HERSCHEL / PLANCK

Planck Telescope Optical and RF System Specification (PTELORF-S)

H-P-3-ASPI-SP-0274

Product Code : 220 000

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ENREGISTREMENT DES EVOLUTIONS / *CHANGE RECORD*

ISSUE	DATE	§ : DESCRIPTION DES EVOLUTIONS *§ : CHANGE RECORD*	REDACTEUR *AUTHOR*
01	01/07/02		
2.0	09-Apr-2004	Issue for the Planck Critical Design Review Data Package including : **- the clarifications agreed in EM from Daniel de Chambure dated on February, 6th, 2004** Document generated by DOORS 5.2 / TREK 3.0. §2.1 Terms and acronyms : FPU introduced § 3.1 Applicable documents : Reflector specification reference corrected § 3.1 Applicable documents : SRS reference corrected § 3.2 Referencee documents : H-P-3-ASP-PL-137 Optical and RF verification and test Plan added § 4.1 Description of the Planck telescope assembly : "ISM" added for clarification § 4.2 General functional requirement of the telescope : HFI and LFI added § 4.3 Axis system : "see figure 4.3.3 added" §5.2.1, § before Table 5.2.1-2: "table below" replaced by "table 5.2.1-2". §5.2.1 Telescope performance : LFI 100 GHz horn removed of table 5.2.1-2 and table 5.2.1-3. §5.2.1, § after Table 5.2.1-2: "table below" replaced by "table 5.2.1-3". §5.2.1 Telescope performance : Title for the table of the gaussian apodisation definition added. Theoritical telescope WFE table renamed 5.2.1-3. § 5.2.2 Straylight : RD 2 replaced by AD4 §5.4 Interface requirements : AD 4 replaced by AD 2, AD 3 and AD 4. **- Additional updates proposed by ASP :** § Annex 1 : Update of the verification matrix. Comments (1), (2), (3) and (4) added. § Annex 1 : All P-TEL-PERF replaced by P-TEL-PER. § Annex 1 : Verification matrix updated according to the uptade applied to P-TEL-FUN-005 (typo error) Verification by test at telescope level for § Annex 1 : P-TEL-VER-060 removed (verification by inspection of the correct responsibility definition	J.B.Riti

ISSUE	DATE	§ : DESCRIPTION DES EVOLUTIONS *§ : CHANGE RECORD*	REDACTEUR *AUTHOR*
		will be enough) Requirements modified in, new in or deleted in issue 2.0: see list below.	

List of the requirements modified, deleted or new in issue 2.0

§ nb	Req. identifier	Change Status	Doc. issue	Reason of Change	Change Ref.
§5.1	**[P-TEL-PER-005 a]**	Modified in	2.0	Typo error correction and requirement identifier P-TEL-FUN-005 replaced by P-TEL-PER-005.	
§5.2	**[P-TEL-PER-010 a]**	Modified in	2.0	Typo error.	
§5.2.1	**[P-TEL-PER-020 a]**	Modified in	2.0	Typo error.	
§5.2.1	**[P-TEL-PER-030 a]**	Modified in	2.0	Evolution of the LFI design (100 GHz channels removed) / § 5.8 added / "Table 5.2.1-1" replaced by "Table 5.2.1-4".	
§5.2.1	**[P-TEL-PER-035 a]**	Modified in	2.0	Evolution of the LFI design (100 GHz channels removed) / § 5.8 added / Title of the table added / TBC removed.	
§5.2.1	**[P-TEL-PER-040 a]**	Modified in	2.0	Typo error corrected ("P-TEL-PER-035 and P-TEL-PER-035" replaced by "P-TEL-PER-030 and P-TEL-PER-035").	
§8.3	**[P-TEL-VER-040 a]**	Modified in	2.0	Typo error : Paragraph 6.5 replaced by Paragraph 6.	
§8.3	**[P-TEL-VER-045 a]**	Modified in	2.0	Typo error : Paragraph 6.5 replaced by Paragraph 6.	
§8.3	**[P-TEL-VER-050 a]**	Modified in	2.0	Typo error : Paragraph 6.5 replaced by Paragraph 6.	
§8.3	**[P-TEL-VER-052 a]**	Modified in	2.0	Typo error : reference to P-TEL-PERF-03 replaced by reference to P-TEL-PERF-030 / spill-over lobes added.	

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1. INTRODUCTION AND SCOPE

1.1 Introduction

ESA's Horizon 2000 Science Programme has two important missions for performing astronomical investigations in the far-infrared, sub-millimetre and millimetre wavelength range:

- FIRST, the Far Infrared and Sub-millimetre Telescope, an observatory type mission;
- Planck, a survey mission.

Planck is the third Medium size mission of the ESA long term scientific plan Horizon 2000. The scientific payload forms an integrated mutually complementary package optimized to fulfil the scientific aims of the mission.

The objective of the Planck mission is to image over the whole sky the temperature anisotropy's of the cosmic background radiation, with a sensitivity $\Delta T/T < 2x10^{-6}$ and an angular resolution down to 10 arcminutes for LFI and to 5 arcminutes for HFI. To achieve this objective, the whole sky will be mapped in nine frequency channels ranging between 25 and 1000 GHz, with a sensitivity and an angular resolution which allow the separation of the cosmological signal from all other sources of confusion.

The Planck Telescope consists of two ellipsoidal reflectors (primary and secondary), the supporting structures. The Focal Plane Assembly includes both instruments, (LFI and HFI) and its mounting structure (3 bibodes) through which it is mounted to the telescope structure. The telescope assembly is composed of the telescope and the FPA. The reflectors are Customer Furnished Equipment's. The IMS are part of the reflector delivery (not part of the telescope).

The Telescope main Baffle is not a part of the Telescope.

1.2 Scope

This document specifies the global system performance and the qualification tests of the **telescope assembly**, taking into account the reflectors and FPA performances as guaranteed respectively by the reflector's supplier instruments teams.

