MORFEO Project Management Plan

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Change Record from previous version

Date	Affected Section(s)	Changes / Reason / Remarks
2016-01-25	All	First issue
2017-07-28	13	CV update
2017-11-29	3.2.2.1	Added OAAB -- Osservatorio d'Abruzzo (Teramo)
	4.2.1	New MORFEO Management Diagram
	4.2.4	New MORFEO Science Team
	4.2.6.5	Introduction of the Project Scientist
	5.1	New Product Tree
	5.2	New WBS
2018-03-09	All	**Version 2** for Consolidation Meeting
	4.2.2	Variation in the Co-I Committee
	4.2.3	Executive Funding Committee changed to Board of Directors
	4.2.6	Updated CNRS/INSU Local Project Office
2019-01-28	All	**Version 3** after PI change in MORFEO Project
2019-03-15	All	New draft Version after comment from PFE and CNRS/INSU

2019-03-25	5.0	New numbering definition for PT and WBS
2019-06-21	All	**Version 4** NUIG joins the MORFEO Consortium as new partner
2020-01-31	All	**Version 4** Second draft. Change of PM name and of PT figure
2020-11-16	Sect. 5, Sect. 7	Reference to CMP, WBS expanded Master Schedule
2021-01-29	Sect. 5 Annex 1 Annex 2 Annex 3 Annex 4	**Version 4** for PDR. Integrated the WP Descriptions for all Phases of the project (Phase D and E still TBD). Added the graphical schedule of the whole project.
2021-06-01	Added Section 7.2 - MORFEO procurement process Sect. 13 New WPs added to Phase C (MP0 – Procurement, PW0 – WFS cameras)	MAO-315 Review Action Item: Procurement tasks
2021-06-15	Sect. 2.2 Added RD6 (Project schedule) Section 7.3.1 Removed the TBDs in the table of key milestones. Added the reference to Project schedule, RD3	Action Item Jira MAO-334 and its parent RIX MAO-99 Action Item MAO-731 Action Item MAO-192
2021-06-15	Sect. 7.3.4 added to describe Long-Lead Items.	Action Item MAO-737 and its parent RIX MAO-116

	Sect. 3.1 updated to describe the current shift with respect to original dates of the milestones. Sect. 16.1 added to describe the critical path and the margins in the schedule. In Sect. 16.1 the reference to ESO deliverables has been added	
2021-11-16	Sect. 12.1	MAO-316 Review Action Item: rephrased the description of system engineering scope, according to reply to RIX MAO-101
2022-11-08	 Sect. 5.2 Sect. 7	MAO-315 Review Action Item: Procurement tasks reopening. Added new WPs to the WBS More details on the procurement strategy
2025-12-15	Sect. 4.3	Update of project organization chart
2025-12-15	All	Changed MAORY into MORFEO
2025-12-15	Sect. 14	Reviewed deliverables for Phase-C
2025-12-15	Sect. 14	Updated WBS for Phase C, as per MAO-1632
2025-12-15	Sect. 12.22	Added PhaseB closure section as per MAO-1039
2025-12-15	Sect. 15	Updated PhaseD as per MAO-1035

Contents

1. Introduction

1.1 Scope

This document describes the management of the design, construction, assembly, test and commissioning of the Multi-conjugate Adaptive Optics RelaY (MORFEO) which is one of the first light instruments of the European Extremely Large Telescope (ELT).

1.2 Definitions, Acronyms and Abbreviations

AD	Applicable Document
ADP	Acceptance Data Package
AO	Adaptive Optics
AIT	Assembly Integration Test
AIV	Assembly Integration Verification
CBS	Cost Breakdown Structure
CMP	Configuration Management Plan
CoI	Co-Investigator
CV	Curriculum Vitae
CNRS	Centre National de la Recherche Scientifique
ELT	European Extremely Large Telescope
EFC	Executive Funding Committee
ESO	European Southern Observatory
DM	Deformable Mirror
DRD	Document Requirements Definition
FDR	Final Design Review
FoV	Field of View
FTE	Full Time Equivalent
GTO	Guaranteed Time Observing allocation
HW	Hardware
ICDR	Instrument Critical Design Review
IECR	Instrument End of Commissioning Review
INAF	Istituto Nazionale di AstroFisica
INS	Instrumentation Software
INSU	Institut National des Sciences de l'Univers

IORR	Instrument Operations Readiness Review
IPAG	Institut de Planétologie et d'Astrophysique de Grenoble
IPDR	Instrument Preliminary Design Review
ISQR	Instrument System Qualification Review
ISRR	Instrument System Requirements Review
KO	Kick Off
LGS	Laser Guide Stars
LOR	Low Order and Reference
MAD	Multi conjugate Adaptive optics Demonstrator
MORFEO	Multi Conjugate Adaptive Optics Relay for ELT
MCAO	Multi Conjugate Adaptive Optics
MICADO	Multi-AO Imaging Camera for Deep Observations
MoU	Memorandum of Understanding
MRB	Material Review Board
MSQR	MORFEO System Qualification Review
MTA	Milestone Trend Analysis
N/A	Not Applicable
NCR	Non Conformity Report
NGS	Natural Guide Star
NUIG	School of Physics at the National University of Ireland Galway
OAA	Osservatorio Astrofisico di Arcetri
OAAB	Osservatorio Astronomico d' Abruzzo
OAB	Osservatorio Astronomico di Brera
OACN	Osservatorio Astronomico di Capodimonte
OAPD	Osservatorio Astronomico di Padova
OAS	Osservatorio di Astrofisica e Scienza dello Spazio di Bologna
PA	Product Assurance
PAC	Preliminary Acceptance Review in Chile
PAE	Preliminary Acceptance Europe
PAP	Product Assurance Plan
PDM	Product Data Management
PDR	Preliminary Design Review
PI	Principal Investigator

PM	Project Manager
PMP	Project Management Plan
PSF	Point Spread Function
PT	Product Tree
QE	Quantum Efficiency
RAMS	Reliability, Availability, Maintainability, Safety
RD	Reference Document
RMS	Root Mean Square
RON	Read Out Noise
RTC	Real-Time Computer
SAT	System Architect Team
SCAO	Single-conjugate Adaptive Optics
SET	System Engineering Team
SOW	Statement of Work
SQR	System Qualification Review
SR	Strehl Ratio
SRR	System Requirements Review
SW	Software
TAT	Technical Advisor Team
TBC	To Be Confirmed
TBD	To Be Defined
TBH	To Be Hired
TBW	To Be Written
TCS	Telescope Control Software
TRA	Technology Readiness Assessment
TRL	Technology Readiness Level
TRR	Test Readiness Review
TTF	Tip Tilt & Focus
VCD	Verification Control Document
VLT	Very Large Telescope
WBS	Work Breakdown Structure
WFS	Wavefront Sensor
WP	Work Package

2. Related Documents

2.1. Applicable Documents

The following applicable documents form a part of the present document to the extent specified herein.

AD1. MORFEO Agreement (incl. Amendment No. 2 to AGREEMENT)
ESO-281109 Version 1

AD2. MORFEO (E-ELT MCAO) Statement of Work
ESO-257875 Version 1

AD3. MORFEO (E-ELT MCAO) Technical Specification
ESO-254311 Version 2

AD4. Common Requirements for E-ELT Instruments
ESO-254547 Version 2

AD5. MORFEO Configuration Management Plan
E-MAO-000-INA-PLA-002 Version 1

AD6. MORFEO Product Assurance Plan
E-MAO-000-INA-PLA-003 Version 1

AD7. MORFEO Risk Management Plan
E-MAO-000-INA-PLA-004 Version 1

AD8. MORFEO Risk Analysis Plan
E-MAO-000-INA-RRR-001 Version 23

AD9. MORFEO Long Term Schedule
E-MAO-000-INA-SCD-006 Version 8

AD10. MORFEO Phase-B work packages
E-MAO-000-INA-PLA-011 Version 2 Draft 1.

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 ESO PDM Document Types and Definitions
Number ESO-231062 Version 1

RD2 Systems Engineering General Requirements
ECSS-EST-10C Version 3

RD3 MORFEO System Overview
E-MAO-000-INA-DER-001 Version 2

3. Project History and Overview

3.1. Project history

The Phase-A study of MORFEO was carried out in the framework of the ELT instrumentation studies sponsored by ESO. The Phase-A had a temporal duration of about two years. The main milestones were

- Kick-off meeting, 9 November 2007
- Phase 1 review, 24 October 2008
- Phase 2 review, 10-11 December 2009.

The Phase-A Consortium members were three institutes of INAF, the Italian National Institute for Astrophysics (Osservatorio Astronomico di Bologna, Osservatorio Astronomico di Padova, Osservatorio Astrofisico di Arcetri), University of Bologna (Italy) as an associated partner to INAF and ONERA (France). The Consortium was led by INAF Osservatorio Astronomico di Bologna. ESO, in addition to its role of supervisor, supported critical technology developments (DM, WFS cameras and controllers).

After a long period of stand-by, the project kick-off meeting for Phase B took place in Bologna on 2016-02-02 between the MORFEO consortium and ESO. In November 2018 the INAF Directorate of Science decided the change of the Principal Investigator. A reorganization process of the consortium and an in-depth analysis of the technical solution started. The main reason for this activity is that the system technical baseline considered until November 2018 had three major drawbacks :

1. Performances very close to minimum requirements and far from goals;
2. High risks in manufacturing and alignment of optics;
3. Extensive calibration required due to high variability of the NCP aberrations on the technical FOV and on the LGS focal plane

In February 2019 the MORFEO Consortium was placed by ESO in a red flag status and a Consolidation Phase was opened.

In May 2019, as part of the MORFEO consortium reorganization and strengthening, a new external institute joined the consortium : the School of Physics at the National University of Ireland Galway ,NUIG, (Ireland), recognized for its expertise in the adaptive optics field.

In July 2019 ESO turned the «red flag» status into a «yellow flag» to acknowledge the very positive gradient of the project and the work of the technical team that had elaborated a new technical solution.

In early 2020, in agreement with ESO, the MORFEO baseline design was completely changed in order to provide also for the second instrument a gravity invariant port. The performances guaranteed to MICADO were maintained and extended also to the second instrument. In October 2020 the Consolidation Phase and the yellow flag status were positively closed by ESO and the MORFEO Consortium went back to the normal Phase-B activities towards the PDR. In agreement with ESO, the MORFEO PDR has been split in two phases: PDR1 with the delivery of mostly all system documents and several sub-systems and PDR2 with the delivery of all the rest of the documents.

The overall PDR process was formally closed with ESO approval in February 2022.

Following the PDR, MORFEO and ESO agreed to anticipate dedicated FDR sessions for the Deformable Mirrors and for the LGS, NGS, and RTC subsystems, identified as long-lead items due to their extended Phase-D timelines. The session covering the last three subsystems is formally referred to as **FDR1**. In parallel, joint FDRs are planned for the main third-party contract deliverables (mirrors, Calibration Unit, and Main Structure) ensuring coordinated design approval and procurement readiness ahead of the final system-level review (FDR2).

Deformable Mirrors FDR was held in December 2024 and formally closed in June 2025.

In April 2025, MORFEO and ESO carried out a formal review of the contractual Technical Specifications to incorporate the second deformable mirror. The review updated the specification baseline to reflect the current hardware configuration and revised performance budgets, and defined optimized, verifiable requirements. The activity was formally concluded with the release of the respective CRE from ESO and its acceptance by the MORFEO consortium in December 2025.

In the following is reported a table with the original dates of main milestones and the corresponding dates, according to the current schedule (AD9):

Milestone Number	**Phases – Key milestones**	**Due Time (original planning at Feb 2016)**	**Due Time (current planning)**
1	Kick Off Meeting (T_0)	2016-02-02	2016-02-02
2	Preliminary Design Review (PDR)	2018-02-02	2021-06-28
3	Optical Final Design Review (OFDR)	N.A.	2023-07-28
4	LLI FDR (DMs) (previously called LLI FDR)	N.A.	**2024-12-10**
5	FDR 1 (previously LLI FDR2)	N.A.	**2026-02-11**
6	FDR 2 (previously simply FDR)	2019-08-02	**2027-12-08**
7	Integration Readiness Review	N.A.	2028-10-5
8	Preliminary Acceptance Europe (PAE)	2024-02-02	2031-10-21
9	Provisional Acceptance Chile (PAC)	2025-08-02	2033-08-24
10	Final Acceptance (end of Guarantee period)	2027-08-02	2035-08-07

3.2. Project overview

The MORFEO instrument description given here is based on the design developed in the project Phase B, which is described in RD4 MORFEO System Overview.

3.2.1. Instrument overview

The main function of MORFEO is to relay the light beam from the ELT focal plane to the client instrument while compensating the effects of the atmospheric turbulence and other disturbances affecting the wavefront from the scientific sources of interest.

MORFEO has two operation modes.

- In MCAO mode, wavefront sensing is performed by up to six LGS and three NGS. The NGS are used for both Low-Order and Reference (LOR) sensing; wavefront compensation is performed by means of the telescope's M4/M5 mirrors and by two post-focal DMs inside MORFEO. The choices to implement the MCAO technique and to use LGS for wavefront sensing have been taken to improve the performance uniformity over the field of view and the sky coverage. The MCAO technique has already been demonstrated on sky by MAD on VLT and, together with multiple LGS, by GeMS on the Gemini Telescope.
- In SCAO mode, wavefront sensing is performed by a single NGS as close as possible to the direction of the scientific target in the sky; wavefront compensation is performed in this mode by means of the telescope's M4/M5 mirrors only. The SCAO mode is a joint development between the MORFEO and the MICADO consortia (AD2 Statement of Work and AD3 MORFEO Technical Specification).

MORFEO has to be installed on the ELT Nasmyth platform. It feeds two focal stations: the gravity invariant port underneath the MORFEO bench for MICADO and the lateral port for another instrument TBD.

The next figure shows the functional block diagram of the instrument.

