a remaining level of contamination of 1000 ppm for the grooves . A procedure has to be developed. It is assumed that the cleaning to be performed is efficient only with respect to particulate contamination.

5-4 End of life figure

Taking into account the assumptions listed here before the figure of the contamination reached on Planck satellite at end of life is summarised here after. Particulate cleaning operation are included in these figures:-before integration of panels
- before baffle mounting
-before test 1 at the end of assembly/integration phase
-before the first thermal vacuum test
- before encapsulation

PARTICULATE	SVM	BAFFLE (ext side)	GROOVES	CAVITY	M1/M2	FPU
Level at delivery to spacecraft					900	300
Level before encapsulation	2135	1000	1000	2205	1430	830
Homogeneity(note 2)	2135	1000	1000	1895	1895	1895
From encapsulation to separation	1000	1000	1000	1000	1000	1000
In orbit (redistribution, µmeteoride)	0	0	0	0	0	0
TOTAL	3135	2000	2000	2895	2895	2895

Note 1 : except the FPU and reflectors all the items are submitted to an individual cleaning operation before its integration, this phase is taken into account into the breakdown, that why no figure is provided in the row " level at delivery to spacecraft".
Note 2 : It is considered that due to on ground activities the parts located in the same volume will reach an identical level. This assumption is made for Cavity, M1, M2 and FPU. The level is obtained based on a surface ratio.

MOLECULAR	SVM	BAFFLE (ext side)	GROOVES	CAVITY	M1/M2	FPU
Level at delivery to spacecraft	1 10-6	10-6	10-6	5 10-7	5 10-7	3 10-6
AIT	1 10-6	3,6 10-7	3,9 10-7	2,1 10-7	1,4 10-7	1,4 10-7
From encapsulation to separation	4 10-7	4 10-7	4 10-7	4 10-7	4 10-7	4 10-7
In orbit (outgassing, thruster plume) 1)	2)	9,65 10-7	From 1,64 10-7 to 1,52 10-5 3)	7,96 10-7	7,08 10-7 M1 8,12 10-7 M2	8,97 10-7
TOTAL	2,4 10-6	2,73 10-6	From 1,95 10-6 to 1,76 10-5 3)	1,91 10-6	1,75 10-6 M1 1,85 10-6 M2	4,44 10-6

1) Total contamination including outgassing and plume NH3, H2O
2)Taking into account the temperature no contamination is expected
3) Minimum value on groove 2 +X, maximum on groove 2 -X

5-5CONCLUSION/RECOMMANDATION

The cleaning of the reflectors on Planck is considered as a risky operation due to the configuration of these items while integrated into the satellites. In consequence these surfaces must be protected as long as they are not needed in the AIT sequences. This comment is also valid for the entrance window of the FPU.

The contamination level reached on the outer surfaces of the satellites implies a cleaning phase as close as possible before launch.

In any case a cleaning process should be developed to remove any accidental contamination.

On molecular point of view, this budget shows that, the requirements will be met, on secondary reflector is marginal but compensated by the level on the primary. One important contributor of this budget is the level at experiment delivery to the spacecraft (3 10-6 g/cm^2) which has to be reduced by cleaning. This cleaning is needed to provide some margins at system level.

On particulate point of view the requirements can be met pending the compliance to the 1000ppm allocated to the lift of phase. This value is not consolidated and negotiation have to be implemented with Arianespace

The following aspects need to be consolidated:

-Contribution of the fairing
-Definition of cleaning procedures.
-Detailed definition of protection for sensitive surfaces.

Based on what is described above and in order to take margin over the figures presented the following specification can be proposed:

PARTICULATE (ppm)	SVM	BAFFLE (ext side)	GROOVES	CAVITY	M1/M2	FPU
Level at delivery to spacecraft	3000	3500	3500	900	900	300
From AIT start to encapsulation	3400*	1500*	1500*	2400*	800	800
From encapsulation to separation	2300	2300	2300	2300	2300	2300
In orbit (redistribution, µmeteoride)	10	10	10	10	10	10
TOTAL	5710	3810	3810	4710	4010	3410

* These parts have to be submitted to particulate cleaning during the sequence, this level correspond to a level at encapsulation.

MOLECULAR (g/cm²)	SVM	BAFFLE (ext side)	GROOVES	CAVITY	M1/M2	FPU
Level at delivery to spacecraft	1 10-6	10-6	10-6	5 10-7	5 10-7	3 10-6
From AIT start to encapsulation	2 10-6	6 10-7	6 10-7	4 10-7	3 10-7	3 10-7
From encapsulation to separation	8 10-7	8 10-7	8 10-7	8 10-7	8 10-7	8 10-7
In orbit (outgassing, thruster plume))	1)	3,7 10-5 2)	3,7 10-5 2)	21,8 10 -5 3)	2,4 10-6 4)	1,9 10-6
TOTAL	3,8 10-6	3,94 10-5	3,94 10-5	22 10-5	4 10-6	6 10-6

1) Taking into account the temperatures no contamination is expected
2) Total for 2,5 10-5 g/cm² H2O et 1,2 10-5 g/cm² NH3
3) Total for 17 10-5 g/cm² H2O et 4,8 10-5 g/cm² NH3
4) Average value on each reflector (the distribution can be changed provided the sum remain 4,8 10-6)

6°)HERSCHEL

6-1 AIT activities

The assembly integration and test sequence are performed in clean-rooms for which the obscuration factor caused by particle fall out with respect to the cleanliness levels of the rooms are given in the ESA PSS 01 201 and recalled here after:

Class 100 000: 225 ppm / 24 working hours per day
Class 10 000 : 60 ppm / 24 working hours per day
Class 1000 : 12 ppm / 24 working hours per day
Class 100 : 1,5 ppm / 24 working hours per day

Considering that during AIT sequence the working time is in general 8 hours per day - plus 4 hours margin - and that the flight hardware is protected for 12 hours per day, the 24 h-related ppm values were divided by two for the contamination budget, as agreed during cleanliness team meeting No 6 (same rational than for Planck, here the coefficient is 0.5).

As far as the molecular contamination is concerned the contamination rates taken for the Herschel AIT budget are based on measurements at ESTEC facilities, ref. doc.: YTO/REP/ALL/0474/C. The rates are:

Class 100 000: 4 ng/cm^2/day = 1.46x10-6 g/cm^2/year
Class 100 : 1 ng/cm^2/day = 3.65x10-7 g/cm^2/year

Contamination rate on launch pad acc. to RD08: 2x10-7 g/cm^2/week = 28.6 ng/cm^2/day

For test under vacuum, the sensitive sequences with respect to contamination are the pump-down, the cool down to cryo temperature the warm up and the pressure recovery. The contamination rate is independent from the duration at cryo temperature.

The installation of protections prevent an increase of the contamination level.
The transports are performed under clean shell into container, it is considered that each transport contributes to no increase of contamination (see RD02).

6-2 Launch campaign activities

The launch campaign activities are described in RD12. With respect to contamination the major events can be summarised as follows.
Both satellites arrive in CSG 15 weeks before launch, a complete cleaning is performed before their transport to Kourou. A first set of operations is performed in the S5C building (inspections, preparation validation) in a class 100000 clean-room, during that time the sensitive elements are protected. At the end of this period a final cleaning of the non protected areas is performed and the protections are changed to ones compatible with safety rules. At launch date minus 3 weeks both satellites are transferred into S5A/B building for propellant loading. This phase lasts 10 days in class 100000 with protection on, after both satellites are transferred into the BAF for final activities of integration on the launcher. The activities start with Planck satellite, at launch minus 10 days Planck is installed under the Sylda, the protections are removed and the satellite is entirely exposed to class 10000 environment. On Herschel the activities of mating with Sylda and Helium tank filling start at launch minus 9 days up to launch minus 4 days when the protections are removed and the satellite is entirely exposed to class 10000 environment. During this period the molecular rate is 2x10-7 g/cm^2/week see RD 08.

Special attention must be paid to the Helium filling process. Top-up and depletion will be performed one day before launch. It may become necessary for operators to work at the satellite inside the fairing. Special care will be taken to minimise the contamination caused by this activities. Operators have to wear clean room class 100 compatible clothes, their tools shall be cleaned and secured against falling down. The Helium may be shipped from Europe or procured in Kourou. The He will be transferred through filters into specially cleaned dewars. From these dewars it will be filled into the cryostat-tank. All equipment needed for the filling process (pipes, gas-cylinders, instrumentation, filters) will be provided by Astrium and specially cleaned before use.

6-3 Herschel cleanliness budget

The figure for the AIT sequence of Herschel satellite is given in annex 2.

6-3-1: Redistribution of particles on ground and during lift off

Redistribution of particles is considered negligible for the FPUs during transports as well as during lift off. The temperature in the vicinity of the Optical Bench will be 25-50 K during both events. At these cold temperatures small particles will stick to the surface.

6-3-2: Air permeation through seals

Following the current AIT schedule the PLM PFM bake out will be 575 days before launch. The air permeation for this period was calculated and the results are reported in RD-09. According to the calculation of the air permeation in issue 2 of RD-09 - issued 31 Oct 02 considering the latest design status - the resulting amount of water ice on the FPUs during the 575 days would be 2x10-6 g/cm^2 (Issue 1 of RD-09: 9.2x10-6 g/cm^2). The air permeation was calculated with Viton-material for all CVV-seals except at the filling port (Helicoflex seal).
In order to minimise the total amount of air and humidity inside the CVV a warm up of the whole cryostat to a temperature above the sublimation point (e.g. 220 K for water is the highest) shortly before launch is recommended. This could be done during the transport to Kourou and needs additional 2 to 3 weeks for cool down.

6-4 End of life figure

Taking into account the assumptions listed here before and the inputs provided in the Herschel contamination control plan RD 23, the figure of the contamination reached on Herschel satellite at end of life is summarised here after. Cleaning operations in Europe and in Kourou are included in these figures.

PLM integration takes place in a cleanroom class 100.
S/C integration and tests take place in class 100 000 environment.

Particulate contamination

PARTICULATE in ppm	PLM inside CVV except FPU & OB	S/C outside	TELESCOPE	FPU and Optical Bench
Level at delivery to Astrium	50	(100 - 300) 4)	300	300 2)
AIT, incl. cleaning steps up to encapsulation	304.5	2060	1600 1)	75
From encapsulation to separation	0	1000 3)	1000 3)	0
In orbit (redistribution, μmeteorides)	0	0	0	0
Total EOL (ppm)	**354.5**	**3060**	**2900**	**375**

1) No cleaning foreseen, but protection with cover during majority of AIT sequence
2) 300 ppm is the specified level at the delivery to Astrium . According to RD 23 the cleanable surfaces (OB and instruments outside) can be cleaned to < 200 ppm
3) 1000 ppm is a goal, pending negotiations between Alcatel and Arianespace
4) not relevant for EOL value because of several cleaning steps

Molecular contamination

MOLECULAR in 10-7 g/cm2	PLM inside CVV	S/C outside	TELESCOPE	FPU and Optical Bench
Level at delivery to Astrium	1	1 5)	2	30 1)
AIT, incl. cleaning steps up to encapsulation	2,03	14,02	0,87	0.5
Contamination from CVV inter-nal outgassing	n. a. 3)	n. a.	n. a.	22 4)
Water ice from air permeation through seals	0,72 2*)	n. a.	n. a.	20 2)
From encapsulation to separation	0	4	4	0
In orbit (outgassing, thruster plume)	0,343	166	10,7 on M1 11,6 on M2	1
Total EOL (10-7 g/cm2)	**4,093**	**184,2**	**17,57 on M1** **18,47 on M2**	**73.5**

1) Level 3x10-6 g/cm2 was given by ESA representative as information from the instrumenters during 5th Cleanliness Team Meeting, see HP-ASED-MN-0103Cleanable surfaces (OB and instruments outside) can be cleaned to < 2x10-7 g/cm2
2) see section 6-3-2: Air permeation through seals RD-09 .

2*) Taking into account the new number presented in RD9 (2 10-6 g/cm²)with respect to the previous one (9,2 10-6 g/cm²) it is assumed that the contamination amount corresponding to difference these 2 numbers (ie 7,2 10-6 g/cm²) is equally distributed inside CVV. Taking into account a ratio of 1000 to cover the surfaces difference between FPU and internal CVV (10 m²/0,01 m²) this leads to a value of 7,2 10-9 g/cm² on which we apply a factor 10 to cover the uncertainties.
3) no increase of total contamination inside CVV after cover closure, only travel of molecules from CVV-internal organic materials to the FPUs considered here
4)calculation see annex 2-3
5)Not relevant for EOL value because of several cleaning steps

6-5CONCLUSION/RECOMMENDATIONS

The cleaning of the telescope mirrors on Herschel is considered as a risky operation due to the configuration of these items while integrated into the satellites. In consequence these surfaces must be protected as long as they are not needed in the AIT sequences.

Pending their contamination level the outer surfaces of the satellites have to be cleaned as close as possible before launch.

In any case a cleaning process should be developed to remove any accidental contamination.

The budget presented here evidence a major non conformance on molecular contamination on FPU and optical bench due to permeation of seals. The action plan to solve this point by one of the following measures:

- use of Helicoflex seals instead of Viton; permeation through Helicoflex seals is about a factor of 10^5 lower.
- additional warm up of the PLM in Kourou to dry the internal surfaces of the PLM

One can highlight that one important contributor of this budget is the level at experiment delivery to the spacecraft (3 10-6 g/cm²) which has to be reduced by cleaning in order to improve the figure.

Taking into account the figure of the S/C outside dedicated attention shall be paid for the LOU external window which required a lower value (1200 ppm). Dedicated protection or cleaning phases have to be defined.

The integration of Herschel experiments on optical bench into the CVV and activities up to closure of the cryostat will be performed in class 100. This rational is in line with what has been performed on ISO.

The following tables shoe the Herschel contamination budgets with margins. The figures can be interpreted as contamination goals in order to meet the EOL requirements.