2. TERMS, ACRONYMS AND ABBREVIATION LIST

2.1 Terms and acronyms

AD	Applicable Document
BOL	Begin of Life
EOL	End of Life
EP	Entrance Pupil
FPA	Focal Plane Assembly
FPU	Focal Plane Unit
FOV	Field-of-view
ISM	Isostatic Mounting System
HFI	High Frequency Instrument
LFI	Low Frequency Instrument
LOS	Line Of Sight
MOS	Margin of Safety
NYA	Not Yet Available
N/A	Not applicable
PA	Product Assurance
PLM	Payload Module
PPLM	Planck Payload Module
PR	Primary Reflector
PSF	Point-Spread-Function
PtV	Pic to valley
RD	Reference Document
RH	Relative Humidity
RMS	Root Mean Square
S/C	Spacecraft
SR	Secondary Reflector
TA	Telescope Assembly
TBC	To be confirmed
TBD	To be determined
WFE	Wave Front Error
wrt	With Regards To

2.2 Abbreviation list for requirements

The requirements in this specification have been systematically numbered. The code applied consists of four letters and three digits. The four letters start for the telescope with PT, continued with an abbreviation of the area concerned. The systematic applied is illustrated in the below given table.

Requirement Type	Abbreviation	Specification paragraph
Functional	P-TEL-FUN- xxx	5.1.
Performance	P-TEL-PER- xxx	5.2
Environmental	P-TEL-ENV-xxx	6.
Product Assurance	P-TEL-PA-xxx	7.
Verification	P-TEL-VER-xxx	8.

3. DOCUMENTS

The following documents of the exact issue shown form a part of this specification. In the event of conflict between documents referenced herein and the content of the specification, the contents of this specification shall be considered a superseding requirement.

3.1 Applicable documents

Ref.	No.	Issue/date	Title
AD 1	SCI-PT-RS-07422	Latest issue	Primary Reflector, Secondary Reflector and Inner Baffle Specification
AD 2	SCI-PT-IIDB/ HFI04141	Latest issue	HFI Instrument Interface Document
AD 3	SCI-PT-IIDB/LFI04142	Latest issue	LFI Instrument Interface Document
AD 4	SCI-PT-RS-05991	Latest issue	H/P System requirement Specification

3.2 Reference documents

Ref.	No.	Issue/date	Title
RD 1	SCI-PT—IIDA-04624	Latest issue	Instrument Interface Document – Part A
RD 2	H-P-3-ASPI-SP-004	Latest issue	Planck telescope specification
RD 3	H-P-3-ASP-PL-0137	Latest Issue	Planck Optical and RF verification and test plan

4. GENERAL DESCRIPTION

4.1 Description of the Planck telescope assembly

The Planck Telescope is designed as an off-axis tilted system offering the advantage of an unblocked aperture. The telescope LOS lies in the Z, X plane of the spacecraft co-ordinate system and is tilted at an angle of 85° with respect to the X spacecraft axis.

The telescope has an off axis 1.5 m diameter projected aperture and operates at a temperature between 40K and 65K.

The telescope is composed of :

- an ellipsoidal primary reflector (PR)
- an ellipsoidal secondary reflector (SR)
- the telescope structure
- The Focal Plane Unit
- instrumentation for the telescope hardware as required (heaters, temperature sensors).
- the required hardware to interface with the PPLM (cryo-structure, baffle) and the instruments (FPA, Wave guide, harness, J-FET box)

Any readout/operation of telescope instrumentation is considered part of the PPLM, i.e. is not performed by the Planck telescope.

The telescope interfaces with the spacecraft (PPLM).

An overview of the telescope is given in on Figure 4.1-1. The telescope structure is mainly composed of the following elements :

- the main frame interfacing with the cryo-structure and supporting the PR structure, the SR structure and the telescope baffle
- the primary reflector structure made of :
  - a sandwich panel on which is mounted the PR through flexible blades (ISMs) and inserts.
  - a set of struts fixed on the back side of the PR panel to increase its stiffness
  - 2 lateral struts to support the PR panel onto the main frame.
- the secondary reflector structure made of :
  - a triangular frame (or plate) on which is mounted the SR through flexible blades (ISMs) and inserts.
  - a set of struts which support SR plate onto the main frame

The PR panel and the main frame provide respectively 4 and 2 I/F points for FPA fixation (3 bipods).