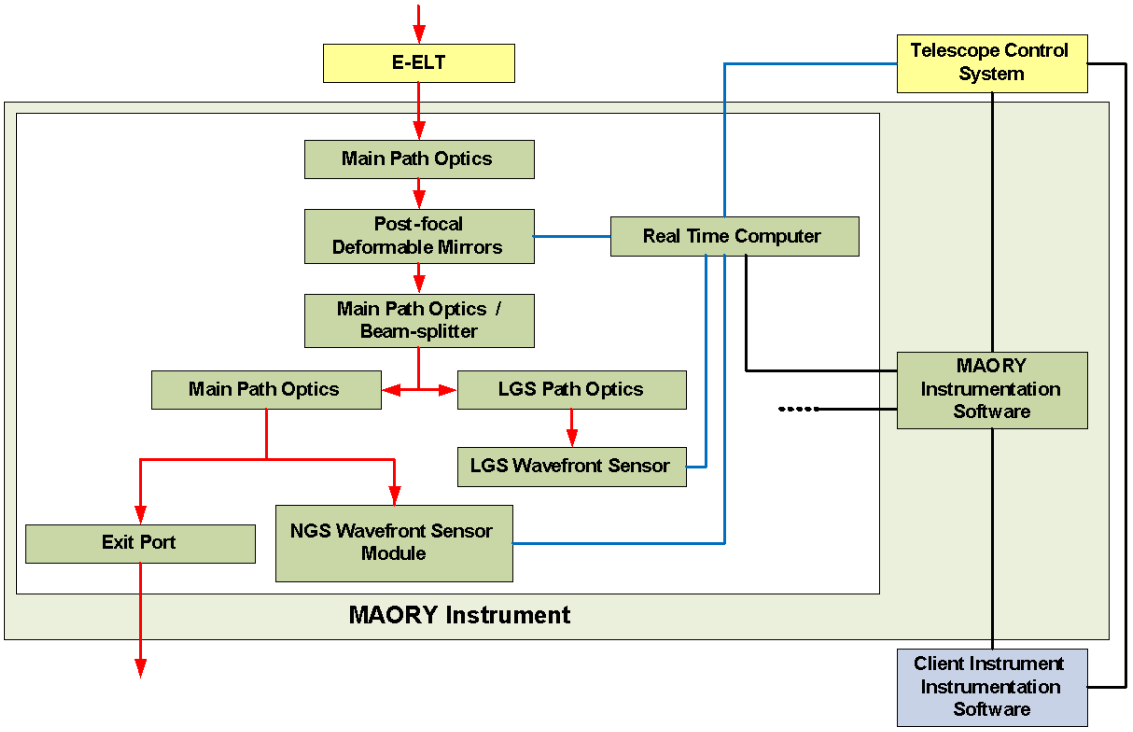


Figure 3-1. MORFEO Instrument functional block diagram. Red arrows: light path. Blue lines: real-time signals. Black lines: non real-time signals. The black dotted line departing from the MORFEO Instrumentation Software block indicates that this block has connections with other sub-systems which are not shown in this diagram for simplicity.

The light from the telescope enters MORFEO through the Main Path Optics. Upon wavefront compensation by the Post-focal DMs (which complement the telescope's M4/M5), the light is split by a Beam-splitter, which is still part of the Main Path Optics.

The light of wavelength shorter than about 600 nm is propagated from the Beam-splitter through the LGS Path Optics and then to the LGS Wavefront Sensor sub-system (this sub-system is in use only in the MCAO mode).

The light of wavelength longer than about 600 nm is propagated from the Beam-splitter through the last segment of the Main Path Optics to the Exit Port, where the MORFEO exit focal plane is made available to the scientific instrument, while the light of the required NGSs is picked off by the LOR Wavefront Sensor or by the SCAO Wavefront Sensor depending on the MORFEO operation mode.

The wavefront measurements performed by the LGS and LOR Wavefront Sensors in the MCAO mode or by the SCAO Wavefront Sensor in the SCAO mode are collected by the MORFEO Real Time Control System, which drives in closed loop the MORFEO Post-focal DMs and the telescope's M4/M5.

All instrument operations are controlled by the MORFEO Instrumentation Software, which also provides interfaces to the Telescope Control System and to the MICADO (or other) client instrument Instrumentation Software.

3.2.2. Stakeholder analysis

Each Consortium partner depends on organisations within their own countries that provide either logistic support or financial support (or both). These organisations require information and interface management activity from the Consortium to ensure all provisions expected from them are available in a timely and continuous manner.

3.2.2.1. MORFEO Consortium in Italy

The local Observatories involved in the development of MORFEO in Italy are the following:

- INAF OAS (Bologna) providing MORFEO PI, PM, System Engineering Team personnel and developing MORFEO sub-system(s);
- INAF OAA (Arcetri - Firenze) providing System Engineering Team personnel and developing MORFEO sub-system(s);
- INAF OAB (Brera - Milano) providing System Engineering Team personnel and developing MORFEO sub-system(s);
- INAF OACN (Capodimonte - Napoli) providing project personnel and developing MORFEO sub-system(s);
- INAF OAPD (Padova) providing System Engineering Team personnel, PA manager, project personnel and developing MORFEO sub-system(s);
- INAF OAAB (Abruzzo – Teramo) providing project personnel and developing the MORFEO sub-system(s).

These local Observatories are all part of the National Institute for Astrophysics (INAF) under the Italian Ministry for Education, Universities and Research (MIUR).

INAF will be represented by its President that will sign all Agreements with ESO and the necessary organisations of the Consortium partners, and will ensure the financial support necessary to maintain the INAF institutes personnel within the MORFEO project.

The INAF President will be aided by the INAF Director of Science or his/her delegate.

The MORFEO PI will:

- Ensure her/him regular reporting on programmatic and financial issues within Italy and as known for the ESO ELT Program as a whole;
- Invite her/him to all MORFEO Reviews and Progress Meetings organised by the MORFEO Project Office;
- Request ESO to invite her/him to the ESO formal reviews of MORFEO.

The local Observatories within INAF provide logistic support to the project and their respective personnel and are represented by their Directors. Through the MORFEO PI and PM these will be kept informed of the needs from their institutes.

Periodic meetings will be held at the INAF and local Observatories level to ensure proper coordination of the Italian contribution to the MORFEO Consortium.

3.2.2.2. MORFEO Consortium in France

The institute involved in the development of MORFEO in France is, CNRS/INSU (Centre National de la Recherche Scientifique/Institut National des Sciences de l'Univers) representing IPAG, that is responsible for providing the whole LGS WFS sub-system and will participate to all phases of the MORFEO project, from the design phases to the integration phases.

IPAG was the PI of the SPHERE (Spectro-Polarimetric High-Contrast Exoplanet Research) instrument installed on the Very Large Telescope from ESO.

IPAG is a multi-institutional entity, including the Université Grenoble Alpes and the CNRS . IPAG depends on the Institut National des Sciences de l'Univers (INSU), one of the 10 institutes of the Centre National de la Recherche Scientifique (CNRS). The CNRS institutes are structures aimed at implementing the organization's scientific policy. They are created at the initiative of the President of CNRS, following consultation of the Scientific Board and approval by the Board of Trustees. INSU aims to design, promote and coordinate national and international research in the fields of astronomy and of solid Earth, ocean, atmospheric and space sciences. One of the INSU strategic priorities is the formation and evolution of the universe, its components (especially dark matter and energy), and the objects that make it up (galaxies, stars and planetary systems).

All contractual documents concerning the French participation in the ELT are approved and signed by CNRS. INSU will monitor the French participation to all ELT instruments via regular progress meetings and a steering committee in charge of the project monitoring at high level.

3.2.2.3. MORFEO Consortium in Ireland

The institute involved in the development of MORFEO in Ireland is the School of Physics at the National University of Ireland Galway (NUIG). The main part of the School of Physics concerned with the MORFEO project is the Applied Optics Group. This was established in 2002 as a centre of excellence in many areas of optics, including visual optics, computational imaging, exoplanet detection techniques and high-speed astronomical polarimetry. It has particular expertise in Active and Adaptive Optics, for example leading an ESA-funded consortium to develop a prototype Active Optics system for future Space Telescopes. It has also carried out several projects in applying Adaptive Optics to retinal imaging, microscopy and optical communications.

All contractual documents concerning the Irish participation to the ELT are approved and signed by NUIG.

3.2.2.4. MORFEO Consortium in Canada

The institute involved in the development of MORFEO in Canada is the Herzberg Astronomy and Astrophysics Research Centre (HAA) of the National Research Council of Canada (NRC). HAA is Canada's national center for astronomy and astrophysics, headquartered in Victoria, British Columbia. It operates major facilities such as the Dominion Astrophysical Observatory and the Dominion Radio Astrophysical Observatory, and manages the Canadian Astronomy Data Centre (CADC), which provides access to

international astronomical archives. HAA represents Canada in global collaborations including the Gemini Observatory, the Canada-France-Hawaii Telescope, ALMA, and the Square Kilometre Array, and has a long tradition of developing advanced astronomical instruments and data systems.

Within MORFEO, NRC-HAA is responsible for the development of the Hard Real-Time Controller (H-RTC), a critical subsystem for adaptive optics. This work is based on their proprietary high-performance computing platform called HEART (Herzberg Extensible Adaptive Real-Time platform), which has been designed to deliver deterministic, low-latency control for large-scale astronomical instruments. By leveraging HEART, the Canadian team ensures that MORFEO's adaptive optics system can process wavefront sensor data and drive deformable mirrors with the precision and speed required for ELT observations.

All contractual documents concerning Canadian participation to the ELT are approved and signed by the NRC, which coordinates the national contribution to international observatory projects.

3.2.2.5. MORFEO Consortium in Japan

The institutes involved in the development of MORFEO in Japan are the National Astronomical Observatory of Japan (NAOJ) in Tokyo, the University of Osaka, and the University of Kyoto. NAOJ is Japan's national center for astronomy, operating world-class facilities such as the Subaru Telescope in Hawaii and contributing to major international projects including ALMA and KAGRA. The University of Osaka, through its Department of Earth and Space Science and Theoretical Astrophysics Group, advances research in astrophysics, cosmology, planetary science, and high-energy phenomena, with a tradition of contributions to radio and X-ray astronomy. Kyoto University, via its Department of Astronomy and affiliated observatories such as Kwasan and Hida, conducts cutting-edge research in stellar physics, galactic evolution, solar activity, and cosmology, and operates the Seimei Telescope for advanced optical observations.

Within MORFEO, the JPI group is responsible for the design and manufacturing of two critical optical components: the entrance window and the folding mirror for the Calibration Unit (CU). These elements are essential for ensuring the accuracy and stability of MORFEO's optical system. The Japanese partners will participate in the design, manufacturing, and integration phases, bringing their expertise in precision optics and instrumentation to the consortium.

All contractual documents concerning the Japanese participation to the ELT are approved and signed by NAOJ, which coordinates the national contribution to international observatory projects.

4. MORFEO Project Organisation and Responsibilities

4.1. Project organisation

A prime objective of the MORFEO management structure will be to ensure that all project requirements are met on time and within agreed costs.

In order to meet the project requirements whilst minimising development risks, an essential requirement is an efficient, well defined, management structure with clearly identified interfaces and clear subdivision of the responsibilities.

Effective reporting will be set in place to ensure visibility of project activities and provide the means of monitoring the execution of all tasks and detect existing problems so that timely corrective action can be taken.

The individual teams collaborating to the project have formed the MORFEO Consortium and are drawn from different countries and consequently effective means of communication are necessary.

4.2. MORFEO Consortium

The MORFEO Consortium is a consortium of Institutes that will supply MORFEO to ESO on the basis of agreed specifications, schedule and costs.

The MORFEO Consortium is composed of three Institutes: INAF from Italy, CNRS/IPAG from France and NUIG from Ireland. The lead Institute is INAF.

A list of Consortium Institutes showing the respective supplies is given in Table 1.

ESO, although not a Consortium partner, provides specific contributions which are described in AD2 Statement of Work.

Country	Institute	Principal supplies
Italy	Istituto Nazionale di Astrofisica (**INAF**)	System level: Principal Investigator , Project Office Sub-system level: ICS software, instrument control hardware, main structure, post-focal relay optics, opto-mechanics, LOR WFS module, RTC, DMs, calibration unit, science support tools Contribution to SAT, System Team and Science Team

France	CNRS/INSU (Centre National de la Recherche Scientifique/Institut National des Sciences de l'Univers) representing IPAG and LMA	Sub-system level: - LGS WFS - Dichroic (filter) Contribution to SAT System Team and Science Team
Ireland	School of Physics at the National University of Ireland Galway (NUIG)	Subsystem level : Test and Wavefront Correction Verification Contribution to SAT and System Team and Science Team
Canada	Herzberg Astronomy and Astrophysics Research Centre at National Research Council Canada	Sub-System Level: H-RTC Contribution to AO and System Calibration teams
Japan	National Astronomical Observatory of Japan (NAOJ), the University of Osaka, Kyoto University	Sub-System Level: Calibration Unit Folding Mirror and Corrective Plate Contribution to System Architect Team and Science Team

Table 1. MORFEO Consortium Institutes.

4.3. MORFEO Management

The organisation chart showing the management structure within the MORFEO Project is shown in Figure 2.

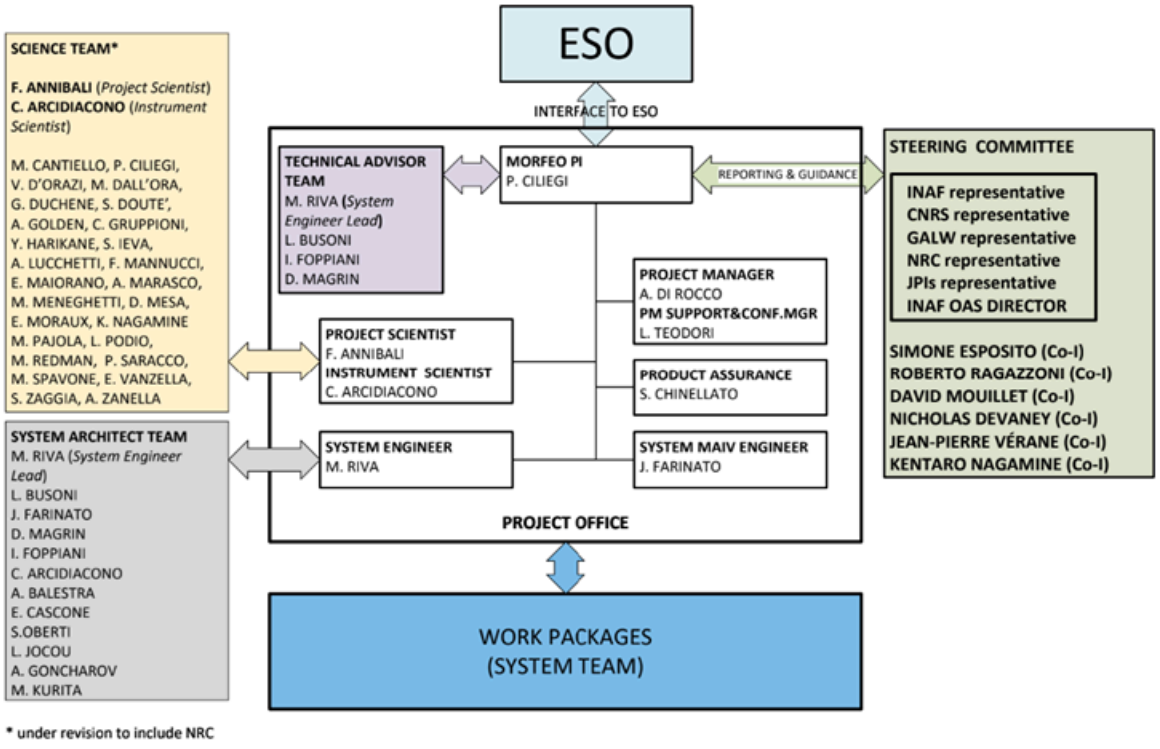


Figure 4-1. MORFEO Management Diagram.