<u>Particulate contamination budget</u>

PARTICULATE in ppm	PLM inside CVV except FPU & OB	S/C outside	TELESCOPE	FPU and Optical Bench
Level at delivery to Astrium	200	(400) 4)	300	300
AIT, incl. cleaning steps up to encapsulation	500	2500 6)	1890 1)	200
From encapsulation to separation	0	2300 3)	2300 3)	0
In orbit	50	10	10	50

(redistribution, µmeteorides)				
Total EOL	**750**	**4810**	**4500**	**550**
Requirements from instrumenters	1200	NA 2)	4500 5)	1200
Remaining margin	450	NA	0	650

1) No cleaning foreseen, but protection with cover during majority of AIT sequence
2) No requirement. Only a requirement of 1200 ppm for the external window of LOU
3) Considering 1000 ppm from fairing during lift off, tbc by Alcatel-negotiations with Arianespace
4) not relevant for EOL value because of several cleaning steps
5) This value is an average of the requirement for M1 and M2
6)Value at encapsulation

Molecular contamination budget

MOLECULAR in 10-7 g/cm2	PLM inside CVV except FPU & OB	S/C outside	TELESCOPE	FPU and Optical Bench
Level at delivery to Astrium	2	2	2	30
AIT, incl. cleaning steps up to encapsulation	4	25	4	1
Contamination from CVV internal outgassing	n. a. 2)	n. a.	n. a.	25
Water ice from air permeation	1	n. a.	n. a.	20 1)
From encapsulation to separation	0	8	8	0
In orbit (outgassing, thruster plume)	2	200	26	2
Total EOL	**9**	**235**	**40**	**78** 1)
Requirement	60	3)	40	60
Remaining margin	51	NA	0	- 18

1) see section 6-3-2: Air permeation through seals RD-09. The value 20 is the result of a worst case calculation and thus already including some margin
2) no increase of total contamination inside CVV after cover closure, only travel of molecules from CVV-internal organic materials to the FPUs considered here
3) No requirement. Only a requirement of 8,5 10-6 g/cm² on each surface of the LOU window.

The following aspects need to be consolidated:

-Approbation of the end of life cleanliness specification including need of experimenters.
-Contribution of the fairing
-Definition of cleaning procedures for both satellite.

-Detailed definition of protection for sensitive surfaces (mirrors, external LOU window).
-AIT sequences, duration, phases during which the sensitive surfaces are protected, cleanroom class.

7°)Annexes

ANNEX 1

Planck particulate contamination breakdown

	Nb of day	Coef.	Class room			Cumulation				
classe			100000	10000	1000	SVM	baffle ext	Grooves	Cavité	M1/M2/FPU
ppm/day			225	60	12					
Cryo. struct. and WU panels assy										
+Z WU Panel Preparation	1	0								
WU (DPU/REBA) electrical Integration	20	0								
SCC Panels Preparation	10	0								
SCC Panels Mounting	2	0								
0.1 K Panel Preparation	2	0								
0.1K Panel leak test	2	0								
4K Panel Preparation	2	0								
4K Panel leak test	2	0								
Subplatform DAE ctrl bx Mounting	1	0								
BEU/DAE; REBA/DAE; Pwr harness routing	2	0				300		0	0	0
RAA and harness Mounting	2	1	450			450		0	0	
Cryo Structure Assembly	7	1	1575			1575		1575	0	0
Grooves Piping fastening & Thermal Control routing	3	1	675							
PAU . Cryo harness mounting	1	1	225			900		900	0	0
Mating and telescope adjustment										
RCS leak test on SVM	4	0								
He Tank & 0.1k piping Mounting on SVM	3	0								
He Tank & 0.1k lines leak test on SVM	3	0								
SVM STM - Cryo. structure Mating	3	0				2925		0	0	0
Telescope Mounting	3	1	675			675		675	675	
RAA Adjustment	5	1	1125			1125		1125	1125	
JFET and cryo. harness routing	1	1	225			225		225	225	0
0.1 K Panel Mounting	2	0								
+Z WU and 4 K Panel s Mounting	2	0				900		0	0	0
S/C completion integration										
coolers end line / FPU connection	2	1	450			450		450	450	
0.1 K / 4K leak test	3	1	675			675		675	675	
0.1K / 4K purging	3	1	675			675		675	675	
4K CCE/DCCU cryo. harness	1	1	225							0
01K CCE/CEU cryo. harness	1	1	225			450		450	450	0
4 K Electrical check	3	0								
0.1K Electrical check	3	0				1350		0	0	0
SCS Electrical integration	4	0								
Image HFI electrical integration(PAU/REUDPU harness routing)	7	0								
Image LFI electrical integration (BEU/DAE/REBA harness routing)	7	0				4050		0	0	0
Thermal Control Check(harness routing)	3	1	675			675		675	675	0
solar array (central part) mounting	3	0				675		0	0	
Upper panels closure mounting	4	0	0			900		0	0	0
antennaes integration, STR baffle mounting	7	0				1575		0	0	0

Total before PPLM cleaning						20550,0		7425,0	4950,0	0,0
Total after PPLM cleaning	2		450			21000,0		**1000**	**1000**	**0**
Baffle Mounting	2	1	450			450	450	450	450	0
External Groove & MLI mounting	5	1	1125			1125	1125	1125	0	0
Total before S/C cleaning						22575,0	1575	2575	1450	0
Total after S/C cleaning						3157,5	**1000**	**1000**	1450	0
IST 1 and EMC tests										
Funct. tests (IST1)	10	0				2250	0	0	0	0
EMC tests	10	0				2250	0	0	0	0
LFI RF test	4	0,5	450			900	450	0	115	115
SVT 1	5	0				1125	0	0	0	0
Alignts & physical prop.										
Alignment check	3	0,17	114,75			675	114,75	0	0	0
MCI	8	0,4	720			1800	720	0	0	0
Balancing	3	0,5	337,5			675	337,5	0	0	0
balancing mass and alignment check	7	0				1575	0	0	0	0
Virations tests										
Vibrations set up	5	0,3	337,5			1125	337,5	0	0	0
RCS filing	3	0				675	0	0	0	0
Vibration & Acoustic	15	#	50			50	50	50	50	50
Fit check	2	0				450	0	0	0	0
Post Virations tests										
Leak Test 0,1K; 4K	3	0,5	337,5			675	337,5	0	0	0
RCS Draining & Drying & Leak Test	5	0				1125	0	0	0	0
S/CFunctional Tests	7	0				1575	0	0	0	0
Alignment check	3	0,17	114,75			675	114,75	0	0	0
SA dismount., Instrum. replace,	10	1	2250			2250	2250	225	225	0
Thermal tests (part 1)										
Transport	6	#	25	(forfait)		25	25	25	25	25
EGSe validation	3	0				180	0	0	0	0
SC prep. BTY charge, SA exter., He filing	15	0				900	0	0	0	0
Total before S/C cleaning						24112,5	5737	1300	1865	190
Total after S/C cleaning						3311,3	**1000**	**1000**	1865	190
Shrouds installation	10	1		600						
S/C connections and checks	5	1		300						
cooling leak test	2	1		120		1020	1020	1020	60	60
TOTAL before vacuum phase						4331,3	2020,0	2020,0	1925,0	250,0
Vacuum Phase	5	#								
Th/Vac.	28	#								
Return at Ambient	3	#	25			25	25	25	25	25
Shrouds removal	3	1		180		180	180	180	60	60
Thermal tests (part 2)										
S/C return	2	1		120						
S/C healthcheck	3	1		180		300	300	300	0	0
Shrouds installation	10	1		600						
S/C connections and checks	5	1		300						
cooling leak test	2	1		120		1020	1020	1020	60	60
TOTAL before vacuum phase						5856,3	3545,0	3545,0	2070,0	395,0
Vacuum Phase	5	#								
Th/Vac.	17	#								
Return at Ambient	3	#	25			25	25	25	25	25

Shrouds removal	3	1		180		180	180	180	60	60
S/C exit	2	1		120		120	120	120	0	0
S/C functional tests	8	1		480		480	480	480	0	0
packing	4	0		0		240	0	0	0	0
IST 2										
Transport/unpacking	9	#	25	(forfait)		25	25	25	25	25
Alignment check	3	0,17	114,75			675	114,75	0	0	0
EGSE validation	3	0				675	0	0	0	0
Funct. tests (IST2)	15	0				3375	0	0	0	0
SA mounting	3	0				675	0	0	0	0
Campaign preparation & transport to Kourou	15	#	25	(forfait)		25	25	25	25	25
Launch Campaign		0								
TOTAL end of AIT before cleaning	438		14852	3300	0	12351,3	4514,8	4400,0	2205,0	530,0
TOTAl after cleaning before encapsulation (assuming that the last cleaning is performed just before encapsulation)						2135,1	**1000**	**1000**	2205,0	530,0

ANNEX 1 (con't)

Planck molecular contamination breakdown

	Nb of day	Coef.	Class room			Cumulation				
classe			100000	10000	1000	SVM	baffle ext	Grooves	Cavité	M1/M2/FPU
ppm/day			2,7E-09	2,7E-09	1,1E-09					
Cryo. struct. and WU panels assy										
+Z WU Panel Preparation	1	0								
WU (DPU/REBA) electrical Integration	20	0								
SCC Panels Preparation	10	0								
SCC Panels Mounting	2	0								
0.1 K Panel Preparation	2	0								
0.1K Panel leak test	2	0								
4K Panel Preparation	2	0								
4K Panel leak test	2	0								
Subplatform DAE ctrl bx Mounting	1	0								
BEU/DAE; REBA/DAE; Pwr harness routing	2	0				1,2E-07		0,0E+00	0,0E+00	0,0E+00
RAA and harness Mounting	2	1	5,5E-09			5,5E-09		0,0E+00	0,0E+00	
Cryo Structure Assembly	7	1	1,9E-08			1,9E-08		1,9E-08	0,0E+00	0,0E+00
Grooves Piping fastening & Thermal Control routing	3	1	8,2E-09							
PAU . Cryo harness mounting	1	1	2,7E-09			1,1E-08		1,1E-08	0,0E+00	0,0E+00
Mating and telescope adjustment										
RCS leak test on SVM	4	0								
He Tank & 0.1k piping Mounting on SVM	3	0								
He Tank & 0.1k lines leak test on SVM	3	0								
SVM STM - Cryo. structure Mating	3	0				3,6E-08		0,0E+00	0,0E+00	0,0E+00
Telescope Mounting	3	1	8,2E-09			8,2E-09		8,2E-09	8,2E-09	
RAA Adjustment	5	1	1,4E-08			1,4E-08		1,4E-08	1,4E-08	
JFET and cryo. harness routing	1	1	2,7E-09			2,7E-09		2,7E-09	2,7E-09	0,0E+00
0.1 K Panel Mounting	2	0								
+Z WU and 4 K Panel s Mounting	2	0				1,1E-08		0,0E+00	0,0E+00	0,0E+00
S/C completion integration										
coolers end line / FPU connection	2	1	5,5E-09			5,5E-09		5,5E-09	5,5E-09	
0.1 K / 4K leak test	3	1	8,2E-09			8,2E-09		8,2E-09	8,2E-09	
0.1K / 4K purging	3	1	8,2E-09			8,2E-09		8,2E-09	8,2E-09	
4K CCE/DCCU cryo. harness	1	1	2,7E-09							0,0E+00
01K CCE/CEU cryo. harness	1	1	2,7E-09			5,5E-09		5,5E-09	5,5E-09	0,0E+00
4 K Electrical check	3	0								
0.1K Electrical check	3	0				1,6E-08		0,0E+00	0,0E+00	0,0E+00
SCS Electrical integration	4	0								
Image HFI electrical integration(PAU/REUDPU harness routing)	7	0								
Image LFI electrical integration (BEU/DAE/REBA harness routing)	7	0				4,9E-08		0,0E+00	0,0E+00	0,0E+00
Thermal Control Check(harness routing)	3	1	8,2E-09			8,2E-09		8,2E-09	8,2E-09	0,0E+00
solar array (central part) mounting	3	0				8,2E-09		0,0E+00	0,0E+00	
Upper panels closure mounting	4	0	0			1,1E-08		0,0E+00	0,0E+00	0,0E+00
antennaes integration, STR baffle mounting	7	0				1,9E-08		0,0E+00	0,0E+00	0,0E+00

Total before PPLM cleaning						3,7E-07		9,0E-08	6,0E-08	0,0E+00
Total after PPLM cleaning	2		5,5E-09			3,7E-07		9,0E-08	6,0E-08	0,0E+00
Baffle Mounting	2	1	5,5E-09			5,5E-09	5,5E-09	5,5E-09	5,5E-09	0,0E+00
External Groove & MLI mounting	5	1	1,4E-08			1,4E-08	1,4E-08	1,4E-08	0,0E+00	0,0E+00
Total before S/C cleaning						3,9E-07	1,9E-08	1,1E-07	6,6E-08	0,0E+00
Total after S/C cleaning						3,9E-07	1,9E-08	1,1E-07	6,6E-08	0,0E+00
IST 1 and EMC tests										
Funct. tests (IST1)	10	0				2,7E-08	0,0E+00	0,0E+00	0,0E+00	0,0E+00
EMC tests	10	0				2,7E-08	0,0E+00	0,0E+00	0,0E+00	0,0E+00
LFI RF test	4	0,5	5,5E-09			1,1E-08	5,5E-09	0,0E+00	1,4E-09	1,4E-09
SVT 1	5	0				1,4E-08	0,0E+00	0,0E+00	0,0E+00	0,0E+00
Alignts & physical prop.										
Alignment check	3	0,17	1,4E-09			8,2E-09	1,4E-09	0,0E+00	0,0E+00	0,0E+00
MCI	8	0,4	8,8E-09			2,2E-08	8,8E-09	0,0E+00	0,0E+00	0,0E+00
Balancing	3	0,5	4,1E-09			8,2E-09	4,1E-09	0,0E+00	0,0E+00	0,0E+00
balancing mass and alignment check	7	0				1,9E-08	0,0E+00	0,0E+00	0,0E+00	0,0E+00
Virations tests										
Vibrations set up	5	0,3	4,1E-09			1,4E-08	4,1E-09	0,0E+00	0,0E+00	0,0E+00
RCS filing	3	0				8,2E-09	0,0E+00	0,0E+00	0,0E+00	0,0E+00
Vibration & Acoustic	15	#	4,0E-08			4,0E-08	4,0E-08	4,0E-08	4,0E-08	4,0E-08
Fit check	2	0				5,5E-09	0,0E+00	0,0E+00	0,0E+00	0,0E+00
Post Virations tests										
Leak Test 0,1K; 4K	3	0,5	4,1E-09			8,2E-09	4,1E-09	0,0E+00	0,0E+00	0,0E+00
RCS Draining & Drying & Leak Test	5	0				1,4E-08	0,0E+00	0,0E+00	0,0E+00	0,0E+00
S/CFunctional Tests	7	0				1,9E-08	0,0E+00	0,0E+00	0,0E+00	0,0E+00
Alignment check	3	0,17	1,4E-09			8,2E-09	1,4E-09	0,0E+00	0,0E+00	0,0E+00
SA dismount., Instrum. replace,	10	1	2,7E-08			2,7E-08	2,7E-08	2,7E-09	2,7E-09	0,0E+00
Thermal tests (part 1)										
Transport	6	#			6E-09	6,0E-09	6,0E-09	6,0E-09	6,0E-09	6,0E-09
EGSe validation	3	0				8,2E-09	0,0E+00	0,0E+00	0,0E+00	0,0E+00
SC prep. BTY charge, SA exter., He filing	15	0				4,1E-08	0,0E+00	0,0E+00	0,0E+00	0,0E+00
Total before S/C cleaning						7,2E-07	1,2E-07	1,6E-07	1,2E-07	4,7E-08
Total after S/C cleaning						7,2E-07	1,2E-07	1,6E-07	1,2E-07	4,7E-08
Shrouds installation	10	1		3E-08						
S/C connections and checks	5	1		1E-08						
cooling leak test	2	1		5E-09		4,7E-08	4,7E-08	4,7E-08	2,7E-09	2,7E-09
TOTAL before vacuum phase						7,7E-07	1,7E-07	2,0E-07	1,2E-07	5,0E-08
Vacuum Phase	5	#								
Th/Vac.	28	#								
Return at Ambient	3	#			3,6E-08	3,6E-08	3,6E-08	3,6E-08	3,6E-08	3,6E-08
Shrouds removal	3	1		8E-09		8,2E-09	8,2E-09	8,2E-09	2,7E-09	2,7E-09
Thermal tests (part 2)										
S/C return	2	1		5E-09						
S/C healthcheck	3	1		8E-09		1,4E-08	1,4E-08	1,4E-08	0,0E+00	0,0E+00
Shrouds installation	10	1		3E-08						
S/C connections and checks	5	1		1E-08						
cooling leak test	2	1		5E-09		4,7E-08	4,7E-08	4,7E-08	2,7E-09	2,7E-09
TOTAL before vacuum phase						8,7E-07	2,7E-07	3,1E-07	1,6E-07	9,2E-08
Vacuum Phase	5	#								
Th/Vac.	17	#								
Return at Ambient	3	#			2,5E-08	2,5E-08	2,5E-08	2,5E-08	2,5E-08	2,5E-08