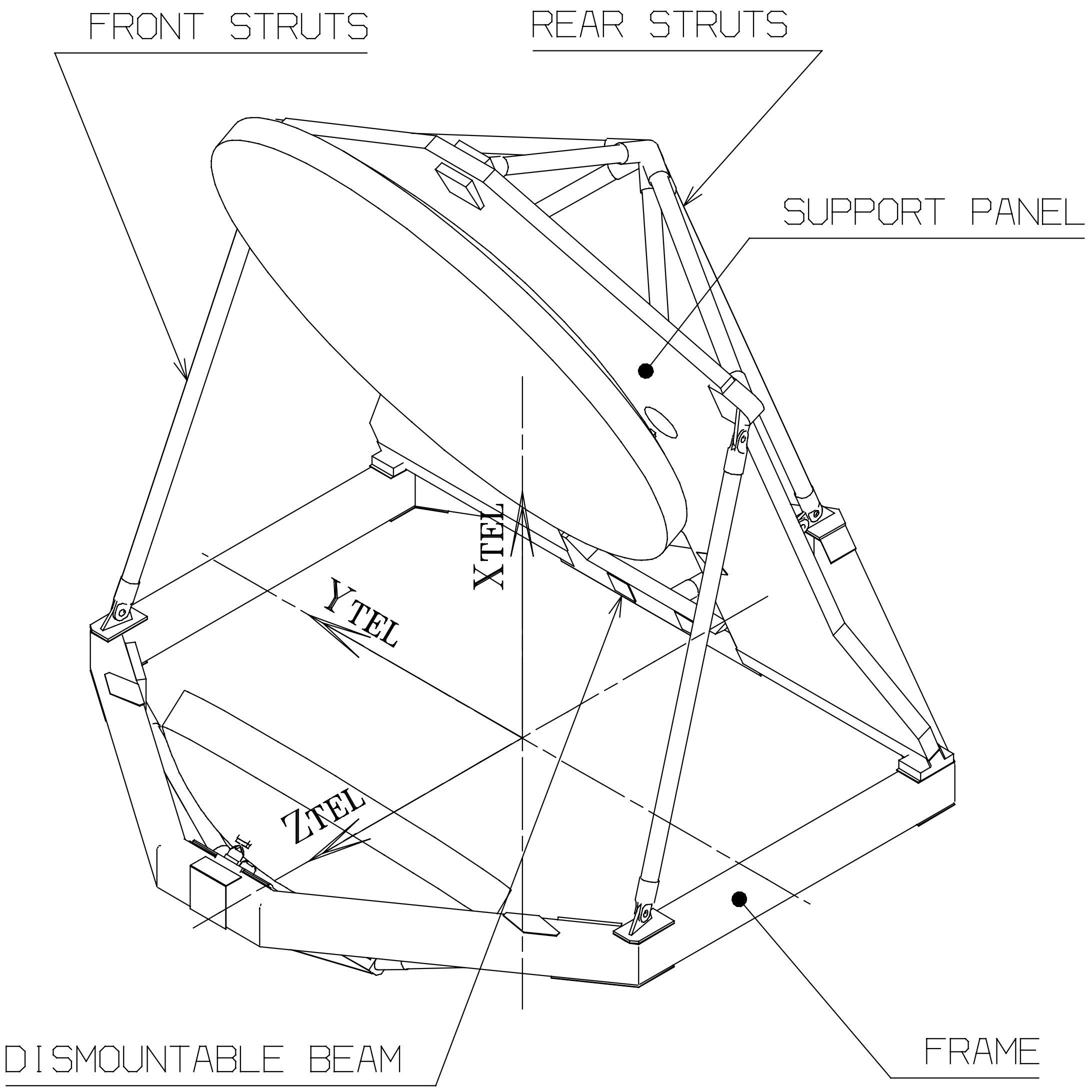


Figure 4.1-1: telescope overview

4.2 General functional requirement of the telescope

The telescope primary reflector shall collect the electromagnetic radiation and shall deliver the collected power via the secondary reflector to the HFI and LFI Planck instruments

4.3 Axis System

Different axis systems are appropriate for the Planck s/c, the telescope, the FPU and the reflectors.

These co-ordinate systems are summarized in this paragraph. All co-ordinate systems defined below are right-handed Cartesian systems.

Planck s/c axis system

The Planck s/c co-ordinate system (0_{sc}, X_{sc}, Y_{sc}, Z_{sc}) is defined as follows (Figure 4.3-2)

- the origin 0_{sc} is at centre of the s/c to launcher i/f,
- the X_{sc} is the spin axis of the s/c with the sun nominally in –x direction,
- the Zsc axis is perpendicular to the Xsc axis and contained in the symmetry plane of the telescope, with the positive direction on the concave side of the telescope
- the Y_{sc} complements the co-ordinate system.

Planck Telescope axis system

The Planck Telescope co-ordinate system (0_{Tel}, X_{Tel}, Y_{Tel}, Z_{Tel}) is a shifted s/c co-ordinate system and defined as follows (see Figure 4.3-2) :

- the origin 0_{Tel} is the intersection of the interface plane P1 made by the lower face of the hexagonal frame and the X_{sc},
- the X_{Tel} is the s/c X_{sc} axis,
- the Y_{Tel} is the s/c Y_{sc} axis,
- the Z_{Tel} complements the co-ordinate system.

Planck Telescope Primary Reflector axis system

The Planck Telescope Primary Reflector co-ordinate system (0_{M1}, X_{M1}, Y_{M1}, Z_{M1}) system is a local co-ordinate system and defined as follows (see Figure 4.3-3)

- the origin 0_{M1} is at the vertex of the primary reflector,
- the X_{M1} is along the minor axis of the ellipsoid, with positive direction toward the PR
- the Z_{M1} is the X_{M1} is along the major axis of the ellipsoid, with positive direction on the concave side of the PR
- Y_{M1} complete the frame

Planck Telescope Secondary Reflector axis system

The Planck Telescope Secondary Reflector co-ordinate system (0_{M2}, X_{M2}, Y_{M2}, Z_{M2}) system is a local co-ordinate system and defined as follows (see Figure 4.3-3:

- the origin 0_{M2} is at the vertex of the vertex of the SR
- the X_{M2} is along the minor axis of the ellipsoid with positive direction toward the PR
- the Z_{M2} is along the major axis of the ellipsoid, with positive direction on the convex side of the SR
- Y_{M2} complete the frame

Planck Telescope Reference Detector Plane axis system

The Planck FPU co-ordinate system (0_{RDP}, X_{RDP}, Y_{RDP}, Z_{RDP}) is defined as follow (see Figure 4.3-2)

- the origin 0_{RDP} is at nominal focus of the telescope, i.e. at the centre of the FOV,
- the Z_{RDP} is within the s/c X-Z plane, positive in the direction of the SR and tilted of 21.27° from X_{M2}
- the X_{RDP} is perpendicular to the Z_{FPU} axis, within the s/c X-Z plane, positive in the direction of the primary reflector
- the Y_{RDP} complements the co-ordinate system.

The LOS nominal direction is defined as the direction of the incident beam in the object space which is imaged by the perfect telescope at the 0_{RDP} point.

The actual LOS direction is defined as the direction of the incident beam in the object space which is imaged by the actual telescope at the 0_{RDP} point.