4.4. Tasks and responsibilities

4.4.1. Principal Investigator

The PI is the lead of the scientific and technical teams and be the ultimate decision-maker in the project, only to be overruled by the Steering Committee

The PI has full responsibility for all the procurement, production, integration, test and delivery activities of MORFEO, and its associated scientific exploitation within the Guaranteed Time allocated to the Consortium through the MOU with ESO.

The PI is the formal point of contact with ESO on all MORFEO development and science related matters.

The PI works in coordination with the INAF Scientific Directorate and the Project Office.

Within Italy the PI is the key contact point with INAF ensuring there are adequate resources to deliver the project.

Finally the PI has the responsibility to report the activities of the Consortium to the Steering Committee and receive guidance from it about the main direction of the project.

The Principal Investigator (PI) is appointed by the INAF President as signatory of the agreement, under the indication of the Science Director as the initiator of the agreement and after an approval from the Steering Committee.

4.4.2. Co-Is

Co-Is are experts in the field and representatives of major research teams involved in the project. They provide advice to the project and to the PI. Current Co-Is are Nicholas Devaney (NUIG), Simone Esposito (INAF/OAArcetri), Philippe Feautrier (CNRS/INSU) and Roberto Ragazzoni (INAF/OAPadova).

4.4.3. Steering Committee

The Steering Committee provides the project with ultimate guidance and ensures feedback to/from the funding agencies. It also has the responsibility of monitoring the Project Office.

The Steering Committee monitors the development of the project and ensures that MORFEO meets its science objectives. It allows a proper connection with the funding agencies ensuring that adequate level of funding, manpower resources and infrastructures necessary to the MORFEO Project are obtained.

The Steering Committee does not operate on technical grounds. The Steering Committee approves high-level decisions proposed by the PI after ensuring that professional management procedures, appropriate risk analysis and the programmatic interests of the partners have been properly taken into account.

The Steering Committee is composed by three members:

- One representative of each partner (INAF, CNRS/INSU and NUIG);
- The director of the INAF OAS Institute in Bologna where MORFEO will be integrated;

The PI and the Co-Is attend the meeting of the Steering Committee with no voting right.

The Steering Committee will elect a chair.

The Steering Committee meets twice a year and whenever the Chair, the INAF, the CNRS/INSU or NUIG representatives or the PI deems necessary.

Major changes to the project (including the appointment or change of any member of the project office as well as major decision in the design, procurement and integration of the instrument) must be agreed upon by Steering Committee with the unanimous consent of the two Partner Representatives.

Table 2 shows the members of the Steering Committee

Country	Name/Role	Affiliation
Italy	Representative	INAF
France	Representative	CNRS
Ireland	Representative	NUIG

Italy	Director	INAF OAS
Canada	Representative	NRC

Table 2. MORFEO Steering Committee

4.4.4. Science Team

The MORFEO Science Team manages the Announcement of Opportunity for Guaranteed Time (GTO) related to MORFEO, as defined in the MORFEO Agreement for ELT and is actively involved in the definition of the scientific targets of interest. The Science Team operates to maximise the scientific exploitation and return of the ELT-MORFEO-MICADO system.

The Science Team is composed of scientific Representatives for each Consortium partner. It will meet with the MICADO Science Team to co-ordinate the use of the GTO of MORFEO with that of MICADO.

The MORFEO Science Team is chaired by the MORFEO Instrument Scientist.

Table 3 shows the list of the current members of the MORFEO Science Team.

Country	Name	Affiliation
Italy Instrument Scientist Chairman	Carmelo Arcidiacono	INAF OAPD
Italy	Eros Vanzella	INAF OAS
Italy	Francesca Annibali	INAF OAS
Italy	Elisabetta Maiorano	INAF OAS
Italy	Paolo Ciliegi	INAF OAS
Italy	Filippo Mannucci	INAF OAA
Italy	Linda Podio	INAF OAA
Italy	Simone Zaggia	INAF OAPD
Italy	Valentina D'Orazi	INAF OAPD
Italy	Paolo Saracco	INAF OAB
Italy	Marilena Spavone	INAF OACN
Italy	Massimo Dall'Ora	INAF OACN
Italy	Michele Cantiello	INAF OAAB
France	Estelle Moraux	CNRS/ IPAG
France	David Mouillet	CNRS/IPAG
France	Gaspard Duchane	CNRS/IPAG
France	Sylvain Douté	CNRS/ IPAG

Ireland	Matt Redman	NUIG
Ireland	Aaron Golden	NUIG
Japan	Kentaro Nagamine	Osaka University
Japan	Yuuichi Harikane	Tokyo University

Table 3 MORFEO Science Team.

4.4.5. System Architect Team

The System Architect Team (SAT) assists the SE in his/her activities and ensures that the system overview of the whole MORFEO instrument is shared between an adequate number of people. The SAT has the role to define system architecture. Members of the SAT will contribute to the team according to their personal background but their main task is a teamwork aimed to produce the best system design. The MORFEO System Architect Team is led and chaired by the MORFEO System Engineer.

Table 4 shows the list of the current members of the MORFEO System Architect Team

Country	Name	Affiliation
Italy System Engineer Lead	Marco Riva	INAF OAB
Italy	Lorenzo Busoni	INAF OAA
Italy	Jacopo Farinato	INAF OAPD
Italy	Carmelo Arcidiacono	INAF OAPD
Italy	Italo Foppiani	INAF OAS
Italy	Demetrio Magrin	INAF OAPD
Italy	Andrea Balestra	INAF OAPD
Italy	Enrico Cascone	INAF OACN
France	Laurant Jocou	CNRS/IPAG
Germany	Sylvain Oberti	ESO
Ireland	Alexander Goncharov	NUIG
Japan	Mikio Kurita	JPI

Table 4 MORFEO System Architect Team.

4.4.6. MORFEO Project Office

The MORFEO Project Office provides all the necessary functions to ensure the correct system development of the instrument at system and sub-system level with the exception

of the sub-systems that have their own Local Project Offices (LPO). In the current plan, the sub-systems with a Local Project Office are the LGS WFS module and the LOR WFS module.

The MORFEO Project Office includes

- Principal Investigator
- Project Manager
- Project Manager Assistant
- Instrument Scientist
- System Engineer
- System MAIV Engineer
- Product Assurance Manager
- Technical Advisor Team.

4.4.6.1. Project Manager

The management of MORFEO shall be under the control of the MORFEO Project Manager (PM), who shall:

- Define the MORFEO overall schedule necessary to meet the project milestones
- Monitor the MORFEO project-wide deployment resources
- Define deadlines and requirements for WP Managers and advise them on project priorities
- Monitor with the support of the Instrument Scientist the adequacy of the instrument implementation versus scientific requirements
- Monitor the progress of the participating institutes and industries
- Define and convene internal project reviews and meetings as necessary to ensure successful project development
- Represent MORFEO towards the ESO Management Team
- Report regularly to the ESO Management Team on the project programme

4.4.6.2. Configuration Manager/Project Manager assistant

The Configuration Manager / Project Manager assistant shall support the Project Manager in the overall coordination and administrative management of MORFEO, and in particular shall:

- Maintain the MORFEO configuration control system, ensuring traceability and consistency of all technical and managerial documentation
- Assist in the definition, monitoring, and update of project schedules and milestones
- Organize Governance meetings and follow-up of related actions
- Support risk and action tracking activities, ensuring timely follow-up and reporting

- Act as interface with the document management systems of ESO and partner institutions
- Facilitate the communication flow across all Work Packages.

4.4.6.3. Instrument Scientist

The MORFEO Instrument Scientist is responsible for ensuring that MORFEO fulfils all the scientific requirements. The Instrument Scientist will advise the MORFEO Project Office on all the scientific and operational requirements.

The Instrument Scientist is responsible for the coordination between the Science Team and the Technical Work Packages and is responsible for the instrument operational concept and data processing.

4.4.6.4. System Engineer

The System Engineer (SE) is responsible for

- Ensuring the integration of the engineering activities in project
- Agreeing on a system architecture
- Definition and/or control of external and internal interfaces
- Maintenance of the system budgets
- Verification of design and performance against requirements.

The activities of the System Engineer are supported by the System Architect Team for what concerns system architectures, and by the system team for what concerns system products.

The MORFEO System Engineer is a permanent member of the Technical Advisor Team.

4.4.6.5. System MAIV Engineer

The System MAIV Engineer is responsible for

- Production of the MORFEO MAIV Plan and test procedures
- Verification of the sub-systems MAIV plans and procedures
- Production of the MORFEO Verification Control Document (VCD)
- Agreeing the MORFEO integration, test and verification procedures with ESO for the integration and commissioning of MORFEO with MICADO and the Telescope.

4.4.6.6. Product Assurance and Quality Assurance Manager

The MORFEO Product Assurance Manager is responsible for the following:

- Approving and implementing the MORFEO Product Assurance Plan
- Liaising with and advising PA Managers of the MORFEO Consortium partners
- Approving the PA Plans of the MORFEO Consortium partners

- Carrying out PA surveillance and control of MORFEO Consortium institutes including audits and acceptance of items
- Define a project NCR and waiver system including sub-contractor and supplier NCR's convening and chairing Non-conformity Review Boards (NRB)
- Attend to Test Readiness Reviews (TRR), Test Review Boards (TRB), Integration review Boards (IRR), Qualification Status Review (QSR)
- Attending Incoming and Outgoing Inspections
- Ensuring the Reliability; Availability and Maintainability (RAM) analysis is properly carried out
- Agreeing and approving the necessary documentation in the form of Log Books and Acceptance Data Packages
- Attending all major reviews and tests and providing the relevant PA inputs
- Ensuring that cleanliness, contamination control and safety aspects are properly covered

The same responsibilities apply also to software quality assurance (SQA) management, where applicable, and in accordance with the SQA Plan.

The PA manager is a member of the MORFEO Project Office and works in co-ordination with the Project Manager and System Engineer. The PA manager has direct access to the ESO PA Manager and if necessary to upper INAF level management.

The PA manager has an independent role within the team and has the right to act independently of the PM in the PA matters when necessary towards the PI and ESO.

4.4.6.7. Technical Advisor Team

The Technical Advisor Team (TAT) is a small team (no more than 4 persons). The MORFEO System Engineer is a permanent member of the TAT. The TAT is the technical core team of the project and it is the main technical advisor for the PI. As MORFEO is a very complex instrument and the knowledge of the whole instrument cannot be delegated to one or two persons, the TAT provides the PI with technical advice on either global or urgent matters whenever necessary. The TAT is chaired by the MORFEO PI.

4.4.7. Work Package Managers (System Team)

Each WP is assigned a work package manager. All the work package managers form the System Team led by SE. The System Team is the place where all decision taken in the SAT flow down to the subsystems and WP managers can report their feedback.

The Work Package Managers have local responsibility for the activities within a particular WP. They report to the PM , SE and PI.

In particular, Work Package Managers are expected to collaborate with the MORFEO PM to maintain a detailed schedule of activities with clear links to the overall integrated master schedule. They collaborate with the MORFEO PM and System Engineer to ensure compliance with the risk management plan, identifying and tracking risks relevant to the WP scope.

The System Team work with the System Engineer and the System AIV Engineer to ensure technical compliance of the work package deliverables by agreeing requirements, ICD's, technical performance budgets, AIV plans, execution of the verification tests.

4.5. Communication

The scope of the communication within and externally to MORFEO is to ensure a clear and unambiguous working environment for the development of MORFEO that while respecting the project organisation ensures efficient communication avoiding delays. The detailed methods of the communication process are given in the MORFEO Configuration Management Plan (AD5).

4.5.1. Communication and relationship with ESO

The PI will be the formal point of contact with ESO.

The MORFEO Project Manager and the System Engineering Team will support the PI for all programmatic and technical matters.

Copies of all correspondence on technical issues shall be sent to the MORFEO Project Manager, the MORFEO System Engineer and the PI.

Transmission of communication and correspondence may be via e-mail, file transfer, WWW, fax, courier, or mail, as appropriate.

The relationship will be maintained also with progress and interface meetings, and teleconferences.

4.5.2. Communication and relationship between MORFEO Project Office and Work Package Managers

All formal communications and provision of documents to/from the MORFEO Project Office shall be distributed through the Work Package Manager who shall also be responsible for ensuring that any relevant material is passed locally to her/his appropriate colleagues.

Transmission of communication and correspondence may be via e-mail, file transfer, WWW, fax, courier, or mail, as appropriate.

The relationship will be maintained also with progress and interface meetings, and teleconferences.

4.5.3. Communication and relationship with the MICADO and Telescope Team

The MORFEO team is committed to providing ESO with MORFEO such that it can be integrated, tested, performance verified, commissioned and operated with MICADO and the Telescope.

ESO will manage the interfaces between MORFEO, MICADO and the Telescope.

The relationship between MORFEO and ESO will be maintained by the MORFEO PI through regularly convened interface meetings organised by ESO, and transmission of communications and correspondence may be via e-mail, file transfer, WWW, fax, courier, or mail, as appropriate.

4.6. MORFEO Project Meetings and Reviews

The MORFEO Project shall be controlled through progress meetings, technical status meetings and Project Reviews.

4.6.1. Project Meetings

The following meetings are foreseen (for details see below):

- Progress Meetings at MORFEO System Level
- Interface Meetings

In addition ESO require the following status meetings whose scope and purpose are described in MORFEO (ELT MCAO) SOW (AD2):

- Kick-Off Meeting
- Data Reduction Prototype Assessment Meetings
- Integration Readiness Meeting (concomitant with the MORFEO Qualification Review)
- Test Readiness Meeting
- Commissioning Meetings

These additional meetings are convened by ESO. For all the meetings, the Consortium shall take the minutes of the meeting and record the action items with the exception of the Interface Meetings where ESO shall take the minutes and record the action items.

4.6.2. MORFEO Progress Meetings at System Level

Progress Meetings will be organized and chaired by the MORFEO Consortium on a four monthly basis. The MORFEO Project Office shall provide ESO a progress report (see DRD 020 of AD2 for the Progress Report contents/format) one week in advance of the progress meeting. All documentation needed for Progress Meetings such as technical reports, drawings etc., which have not yet been delivered to ESO prior to the meeting, shall also be sent, at the latest, together with the Progress Report. Agenda items shall include but not necessarily be limited to

1. Status of the Action Items List.
2. Progress over the reporting period (for the baseline and for the options, if any); including a milestone trend analysis (MTA) with a graphical summary, if appropriate.
3. Activities for the next period (for the baseline and for the options, if any).