Shrouds removal	3	1		8E-09		8,2E-09	8,2E-09	8,2E-09	2,7E-09	2,7E-09
S/C exit	2	1		5E-09		5,5E-09	5,5E-09	5,5E-09	0,0E+00	0,0E+00
S/C functional tests	8	1		2E-08		2,2E-08	2,2E-08	2,2E-08	0,0E+00	0,0E+00
packing	4	0		0		1,1E-08	0,0E+00	0,0E+00	0,0E+00	0,0E+00
IST 2										
Transport/unpacking	9	#			9E-09	9,0E-09	9,0E-09	9,0E-09	9,0E-09	9,0E-09
Alignment check	3	0,17	1,4E-09			8,2E-09	1,4E-09	0,0E+00	0,0E+00	0,0E+00
EGSE validation	3	0				8,2E-09	0,0E+00	0,0E+00	0,0E+00	0,0E+00
Funct. tests (IST2)	15	0				4,1E-08	0,0E+00	0,0E+00	0,0E+00	0,0E+00
SA mounting	3	0				8,2E-09	0,0E+00	0,0E+00	0,0E+00	0,0E+00
Campaign preparation & transport to Kourou	15	#			2E-08	1,5E-08	1,5E-08	1,5E-08	1,5E-08	1,5E-08
Launch Campaign		0								
TOTAL end of AIT before cleaning	438		2,2E-07	2E-07	9E-08	1,0E-06	3,6E-07	3,9E-07	2,1E-07	1,4E-07
TOTAl after cleaning before encapsulation (assuming that the last cleaning is performed just before encapsulation)						1,0E-06	3,6E-07	3,9E-07	2,1E-07	1,4E-07

ANNEX 2

Herschel contamination breakdown

ANNEX 2-1: Particle contamination budget for Herschel EPLM AIT

The following table shows the particle contamination budget for the Herschel EPLM AIT sequence.
It was agreed during the Cleanliness Team Meetings, to calculate with the half of the maximum values for the particle fallout given in PSS-01-204, taking into account 8 h work, 12 h H/W covered and 4 h margin per day.
A conclusion of the results is given at the end of the table.

	days	ppm		local budgets (ppm)			
Cleanroom Class / affected H/W		100 000	100	CVV intern	OB	CVV extern	Teles-cope
ppm / day (Cleanroom requirements in PSS-01-204)		225	1.5				
ppm / day for calculation		112.5	1.5 *)				
(8 h work, 12 h H/W covered, 4 h margin)							
Cryostat Integration							
Requirement at delivery to Astrium				50	50	100	
Assembly SFW to He-II Tank	5		7.5	7.5	7.5	7.5	
Preparation Tank & SFW (harness, MLI...)	14		21	21	21	21	
Assembly CVV & He-II Tank & cyl. shields	15		22.5	22.5	22.5	22.5	
Installation internal harness	30		45	45	45	45	
Integration He-I Tank	6		9	9	9	9	
Integration lower shields and lower bulkhead	13		19.5	19.5	19.5	19.5	
PLM PFM (STM) Integration							
Integration optical bench incl. FPUs (STM)	16		24	24	24	24	
PLM PFM (STM) closure	40		60	60	60	60	
PLM PFM (STM) Qual. Test Sequence 1							
Evacuation & leak check	8	900				900	
Vibration warm	10	1125				1125	
Prep. cooldown & filling, alignment	6	675				675	
cooldown & filling	10	1125				1125	
S/C Structure Qual. (SM Campaign)							
Integration EPLM (sunshield & telescope)	16	1800				1800	
Preparation & mating SVM-SM / EPLM	13	1462.5				1462.5	
Acoustic qualification (He-II tank filled with He I)	15	1687.5				1687.5	
Vibration cold	13	1462.5				1462.5	
Separation shock test	5	562.5				562.5	
Demating SVM-PLM	5	562.5				562.5	
Deintegr. sunshield & telescope (EPLM->PLM)	3	337.5				337.5	
PLM PFM (STM) Qual. Test Sequence 2							
He II production & top-up	11	1237.5				1237.5	
Preparation of TV/TB test	15	1687.5				1687.5	
TV/TB test	25		25**)			25	
Removal from test chamber & packing	5	562.5				562.5	
Transport to Astrium	1		25**)			25	
Depletion & warm-up	7		10.5			10.5	
Partial deintegration of PLM	14		21	21	21	21	
Contamination level of Optical Bench before integration of FM FPUs					**279.5**		

	days	ppm		local budgets (ppm)			
Cleanroom Class / affected H/W		100 000	100	CVV intern	OB & FPUs	CVV extern	Teles-cope
Integration PLM (after Qual. Test Sequence 2)							
Instruments at delivery					(300)		
Cleaning of Opt. Bench Assy and FPUs outside to a level of < 200 ppm					200		
Integration FM FPUs	32		48	48	48	48	
Closing PLM PFM	18		27	27	27	27	
Total after PLM PFM closure				**354.5**	**275**	**15 652**	**0**
PLM Acceptance Test Sequence							
Evacuation & leak test / bake-out	7/10	787.5	15			802.5	
Vibration warm	5	562.5				562.5	
Prep. cooldown & filling	18	2025				2025	
Cooldown & filling, functional test cold	10	1125				1125	
Alignment cold	5	562.5				562.5	
He II production & top-up	3	337.5				337.5	
Integr. Module test incl. instrum. oper. program	20	2250				2250	
Dark background test	10	1125				1125	
Conversion to He I & transp. to system tests (OTN)	1	112.5				112.5	
Cleaning PLM outside							
Contamination value after cleaning				**354.5**	**275**	**1000**	**0**
S/C Integration							
Mating SVM / Cryostat & Sunshield	15	1687.5				1687.5	
Cleaning and MLI installation				**354.5**	**275**	**1000**	**0**
S/C AIT Sequence							
He II production & top-up	10	1125				1125	
System (S/C) function and performance tests IST1	30	3375				3375	
EMC and short function test	10	1125				1125	
Conversion to He-I	5	562.5				562.5	
Transport to ESTEC	15		25**)			25	
Telescope at delivery							300
Integration telescope & sunshade	5	562.5				562.5	
Alignment telescope	5	562.5				562.5	
Alignment LOU	5	562.5				562.5	
Short function test	2	225				225	
Acoustic noise test & AFT	22	2475				2475	825
Sine vibration & AFT	20	2250				2250	750
Alignment check	5	562.5				562.5	
Mechanical properties	5	562.5				562.5	
SVT1	15	1687.5				1687.5	
He II production & top-up	10	1125				1125	
TV / TB thermal cycling	30		25**)			25	25
Alignment check	5	562.5				562.5	
IST2	30	3375				3375	
Conversion to He-I	7	787.5				787.5	
S/C delivery to ALCATEL at ESTEC	1	112.5				112.5	
Contingency (assumption: storage in class 100)	63		94.5			94.5	
PFM AIT total amounts	**775**			**354.5**	**275**	**22 745**	**1 900**

Transport to Kourou	10		25**)			25	
Launch campaign: preparations in S5	74	8325				8325	
Cleaning S/C outside, Value after cleaning:						**1500**	
Activities from last cleaning to encapsulation	5	560 ***				**560**	****)
Total before-encapsulation				**354.5**	**275**	**2060**	**1900**

*) For environment class 100 the original value of 1,5 ppm/day was taken for the calculation. 0,5 PPM/day would be too optimistic. PFO measurements during former programs showed that 1 ppm/day is a realistic figure for class 100 cleanrooms and 8 hours working time per day, so that 1,5 ppm/day includes some margin.

**) Assumption made by the Cleanliness Team: 25 ppm per transport and per TV / TB test.

***) Cleanroom class 100 000, 12 h S/C protected, i. e. 112.5 ppm per day for calculation

****)Assumption made that protection is removed just before encapsulation

Particulate contamination conclusion:

The particulate contamination inside the cryostat results in 354,5 ppm on structure parts and 275 ppm on the Optical Bench and FPUs.

The particulate contamination of the telescope results in 1900 ppm before encapsulation. The baseline is to keep the protective cover on the telescope during all AIT activities. Only for TV/TB test and during parts of acoustic noise and vibration testing the cover will have to be removed. Assuming that during acoustic noise and vibration testing the cover shall be removed for 33 % of the test duration, the particle fallout on the telescope was calculated here as 33 % of the value in column CVV extern.

The total value of 22 745 ppm outside PLM at the end of the AIT phase requires additional cleaning steps or a cleaner environment.

The final cleaning could be done in a step approach:

- one cleaning in Europe before mating with the S/C service module
- one cleaning in Kourou during launch campaign

This will result in a PLM outside contamination of nominally 500 ppm. Considering that not all areas can be reached properly during cleaning, a figure of < 1000 ppm after cleaning on PLM level and < 1500 ppm after cleaning on S/C level will be considered for further calculation.

ANNEX 2-2: Molecular contamination budget for Herschel EPLM AIT

The following table shows the molecular contamination budget for the Herschel EPLM AIT sequence. Only contamination coming from the environment is taken into account. Contamination of sensitive instrument surfaces due to outgassing S/C materials is part of another calculation, see annex 2-3. Also uneven distribution of contamination caused by cryo pumping or cold traps needs specific calculation and is not taken into account for the budgeting.
The growth rates are based on measurements at ESTEC facilities, ref. doc.: YTO/REP/ALL/0474/C.
Measurements at Astrium facilities revealed growth rates far below 1 ng/day, even in class 100 000.
A conclusion of the results is given at the end of the table.

	days	ng / cm2		local budgets (ng / cm2)			
Cleanroom Class / affected H/W		100 000	100	CVV intern	OB	CVV extern	Telescope
ng / cm2 / day		**4**	**1**				
(8 h work, 12 h H/W covered, 4 h margin)							
Cryostat Integration							
Requirement for PLM parts at delivery to Astrium			100	100	100	100	
Assembly SFW to He-II Tank	5		5	5	5	5	
Preparation Tank & SFW (harness, MLI...)	14		14	14	14	14	
Assembly CVV & He-II Tank & cyl. shields	15		15	15	15	15	
Installation internal harness	30		30	30	30	30	
Integration He-I Tank	6		6	6	6	6	
Integration lower shields and lower bulkhead	13		13	13	13	13	
PLM PFM (STM) Integration							
Integration optical bench incl. FPUs (STM)	16		16	16	16	16	
PLM PFM (STM) Closure	40		40	40	40	40	
PLM PFM (STM) Qual. Test Sequence 1							
Evacuation & leak check	8	32				32	
Vibration warm	10	40				40	
Prep. cooldown & filling, alignment	6	24				24	
cooldown & filling	10	40				40	
S/C Structure Qual. (SM Campaign)							
Integration EPLM (sunshield & telescope)	16	64				64	
Preparation & mating SVM-SM / EPLM	13	52				52	
Acoustic qualification (He-II tank filled with He I)	15	60				60	
Vibration cold	13	52				52	
Separation shock test	5	20				20	
Demating SVM-PLM	5	20				20	
Deintegr. sunshield & telescope (EPLM->PLM)	3	12				12	
PLM PFM (STM) Qual. Test Sequence 2							
He II production & top-up	11	44				44	
Preparation of TV/TB test	15	60				60	
TV/TB test	25		25			25	
Removal from test chamber & packing	5	20				20	
Transport to Astrium	1		1			1	
Depletion & warm-up	7		7			7	
Partial deintegration of PLM	14		14	14	14	14	
Contamination level of Optical Bench before integration of FM FPUs					253		
Integration PLM PFM							
Instruments at delivery					3000		

	days	ng / cm2		local budgets (ng / cm2)			
Cleanroom Class / affected H/W		100 000	100	CVV intern	OB & FPUs	CVV extern	Teles cope
Cleaning of Opt. Bench Assy and FPUs outside to a level of < 200 ng / cm2					200		
Integration FM FPUs	32		32	32	32	32	
Closing PLM PFM	18		18	18	18	18	
Total after PLM PFM closure				**303**	**250**	**876**	**0**
PLM Acceptance Test Sequence							
Evacuation & leak test / bake-out	7/10	28	10			38	
Vibration warm	5	20				20	
Prep. cooldown & filling	18	72				72	
Cooldown & filling, functional test cold	10	40				40	
Alignment cold	5	20				20	
He II production & top-up	3	12				12	
Integr. Module test incl. instrum. oper. program	20	80				80	
Dark background test	10	40				40	
Conversion to He I & transp. to system tests (OTN)	1	4				4	
Cleaning PLM outside							
Contamination value after cleaning				**303**	**250**	**200**	**0**
S/C Integration							
Mating SVM / Cryostat & Sunshield	15	60				60	
Cleaning and MLI installation				**303**	**250**	**200**	**0**
S/C AIT Sequence							
He II production & top-up	10	40				40	
System (S/C) function and performance tests IST1	30	120				120	
EMC and short function test	10	40				40	
Conversion to He-I	5	20				20	
Transport to ESTEC	15		15			15	
Telescope at delivery							200
Integration telescope & sunshade	5	20				20	
Alignment telescope	5	20				20	
Alignment LOU	5	20				20	
Short function test	2	8				8	
Acoustic noise test & AFT	22	88				88	30
Sine vibration & AFT	20	80				80	27
Alignment check	5	20				20	
Mechanical properties	5	20				20	
SVT1	15	60				60	
He II production & top-up	10	40				40	
TV / TB thermal cycling	30		30			30	30
Alignment check	5	20				20	
IST2	30	120				120	
Conversion to He-I	7	28				28	
S/C delivery to ALCATEL at ESTEC	1	4				4	
Contingency (assumption: storage in class 100)	63		63			63	
PFM AIT total amounts	**775**			**303**	**250**	**1076**	**287**
Transport to Kourou	10					10	
Launch campaign: preparations in S5	74	296				296	
Cleaning S/C outside (only removal of particles)							

Activities from last cleaning to encapsulation	5	20					**20**	*
Total before encapsulation					**303**	**250**	**1402**	**287**

*)Assumption made that protection is removed just before encapsulation

Molecular contamination conclusion:

The molecular contamination inside the cryostat, except for the instruments, results in 3.03 x 10E-7 g/cm2.