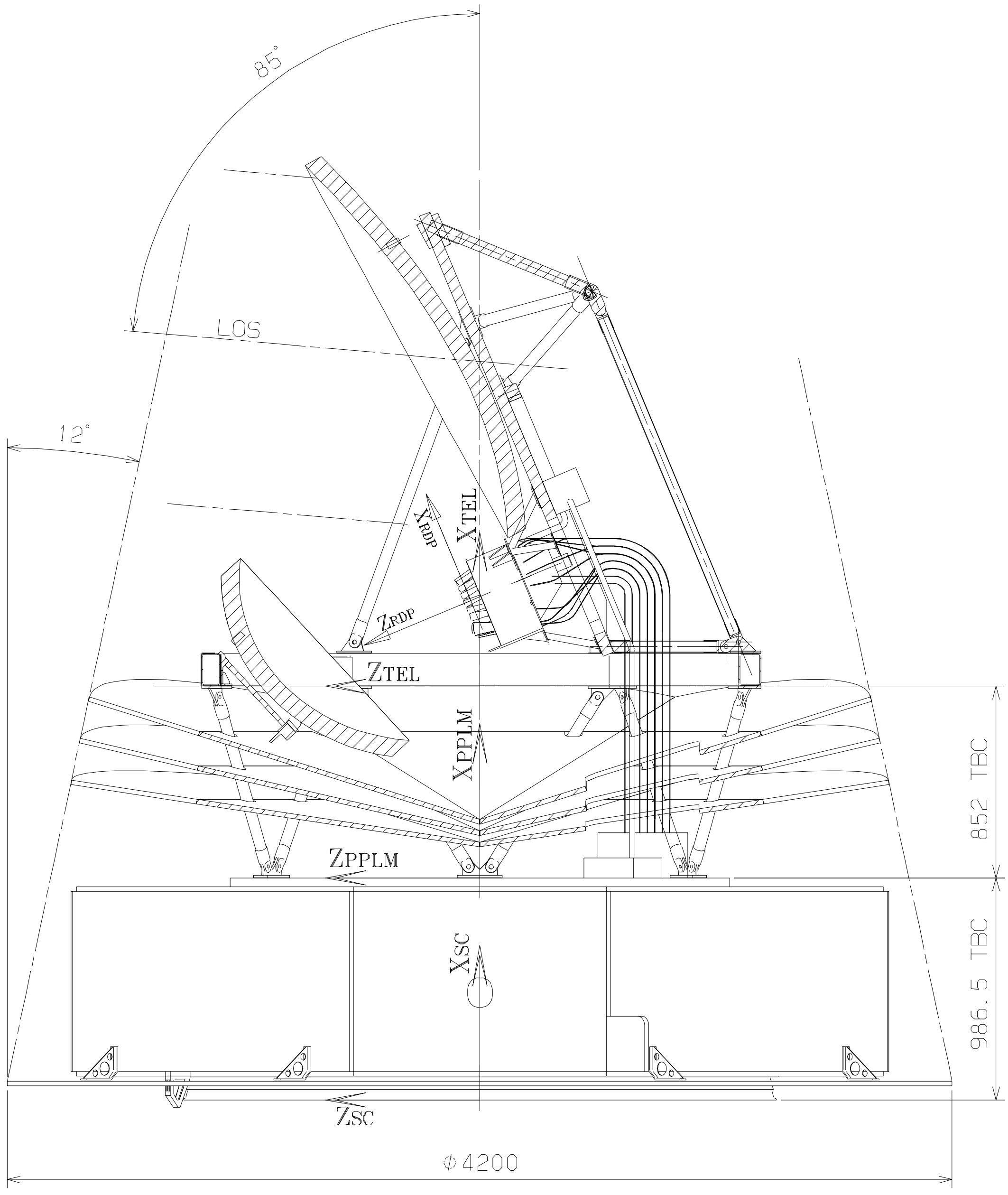


Figure 4.3-1 : Spacecraft axis system

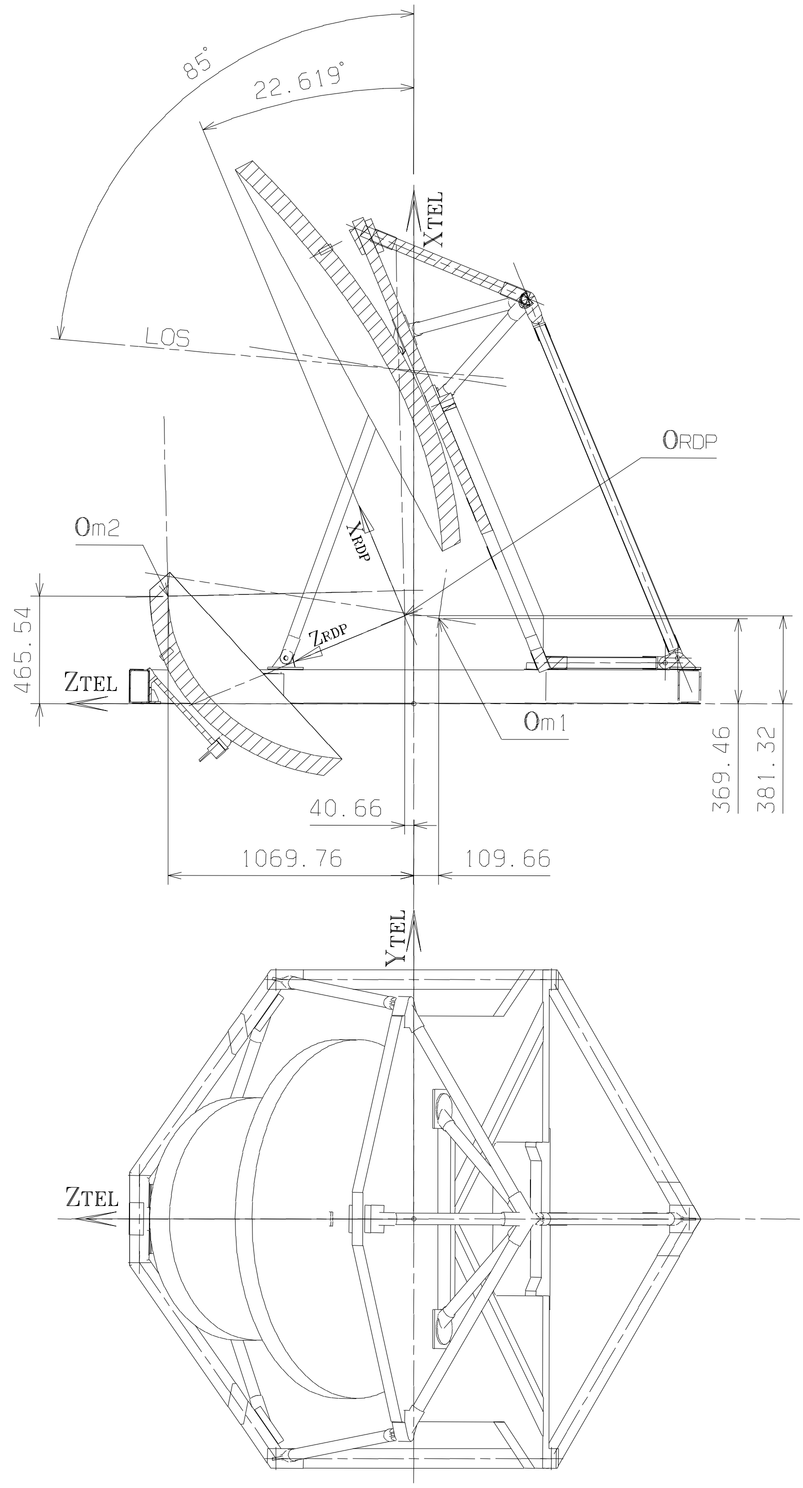


Figure 4.3-2 : Telescope, reflector and detector plane axis system

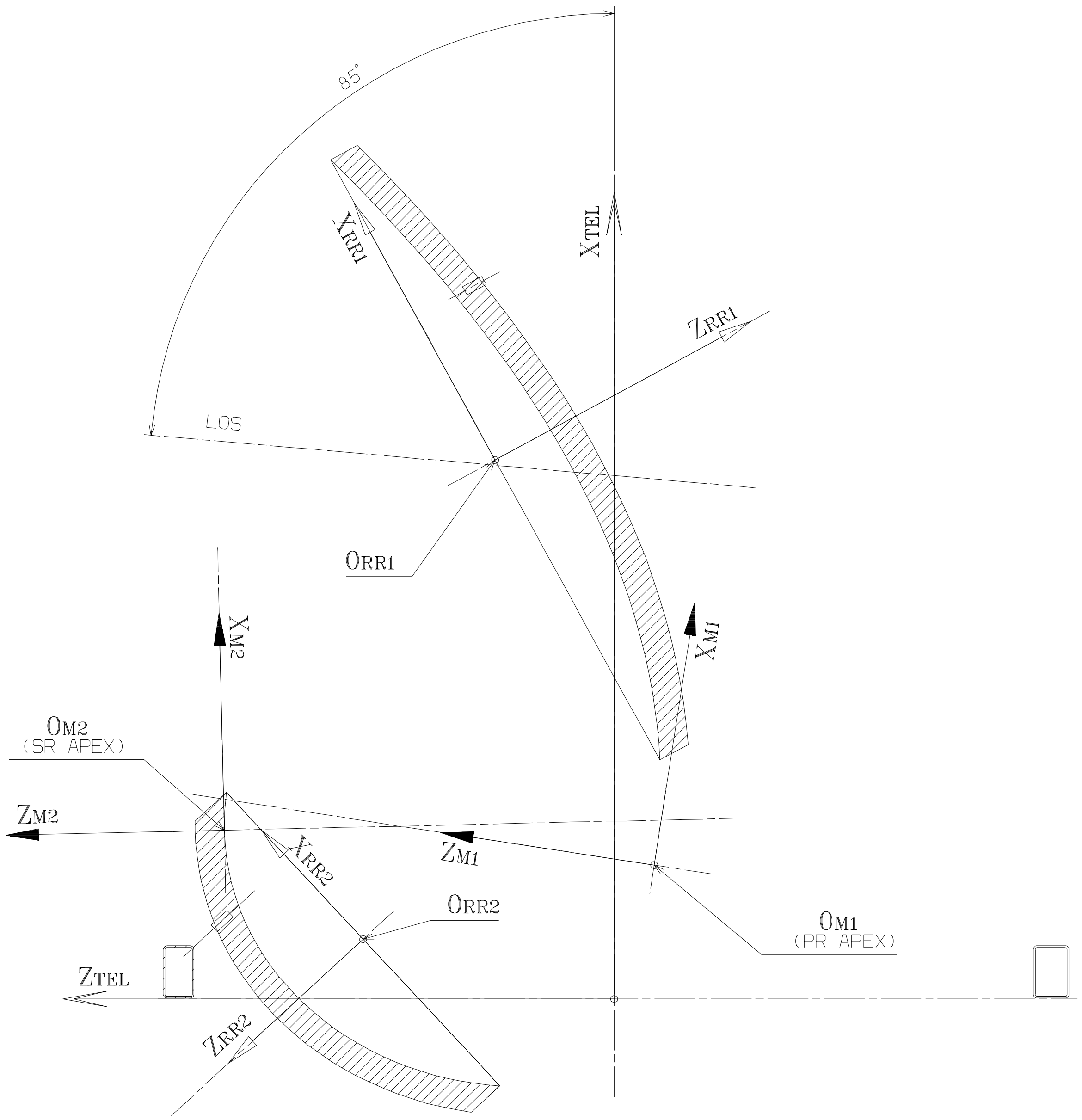


Figure 4.3-3 : Telescope and Reflectors axis system

5. MISSION AND PERFORMANCE REQUIREMENTS

5.1 General Specifications for the Planck Telescope

Reference **P-TEL-PER-005 a**

The telescope shall meet its performance as defined in §5.2 within a temperature range of 40 K to 65 K, at a frequency range from 25 to 1000GHz

*

5.2 Performance requirement

Reference **P-TEL-PER-010 a**

The telescope shall maintain the specified performance defined in § 5.2 over its lifetime

*

5.2.1 Telescope performance

Reference **P-TEL-PER-015**

The telescope design shall be in line with the opto-mechanical definition given in Table 5.2.1-1 and. Figure 5.2.1-1.