4. Changes to Compliance matrix or configuration (if any).
5. Updated or reconfirmed Master schedule maintaining reference to the initial baseline schedule.
6. A comparison of expected against actual spending.
7. Updated risk status (if any).

As a general rule, the Project Office and the WP Managers shall attend the progress meetings. In addition, each party may decide at its sole discretion to add participants.

The Consortium shall take the minutes and maintain an Action Item List (see DRD030 of AD2 for contents/format). The Action List shall be regularly updated and attached to the minutes of meetings.

The MORFEO Progress Meetings with ESO would normally be expected to be held at the site of the MORFEO Project Office or via video conferencing.

In order to allow the MORFEO PM to provide ESO with these regular reports, each WP Manager shall supply the MORFEO PM with their progress reports following the same contents/format as for the System level progress reports and action lists.

4.6.3. Interface Meetings

MORFEO will support ESO in the interface meetings necessary for defining and agreeing the interfaces with MICADO and the telescope. MORFEO shall be represented at these meetings by the MORFEO PI, PM, System Engineer, and WP Managers and other team members when deemed necessary.

4.7. MORFEO Project Phases and Reviews

ESO will plan and prepare project reviews in consultation with the MORFEO Consortium, particularly with regard to the agenda, participants and contents of the reviews. The MORFEO project will contain three phases with their associated system level reviews.

- Phase B
  - With the MORFEO Preliminary Design Review (PDR) at the end of Phase B2
- Phase C/D
  - With the MORFEO Final Design Review (FDR) at the end of the phase C
  - With the MORFEO Test Readiness Meeting (TRM)) during the Phase D
  - The MORFEO Preliminary Acceptance in Europe (PAE) review will be held at the end of the Phase D
- Phase E
  - MORFEO Readiness Review, review of readiness to be mounted on the Nasmyth Platform
  - The Phase E terminates with the MORFEO Provisional Acceptance Review in Chile (PAC).

4.7.1. Phase B (Consolidation of the Preliminary Design)

4.7.1.1. Principal Tasks

The principal tasks of the Phase B are the following:

- Finalize the project management, engineering and product assurance plans.
- Establish the baseline master schedule.
- Elaborate the baseline cost to completion.
- Confirm technical solution(s) for the system and operations concept(s) and their feasibility with respect to programmatic constraints.
- Conduct “trade-off” studies and select preferred technical solution(s) to consolidate the preliminary design.
- Determine and consolidate the verification program.
- Identify and define external interfaces.
- Prepare the next level specification and contractual documents.
- Conclude pre-development work on critical technologies or system design areas when it is necessary to reduce the development risks.
- Consolidate the identification of long lead items and if necessary commence early procurement to meet the project schedule
- Conduct reliability and safety assessments.
- Finalize the product tree, the work breakdown structure and the specification tree for the phase C/D.
- Update and maintain the risk assessment.
- Identify telescope hypothesis (or refer to a document describing this)
- Generate AIT plan describing what will be validated in the institutes before going to the telescope.

4.7.1.2. Associated Phase B Reviews

MORFEO Preliminary Design Review (PDR) at the end of Phase B to:

- Verify the preliminary design of MORFEO and its technical solutions against project and system requirements.
- Release of final management, engineering and product assurance plans.
- Release of product tree, work breakdown structure.
- Release of the verification plan.

Further specific requirements to be met and activity to be concluded during phase B are given in AD2.

4.7.2. Phase C/D (Detailed Design Completion, Qualification and Production)

The principal tasks of the Phase C/D are the following:

- Completion of the detailed design definition of the MORFEO system at all levels in the customer-supplier chain.
- Detailed definition of internal and external interfaces.
- Production, development testing and pre-qualification of selected critical elements and components.
- Production and development testing of engineering models, as required by the selected model philosophy and verification approach.
- Completion of assembly, integration and test planning for the MORFEO system and its constituent parts.
- Issue draft MORFEO user manual by end of Phase C.
- Complete qualification testing and associated verification activities.
- Complete manufacturing, assembly and testing of the MORFEO hardware/software and associated operations support hardware/software.
- Complete the interoperability preliminary testing between MORFEO, MICADO and the Telescope (TBC).
- Prepare the acceptance data package of MORFEO.
- Update and maintain the risk assessment.

4.7.2.1. Associated Phase C/D Reviews

MORFEO Final Design Review (FDR) at the end of the phase C to:

1. Assess the qualification and validation status of the critical processes and their readiness for their use in phase D.
2. Confirm compatibility with external interfaces.
3. Release the final design of MORFEO for production.
4. Release assembly, integration and test planning.
5. Release final hardware/software manufacturing, assembly and testing documentation.
6. Release the draft MORFEO user manual.

Where necessary, the FDR for long lead items will be anticipated to the time of the PDR at the end of the MORFEO Phase B or during Phase C.

MORFEO System Qualification Review (MSQR) during the Phase D and to be completed by the commencement of MORFEO AIT:

- To confirm that the verification processes on the MORFEO subsystems have demonstrated that their design, including any margins, meet the applicable requirements prior to MORFEO System AIT commencement.
- To verify that the MORFEO verification records are complete at MORFEO Sub-System and all lower levels in the customer-supplier chain.

- To verify the acceptability of all waivers and deviations.

Where development encompasses the production of one or several recurring products, the MSQR is completed by a functional configuration verification during which:

- The first article configuration is analysed from the viewpoint of reproducibility.
- The production master files for the series productions are released.
- The series production go–ahead is accepted by the customer.

It is clear that elements of the MSQR effecting units will need planning into the sub-system production activities to reduce risks and be effective.

The Preliminary Acceptance in Europe (PAE) review will be held at the end of the Phase D:

- To verify that the MORFEO performance conforms with the technical specification and its applicable documents.
- To confirm that the verification processes applied to MORFEO have demonstrated that the product is free of workmanship errors and is ready for subsequent operational use.
- To verify that the acceptance verification record is complete at this and all lower levels in the customer-supplier chain.
- To verify that all deliverable products are available per the approved deliverable items list.
- To verify the “as-built” product and its constituent components against the required “as designed” product and its constituent components.
- To verify the acceptability of all waivers and deviations.
- To verify that the Acceptance Data Package is complete.
- To authorize delivery of MORFEO.
- To release the MORFEO certificate of acceptance.
- To release MORFEO for Shipment to the Telescope site.

Further specific requirements to be met and activity to be concluded during the phase C/D are given in AD2.

4.7.3. Phase E (Site Integration and Commissioning)

The Principal Task of the Phase E are the following:

- Perform the integration of MORFEO with MICADO and the Telescope on site.
- Perform commissioning and verification.
- Perform all on-sky operations in order to achieve the project objectives.
- Perform all preliminary operational activities needed to ensure continued operation of MORFEO, including the completion of training of ESO personnel.

4.7.3.1. Associated Phase E Reviews

The list of formal reviews required by ESO during the Phase E are given below:

MORFEO Installation Readiness Review

- This review will be held at the observatory prior to the installation of the instrument on the telescope, to determine whether the instrument has successfully completed all of the tests foreseen when it arrived at the observatory and is ready to be mounted on the telescope.

MORFEO Provisional Acceptance Review in Chile (PAC)

- MORFEO shall prepare and deliver within 6-12 weeks after the end of Commissioning the Provisional Acceptance (Chile) Data Package (see AD(9) for contents), including the results of operational and observational tests performed at the Observatory and the final updated versions of manuals, documentation, drawings and software (control software). Condition for successful PAC is that MORFEO meets the requirements of the Technical Specification and its applicable documents, and that all tasks described in AD2 have been satisfactorily fulfilled. Compliance shall be demonstrated in the Commissioning / Instrument Performance Report. A PAC meeting between the MORFEO Consortium and the involved teams of ESO will be held within 4 months after the end of Commissioning with the scope of declaring PAC.

Further specific requirements to be met and activity to be concluded during phase E are given in AD2.

After the Phase E there will be the guaranteed period of 2 years followed by the Final Acceptance of MORFEO in Chile performed on the basis of documentation prepared by the ESO Project Team and Instrument Scientists.

5. Project Breakdown Structures

5.1. Product tree (PT)

The MORFEO PT forms the basis of the MORFEO Work Breakdown Structures (WBS) and demonstrates the current MORFEO Project baseline as agreed between all the MORFEO Consortium Partners.

Each MORFEO Partner (INAF CNRS/INSU, representing IPAG, NUIG, NRC-HAA and JPIs) will complete the PT at its own level for the products under its responsibility.

In terms of hierarchy definition, we propose to adopt the standard ESO already used in past projects:

1. Instrument (MORFEO)
2. Sub-System
3. Equipment
4. Assembly[1]
5. Unit
6. Component
7. Piece

5.1.1. MORFEO PT Numbering

PT numbering is defined in the MORFEO Configuration Management Plan (AD5).

Refer to that document for details.

5.1.2. MORFEO PT Figures

The high level MORFEO PT is shown in Figure 3

[1] To be noted that when we refer to Assembly drawings we consider the Drawing that explain the mounting of any sublevel items that realise an upper level one, so it is applicable to all levels from 1 to 6

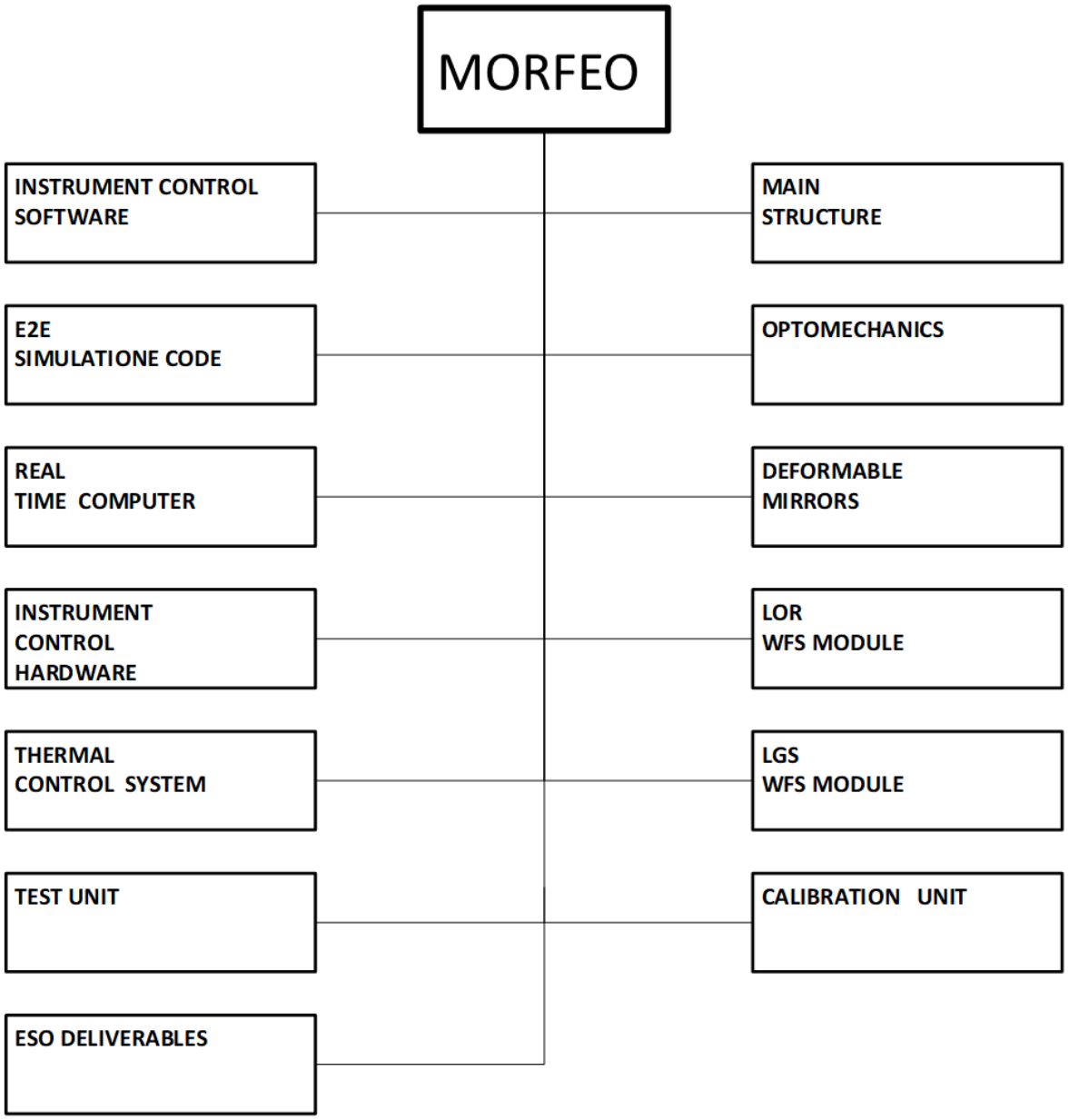


Figure 5-1. MORFEO High Level Product Tree

5.2. Work Breakdown Structure (WBS)

The MORFEO WBS contains the structured breakdown of the whole project activities based on the analysis of the tasks required to achieve the products identified in the MORFEO PT.

The MORFEO Project WBS provided here is for the Phase B and serves these functions:

.

- To define all the work packages (WP) necessary for MORFEO project management
- To define all WP necessary to manage the MORFEO at system level
- To identify all the WP necessary for the creation of the deliverable MORFEO products
- To establish the basis for the MORFEO project schedule and cost planning.

If necessary, WP Managers will complete their own WBS to a lower level than that shown in the MORFEO Project WBS to ensure the criteria listed above are fulfilled within their own project.

5.2.1. MORFEO WBS Box Description

Each box shown in the MORFEO WBS contains the following information:

− Short Title of the Activities

− WP Manager

5.2.2. MORFEO WBS numbering guidelines

The proposed WP number system is derived from the numbering system of product tree, and is the following:-

X-Y-num-*NUMB*

Where, for the MORFEO instrument

X-Y-num: is the PT Code down to Units and Subassemblies given in Section 5.1.1

NUMB:

N: To identify the Phase of the Project, as follows:

1	Phase B
2	Phase C
3	Phase D
4	Phase E

UMB: three numerical digits used to identify the Work Packages in the following hierarchical way-

100, 110, 111, 112, 113 etc.

120, 121, 122, 123 etc.

200, 210, 211, 212, 213 etc.

If the three digits is not sufficient, each Project Office will allocate extra digits as necessary to complete its WBS.

WP codes are reported in table 5.