On the cleanable surfaces of the instruments on the Optical Bench a level of ≤ 2.5 x 10E-7 g/cm2 can be achieved. The contamination level on the non cleanable surfaces is mainly depending on the level at delivery.

Contamination caused by internal outgassing and air permeation through seals is not considered in above table, refer to section 6-3-2 and Annex 2-3.

The molecular contamination of the telescope before encapsulation results in 2,87x 10E-7 g/cm2 including the contamination level of 2 x 10E-7 g/cm2 at delivery to Astrium GmbH. The baseline is to keep the protective cover on the telescope during all AIT activities. Only for TV/TB test and during parts of acoustic noise and vibration testing the cover will have to be removed. Assuming that during acoustic noise and vibration testing the cover shall be removed for 33 % of the test duration, the particle fallout on the telescope was calculated here as 33 % of the value in column CVV extern.

The total value of 1.4 x 10E-6 g/cm2 outside PLM is considered acceptable.

ANNEX 2-3: Analysis of contamination from outgassing of organic materials inside CVV

This analysis was performed according to the calculation method in the ISO Cleanliness policy. The isolator material for the feed-through connectors is glass, and the connectors with organic isolator materials are located close to the instruments, where there temperature is below 50 K. Thus the connectors do not contribute to the thermal effective mass.

Table below: Mass and surface temperatures of organic materials inside CVV - thermal effective mass

Component	Material	Mass [kg]	Temperature [K] Ground / Orbit	Therm. effect. Mass [g]	Outgassing Prop. Simulated by	Remark
MLI on He Tanks	Mylar	6.53	100 / 30	-	Mylar	
MLI HS1 (inner layer) MLI HS1 (outer layer)	Mylar Mylar	5.25	90 / 33 146 / 40	-	Mylar Mylar	
MLI HS2 (inner layer) MLI HS2 (outer layer)	Mylar Mylar	8.02	154 / 40 208 / 53	-	Mylar Mylar	
MLI HS3 (inner layer) MLI HS3 (outer layer)	Mylar Mylar	11.26	215 / 56 289 / 65	292	Mylar Mylar	
MLI on OB shield	Mylar	1.41	25-50 / 15	-	Mylar	
MLI on Filling Ports & Valves	Mylar	0.23	298 / 65	230	Mylar	
Suspension straps	CFRP / GFRP	3 (only FRP parts) Strap4: 0.53 kg	28-100 / 10-33 93-293 / 33-70	70	CFC	only strap 4 (293K - 214K) for TEM calculation
Tank bones	CFC - tubes	0.36	2-54 / 2-17	-	CFC	
Tank Struts	CFC - tubes	0.48	2-54 / 2-17	-	CFC	
Fixations for vent line 1 on OB	CFC - angles	< 0.5	2-30 / 2-15	-	CFC	

Component	Material	Mass [kg]	Temperature [K] Ground / Orbit	Therm. effect. Mass [g]	Outgassing Prop. Simulated by	Remark
Harness insulation	Gore	4.15 (only wire insulation)	15-298 / 5-70	58	Goretex-S4	assumptions acc. to ISO cleanliness policy
Vacuum Feed-through Connectors	glass isolators	9.7 total mass of conn. inside CVV	298 / 70	-	glass	instrument connectors are below 50 K → TEM = 0
O-Rings	VITON	1.05	298	525	CFC	assumptions acc. to ISO cleanliness policy
Total		51.94		522 g Mylar 595 g CFC 58 g Goretex 1175 g		

View Factors:
Following the logic given in the ISO cleanliness policy, the view factor can be calculated as follows:

V total = V1 x V2

$$V1 = \frac{\text{Surface of openings to instruments in Heat Shield 1}}{\text{Surface of all openings in Heat Shield 1}}$$

$$V2 = \frac{\text{Cleanliness sensitive surfaces (mirrors \& SPIRE filter)}}{\text{total surface inside the OB cavity}}$$

Openings in HS1:
F1: Ring slot on top (Baffle ring under Cryo cover), open to instr.
F2: 7 holes for LOU windows ø 35 and 2 alignment holes ø 34, open to instr.
F3: Slots around tank suspension straps, open to tank, 16 x 5 cm2
F4: Cut-out for rupture disc ø 100

V1 = (F1+F2) / (F1+F2+F3+F4) = (88+85)cm2 / (85+85+80+78)cm2 = 0,523

V2 = (70+90+50)cm2 / (1.3+2.1+1.96+4+4.8)x10000 cm2 = 0.00148

V total = 0.523 x 0.00148 = 0.000774

TEM x V total:

58 g Goretex x 0.000774 = 0.045 g
595 g CFC x 0.000774 = 0.46 g
522 g Mylar x 0.000774 = 0.40 g

Calculation of tolerable H2O mass:
Surface of instrument mirrors & SPIRE filter: 210 cm2
Max. allowed EOL contamination: 6x10-6 g/cm2
Contamination at instruments delivery to S/C AIT: 3x10-6 g/cm2
Contamination on instruments from environment during S/C AIT: 0.05x10-6 g/cm2
Tolerable H2O contamination: 6 - 3.05 = 2.95x10-6 g/cm2
Total tolerable H2O mass = 2.95x10-6 g/cm2 x 210 cm2 = **6.2 x 10-4 g**

Bake out 100h at 80 °C

Material	TEM (g)	Cont pot. (%)	H2O mass (g)
Gore	0.045	10-5	4.5x10-9
CFC	0.46	0.1	4.6x10-4
Mylar	0.40	2x10-4	8.0x10-7
		Sum:	**4.6x10-4**

Contamination potentials taken from ISO Cleanliness Policy
Similar to the ISO approach VITON was calculated with VBQC values measured for CFC (worst case).
Nevertheless the calculated 4.6 x 10-4 g is below the tolerable mass of 6.2 x 10-4 g

The figure for contamination from CVV internal outgassing is 4.6 10-4/210 cm² = 22 10-7 g/cm²

ANNEXE 3

Meteoroids impact

ISO (according to RD06)

diameter(mm)	flux(impact/m2/year)	Sd (year-1)
2,25E-03	1114	7,09E-08
4,86E-03	711	2,11E-07
1,05E-02	343	4,75E-07
2,25E-02	122	7,76E-07
4,86E-02	32,4	9,62E-07
1,05E-01	6,48	8,98E-07
2,25E-01	0,673	4,28E-07
4,86E-01	4,12E-02	1,22E-07
1,05E+00	2,52E-03	3,49E-08
2,25E+00	1,55E-04	9,86E-09
4,86E+00	9,46E-06	2,81E-09
1,05E+01	5,79E-07	8,02E-10
		3,99E-06
ppm EOL		**5,99E+00**

Herschel/Planck

diameter(mm)	flux(impact/m2/year)	Sd (year-1)
0,001	162,355	2,04E-09
0,01	14,1969	1,78E-08
0,03	3,23992	3,66E-08
0,05	1,19637	3,76E-08
0,07	0,549184	3,38E-08
0,09	0,288108	2,93E-08
0,1	0,216457	2,72E-08
0,3	0,0151895	1,72E-08
0,5	0,00260643	8,19E-09
0,7	0,000771818	4,75E-09
1	0,000204886	2,57E-09
3	2,97E-06	3,36E-10
5	9,87E-07	3,10E-10
7	2,61E-07	1,61E-10
10	6,33E-08	7,95E-11
30	7,85E-10	8,88E-12
		2,18E-07
ppm EOL Herschel		**7,63E-01**
ppm EOL Planck		**3,27E-01**

ANNEXE 4
Identification of organic material

I)PLANCK

I-1°) SVM

SUBSYSTEM/ITEM	SURFACE	TEMPERATURE	MASS OF ORGANIC MATERIAL	TML/CVCM	COMMENTS
STRUCTURE					
PANELS Sandwich aluminium skin Thermal coatings	10 M² 16 m² internal 6m² external		2 KG of BSL 312 L Black paint Z306 :2,24Kg Black paint Z 306 or DC93500 for OSR	TML: 0.40-0.70 / CVCM: 0.01-0.09 TML:1.5 / CVCM: 0.02 TML:0.3 / CVCM:0.03	10 m² on equipment = 1,4 Kg on equipment
Central tube Sandwich CFRP skin 0.8mm thick			10 Kg of CFRP G969/M18 1 Kg of BSL 319 L	TML: ? / CVCM: ? TML: 1.15-1.31 / CVCM: 0.01-0.05	Mass of resin ? TVS data referred to cured samples (1h @ 170/175°C)
Shear walls Sandwich CFRP skin			6 Kg of CFRP resin G969/M18 0.6 Kg of BSL 319 L	TML? CVCM ? TML: 1.15-1.31 / CVCM: 0.01-0.05	Mass of resin ? TVS data referred to cured samples (1h @ 170/175°C)
Top platform Sandwich CFRP skin			7 Kg of CFRP resin G801/M18 1.8 Kg of BSL 319 L	TML? CVCM ? TML: 1.15-1.31 / CVCM: 0.01-	Mass of resin ? TVS data referred to

				0.05	cured samples (1h @ 170/175°C)
Lower closure panel Sandwich CFRP skin			6 Kg of CFRP resin G801/M18 1.4 Kg of BSL 319 L	TML? CVCM ? TML: 1.15-1.31 / CVCM: 0.01-0.05	Mass of resin ? TVS data referred to cured samples (1h @ 170/175°C)
Sub platform Sandwich CFRP skin			6 Kg of CFRP resin G801/M18 0.6 Kg of BSL 319 L	TML? CVCM ? TML: 1.15-1.31 / CVCM: 0.01-0.05	Mass of resin ? TVS data referred to cured samples (1h @ 170/175°C)
Support propellant tanks Sandwich CFRP skin			4.5 Kg of CFRP M55J / M18 0.5 Kg of Hysol EA9321	TML:0,3 CVCM :0,0 TML: 0.48-1.24 / CVCM: 0.00-1.00	Mass and ref of resin ? TVS Data referred to cured samples (see MAPTIS code 05289)
RCS support panel Sandwich CFRP skin			3 Kg of CFRP G801/M18 0.5 Kg of BSL 319 L	TML? CVCM ? TML: 1.15-1.31 / CVCM: 0.01-0.05	Mass and ref of resin ? TVS data referred to cured samples (1h @ 170/175°C)
Glue for insert potting			5 Kg STYCAST 1090/9	TML: 0.75-1.93 / CVCM: 0.00-0.43	
TCS					
MLI	12M² internal (8 on tanks , 4 on panels) 30 m² external (14 for back side of solar array ,		Kapton Mylar Dacron Kapton Mylar	TML 1.3 CVCM 0.04 TML 0.3 CVCM:0.03 TML:0.3 CVCM:0.03 TML 1.3 CVCM 0.04 TML 0.3 CVCM:0.03	

	12 under grooves , 4 on panels)		Dacron Nomex Thread RTV 566 Scotch Y-966 Araldite AV 138 Narmco 506/1581 HI-AIR Velcro Teflon	TML:0.3 CVCM:0.03 TML: 4.00 / CVCM: 0.05-0.10 TML: 0.10-0.80 / CVCM: 0.00-0.21 TML: 0.29-5.15 / CVCM: 0.00-0.05 TML: 0.89-1.11 / CVCM: 0.01-0.02 TML: 0.69-0,80 / CVCM: 0.01-0.02 TML: 4.38-6.62 / CVCM: 0.92-2.10	Data are for Narmco 506/81
PCS					
Solar array			11 Kg of CFRP(M18/M55J) 2.4 Kg of redux 319 1.2Kg of DC93500 1.6Kg of RTVS691	TML:0.3 CVCM:0.00 TML 1.2 / CVCM:0.01 TML:0.3 CVCM:0.03 TML: 0.45 CVCM:0.07	Mass of resin ?
PCDU			TBD		
CDMS					
CDMU / ACC			EC 2216 RTV S-691 Z 306 CV 14-2500		For ACC (TBD)
RCS			TBD		
TT&C			TBD		
Harness			TBD		
Payload Warm Units			TBD		

I-2°) PPLM

Hypothesis on composite material mass of resin 40 % of total mass (fiber 60 %)
Hypothesis on mass of glue for Alu on honey comb: 150 G/m²
Hypothesis: thickness of Z 306 40 μm< < 100μm density 1,4 g/m²/μm

SUBSYSTEM	SURFACE	TEMPERATURE	MASS OF ORGANIC MATERIAL	TML/CVCM	COMMENTS
Grooves Sandwich alu skin 0.3 mm thick high 20. mm N°1 N°2 N°3 Or Aluminised kapton 0.08 μm glued with FM24 100 μm	20.18 m² 19.18 m² 11.29 m² 29 m² of painted surface on upper part of groove 3 at the external of the baffle trace (7+ 22 on open honey comb H 10mm)	150 K 100 K 50 K	Glue for alu on NIDA BSL 312 L 7,5 Kg Paint Nextel Suede 3101 125 μm	TML:0,4à0,7 % CVCM:0,01 à 0,09	Hyp: Open honey comb 11080 cells/m² Diam cell 9.5 mm
Cryo structure struts 12 struts GFRP diam 50 mm thick 2mm	1;28 m² of painted surface		Total mass of GFRP 10 Kg Paint Nextel Suede-3101 125 μm	TML: CVCM:	Paint Nextel Suede 3101 125 μm Visible lenght740 mm
Baffle Sandwich alu skin 2 mm thick high 20 mm	Internal aluminium 8;09 m² or Aluminised kapton 0.08 μm glued with FM24 100 μm Paint on 33.7 m² on external (8.1 + 25.6 on open honeycomb High		4,5 Kg Glue for alu on NIDA:BSL 312 L Paint Nextel Suede 3101 125 μm	TML:0,4à0,7 % CVCM:0,01 à 0,09	Hyp: Open honey comb 11080 cells/m² Diam cell 9.5 mm