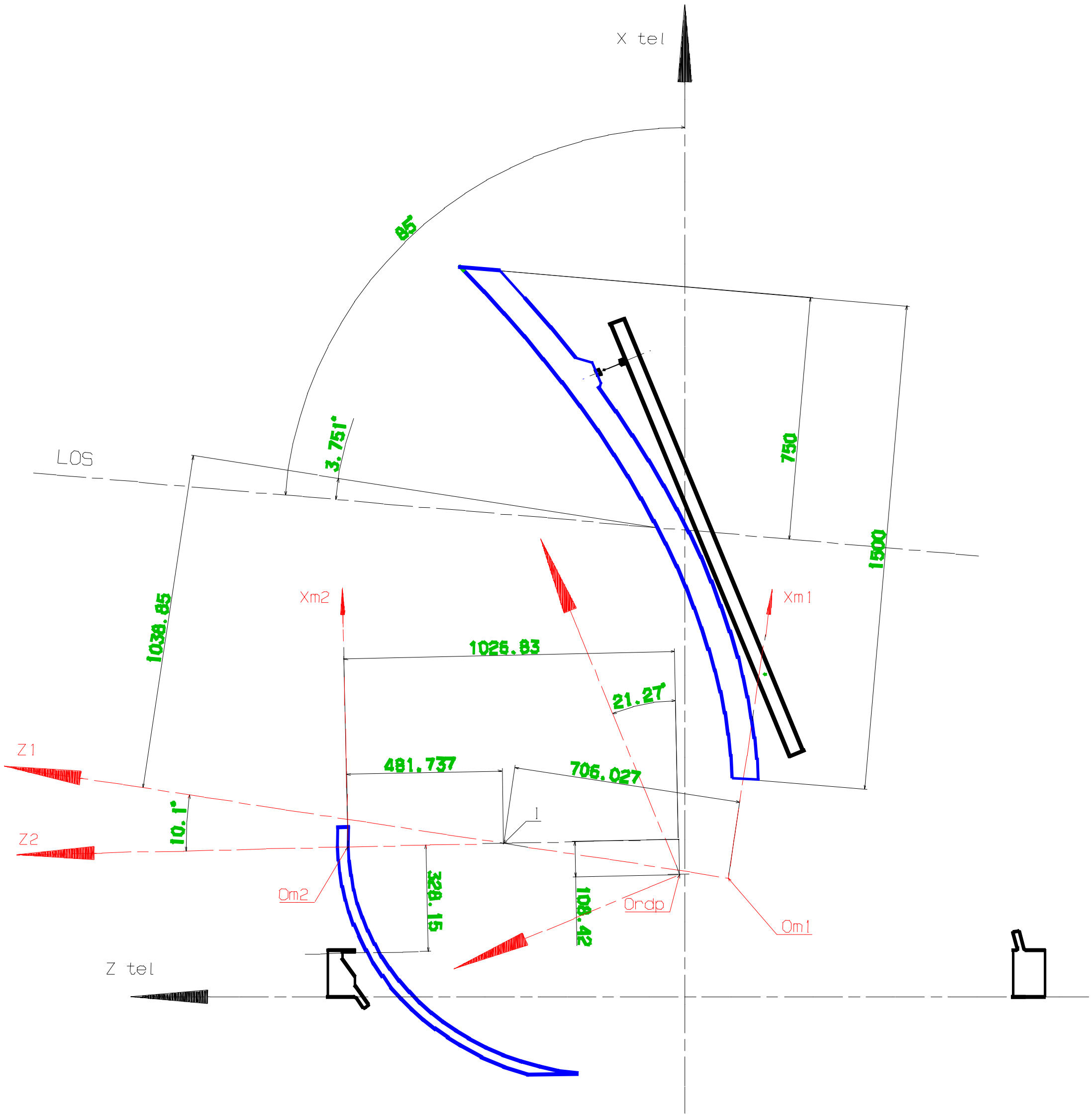
*

Reference **P-TEL-PER-020 a**

The telescope shall have an unobstructed Field of View (FOV) of ± 5°

Telescope	Angle of centre of FoV with respect to ZM1 axis Field of View	-3.751°
Primary Reflector	See definition in AD 1	See definition in AD 1
Secondary Reflector	See definition in AD 1	See definition in AD 1
Position of Secondary reflectorr w.r.t Primary reflector (figure 5.2.1-1)	Angle between Axes (PSI) Ztop (See definition in Figure 5.2-1) Zbot (See definition in Figure 5.2-1)	10.10° 481.737 mm 706.027 mm
Position of Reference Detector Plane (figure 5.2.1-1)	Decenter w.r.t. M2 axis: OH Angle of Normal w.r.t. M2 axis: GAMA HO2	108.420 mm 21.27° 1,026.830 mm

Table 5.2.1-1 : Opto-mechanical Definition of the Planck Telescope



- Ztop = distance between OM1 and I
- Zbot = distance between I and OM2
- PSI = angle between major axis of PR and SR

Figure 5.2.1-1 : Telescope optical design definition (operational environment)

\# *

\# Reference **P-TEL-PER-025**

The total emissivity of the telescope optical surfaces over the entire telescope FOV shall be :

Specification	<6 % EOL
Goal	<3 % EOL

\# *

The WFE requirement on the Planck telescope is defined at a specific set of detector positions (see table) and in a specific way (apodisation).

The exact definition of this parameter, in the following given as WFE, is outlined below:

The WFE has been obtained using apodisation at feed level, while the optical path length difference has been computed in the far-field of the antenna. The apodisation in amplitude is used as a weighting function to determine the weighted root mean square of the optical path length difference. The apodisation applied at feed level is gaussian with a 30 dB level in power from the peak at an angle as defined in the table 5.2.1-2.