Sub-System Code	Product Tree
000	MORFEO System
MA0	PRINCIPAL INVESTIGATOR ACTIVITES
MB0	PROJECT MANAGEMENT
MC0	PRODUCT ASSURANCE MANAGEMENT
MP0	PROCUREMENT
SE0	SYSTEM ENGINEERING
SA0	SYSTEM ADAPTIVE OPTICS ENGINEERING
SM0	SYSTEM MAIV ENGINEERING
SF0	SYSTEM OPTICAL DESIGN
SC0	SYSTEM CALIBRATION
SS0	SYSTEM SCIENCE OPERATIONS
PC0	END TO END SIMULATION CODE
PD0	DEFORMABLE MIRRORS
PE0	ESO DELIVERABLES
PF0	OPTOMECHANICS
PH0	INSTRUMENT CONTROL HARDWARE
PL0	LASER GUIDE STAR WAVEFRONT SENSOR MODULE
PM0	MAIN STRUCTURE
PN0	NATURAL GUIDE STAR (LOR) WFS MODULE
PR0	REAL TIME COMPUTER
PS0	INSTRUMENTATION SOFTWARE
PT0	THERMAL CONTROL
PU0	CALIBRATION UNIT
PV0	TEST UNIT
PW0	WFS CAMERAS

Table 5. Work Packages code list down to level 2 used in the configuration management plan.

5.2.3. MORFEO WBS Figures

The MORFEO WBSs for Phase-B to D are shown in the following figures.

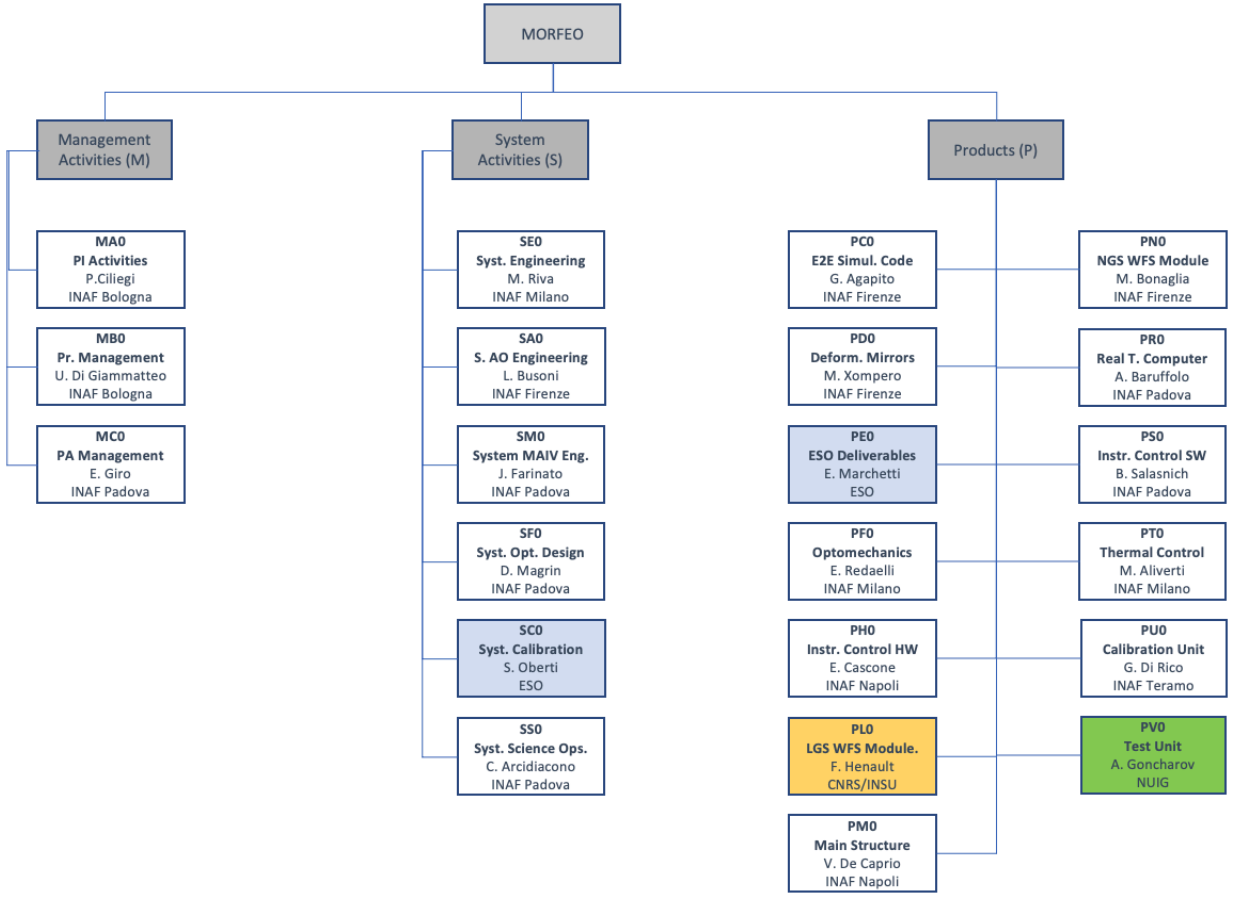

MORFEO
Management Activities (M)
System Activities (S)
Products (P)
MA0
PI Activities
P.Ciliegi
INAF Bologna
MB0
Pr. Management
U. Di Giammatteo
INAF Bologna
MC0
PA Management
E. Giro
INAF Padova
SE0
Syst. Engineering
M. Riva
INAF Milano
SA0
S. AO Engineering
L. Busoni
INAF Firenze
SM0
System MAIV Eng.
J. Farinato
INAF Padova
SF0
Syst. Opt. Design
D. Magrin
INAF Padova
SC0
Syst. Calibration
S. Oberti
ESO
SS0
Syst. Science Ops.
C. Arcidiacono
INAF Padova
PC0
E2E Simul. Code
G. Agapito
INAF Firenze
PD0
Deform. Mirrors
M. Xompero
INAF Firenze
PE0
ESO Deliverables
E. Marchetti
ESO
PF0
Optomechanics
E. Redaelli
INAF Milano
PH0
Instr. Control HW
E. Cascone
INAF Napoli
PL0
LGS WFS Module.
F. Henault
CNRS/INSU
PM0
Main Structure
V. De Caprio
INAF Napoli
PN0
NGS WFS Module
M. Bonaglia
INAF Firenze
PR0
Real T. Computer
A. Baruffolo
INAF Padova
PS0
Instr. Control SW
B. Salasnich
INAF Padova
PT0
Thermal Control
M. Aliverti
INAF Milano
PU0
Calibration Unit
G. Di Rico
INAF Teramo
PV0
Test Unit
A. Goncharov
NUIG

Figure 5-2. MORFEO Phase B WBS

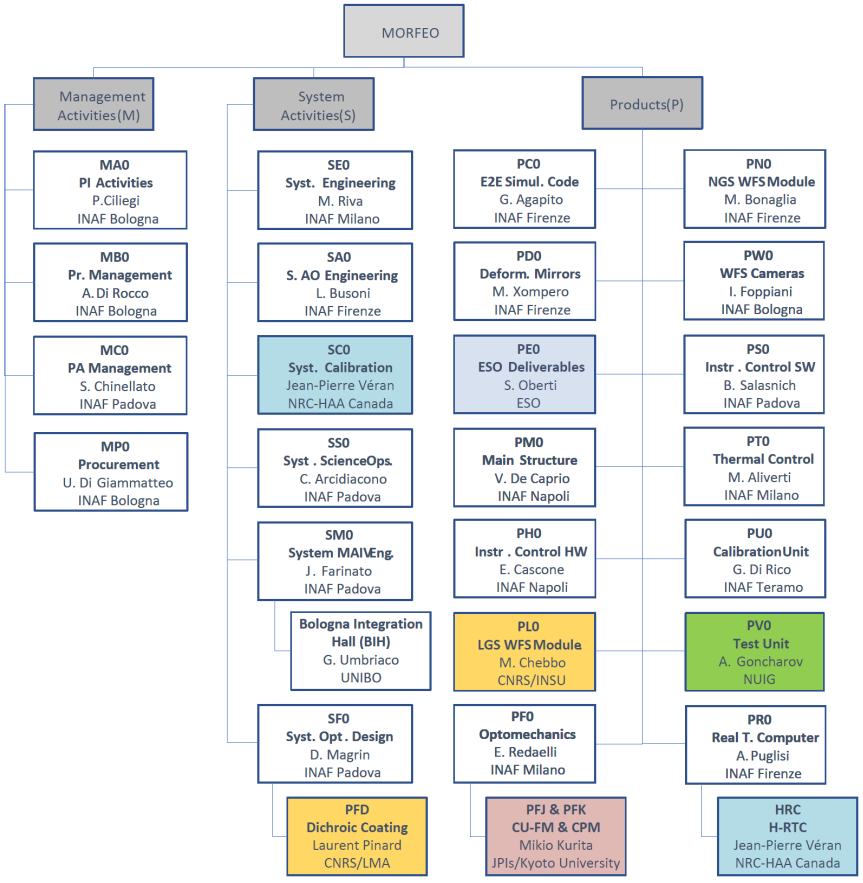


Figure 5-3. MORFEO Phase C WBS

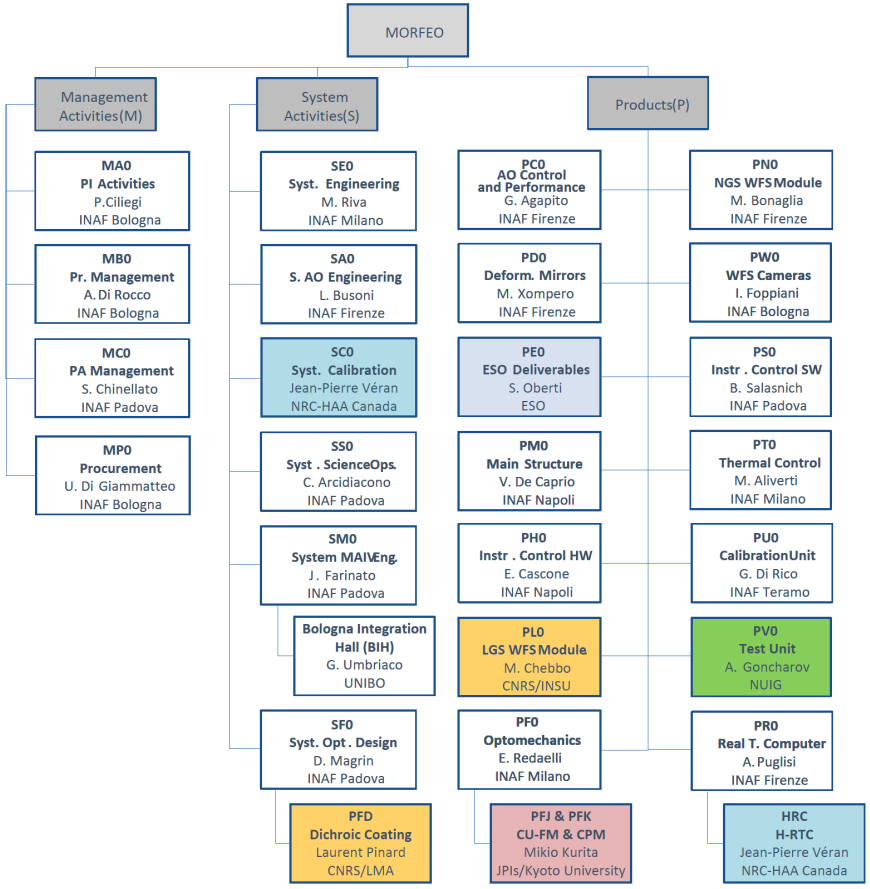


Figure 5-4. MORFEO Phase D WBS

6. Configuration, Information and Documentation Management

A system for configuration management and control is established and implemented within the MORFEO Project. The requirements and procedures established by the MORFEO Configuration Management Plan (CMP) shall be observed and implemented by all personnel involved in the project, responsible for the design, development, procurement, manufacture, assembly and integration in all phases of the MORFEO Project. Thus it applies to all MORFEO Consortium members and their suppliers.

The configuration management of MORFEO will permit the establishment and control of the configuration status of the project during all project phases and forms the basis for an efficient comparison between the nominal (as designed) and actual status of a project (as built status control).

The configuration management process involves the systematic application of disciplines and procedures to accomplish its prime functions, i.e. Configuration Identification, Configuration Control, Interface and Change Control, Configuration Status Accounting and Baseline Management.

All the rules relating to the configuration matters are described in the CMP document (AD5) which must be considered as the reference document for any configuration matters.

7. Cost and Schedule Management

7.1. Cost management

Each WP Manager will collaborate with the MORFEO PM and PI to control its Full Time Equivalent (FTE) effort and its required costs through analysis of its activity at the Work Package level based on a properly prepared WBS and schedule structured to show the development activity phases. The FTE data and costs data will be supplied to the MORFEO Project Office in a separate document (and file).

In all the documents and files, FTE is the full time equivalent per year, defined as total hours worked divided by average annual hours worked in full-time jobs. A FTE of 1.0 is equivalent to a full time equivalent worker, while an FTE of 0.5 signals half of a full work load. As an example, two full time equivalent workers (FTE=1) working on two different Workspaces with a temporal duration of 0.3 and 2 years respectively, will be both reported on the relative Workspace tables with FTE=1. The total time (that could be expressed in years, working days or hours) dedicated on a specific Workspace can be obtained by multiplying the reported FTE by the length (in time) of the Workspace.

The MORFEO Project Office will verify these FTE efforts and costs down to individual Work Package level verifying also that the WBS and the proposed schedule are consistent with the MORFEO WBS and MORFEO Overall Schedule.

The MORFEO Project Office will maintain a summary of the FTE effort and costs broken down to Consortium partner level and project phases, that will be made available to ESO for agreement.

Each Consortium partner will be responsible for demonstrating how they will face possible long term staff evolution, and if applicable how they will deal with fixed term temporary staff in the case of schedule overruns.

7.2. MORFEO procurement process

The following describes the overall procurement process for MORFEO, highlighting the actors involved, the schedule of the various activities, and the impact on the global MORFEO timeline.

Procurement procedures differ depending on the type of item. The number of potential providers is also highly variable: some components are manufactured by only a few actors worldwide, while others can be considered COTS products, produced by many companies and readily available on the market.

Initially, we envisaged the use of innovative procurement instruments (based on co-engineering) for elements expected to require preliminary studies. We therefore explored several possible procedures (e.g. Pre-Commercial Procurement, Competitive Dialogue, and Innovation Partnership) to be applied to the Post-Focal Relay Optics.

In recent months, however, we concluded that these innovative instruments are too complex, costly, and time-consuming. Moreover, the benefits they provide do not justify the effort and delays, especially given the tight schedule constraints.