	10 mm)				
PR support structure Honey comb carbon skin CFRP M40B/Cyanates ester 1.5 mm thick Internal: aluminium or Aluminised kapton 0.08 µm glued with FM24 100 µm External: paint Struts :M55J/Epoxy 3 mm thick , length 70 mm	2.95 m² painted surface on external side 2.95m²of kapton 50µm on internal side On struts 1.68 m² of painted area Miscellaneous : 1.3 m² of painted area .		Total mass of CFRP struts : 15 Kg Total mass of CFRP Kapton skin : 17 Kg Paint Nextel Suede 3101 125 µm 1 Kg of Glue BSL 312 L	TML:1,4 CVCM:0,04	
SR support structure Honey comb carbon skin CFRP M40B/Cyanates ester 2 mm thick Struts: M55J/Epoxy 3 mm thick	0.17 m² painted surface on external side 0.17 m²of kapton 50µm on internal side On struts 0.14 m² of painted area Miscellaneous :0.36 m² of painted area .		Total mass of CFRP struts : 1,5 Kg Total mass of CFRP skin : 1,7 Kg Paint Nextel Suede 3101 125 µm 50 g of Glue BSL 312 L	TML:0,4 à0,7 CVCM:0,01à0,09	
Telescope frame CFRP, M55J/Cyanates ester 2 mm thick 90 mmX90 mm	2.95 m² of painted area		Total mass of CFRP 25Kg Paint Nextel Suede 3101 125 µm		
Primary reflector Carbon Honey comb M 60J/L20SL carbon skinM60J/L20SL 1.8 mm	Active surface aluminised 2.4 m² Back surface with aluminised kapton 2.4		75 g of kapton	TML: 1,4 CVCM:0,04	

thick+gelcoat 39 μmtick + AL 0.5 μm thick+SI02	m^2				
Secondary reflector Carbon Honey comb M 60J/L20SL carbon skinM60J/L20SL 1.8 mm thick+gelcoat 39 μmtick + AL 0.5 μm thick+SI02	Active surface aluminised 1.09 m^2 Back surface with aluminised kapton 1.09 m^2		30 g of kapton	TML: 1,4 CVCM:0,04	

II)HERSCHEL

II-1°) SVM

SUBSYSTEM	SURFACE	TEMPERATURE	MASS OF ORGANIC MATERIAL	TML/CVCM	COMMENTS
STRUCTURE					
PANELS Sandwich aluminium skin Thermal coatings	10 M^2 20 m^2 internal $4m^2$ external		2 KG of BSL 312 L Black paint Z306 Black paint Z 306	TML: 0.40-0.70 / CVCM: 0.01-0.09 TML 1.5 CVCM: 0.02	 10 m^2 on equipements
Central tube Sandwich CFRP skin 0.8mm thick			10 Kg of CFRP G969/M18 1 Kg of BSL 319 L	TML: ?/ CVCM:? TML: 1.15-1.31 / CVCM: 0.01-0.05	Mass of resin ? TVS data referred to cured samples (1h @ 170/175°C)

Shear walls Sandwich CFRP skin			6 Kg of CFRP resin G969/M18 0.6 Kg of BSL 319 L	TML? CVCM ? TML: 1.15-1.31 / CVCM: 0.01-0.05	Mass of resin ? TVS data referred to cured samples (1h @ 170/175°C)
Top platform Sandwich CFRP skin			7 Kg of CFRP resin G801/M18 1.8 Kg of BSL 319 L	TML? CVCM ? TML: 1.15-1.31 / CVCM: 0.01-0.05	Mass of resin ? TVS data referred to cured samples (1h @ 170/175°C)
Lower closure panel Sandwich CFRP skin			6 Kg of CFRP resin G801/M18 1.4 Kg of BSL 319 L + 2 Kg of CFRP resin G801/M18 0.2 Kg of BSL 319 L	TML? CVCM ? TML: 1.15-1.31 / CVCM: 0.01-0.05 TML: 1.15-1.31 / CVCM: 0.01-0.05	Mass of resin ? TVS data referred to cured samples (1h @ 170/175°C) TVS data referred to cured samples (1h @ 170/175°C)
Sub platform Sandwich CFRP skin			6 Kg of CFRP resin G801/M18 0.6 Kg of BSL 319 L	TML? CVCM ? TML: 1.15-1.31 / CVCM: 0.01-0.05	Mass of resin ? TVS data referred to cured samples (1h @ 170/175°C)
Support propelant tanks Sandwich CFRP skin			6 Kg of CFRP M55J / M18 0.5 Kg of Hysol EA9321	TML:0,03 CVCM 0,0 TML: 0.48-1.24 / CVCM: 0.00-1.00	Mass and ref of resin ? TVS Data referred to cured samples (see MAPTIS code 05289)

RCS support panel Sandwich CFRP skin			3 Kg of CFRP G801/M18 0.5 Kg of BSL 319 L	TML? CVCM ? TML: 1.15-1.31 / CVCM: 0.01-0.05	Mass and ref of resin ? TVS data referred to cured samples (1h @ 170/175°C)
Glue for insert potting			5 Kg STYCAST 1090/9	TML: 0.75-1.93 / CVCM: 0.00-0.43	
TCS					
MLI	3M² internal (on tanks) 30 m² external (12 for back side , 12 for TOPs , 6 on panels)		Kapton Mylar Dacron Kapton Mylar Dacron Nomex Thread RTV 566 Scotch Y-966 Araldite AV 138 Narmco 506/1581 HI-AIR Velcro Teflon	TML 1.3 CVCM 0.04 TML 0.3 CVCM:0.03 TML:0.3 CVCM:0.03 TML 1.3 CVCM 0.04 TML 0.3 CVCM:0.03 TML:0.3 CVCM:0.03 TML: 4.00 / CVCM: 0.05-0.10 TML: 0.10-0.80 / CVCM: 0.00-0.21 TML: 0.29-5.15 / CVCM: 0.00-0.05 TML: 0.89-1.11 / CVCM: 0.01-0.02 TML: 0.69-0,80 / CVCM: 0.01-0.02 TML: 4.38-6.62 / CVCM: 0.92-	

				2.10	
PCS					
PCDU			TBD		
CDMS					
CDMU / ACC			EC 2216 RTV S-691 Z 306 CV 14-2500		For ACC (TBD)
RCS			TBD		
TT&C			TBD		
Harness			TBD		
Payload Warm Units			TBD		

II-2°)H EPLM

Component	Material	Mass (kg) or Area	Temperature (K) Ground/Orbit	TML % RML % CVCM %	Test Ref.	Remark
Black paint on Baffles, tbc	Herberts 1002 E or Chemglaze Z 306 or Nextel Black	0.23 m^2	Baffle on HS1: 90 / 33 Baffle on HS2: 154 / 40 Baffle on HS3: 215 / 56	1.90 1.40 0.04 ------------- 1.08 0.47 0.00 ------------- 1.97 0.55 0.00	I-626 I-512 I-FC 9018	paint type tbd listed here only for information, painting is an option, but currently not foreseen to be applied
MLI on CVV heat shields and He Tanks	Mylar, double aluminised tbc	total 35	HS1i: 90/33 HS1o: 146/40 HS2i: 154/40 HS2o: 208/53 HS3i: 215/56 HS3o: 289/65 Tank: 100/30	0.36 0.24 0.01	E-301	Type and outg. values taken from ISO Cleanl. Policy i: inner layer o: outer layer
Suspension straps	T300 carbon / S2-glass fibre fibre with epoxy resin V913	3	T300 CFRP: 28-100 / 10-33 S2- GFRP: 93-293 / 33-70	0.80 0.27 0.02	INTA 626 E	same material as used for ISO
Tank bones	CFC - tubes Resin type tbd	0.36	2-54 / 2-17	0.98 0.64 0.03	I-629	Outg. values taken from ISO Cleanl. Policy
Tank Struts	CFC - tubes Resin type tbd	0.48	2-54 / 2-17	0.98 0.64 0.03	I-629	Outg. values taken from ISO Cleanl. Policy
Fixations for vent line 1 on OB	CFC - angles Resin type tbd	< 0.5	2-30 / 2-15	0.98 0.64 0.03	I-629	Outg. values taken from ISO Cleanl. Policy
Harness insulation (only wire insulation)	PTFE Kapton	total 19	tbd	0.20 0.20 0.00 ------------- 0.87 0.52 0.00	I-543 M/C 65439	data of Gore wire HV 2019 CR data of Kapton foil

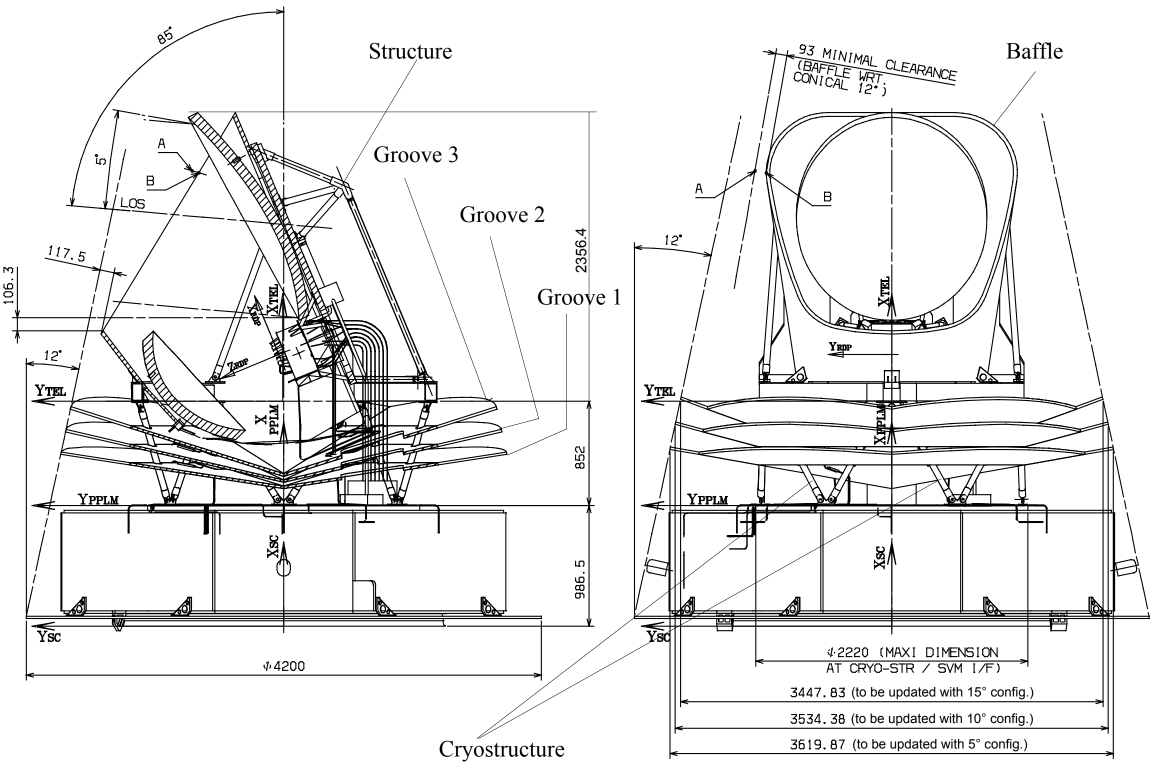
Table 1: Organic materials inside CVV

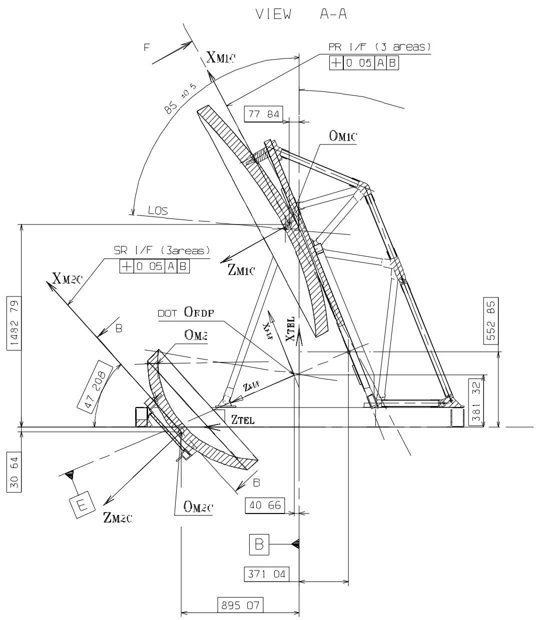
Component	Material	Mass (kg) or Area	Temperature (K) Ground/Orbit	TML % RML % CVCM %	Test Ref.	Remark
Black paint on 4 of the 6 sides of the radiator noses	Herberts 1002 E or Chemglaze Z 306 or Nextel Black	2.22 m^2	293 / 70 ±10	1.90 1.40 0.04 ------------- 1.08 0.47 0.00 ------------- 1.97 0.55 0.00	I-626 I-512 I-FC 9018	paint type tbd painting is one option, black anodizing is also possible
MLI (on CVV, HSS radiators)	Mylar, double aluminised tbc	60	293 / 125-260	0.36 0.24 0.01	E-301	Type and outg. values taken from ISO Cleanl. Policy
Sunshield	CFRP facesheets Prepreg type tbd	13	293 / 403	0.98 0.64 0.03	I-629	Outg. values taken from ISO Cleanl. Policy
Sunshade	CFRP facesheets Prepreg type tbd	15	293 / 270	0.98 0.64 0.03	I-629	Outg. values taken from ISO Cleanl. Policy
Telescope Mounting Structure	GFRP type tbd	ca. 20	tbd	0.98 0.64 0.03	I-629	Outg. values taken from ISO Cleanl. Policy
HSS Supp. Struct.	GFRP type tbd	ca. 50	293/ 70-403	0.98 0.64 0.03	I-629	Outg. values taken from ISO Cleanl. Policy
PLM / SVM Struts	GFRP type tbd	ca. 35	293 / 70-293	0.98 0.64 0.03	I-629	Outg. values taken from ISO Cleanl. Policy
Adhesive film for HSS panels	tbd	17	293 / 270-403	1.00 1.00 0.10	specified limits	worst case assumption
Miscellaneous adhesives	tbd	tbd	tbd	1.00 1.00 0.10	specified limits	worst case assumption
Harness insulation (only wire insulation)	PTFE Kapton	total 19	tbd	0.20 0.20 0.00 ------------- 0.87 0.52 0.00	I-543 M/C 65439	data of Gore wire HV 2019 CR data of Kapton foil