Frequency [GHz]	Angle 30 dB from Peak [°]
30 (LFI)	23.6
44 (LFI)	23,6
70 (LFI)	21.9
100 (HFI)	26.8
143 (HFI)	23.7
217 (HFI)	21.8
353 (HFI)	19.4
545 (HFI)	19.4
857 (HFI)	19.4

Table 5.2.1-2 : Feed apodisation definition

The table 5.2.1-3 presents , for each horn, the computed theoretical WFE as a fraction of the relevant wavelength.

tit	lambda [mm]	WFE [fraction of lambda]
|hfi_100_1|	3	0,0237
|hfi_100_2|	3	0,0216
|hfi_100_3|	3	0,0216
|hfi_100_4|	3	0,0237
|hfi_143_1|	2,1	0,0298
|hfi_143_2|	2,1	0,0210
|hfi_143_3|	2,1	0,0207
|hfi_143_4|	2,1	0,0319
|hfi_143_5|	2,1	0,0389
|hfi_143_6|	2,1	0,0312
|hfi_143_7|	2,1	0,0305
|hfi_143_8|	2,1	0,0396
|hfi_217_1|	1,38	0,0229
|hfi_217_2|	1,38	0,0182
|hfi_217_3|	1,38	0,0184
|hfi_217_4|	1,38	0,0225

tit	lambda [mm]	WFE [fraction of lambda]
|hfi_217_5|	1,38	0,0215
|hfi_217_6|	1,38	0,0165
|hfi_217_7|	1,38	0,0165
|hfi_217_8|	1,38	0,0214
|HFI_353_1|	0,85	0,0580
|HFI_353_2|	0,85	0,0327
|HFI_353_3|	0,85	0,0239
|HFI_353_4|	0,85	0,0236
|HFI_353_5|	0,85	0,0234
|HFI_353_6|	0,85	0,0248
|HFI_353_7|	0,85	0,0355
|HFI_353_8|	0,85	0,0580
|HFI_545_1|	0,55	0,0975
|HFI_545_2|	0,55	0,0564
|HFI_545_3|	0,55	0,0609
|HFI_545_4|	0,55	0,0980
|HFI_857_1|	0,35	0,0640
|HFI_857_2|	0,35	0,0606
|HFI_857_3|	0,35	0,0603
|HFI_857_4|	0,35	0,0674

tit	lambda [mm]	WFE [fraction of lambda]
|LFI_70_1|	4,29	0,0331
|LFI_70_2|	4,29	0,0270
|LFI_70_3|	4,29	0,0250
|LFI_70_4|	4,29	0,0250
|LFI_70_5|	4,29	0,0270
|LFI_70_6|	4,29	0,0331
|LFI_44_1|	6,82	0,0272
|LFI_44_2|	6,82	0,0789
|LFI_44_3|	6,82	0,0789
|LFI_30_1|	10	0,0234
|LFI_30_2|	10	0,0234

Table 5.2.1-3 : Theoritical telescope WFE

The required telescope performance is defined w.r.t. the theoretical performance.

Reference **P-TEL-PER-030 a**

The telescope shall achieve a WFE at the horn position of the detectors as defined in AD 2 and AD 3, *at operational conditions and taking into account FPU performances as specified in* RD 1 *§ 5.8 that does not degrade the theoretical value by more than described in* Table 5.2.1-4

Frequency [GHz]	Default max contribution	
	Goal [micron rms]	Specs.
30	80	119
44	61	92
70	61	92
100	48	72
143	40	60
217	38	57
353	33	50
545	32	48
857	28	42

Table 5.2.1-4 WFE maximum degradation

*

Note: The final WFE = sq root ((max theoretic WFE)^2 + (default max contribution)^2)

Reference **P-TEL-PER-035 a**

The telescope shall achieve a Gain at the horn position of the detectors as defined in AD 2 and AD 3, *at operational conditions and taking into account FPU performances as specified in* RD 1 *§5.8 that does not degrade the theoretical value by more than described in* Table 5.2.1-5

Frequency [GHz]	Max reduction in gain [DBi]
30	.5
44	.5
70	.5
100	.5
143	.5
217	1
353	1
545	1.4
857	2.5

Table 5.2.1-5 Gain maximum degradation

*

Reference **P-TEL-PER-040 a**

The ellipticity of the LFI beam pattern is dominated by the optical distortion of the telescope. Inaccuracies due to telescope manufacturing and alignment shall not increase the ellipticity of the LFI beam pattern by more than 1% of the ellipticity given by P-TEL-PER-030 and P-TEL-PER-035 (see note 1).

*

Note 1: If a=major axis, b=minor axis of the best fit ellipse to the 3 dB beam contour, then R=a/b is the ellipticity ratio. The requirement is deltaR/R <=0.01.

5.2.2 Straylight Requirement

Straylight for Planck is defined as the radiative power that reaches a detector within its RF bandwidth, and that does not originate from sources in the far field of the beam.

The evaluation of the straylight requires the complete set of all elements within the payload module and cannot be performed within one subsystem, i.e. the telescope alone. In order to achieve compliance of the telescope design with the straylight requirements of Planck (see AD 4) all relevant elements belonging to the telescope are explicitly specified in this specification.

The PPLM responsible will follow closely the detailed telescope design and assure that it will be compliant w.r.t. the straylight requirement.

5.3 Physical requirements

The physical requirements of the Planck telescope are covered by the Planck System physical Requirements specified in AD 4. The Planck System physical Requirements are derived into telescope requirements specified in RD 2.

5.4 Interface requirements

The interface requirements of the Planck telescope are covered by the Planck System interface Requirements specified in AD 2, AD 3 and AD 4. The Planck System interface Requirements are derived into telescope requirements specified in RD 2.

6. TELESCOPE LIFE TIME AND ENVIRONMENTS

The telescope life time and environment requirements of the Planck telescope are covered by the Planck System telescope life time and environment Requirements specified in AD 4. The Planck System telescope life time and environment Requirements are derived into telescope requirements specified in RD 2.

7. PRODUCT ASSURANCE REQUIREMENTS

The Product assurance requirements of the Planck telescope are covered by the Planck System Product assurance Requirements specified in AD 4. The Planck System Product assurance Requirements are derived into telescope requirements specified in RD 2.

