MORFEO Calibration Unit Optomechanical System – Optical Interfaces

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1. Introduction

1.1 Content

This document briefly describes the MORFEO Calibration Unit Optomechanical System (PUA) optical design and reports the PUA optical interfaces.

1.2 Definitions, Acronyms and Abbreviations

PUA   MORFEO Calibration Unit Optomechanical System

ELT   Extreme Large Telescope

INAF   Istituto Nazionale di Astrofisica

MORFEO   Multiconjugate adaptive Optics Relay For ELT Observations

TBD   To Be Defined

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2. Related Documents

2.1 Applicable Documents

The following applicable documents form a part of the present document to the extent specified herein. In the event of conflict between applicable documents and the content of the present document, the content of the present document shall be taken as superseding.

AD1   E-MAO-PUA-INA-MOD-001_01 MORFEO Calibration Unit - Optical Model (direct)

2.2 Reference Documents

The following documents, of the exact version shown herein, are listed as background references only. They are not to be construed as a binding complement to the present document.

RD1   E-MAO-PU0-INA-DER-002_01 MORFEO Calibration Unit Optomechanical System - OFDR Design and Analysis Report

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3. Optical design description

The PUA optical design (AD1), shown in Figure 1 and Figure 2, consists of three principal parts: an LGS arm that can be set in two possible configurations (two conjugation altitudes), an NGS arm, a (common) catadioptric "telescope".

The two arms consist of two separated optical systems generating an array of NGSs across the 160'' technical Field of View (R- and H- bands) and 6 extended LGSs centred at 45'' off-axis, respectively. The two optical paths combine and illuminate a common pupil, then sharing the third main part of the relay, a catadioptric system that properly focuses the artificial sources to their respective focal planes, according to the conjugation altitude. The light from the PUA is directed into MORFEO Post-Focal Relay Optics thanks to a folding mirror (CUFM), not belonging to the Calibration Unit subsystem (PU0).

The PUA optical relay has been designed "in reverse direction": the beams, positioned at the required conjugation altitudes, pass first through the telescope relay and then focus on the PUA focal planes (coinciding with the artificial sources masks' planes), so that the effect of the intrinsic aberrations of the ELT (in its nominal configuration) is preserved and can be replicated by the PUA (actually used "in direct direction", i.e. from the masks' planes towards MORFEO).

The peculiarity of this design is the use of a number of semi-reflective (50% transmission and 50% reflection) optics: the largest optics (W and SM), the plano Beam Splitters (BS1 and BS2), the Cube Beam Splitter (CBS). The main reasons for this design choice were its compactness and the need to retain the rotational symmetry for all optical elements used for the LGS path, thus avoiding the introduction of a large differential astigmatism in the LGS beams. This issue is not critical for NGSs because they have only one conjugation, and the NGS beams were made collimated when passing through the tilted plates.

The light from an array of NGS sources (NGS mask) reflects from the semi-reflective surface of BS2 and goes towards the Ellipsoidal Mirror (EM). After reflecting from the EM, the beams are collimated, and pass through the two plano Beam Splitters (BS1 and BS2) and the Cube Beam Splitter (CBS). After the CBS, the light reaches the PM, optically conjugated to the telescope pupil. After reflection from the PM and the 45 deg semi-reflective inner interface of the CBS, the light enters the catadioptric module part from the back surface of the Spherical Mirror (SM), which has a semi-transparent coating on its front surface. The central part of the SM acts as an afocal meniscus lens, and after passing through this lens, the light reaches the flat semi-reflective window W. About 50% of this light exits the system, while the other half is reflected back towards the SM, that focuses the NGS sources onto the PUA exit focal plane (coinciding with ELT focal plane and with MORFEO input focal plane).

Regarding the LGS path, the beams pass through the doublets (D2 and D1), reflect on the LGS Folding Mirror (LFM) and then pass through the single lens (L1). Then, the beams enter the CBS and the catadioptric module, after reflection by the BS1.

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Figure 1. PUA optical layout front view (YZ plane).

Figure 2. PUA optical layout top view (XY plane): only components positioned below W and SM.

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4. Optical interfaces

The PUA NGS and LGS optical interfaces are reported in Table 1, Table 2 and Table 3.

Table 1. PUA optical interfaces: NGS channel. Tolerance empty boxes will be defined for the FDR.

Parameter	Nominal value	Tolerance		Unit	Comment
Input focal plane diameter	140	0		mm	-
Output focal plane diameter	530.5	0		mm	-
Input field radius of curvature	372.57	-1%	1%	mm	convex
Output field radius of curvature	9884			mm	concave
Effective focal length	2175.88			mm	-
Object space F/#	4.7			-	-
Image space F/#	17.75	-1%	1%	-	-
Input plate scale	0.874			mm/asec	-
Entrance pupil diameter	100.3			mm	-
Exit pupil diameter	2258 (@800nm) 2305 (@1650nm)			mm	Nominal ELT: 2134.8
Exit pupil distance	37901 (@800nm) 38623 (@1650nm)			mm	From ELT focal plane. Nominal ELT: 37867.5
Distortion	0.03%			-	

Table 2. PUA optical interfaces: LGS-104km channel. Tolerance empty boxes will be defined for the FDR.

Parameter	Nominal value	Tolerance		Unit	Comment
Input focal plane diameter	89.5	0		mm	-
Output focal plane diameter	350	0		mm	-
Input field radius of curvature	inf.	-	-	mm	flat
Output field radius of curvature	9302			mm	concave

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Parameter	Nominal value	Tolerance		Unit	Comment
Effective focal length	49333.9			mm	-
Object space F/#	5.15			-	-
Image space F/#	20.27			-	-
Input plate scale	0.963			mm/asec	-
Entrance pupil diameter	659.7			mm	-
Exit pupil diameter	2230			mm	Nominal ELT: 2134.8
Exit pupil distance	37752			mm	From ELT focal plane. Nominal ELT: 37867.5
Distortion	0.03%			-	

Table 3. PUA optical interfaces: LGS-150km channel. Tolerance empty boxes will be defined for the FDR.

Parameter	Nominal value	Tolerance		Unit	Comment
Input focal plane diameter	102.5	0		mm	-
Output focal plane diameter	336	0		mm	-
Input field radius of curvature	inf.	-	-	mm	flat
Output field radius of curvature	9488			mm	concave
Effective focal length	20083.34			mm	-
Object space F/#	5.9			-	-
Image space F/#	19.41			-	-
Input plate scale	1.102			mm/asec	-
Entrance pupil diameter	388.7			mm	-
Exit pupil diameter	2226			mm	Nominal ELT: 2134.8
Exit pupil distance	37730			mm	From ELT focal plane. Nominal ELT: 37867.5
Distortion	0.03%			-	

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