For all optical components, we therefore follow standard procurement procedures, which generally involve:

- Final Design of the element (fixed part)
- Manufacturing of the element (optional part, subject to the successful conclusion of the relevant FDRs)

Some elements are considered **Long-Lead Items** because they require extended manufacturing timeframes. Their procurement is expected to begin before the formal closure of the complete FDR, provided that ESO grants formal approval.

The identified Long-Lead Items are:

- Post Focal Relay complete optics
- Post Focal Deformable Mirrors

7.2.1. Optics for the Post Focal Relay

The procurement of the Post-Focal Relay Optics includes the Main Path Optics, the Dichroic, the LGS objective, and the rigid mirrors with the same shape and size as the Deformable Mirrors (DMs), to be used during the AIV phase as dummy DMs.

The process began with a market consultation involving several potential suppliers and progressively evolved into a combination of external procurement and design/development activities within the Consortium.

During Phase B, we received a number of ROM quotations and engaged in iterative discussions with the following companies:

- ➔ Kiwistar Optics
- ➔ Safran Reosc
- ➔ AMOS
- ➔ Heraeus
- ➔ Officina Stellare
- ➔ Thales SESO
- ➔ Coherent
- ➔ L3Harris
- ➔ IDOM
- ➔ Medialario
- ➔ SENER

The main difficulty for companies in providing reliable quotations lies in the complexity of the opto-mechanics under operational conditions. Suppliers must invest significant resources to ensure compliance with requirements and to establish a reasonable price.

A complete set of ROM quotations is available for the Post-Focal Relay Optics, although not all companies expressed interest in the full set of optical elements.

To make the procurement process more effective, we divided the Post-Focal Relay Optics system into blocks of components, organized according to technical similarities.

The blocks identified for the PFRO are the following:

- Aspherical (M7M, M8M)
- Flat (M6M-Fold1, M11M-Flip, M12-Fold3, LGSO-FM1, LGSO-FM3)
- LGS Objective (which includes the following optical elements: L1, L2, L3, L4, LGSO-FM2)
- Dichroic filter
- Correcting Plate (CPM) and Calibration Unit FM (CU-FM)

Initially, all the above-listed blocks were expected to be outsourced. Subsequently, some members of the Consortium (both existing and new entrants) offered to take responsibility for the design and manufacturing of certain components.

In particular:

- **CPM and CU-FM** will be provided by a Japanese group (JPI) led by NAOJ (National Astronomical Observatory of Japan). For these optical elements, we will follow the same path (Final Design plus Manufacturing), but no Call for Tender (CfT) is required. Additionally, no Long-Lead Item (LLI) has been identified so far.
- **Dichroic**
  - Filter and coating: Laboratoire des Matériaux Avancés (L.M.A.) – CNRS/IN2P3, Lyon, France
  - Blank and mirror finishing: procured by INAF
  - Mounting elements: outsourced by INAF
  - Integration and characterization: carried out jointly by INAF and LMA

Remaining Optical Elements (external procurement through public call for tender):

- **Aspherical Mirrors (M7M, M8M)**
  - Prior Information Notice published on 14 March 2023
  - Call for Tender scheduled for Q1 2025
- **Flat Mirrors (M6M-Fold1, M11M-Flip, M12-Fold3, LGSO-FM1, LGSO-FM3)**
  - Prior Information Notice published on 14 March 2023
  - Call for Tender scheduled for Q1 2025
- **LGS Objective** (including L1, L2, L3, L4, FM2)
  - Prior Information Notice published on 13 March 2023
  - Call for Tender scheduled for Q4 2025

7.2.2. Optical mounts

The optical mounts will be included in the calls for the different lots of PFRO elements.

The optical elements will be provided complete with mounts.

7.2.3. Deformable Mirrors

The Call for Tender (CfT) for the Deformable Mirrors covers both the **Final Design (Phase C)** and the **Manufacturing (Phase D)**. The start of the Manufacturing phase is conditional upon the successful completion of the Final Design phase.

The structure of the CfT and the resulting contract is as follows:

- **Final Design Phase (Phase C):**
  This phase comprises the preparation of all required documents, drawings, and deliverables.
- **Manufacturing Phase (Phase D):**
  This phase begins once the Final Design Review (FDR) for the DMs has been successfully passed.

For both phases a Firm and Fixed Price must be submitted by the bidder during the Call for Tender.

It is mandatory for candidates to apply for both phases. The entire contract (Phase C plus Phase D) will therefore be awarded to a single company. This ensures consistency between design and manufacturing, safeguards the Intellectual Property of the technical solution, and avoids the need for the designated contractor to transfer technical information to competitors.

The Call for Tender documentation was prepared and revised internally by INAF Bologna Administration, INAF Headquarters, and the consulting company Martino & Partners. It was subsequently reviewed by ESO through a **Call for Tender Readiness Review**. The documents were updated according to ESO's remarks and re-submitted for approval.

The Call for Tender Readiness Review was formally declared passed on **2 May 2023**, and the Call for Tender was published on **9 June 2023**. A contract with AdOptica (the winning bidder) was signed in **December 2023.**

7.2.4. Main Structure

The same mechanism described for DMs will be applied to the main structure:

- Final Design Phase
- Manufacturing Phase subject to successful FDR with ESO

Economic operators are required to apply for both phases. The contractor awarded the contract will be responsible for both the final design and the manufacturing, with the manufacturing phase commencing only after the successful conclusion of the FDR.

As part of the tender, the scope also includes:

- the design and manufacturing of the support equipment and handling tools to be delivered in Chile
- Transport of the Main Structure to Chile
- Mounting and dismounting of the Main Structure in the Bologna Integration Hall
- Final mounting in Chile

Although the Main Structure does not present significant technical risks and is not expected to involve long design or manufacturing times, its procurement must be closely monitored. This is because the Main Structure will serve as the physical foundation on which the rest of the instrument will be integrated in Bologna.

7.2.5. Real Time Computer

Initially it was foreseen that the RTC would be outsourced almost completely.

After several months of contacts and negotiations the Herzberg Astronomy and Astrophysics Research Centre (NRC/HAA, Victoria - Canada) is now joining the MORFEO Consortium.

The following configuration is thus foreseen now:

- HRTC designed and developed by NRC/HAA
- SRTC designed and developed by INAF

7.2.6. Calibration-Test Unit

The initial plan foresaw that INAF would carry out the design of the Calibration Unit sub-system, with manufacturing outsourced to industry. However, given both the criticality of the CU and the workload already assigned to the INAF team responsible for this sub-system, it was decided to entrust an external company with responsibility for both the Final Design and the Manufacturing for the full optomechanical structures except for fiber plates and associated electronics.

The contractual scheme adopted mirrors that defined for the Optical Elements of the PFRO:

- **Final Design** awarded on a fixed-price basis
- **Manufacturing** conditional upon the successful completion of the FDR

7.2.7. LOR WFS Module

The preliminary design (Phase B) is being carried out mostly internally, with a few limited contracts assigned to support specific aspects of the design.

The initial plan was to conduct the detailed design of the LOR internally and to acquire the necessary parts through a direct purchase process, with the exception of the three arm

stages, which were intended to be procured via a Call for Tender covering both the design (Phase C) and the manufacturing (Phase D).

However, the Call for Tender for the three stages went void, leading us to reconsider the approach. Eventually, we opted for commercial stages, adapted to our requirements, and acquired through direct purchase. This solution was chosen to streamline the process, reduce administrative overhead, and better align with the project's schedule constraints, while still ensuring that the required specifications are met.

7.2.8. LGS WFS Module

The design is carried out internally. The procurement will be done for single components by means of standard open procedures.

7.2.9. Adaptive Optics Wave-Front Sensor camera

We will receive, as ESO deliverables, the following cameras:

- 3x FREDA +1 spare detectors for the NGS
- 3x ALICE +1 spare detectors for the Visible Truth WF.

As regards the cameras for the LGS WFS module, MORFEO has issued a Request for Deviation to use a camera with a SONY detector.

The Request for Deviation has been accepted by ESO, with some warnings, in April 2022.

The adoption of a SONY-based camera implies the start of several activities for the MORFEO Consortium:

- Start of the procurement process
- Adaptation of the camera to the ESO interfaces

The LGS WFS cameras will be procured on the market, according to the specific technical requirements.

A purchase is planned for the design, adaptation, and prototyping of the LGS WFS camera. Following the positive acceptance of the proposed solution, all required customized cameras will then be procured.

A specific new WP (PW0) has been created to include the activities requested for the SONY-based camera.

7.2.10. Electronics at System Level

The design will be carried out internally. The procurement will be done for single components by means of standard open procedures.

7.2.11. AIV tools

Handling tools for the Mirrors

The handling tool used to remove the mirrors from their boxes will be designed and manufactured by the same companies responsible for producing the mirrors, and will therefore be included in the scope of work of the public Call for Tender.

The design and manufacturing of all handling tools intended to position the mirrors within the main structure, given their strict dependence on the design of the structure itself, will be outsourced to the same company manufacturing the main bench, as part of the same tender.

Support Equipment to be delivered to Chile

The design and manufacturing of the support equipment meant to be delivered to Chile (ladders and rail systems) will be outsourced to the same company manufacturing the main bench and part of the same tender.

Other Support Equipment

The design of the MICADO Emulation Structure will be done internally. A call for tender, or a direct negotiation depending on the estimated cost of purchase, will be issued to include the manufacturing of the mechanic.

The co-rotating system for the LOR cabinets is the derotator prototype developed at MPIA for MICADO and already in the Bologna Integration Hall. The main derotator for the LOR will be designed internally and its bearing will be purchased separately.

All the elements of the TAC systems (cameras, motors, arms) are off-the-shelf products, except for the interface flanges that will be designed within the Consortium and either manufactured internally or outsourced. The final choice will be determined by FDR.

7.2.12. Shipment

The shipment will be assigned by means of an open Call for Tenders after a preliminary market consultation. The detailed technical requirements for shipment will depend on the final design of MORFEO, in particular in the way the instrument will be dismounted for transport (number of pieces, respective sizes and weights).

7.2.13. Procurement roles

Procurement of MORFEO elements is a complex process that requires the coordinated action of different actors.

Project Management activities

- Define schedule and needed resources for the procurement process in close collaboration with the PI.

- Monitor and control times, resources and costs of the procurement process from a Project Management point of view, in coordination with the PI and the PA Manager.

PA activities

- Ensure the the conformity of procurement process to the PA requirements

PI activities

- Identify the procurement needs and support the PM in the definition of the relevant process and schedule
- Supervise the procurement process and ensure its coherence with the objectives of the project

To support the MORFEO consortium in the procurement process a specialised company (Martino & Partners) has been selected. This company provides advice on the procedures up to the award of contracts to manufacturers.

The activities foreseen in the various project phases for the PM, the PI and the PAM are now collected in a specific Work Package (MP0).

System Engineering / Technical activities

- Prepare the technical specifications of the elements to be procured
- Check the consistency with the common requirements and with the technical specifications of interfacing elements
- Highlight the technical assumptions and the environmental factors that affect the subsystem
- Identify the verification methods
- Check the Statement of Work in order to assess the coherence of activities with the technical goals
- Refinement and control af all the interfaces

The above activities imply the coordinated effort of the following figures:

- WP Manager of the relevant technical element (0.8 FTE for 1 to 3 months)
- Assistant of the WP Manager (0.5 FTE for 1 to 3 months)
- System Engineer (0.7 FTE for 1 to 3 months)

7.2.14. Procurement strategy

The procurement strategy must take into account several concurrent factors:

- The interactions and dependencies between the subsystems involved in the different procurements
- The time needed to complete the design and to manufacture each item
- The need to comply with laws, regulations and habits (European, National, of INAF/specific institute, of ESO)
- The financial coverage for all elements to be procured

Therefore, for each of the procurements beyond 140 K€, the following steps are necessary:

1. (Preliminary) Publication of Prior Information Notice
2. Questions from potential bidders and Answers from the Consortium
3. Preparation of the Call documentation
    a. Call (Bando di gara)
    b. Rules of the procurement process (Disciplinare)
    c. Statement of Work
    d. Technical Specifications and related Applicable Documents
    e. Other documents (as necessary)
4. Internal Review of documentation
5. Delivery to ESO of Call documentation (if purchase is over 300K€)
6. Closure of Critical Action Items related to the Call documentation (if purchase is over 300K€)
7. Formal approval of the Call documentation and Letter of Financial Support from ESO (if purchase is over 300K€)
8. Update of INAF balance sheet (for the INAF local office that issues the Call)
9. Publication of the Call (Ubuy, INAF site, TED, newspaper), assignment of CIG (Call Identifier)
10. Evaluation of the proposals
11. Award of the project
12. Preparation of “Atto d’obbligo” (Act of Commitment) and assignment of CUP (Project Unique Code)
13. Contract signature (at least 30 days after the award of the project).

Change Requests handling during Call of Tender process

No changes to the requirements are foreseen during the Call for Tender process. Should a requirement need to be modified, a new Call for Tender procedure would have to be reissued, incorporating the amended requirements and thereby resetting the time available to bidders for submitting their proposals.

Typically, however, partial or non-compliance with certain requirements does not prevent bidders from being selected. In such cases, there is no need to reissue a new Call for Tender, as the matter can be addressed during the evaluation process. The Call for Tender can therefore proceed as planned, with any necessary amendments to the requirements introduced after the contract signature.

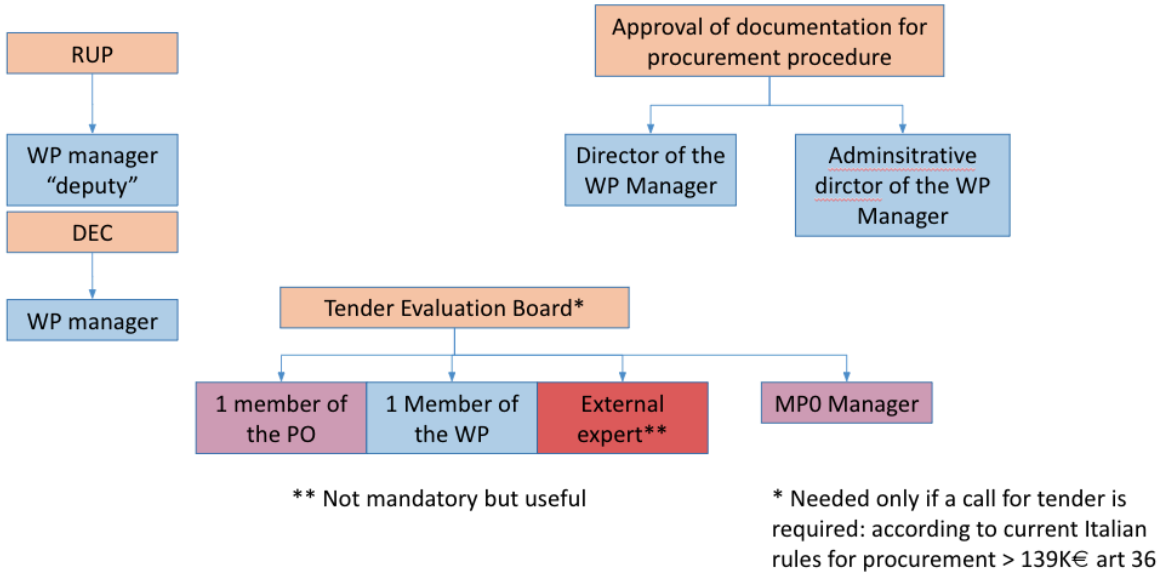
According to the Italian regulations, the main actors of each procurement are:

- The Unique Responsible for the Procedure (Responsabile Unico della Procedura – **RUP**), the person that follows from an administrative and formal point of view the procedure and has the consequent legal responsibility during the Call preparation and during the contract duration. It is normally the Director of the local office issuing the Call.
- The members of the **evaluation commission.**

- The **Manager of the WP "MP0 – Procurement"** has the role to coordinate and harmonise all the procurements in the project
- The Executive Director of the Contract (Direttore Esecutivo del Contratto – **DEC**), the person that, once signed the contract, manages the daily technical activities of the project. It is normally the WP Manager of the procured subsystem.