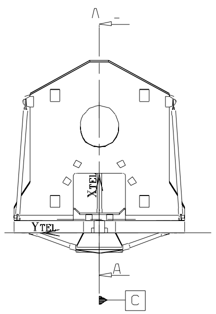
Table 2: Organic materials outside CVV

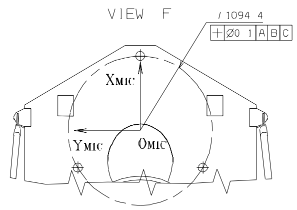
ANNEXE 5

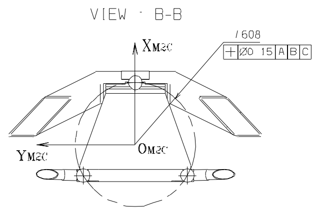
P-PLM general overview

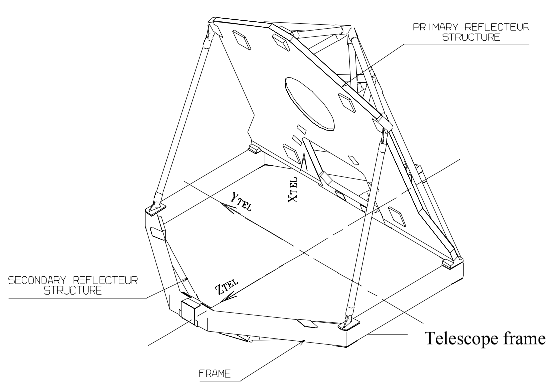


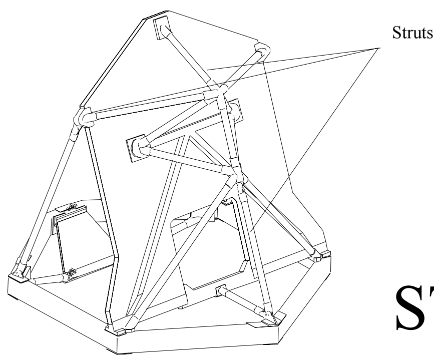

VIEW A-A
PR I/F (3 areas)
SR I/F (3areas)
LOS
DOT
77 84
1492 79
552 85
381 32
47 208
30 64
40 66
371 04
895 07



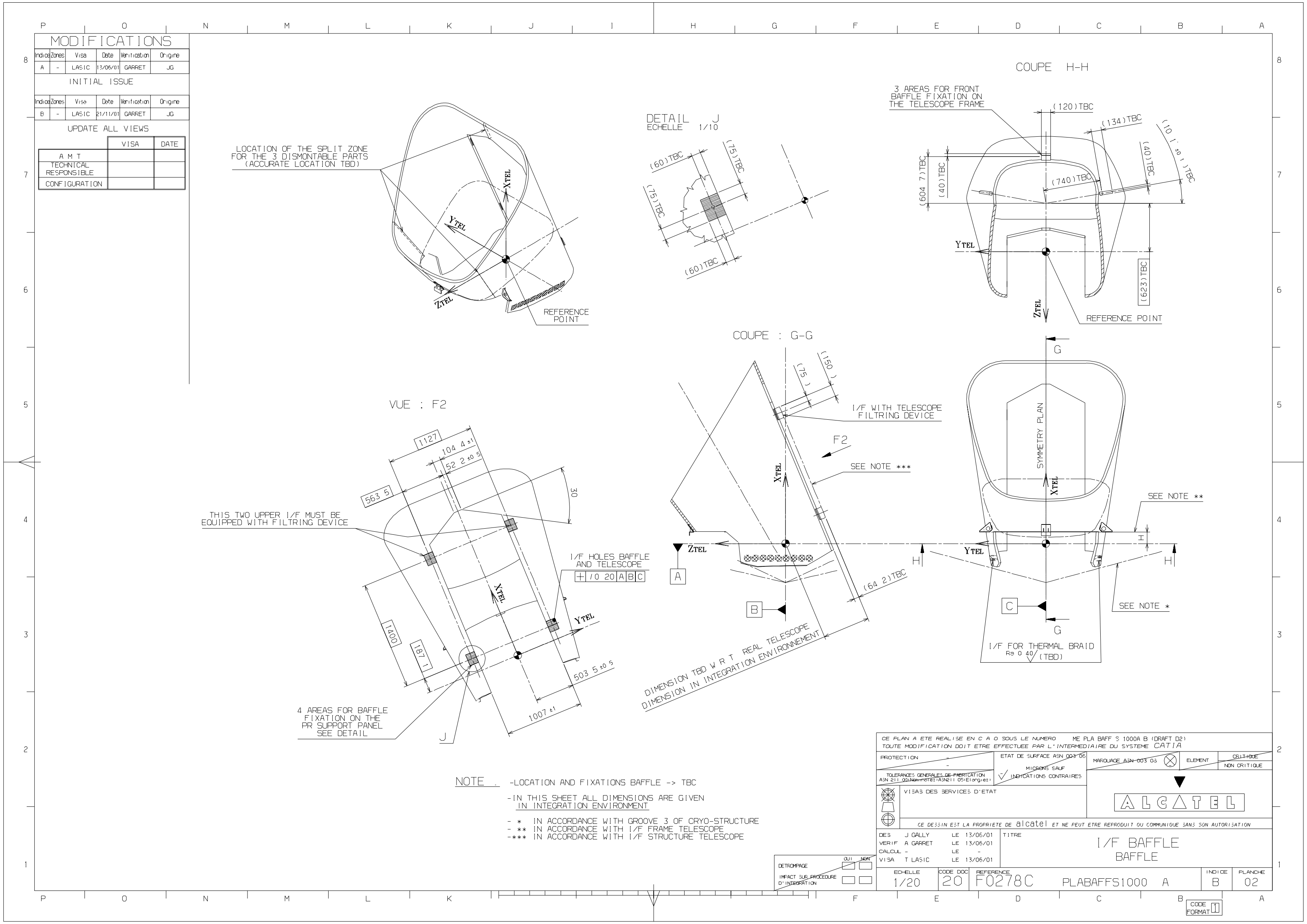

VIEW F
1094 4

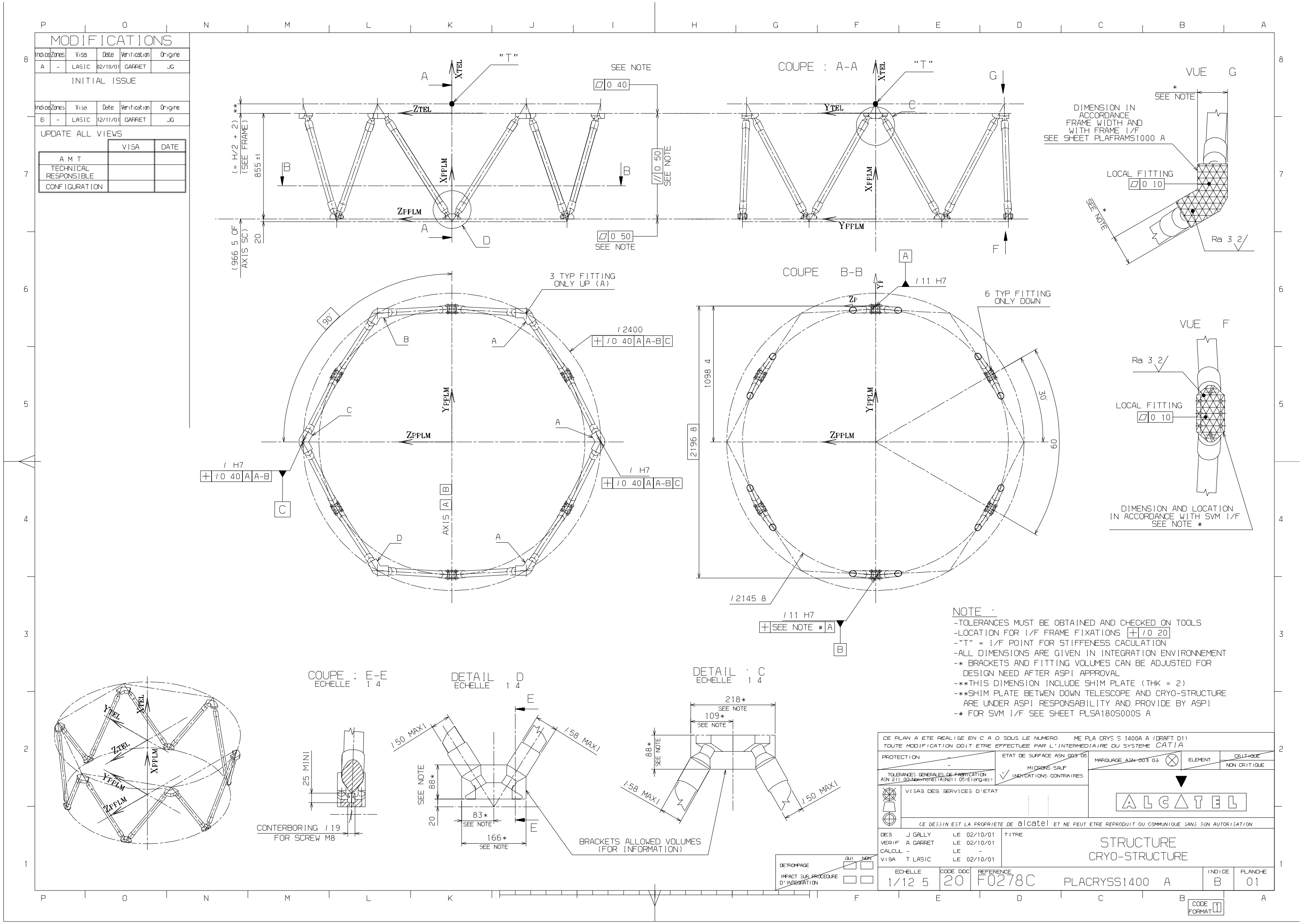

VIEW · B-B
608


PRIMARY REFLECTEUR STRUCTURE
SECONDARY REFLECTEUR STRUCTURE
FRAME
Telescope frame

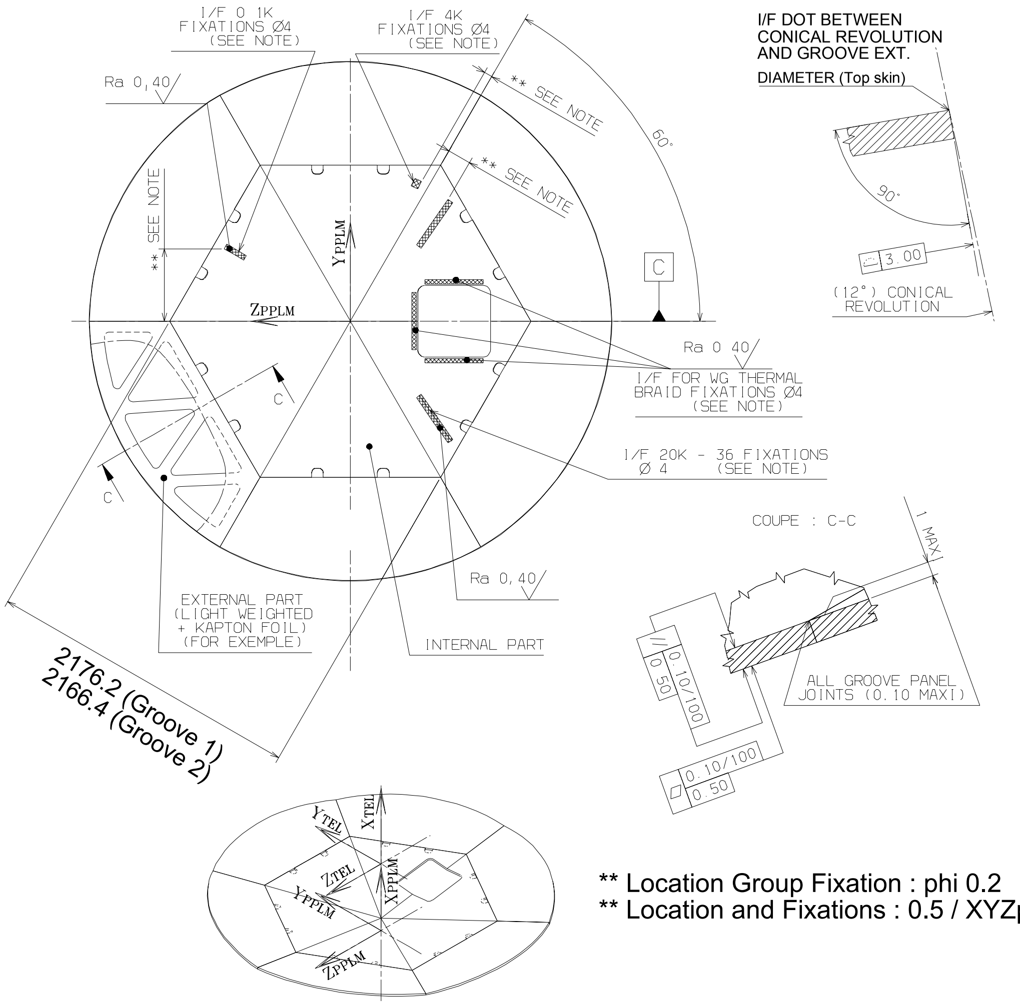

Struts

STRUCTURE


MODIFICATIONS
Indice Zones Visa Date Verification Origine
A - LASIC 13/06/01 GARRET JG
INITIAL ISSUE
B - LASIC 21/11/01 GARRET JG
UPDATE ALL VIEWS
VISA DATE
A M T
TECHNICAL RESPONSIBLE
CONFIGURATION
LOCATION OF THE SPLIT ZONE FOR THE 3 DISMONTABLE PARTS (ACCURATE LOCATION TBD)
REFERENCE POINT
DETAIL J
ECHELLE 1/10
COUPE H-H
3 AREAS FOR FRONT BAFFLE FIXATION ON THE TELESCOPE FRAME
REFERENCE POINT
COUPE : G-G
I/F WITH TELESCOPE FILTRING DEVICE
F2
SEE NOTE ***
SEE NOTE **
SEE NOTE *
SYMMETRY PLAN
I/F FOR THERMAL BRAID
VUE : F2
THIS TWO UPPER I/F MUST BE EQUIPPED WITH FILTRING DEVICE
I/F HOLES BAFFLE AND TELESCOPE
4 AREAS FOR BAFFLE FIXATION ON THE PR SUPPORT PANEL SEE DETAIL
DIMENSION TBD W R T REAL TELESCOPE
DIMENSION IN INTEGRATION ENVIRONNEMENT
NOTE : -LOCATION AND FIXATIONS BAFFLE -> TBC
-IN THIS SHEET ALL DIMENSIONS ARE GIVEN IN INTEGRATION ENVIRONMENT
- * IN ACCORDANCE WITH GROOVE 3 OF CRYO-STRUCTURE
- ** IN ACCORDANCE WITH I/F FRAME TELESCOPE
-*** IN ACCORDANCE WITH I/F STRUCTURE TELESCOPE
CE PLAN A ETE REALISE EN C A O SOUS LE NUMERO ME PLA BAFF S 1000A B (DRAFT D2)
TOUTE MODIFICATION DOIT ETRE EFFECTUEE PAR L'INTERMEDIAIRE DU SYSTEME CATIA
ALCATEL
I/F BAFFLE
BAFFLE
DES J GALLY LE 13/06/01
VERIF A GARRET LE 13/06/01
VISA T LASIC LE 13/06/01
ECHELLE 1/20
CODE DOC 20
REFERENCE F0278C
PLABAFFS1000 A
INDICE B
PLANCHE 02