8. VERIFICATION REQUIREMENTS

8.1 Verification Methods, Programs and Matrices

Reference **P-TEL-VER-005**

The contractor responsible for the telescope shall establish a verification plan that shall be approved by ESA.

He shall also establish a requirement verification matrix and define how he intends to verify all given requirements. The verification could be done by test, analysis or inspection.

It shall define the:

- type of test to be performed
- sequence of tests
- hardware to be tested
- description/objectives of the qualification test
- level of test parameters
- special facilities/equipment needed

*

8.2 Analysis, Inspection and Test

Reference **P-TEL-VER-010**

The requirement verification matrix shall follow the outline as given in Annex 1.

*

Reference **P-TEL-VER-015**

The spectral reflectivity of the reflector surfaces shall be demonstrated with samples tests at representative frequencies. By analysis this spectral reflectivity shall be shown to aply over the entire frequency range and FOV.

*

8.3 Thermo-optical Verification Testing of the Telescope

Reference **P-TEL-VER-025**

The verification of the optical performance of the telescope assembly shall be performed by a combination of tests and analysis. A map of WFE shall be provided.

*

Reference **P-TEL-VER-030**

The optical performance of the qualification model telescope shall be as a minimum demonstrated for a temperature $\leq$ 55 K.

*

Reference **P-TEL-VER-035**

The optical performance of the flight model telescope shall be as a minimum demonstrated for an temperature ≤55 K.

*

Reference **P-TEL-VER-040 a**

The compatibility of the telescope assembly with the maximal temperatures as defined in paragraph 6 shall be demonstrated by test.

*

Reference **P-TEL-VER-045 a**

The compatibility of the qualification model of the telescope assembly with the thermal cycling requirements as defined in paragraph 6 shall be demonstrated by test.

*

Reference **P-TEL-VER-050 a**

The compatibility of the flight model of the telescope assembly with the thermal cycling requirements as defined in paragraph 6 shall be demonstrated by test.

*

Reference **P-TEL-VER-052 a**

The contractor responsible for the telescope shall perform tests on an elegant RF breadboard with the aim of demonstrating the RF properties of the Planck telescope and their correlation with the measurable quantities defined in section 5.5 (in particular P-TEL-PERF-030 & 035), and the established optical model for the telescope. These tests shall established beam shapes, spill-over lobes, straylight and polarisation properties. These tests shall be done with the support of the Instrument teams and the agreement of ESA.

*

8.4 Mechanical Verification Testing of the Telescope

The telescope mechanical verification test requirements of the Planck telescope are covered by the Planck System mechanical verification test requirements specified in AD 4. The Planck System mechanical verification test requirements are derived into telescope requirements specified in RD 2.

8.5 Test Responsibility

Reference **P-TEL-VER-060**

The contractor responsible for the telescope shall clearly define responsibilities for the execution of tests.

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8.6 Acceptance/Rejection Criteria

Reference **P-TEL-VER-070**

The contractor responsible for the telescope shall as part of his test/verification plan and procedures clearly define rejection/acceptance criteria in compliance with the objective of the test.

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Reference **P-TEL-VER-075**

The contractor responsible for the telescope shall define conditions when a retest may be acceptable.

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ANNEX 1: VERIFICATION MATRIX

CHAP 5				
Requirement	**Verification**			
	Inspection/ Review	**Analysis**	**Test**	
			Telescope	**Sample**
P-TEL-PER-005	X	X	X	X
P-TEL-PER-010	X	X	X (1)	X
P-TEL-PER-015	X	X		
P-TEL-PER-020	X	X		
P-TEL-PER-025	X	X		X (2)
P-TEL-PER-030	X	X	X (3)	
P-TEL-PER-035	X	X	X (4)	
P-TEL-PER-040		X		

(1) Tests at telescope level will be WFE measurements at cryo-temperature and RF measurements at ambient. The maintain over lifetime of the performance specified in § 5.2.1 and § 5.2.2 will be done by tests at sample level and analyses.

(2) Tests performed at reflector level

(3) WFE measurement at cryogenic environment

(4) RF measurement at ambient

CHAP 8				
Requirement	**Verification**			
	Inspection/ Review	**Analysis**	**Test**	
			Telescope	**Sample**
P-TEL-VER-005	X			
P-TEL-VER-010	X			
P-TEL-VER-015	X			X
P-TEL-VER-025	X		X	
P-TEL-VER-030	X		X	
P-TEL-VER-035	X		X	
P-TEL-VER-040	X		X	
P-TEL-VER-045	X		X	
P-TEL-VER-050	X		X	
P-TEL-VER-052	X	X	X	
P-TEL-VER-060	X			
P-TEL-VER-070	X			
P-TEL-VER-075	X			

ANNEX 2: TRANSFORMATION OF COORDINATE SYSTEMS

The relationships defined below allow transformations of the coordinate systems defined in paragraph 4.3 as follows

From SC to TEL

Origin of the TEL coordinate system in the SC coordinate system:	(1745 mm, 0 mm, 0 mm)
Rotation of the TEL coordinate systems with respect to the SC coordinate system:	Θ = 0° Φ = 0°

From TEL to M1

Origin of the M1 coordinate system in the TEL coordinate system:	(267.045 mm, 0 mm, -510.63 mm)
Rotation of the M1 coordinate systems with respect to the TEL coordinate system:	Θ = 8.751° Φ = 0°

From M1 to M2

Origin of the M2 coordinate system in the M1 coordinate system:	(- 84.48 mm, 0 mm, 1180.298 mm)
Rotation of the M2 coordinate systems with respect to the M1 coordinate system:	Θ = -10.1° Φ = 0°

From M2 to RDP

Origin of the RDP coordinate system in the M2 coordinate system:	(-108.42 mm, 0 mm, -1026.83 mm)
Rotation of the RDP coordinate systems with respect to the M2 coordinate system:	Θ = -21.27° Φ = 0°

From RDP to FPU

Origin of the FPU coordinate system in the RDP coordinate system:	To be provided by HFI team

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