The actors and responsibilities of the procurement in the subsequent phases of the procurement are shown in the following schemes:

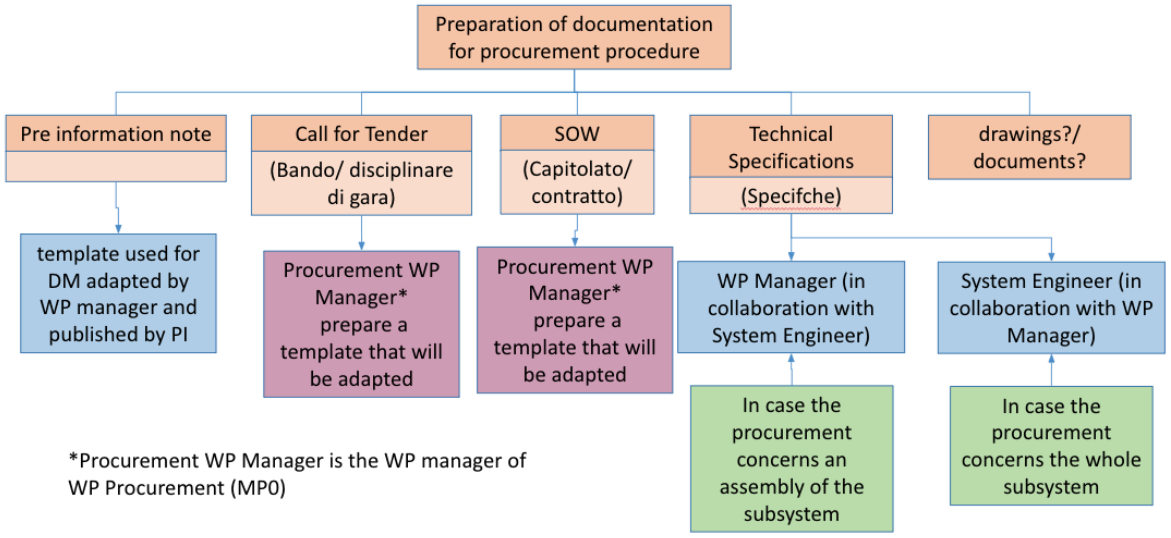
PRELIMINARY ACTIVITIES



** Not mandatory but useful

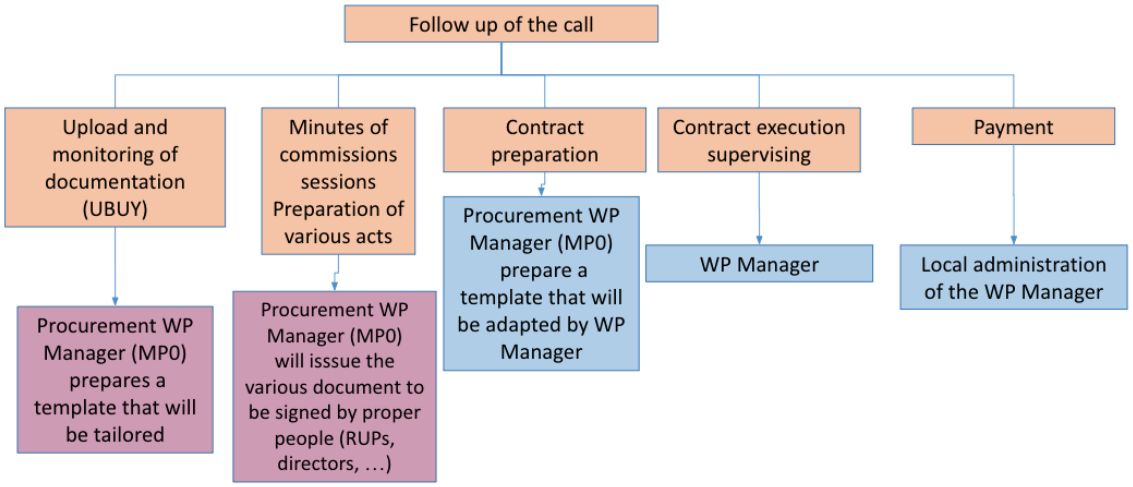
* Needed only if a call for tender is required: according to current Italian rules for procurement > 139K€ art 36

PREPARATION OF PROCUREMENT DOCUMENTATION



*Procurement WP Manager is the WP manager of WP Procurement (MP0)

FOLLOW-UP



The association between procurement procedures and local offices will be as follows:

Procurement Item	RUP	DEC
DMs	INAF Bologna	INAF Arcetri
Optics (plus mounts)	INAF Catania/Brera	INAF Padova/Brera
Main Structure	INAF Capodimonte	INAF Brera
Calibration-Test Unit	INAF Teramo	INAF Bologna
AIV Tools	INAF Capodimonte	INAF Brera

7.3. Schedule management

The MORFEO Project Manager will operate a schedule control system which ensures within the MORFEO Consortium the timely provision of all specified goods and services. Each WP Manager will collaborate with the MORFEO PM to set up and maintain a schedule control system for their activity approved by the MORFEO Project Manager.

The tool used is MS Project ® at all levels of schedule production.

The schedule control system set-up at the MORFEO system level will assure the following:

- The effective communication of current schedule status;
- The use of the schedule to actively control the execution of work;
- The timely reporting of any actual or foreseeable deviation from the schedule;
- The effective processing of schedule deviations including the definition and implementation of any required corrective actions.

7.3.1. The MORFEO Master Schedule

The MORFEO Master Schedule is prepared by the MORFEO Project Office under the responsibility of the Project Manager. The MORFEO Master Schedule shall be submitted to ESO review; once approved by ESO, it will become the MORFEO Baseline Master Schedule.

The MORFEO Master Schedule contains a series of reviews which will act as the major milestone within the project. The list of these milestones is reported in Table, according to the current schedule (AD9).

Milestone Number	Phases – Key milestones	Due Time (current planning)
1	Kick Off Meeting (T_0)	2016-02-02
2	Preliminary Design Review (PDR)	2021-06-28
3	Optical Final Design Review (OFDR)	2023-07-28
4	LLI FDR (DMs) (previously called LLI FDR)	**2024-12-10**
5	FDR 1 (previously LLI FDR2)	**2026-02-11**
6	FDR 2 (previously simply FDR)	**2027-12-08**
7	Integration Readiness Review	2028-10-5
8	Preliminary Acceptance Europe (PAE)	2031-10-21
9	Provisional Acceptance Chile (PAC)	2033-08-24
10	Final Acceptance (end of Guarantee period)	2035-08-07

Table 6. MORFEO Milestones.

The content of the main milestones is described in the Statement of Work.

The intermediate milestones (#6 to #9) are described in detail in the MAIT-V documentation.

7.3.2. The MORFEO Overall Schedule

The MORFEO Overall Schedule is prepared by the MORFEO PM. It is distributed to ESO and the WP Managers for their use at their respective levels in the programme.

The level of detail given in the overall schedule will be agreed between the MORFEO PM, ESO and the WP Managers to allow its use directly for MORFEO Project schedule monitoring and control. Thus it is necessary that a clear and unambiguous relationship exists between this schedule and the lower level development schedules.

The level of detail given in the MORFEO Overall Schedule corresponds with at least the MORFEO WBS given in this document.

The MORFEO Overall Schedule is based on fixed duration. The analysis to make available the necessary resources to meet the MORFEO required dates is the responsibility of the MORFEO WP Managers in the first instance.

The MORFEO Overall Schedule shall be submitted to ESO review; and once approved by ESO, will become the MORFEO Baseline Overall Schedule.

7.3.3. The MORFEO Lower Level Overall Schedules

The lower level overall development schedules shall be produced and maintained by the MORFEO PM in collaboration with the WP Managers.

The WP Managers shall inform the MORFEO PM of any inconsistency between the MORFEO Overall Schedule and their lower level development schedules as part of the process resolution of the inconsistency itself.

The MORFEO WP Managers shall provide the MORFEO PM with their Sub-System / Units / Sub-assembly / Parts – Overall schedules.

The MORFEO low level overall schedules shall respect the following requirements:

- They shall be maintained in MS Project® and formatted such that they can be readily printed in a readable fashion
- They shall allow/demonstrate
    - Development sequence validation and the relationship between planned activities
    - Critical Path Analysis
- They shall be maintained down to the local WBS level of detail
- They shall be built on fixed dates, showing start and completion dates
- They shall show percentage progress of tasks
- They shall be maintained and updated as part of the regular project reporting process, and if not reviewed earlier will be included for review at each progress meeting.

7.3.4. The Long-Lead Items (LLI)

The Long-Lead Items are the elements of MORFEO that require a long procurement process and need to have an accelerated Phase C in order to start their manufacturing as soon as possible.

The Long-Lead Items comprise:

- the Post-Focal Relay Optics (PFRO), that is the whole set of fixed optics
- the Deformable Mirrors

- The Main Structure, which, even if not time consuming in terms of manufacturing, is required to be in place when the various elements of MORFEO arrive in Bologna for integration.

In the first versions of the MORFEO schedule these items concluded their Phase C much earlier than the other elements (FDR around 8 months in advance with respect to non-LLI). In the current version of the schedule (AD9) the time gap between LLI elements and the rest of the system is drastically reduced. The LLI-FDR and the rest of FDR could converge to a unique date, if deemed useful for the overall optimisation of activities.

Nevertheless, the need of an Optical FDR for the start of procurement of the most urgent optical elements (for example the blanks) is an option under discussion.

The driving factors and the strategy for the management of Long-Lead Items are described in Section 7.2.14.

8. MAIT Strategy

The MAIT (Manufacturing, Assembly, Integration, and Testing) phase governs the end-to-end engineering activities leading to the full realization, validation, and delivery of the MORFEO instrument. It spans both subsystem-level development at provider institutes and the system-level integration at the central facility in Bologna.

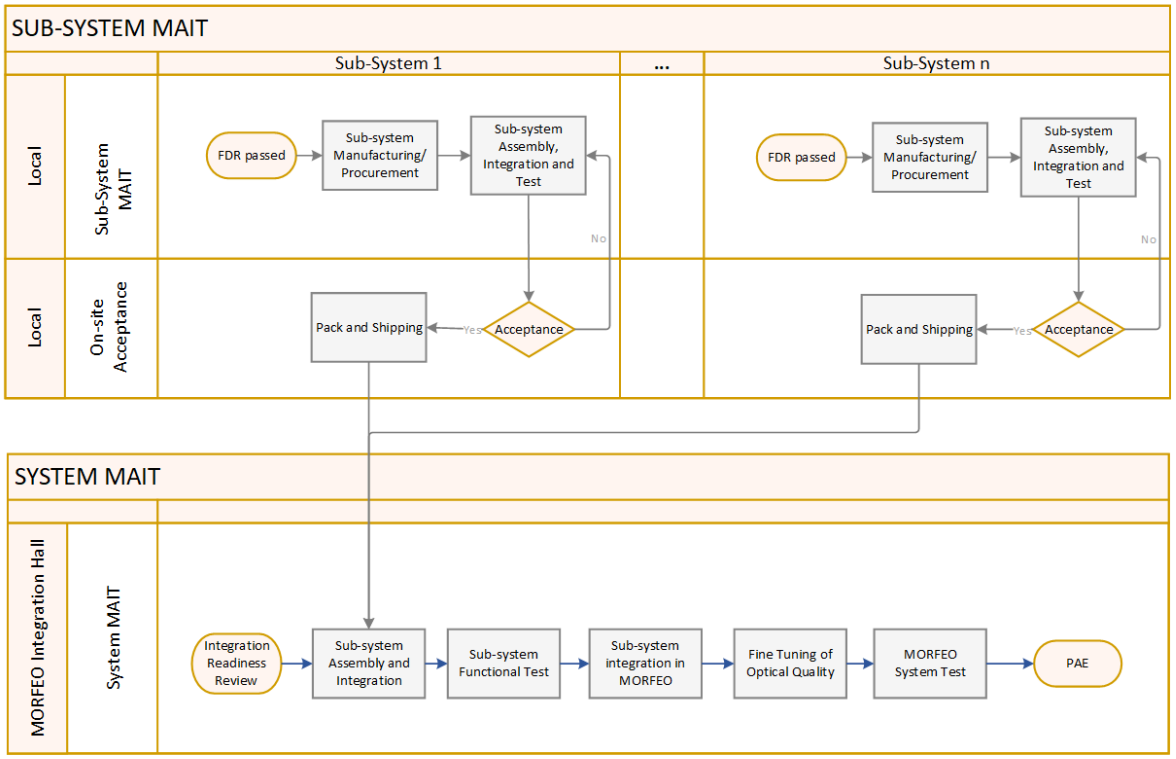


Figure 7-1. MAIT phase

8.1. Subsystem MAIT Activities

Each MORFEO subsystem is manufactured, assembled, and tested at its originating institution under dedicated local MAIT work packages. Key responsibilities include:

- Component production and assembly
- Local functional and performance testing
- Interface compliance verification
- Acceptance Test
- Logistic preparation for transport to Bologna, including environmental conditioning, packaging, and documentation

Upon successful completion, each subsystem is formally accepted and transferred to the main Integration Hall via a coordinated logistics process ensuring safe and traceable delivery.

8.2. System-Level MAIT Activities (Bologna Integration Hall)

After reception and inspection of subsystems, the central MAIT team assumes leadership of the system-level integration process. This includes:

- Subsystem verification post-shipment
- Mechanical, optical, and control interface integration
- Precise alignment and performance tuning
- Full system software deployment
- Execution of system verification and functional test campaigns

These activities culminate in the **Preliminary Acceptance Europe (PAE)**, in partnership with ESO. The MAIT team then oversees final disassembly, shipment preparation, and transfer of the instrument to Chile, supported by outbound logistics planning and documentation.