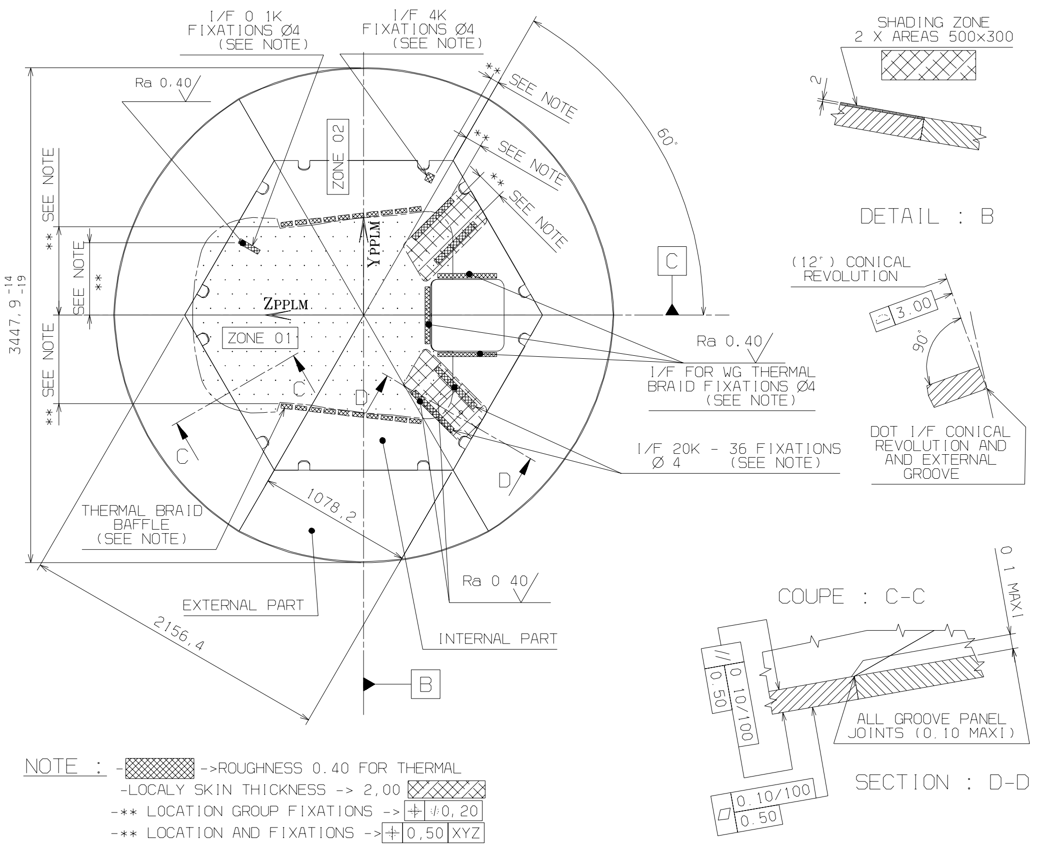


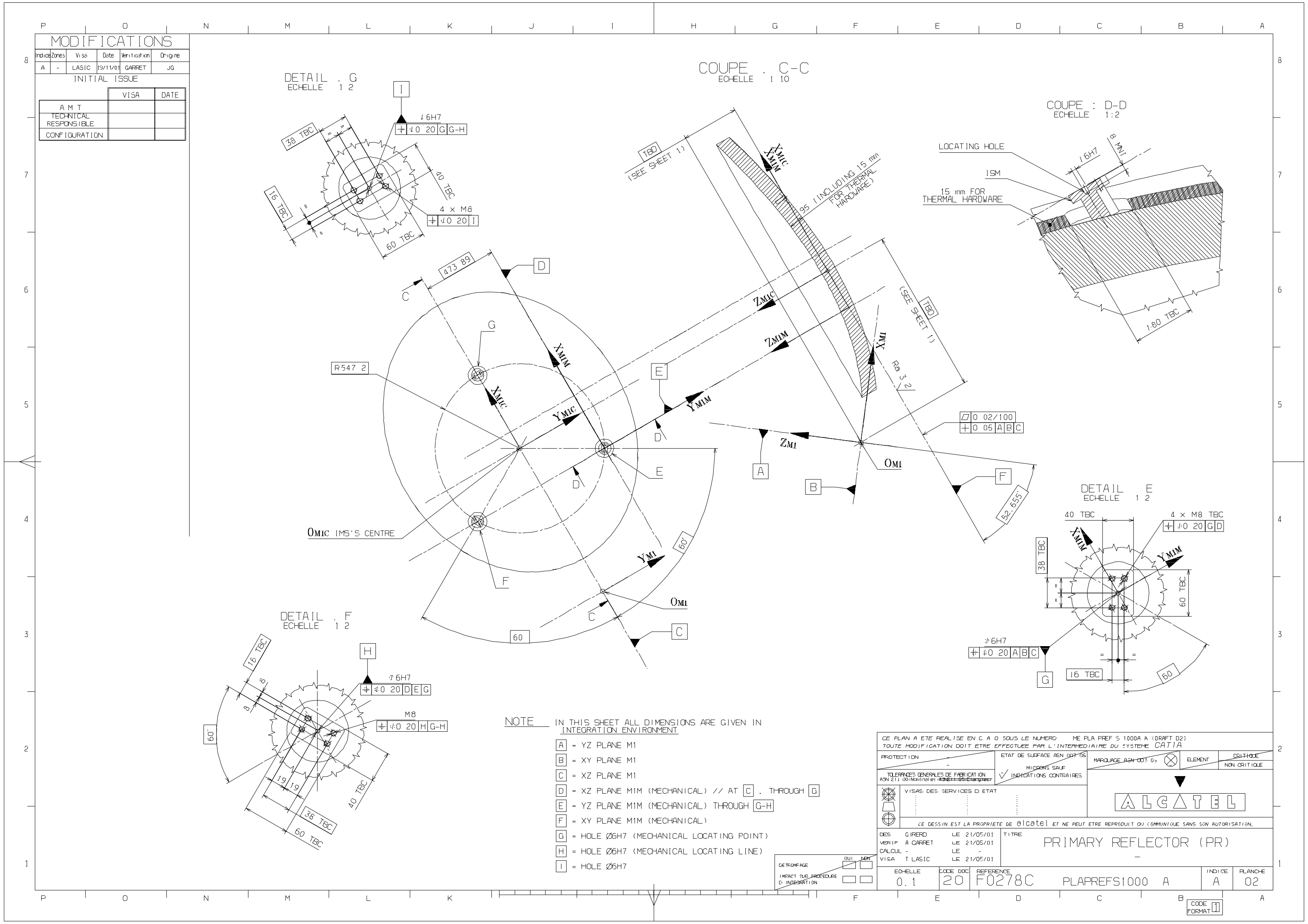
MODIFICATIONS
A - LASIC 02/10/01 GARRET JG
INITIAL ISSUE
B - LASIC 12/11/01 GARRET JG
UPDATE ALL VIEWS
COUPE : A-A
COUPE B-B
VUE G
VUE F
3 TYP FITTING ONLY UP (A)
6 TYP FITTING ONLY DOWN
LOCAL FITTING
DIMENSION IN ACCORDANCE FRAME WIDTH AND WITH FRAME I/F SEE SHEET PLAFRAMS1000 A
DIMENSION AND LOCATION IN ACCORDANCE WITH SVM I/F SEE NOTE *
COUPE : E-E ECHELLE 1 4
DETAIL D ECHELLE 1 4
DETAIL C ECHELLE 1 4
CONTERBORING / 19 FOR SCREW M8
BRACKETS ALLOWED VOLUMES (FOR INFORMATION)
NOTE :
-TOLERANCES MUST BE OBTAINED AND CHECKED ON TOOLS
-LOCATION FOR I/F FRAME FIXATIONS
-"T" = I/F POINT FOR STIFFENESS CACULATION
-ALL DIMENSIONS ARE GIVEN IN INTEGRATION ENVIRONNEMENT
-* BRACKETS AND FITTING VOLUMES CAN BE ADJUSTED FOR DESIGN NEED AFTER ASPI APPROVAL
-**THIS DIMENSION INCLUDE SHIM PLATE (THK = 2)
-**SHIM PLATE BETWEN DOWN TELESCOPE AND CRYO-STRUCTURE ARE UNDER ASPI RESPONSABILITY AND PROVIDE BY ASPI
-# FOR SVM I/F SEE SHEET PLSA180S000S A
ALCATEL
STRUCTURE
CRYO-STRUCTURE
1/12 5
F0278C
PLACRYSS1400 A
B
01

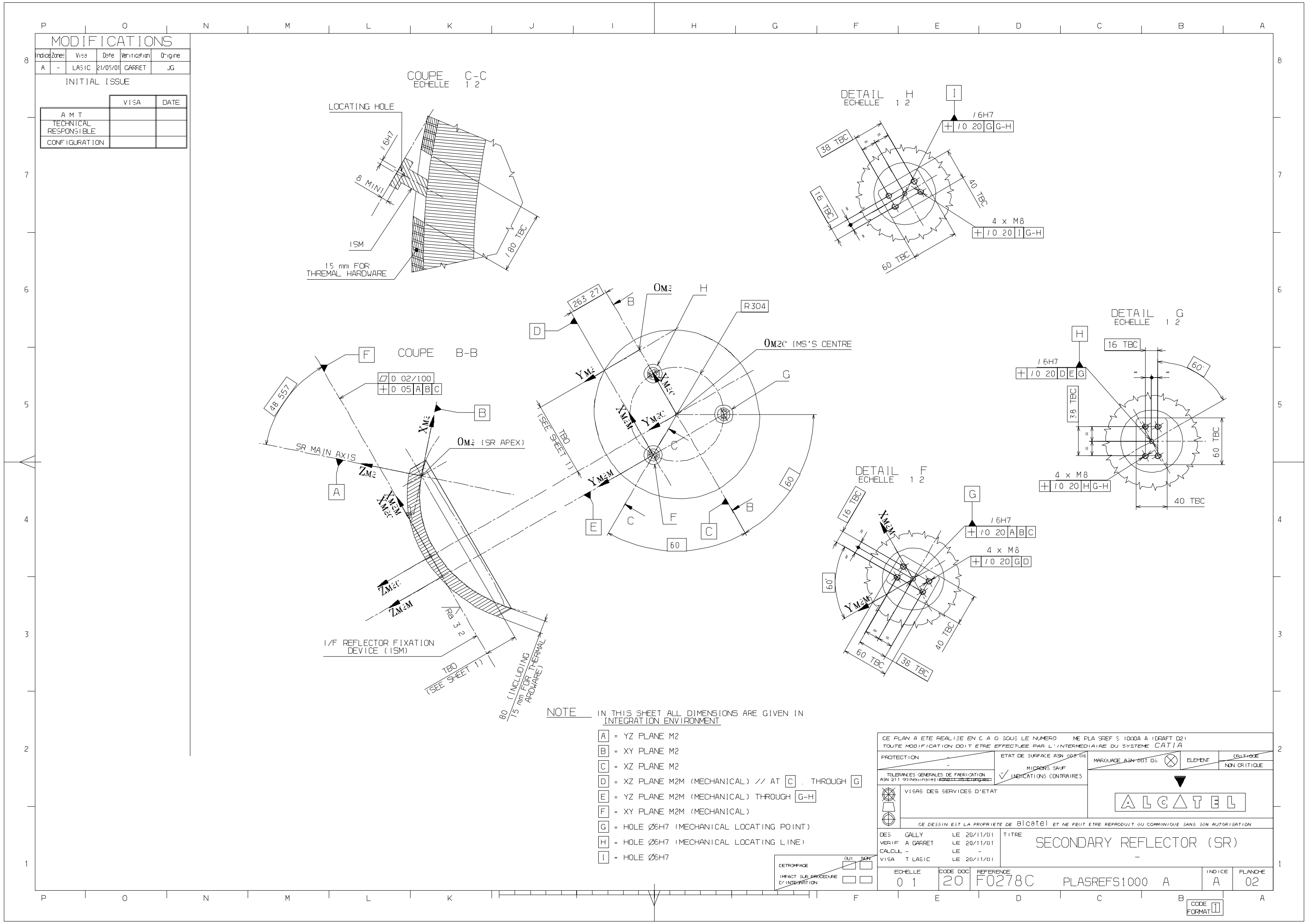


** Location Group Fixation : phi 0.2

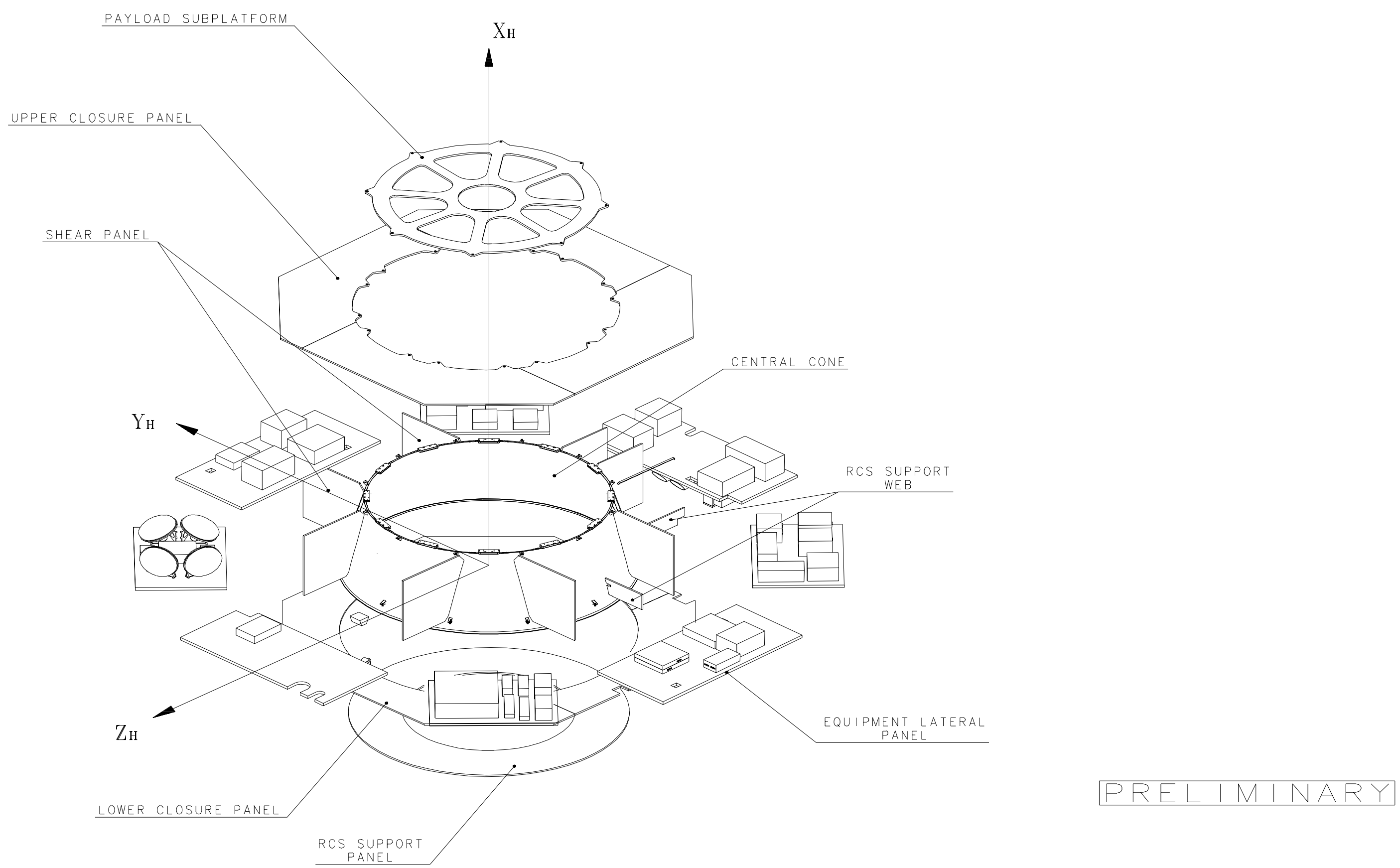
** Location and Fixations : 0.5 / XYZpplm


I/F 0.1K FIXATIONS Ø4 (SEE NOTE)
I/F 4K FIXATIONS Ø4 (SEE NOTE)
Ra 0.40
** SEE NOTE
60°
ZONE 02
ZONE 01
YPPLM
ZPPLM
C
D
Ra 0.40
I/F FOR WG THERMAL BRAID FIXATIONS Ø4 (SEE NOTE)
I/F 20K - 36 FIXATIONS Ø 4 (SEE NOTE)
THERMAL BRAID BAFFLE (SEE NOTE)
1078,2
EXTERNAL PART
2156,4
INTERNAL PART
B
3447,9
SHADING ZONE 2 X AREAS 500x300
DETAIL : B
(12°) CONICAL REVOLUTION
3.00
90°
DOT I/F CONICAL REVOLUTION AND AND EXTERNAL GROOVE
COUPE : C-C
0.1 MAXI
0.10/100
0.50
ALL GROOVE PANEL JOINTS (0.10 MAXI)
SECTION : D-D
NOTE : - ->ROUGHNESS 0.40 FOR THERMAL
-LOCALY SKIN THICKNESS -> 2,00
-** LOCATION GROUP FIXATIONS -> Ø0,20
-** LOCATION AND FIXATIONS -> 0,50 XYZ

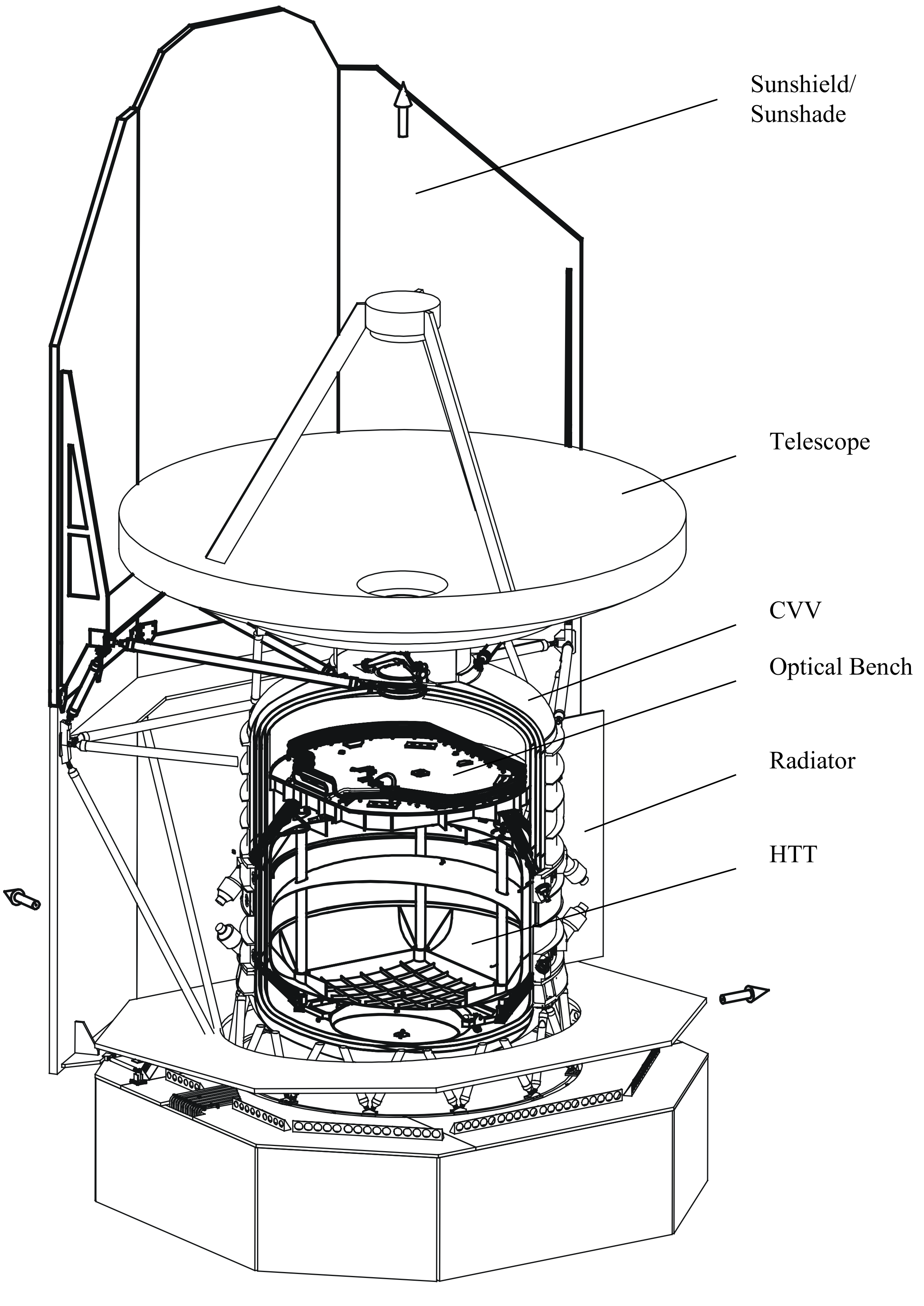

MODIFICATIONS
INITIAL ISSUE
DETAIL . G
ECHELLE 1 2
COUPE . C-C
ECHELLE 1 10
COUPE : D-D
ECHELLE 1:2
LOCATING HOLE
15 mm FOR THERMAL HARDWARE
95 (INCLUDING 15 mm FOR THERMAL HARDWARE)
(SEE SHEET 1)
OMIC IMS'S CENTRE
DETAIL . F
ECHELLE 1 2
DETAIL E
ECHELLE 1 2
NOTE IN THIS SHEET ALL DIMENSIONS ARE GIVEN IN INTEGRATION ENVIRONMENT
A = YZ PLANE M1
B = XY PLANE M1
C = XZ PLANE M1
D = XZ PLANE M1M (MECHANICAL) // AT C . THROUGH G
E = YZ PLANE M1M (MECHANICAL) THROUGH G-H
F = XY PLANE M1M (MECHANICAL)
G = HOLE Ø6H7 (MECHANICAL LOCATING POINT)
H = HOLE Ø6H7 (MECHANICAL LOCATING LINE)
I = HOLE Ø6H7
ALCATEL
PRIMARY REFLECTOR (PR)
F0278C
PLAPREFS1000 A


MODIFICATIONS
INITIAL ISSUE
COUPE C-C
COUPE B-B
DETAIL H
DETAIL G
DETAIL F
LOCATING HOLE
15 mm FOR THREMAL HARDWARE
SR MAIN AXIS
I/F REFLECTOR FIXATION DEVICE (ISM)
NOTE IN THIS SHEET ALL DIMENSIONS ARE GIVEN IN INTEGRATION ENVIRONMENT
A = YZ PLANE M2
B = XY PLANE M2
C = XZ PLANE M2
D = XZ PLANE M2M (MECHANICAL) // AT C . THROUGH G
E = YZ PLANE M2M (MECHANICAL) THROUGH G-H
F = XY PLANE M2M (MECHANICAL)
G = HOLE Ø6H7 (MECHANICAL LOCATING POINT)
H = HOLE Ø6H7 (MECHANICAL LOCATING LINE)
I = HOLE Ø6H7
ALCATEL
SECONDARY REFLECTOR (SR)
F0278C
PLASREFS1000 A

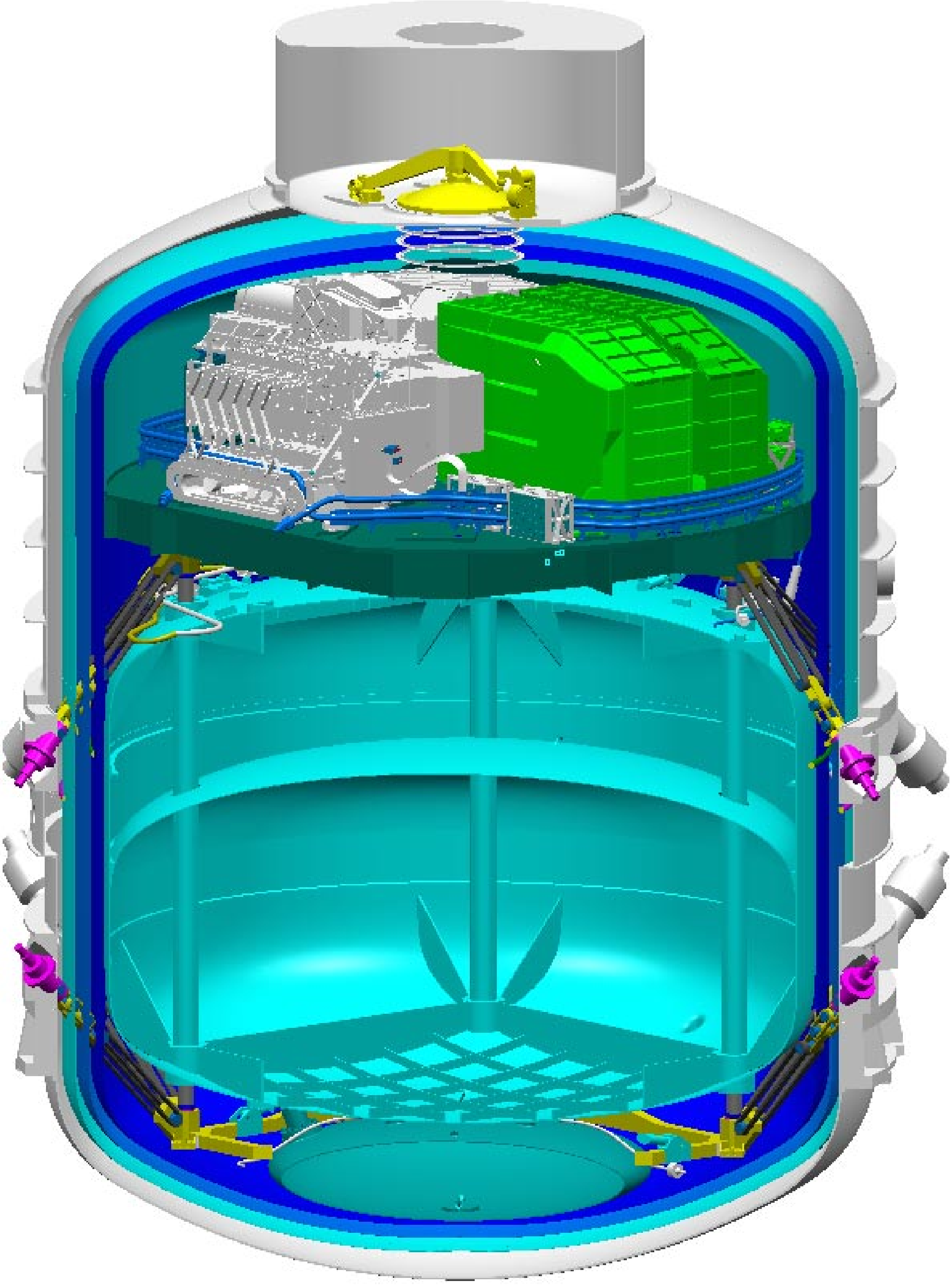
Herschel SVM exploded view



Herschel S/C


Sunshield/
Sunshade
Telescope
CVV
Optical Bench
Radiator
HTT

Herschel CVV



Jean-Michel Lamarre
<lamarre@ias.fr>

19/12/01 10:09

To: Pierre Olivier/estec/ESA@ESA
cc: heurtel@
Subject: Re: mole contamination EoL

Dear Pierre

During 3rd CWG curves have been presented giving absorption versus the complex index for molecular contamination. It appears that a 30nm thickness layer of contaminant entails at the most an 0.002 absorption coefficient.
Alcatel has proposed an EoL molecular contamination of 7x10-6 g/cm2 for the telescope and mirrors.
Considering these curves, this value (70nm of contaminant) gives an absorption coefficient of 0,006.
This value is acceptable for HFI EoL.

Jean-Michel Lamarre

Jean-Michel Lamarre
LERMA: +33 1 40 51 20 64/+33 1 40 51 20 07
IAS: + 33 1 69 85 85 77/+33 1 69 85 85 13