9. Integrated Logistics Support

9.1. MORFEO integration hall

The integration of the MORFEO Instrument will be performed inside a dedicated integration hall, which is located at the INAF OAS premises in the “CNR/INAF Research Area” in Bologna.

The Research Area is 10 minutes by car from the Bologna international airport. It is also very close to the railway station: the town is in a central position with respect to the towns in Italy where the other INAF institutes/observatories involved in the MORFEO project are located and can be reached by fast trains.

Figure 8-1. MORFEO Integration Hall at INAF OAS in Bologna. The laboratory is under refurbishment.

The integration hall was used in the past as an integration laboratory for balloon experiments. It will be remodelled to be adapted to the needs of the MORFEO project.

The main features of the hall after completion of the refurbishment works are summarised here.

- Size 17.5 m × 11.1 m in plant.
- Maximum height 12 m (clear height slightly lower due to ceiling crane).
- Ceiling crane with > 3000 kg load capacity.
- New roof waterproofing.
- Clean environment, achieved and maintained by:
    - walls covered by sheet metal panels with very smooth and washable surface to avoid accumulation of dust and contaminants;
    - resin treatment on the floor;
    - air conditioning and circulation unit (installed outside the building), capable of circulating the volume of air inside the hall up to 11 times per hour and thus keep a clean environment.

- Double windows with remotely controlled curtains in between to make the environment dark when necessary.
- Refrigerating unit installed outside the building to produce cooling liquid for electronics devices.
- The control room is installed inside the integration hall but separated from it by glass walls, where the involved personnel can drive tests from a “normal” (i.e. not laboratory clean) environment.
- Antechamber to be built outside the building (in front of the entrance door shown in Figure 5 left), to separate the clean integration hall from the outside environment.
- Technical room to be built outside the building for installation of power supply unit and other support equipment.

Next to the integration hall the following additional facilities are available.

- Mechanical workshop for adaptation of small parts, etc.
- Meeting and videoconference room for the users of the integration hall.

The design of the civil works for the remodelling of the facility has been performed by specialised engineering companies and has been completed.

At the time of writing, the next phase is underway, during which the new overhead crane is being installed and the surrounding external area is being reworked.

The remodelling of the integration hall is funded by INAF through funds of the Italian Ministry for University and Research (“Progetto Premiale E-ELT”).

9.2. Tools and auxiliary equipment

The following tools and auxiliary equipment will be available in the integration hall.

- Cryogenic facilities, including
  - thermal-vacuum chamber (1.8 m depth, 1.8 m diameter) achieving pressure of 1 mbar and temperature of -30°C;
  - cryogenic facility (1.8 m depth, 2 m diameter) achieving 10^{-5} mbar and different thermal stages from 300°K down to 4°K.
- Laser interferometer for optics alignment and verification.
- General purpose (measurement and support) electronics instrumentation.
- Laser tracker for high precision mechanical measurements and alignment.
- Optical benches and general purpose opto-mechanical tools (laser sources, cameras, opto-mechanical bench components, etc.).

The procurement of the above tools and equipment, with the exception of the cryogenic facilities, is funded by INAF through funds of the Italian Ministry for University and Research (“Progetto Premiale E-ELT”). The procurement is in progress at the moment of this writing.

10. Risk Management

MORFEO will implement risk management processes in conformance with ESO requirements (AD2). This will include a MORFEO risk register and analysis of technology readiness levels (TRLs) as part of the risk mitigation process. The details are included in the MORFEO Risk Analysis Management Plan (AD7) which contains the risk management plan/methodology and in the document Risk Analysis (AD8) which contains the risk assessment report and the Risk Register. The two documents AD7 and AD8 must be considered as the reference documents for any risk matters.

The Risk Analysis will be presented at each Progress Meeting, and each major review with ESO.

11. Product Assurance

The product assurance requirements for MORFEO are described in the MORFEO Product Assurance Plan (AD6) that must be considered as the reference document for any product assurance matters.

12. Systems Engineering Management

System engineering activities are carried out by the System Engineer in collaboration with the System Engineering Team, System AIV Engineer and WP managers (or their delegate) who are referred to as “Sub-System Engineers” in the following. System engineering activities will implement a systems engineering approach following the guidelines of RD2.

The scope of the system engineering activities is summarised here.

- Verify the high-level requirements on MORFEO ensuring their flow down and traceability in the derived specifications at lower level.
- Perform and maintain the performance analysis of MORFEO to ensure that its requirements shall be met.
- Take the lead in the analysis and disposition of all technical risks in the MORFEO risk management program.
- Verify, agree, and control the interface compatibility of the MORFEO system and its elements to MICADO and the Telescope.
- Maintain all necessary budgets required to maintain interface compatibility.
- Propose and control the engineering requirements verification processes throughout MORFEO development.
- Perform the engineering impact assessment of non-conformances, request for waivers, and engineering change proposals in MORFEO, and participate in the relevant Boards of approval of these issues organised by MORFEO and ESO.

Each WP shall maintain an engineering team specifically for the subsystem. Systems engineering team capability will also be required of all industrial suppliers to ensure the implementation of all MORFEO design engineering and verification processes and controls are maintained at lower levels.

12.1. System engineering and MORFEO development

The System Engineering activities in MORFEO change during the development with the Phases of the Program, as described in the following.

Phase B

The scope of the system engineering in Phase B will be to produce the consolidated system & subsystems specifications and to consolidate the detailed preliminary design of MORFEO, with particular reference to the long-lead items where the design state at the end of Phase B will have to be close to final.

Phase C

The scope of the Phase C will be to complete the design of MORFEO to ensure that the Final Design Review will be successful and that the construction, integration and verification activities, and schedule and costs are consolidated in agreement with ESO.

Phase D

Detailed verification of the implementation of MORFEO subsystems, resolving any engineering problems that occur during the development. The System Engineer and the System AIV Engineer will be responsible for the engineering verification of all test results and ensure that the verification process is fully linked to the verification of the MORFEO requirements.

Phase E

Support the activity of integration, test, and commissioning of MORFEO with MICADO and the Telescope in Chile

13. ANNEX 1 - WORK PACKAGES DESCRIPTION FOR PHASE B

The MORFEO WBS for the Phase-B with the name of all the WP manager is reported in Figure 12-2 The MORFEO Phase-B WBS

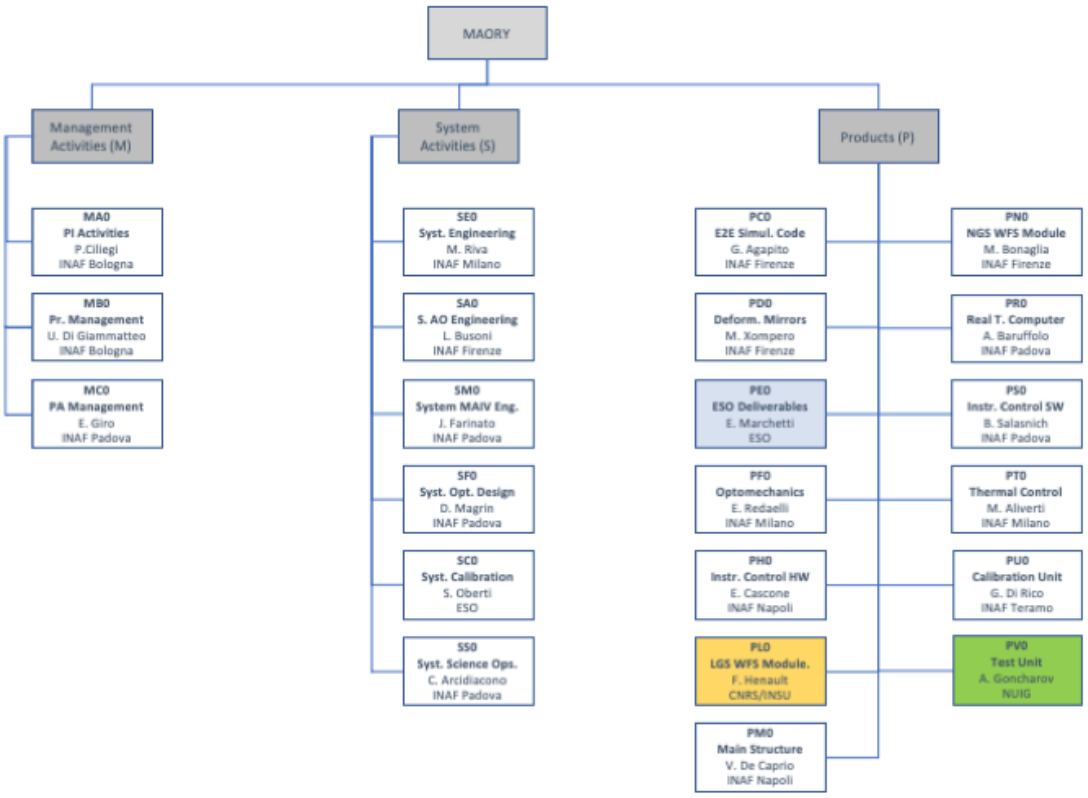


Figure 12-2 The MORFEO Phase-B WBS (First Level)

For each WP we report in the following sections:

- WP Manager
- Resources
- List of expected documents for the PDR
- Description of activities

In each Sub-System work package a Sub-System ICD document has been assigned to the WP manager. However, since almost all the Sub-Systems must interface with the other Sub-Systems, in order to avoid duplication, the content of these documents will be assigned using an N^2 diagram prepared and maintained by the System Engineer.

13.1. MA0 - PRINCIPAL INVESTIGATOR ACTIVITIES

13.1.1. WP description

This WP describes the activities of the MORFEO Principal Investigator for the phase B.

The concerned product is the whole MORFEO system.

13.1.2. Resources

WP responsible	PAOLO CILIEGI (INAF OAS)
WP resources	**FTE/year**
PAOLO CILIEGI (INAF OAS)	0.8
TOTAL	**0.8**

13.1.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO EXECUTIVE SUMMARY E-MAO-000-INA-PLA-005	PCI	D02
MORFEO SYSTEM OVERVIEW E-MAO-000-INA-DER-001	PCI	D10

13.1.4. Principal Investigator activities

The tasks of the Principal Investigator are:

- Maintain on overview of the MORFEO system
- Provide the functions of the formal single point of contact to ESO
- Report the Consortium activities to the MORFEO Steering Committee
- Represent the MORFEO Consortium towards ESO in all Project Reviews
- Represent the MORFEO Consortium in all Progress Meetings of ESO
- Represent the MORFEO Consortium towards ESO in all ELT Reviews
- Manage MORFEO out-reach activities
- Approve all scientific, technical and programmatic documentation of MORFEO

- Manage the funding distribution to the Consortium partners
- Manage the GTO interface to ESO for MORFEO

13.2. MB0 - PROJECT MANAGEMENT

13.2.1. WP description

This WP describes the activities of the MORFEO Project Manager for the phase B.

The concerned product is the whole MORFEO system.

13.2.2. Resources

WP responsible	UGO DI GIAMMATTEO (INAF OAS)
WP resources	**FTE/year**
UGO DI GIAMMATTEO (INAF OAS)	1.0
TOTAL	**1.0**

13.2.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO PROJECT MANAGEMENT PLAN E-MAO-000-INA-PLA-001	UDG	D01
MORFEO Configuration Item Data List E-MAO-000-INA-CIDL-001	UDG	DRD150
MORFEO CONFIGURATION MANAGEMENT PLAN E-MAO-000-INA-PLA-002	UDG	DRD100
MORFEO RISK ANALYSIS E-MAO-000-INA-RRR-001	UDG	D03
MORFEO RISK MANAGEMENT PLAN E-MAO-000-INA-PLA-004	UDG	D03

13.2.4. Project Management activities

The tasks of the Project Management WP are:

- Define and maintain the overall schedule of MORFEO development and milestones in conformity with the requirements of ESO
- Approve the schedules of the MORFEO Consortium suppliers and those of the direct suppliers
- Maintain the MORFEO Document Tree
- Monitor the activities of the Consortium partners and direct suppliers taking all actions necessary to achieve the project milestones
- Manage MORFEO Consortium Working Meetings
- Define the Project Reviews and meetings necessary to ensure the success of the program
- Support and prepare all ESO reviews of MORFEO required by ESO
- Control and support all reviews of the activities of the MORFEO Consortium partners and direct suppliers performed by the MORFEO Engineering System Team
- Prepare and support all Progress Meetings required by ESO
- Perform all Progress Meetings with Consortium partners and direct suppliers
- Manage and maintain the configuration control of the project
- Monitor and control the costs of the program
- Prepare, update and approve the programmatic documentation of the project
- Provide support to the MORFEO PI for Consortium Management
- Time Management, Cost Management, Prepare, update and approve the programmatic documentation of the project (that is approved by the PI, too).

13.3. MC0 - PRODUCT ASSURANCE MANAGEMENT

13.3.1. WP description

This WP describes the Product Assurance activities for the phase B.

The concerned product is the whole MORFEO system.

13.3.2. Resources

WP responsible	ENRICO GIRO (INAF OAPD)
WP resources	**FTE/year**
ENRICO GIRO (MORFEO PA Manager, INAF OAPD)	0.4
SIMONETTA CHINELLATO (INAF OAPD)	0.3
ROSANNA SORDO (INAF OAPD)	0.3
TOTAL	**1.0**

13.3.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO Product Assurance Plan E-MAO-000-INA-PLA-003)	EGI	DRD110
MORFEO Hazard List and Analysis E-MAO-000-INA-ANR-003)	EGI	D04
MORFEO Hazardous Material List E-MAO-000-INA-LIS-004)	EGI	DRD180
MORFEO Reliability Analysis E-MAO-000-INA-ANR-002)	EGI	DRD160
MORFEO FMECA E-MAO-000-INA-ANR-001	EGI	

13.3.4. Product Assurance Management activities

The tasks of the MORFEO Product Assurance WP are:

- Approving and implementing the MORFEO Product Assurance Plan
- Liaising with and advising PA Managers of the MORFEO Consortium partners
- Approving the PA Plans of the MORFEO Consortium partners
- Carrying out PA surveillance and control of MORFEO Consortium institutes including audits and acceptance of items
- Define a project NCR and waiver system including sub-contractor and supplier NCR's convening and chairing Material Review Boards (MRB) and attend to Test Readiness Reviews (TRR), Qualification Status Review for all qualification and verification tests
- Implementing Parts, Material and Processes control activities
- Ensuring the reliability assurance activities are properly carried out
- Issue Part Approval Documents
- Agreeing and providing the necessary documentation in the form of Log Books and Acceptance Data Packages
- Attending all major reviews and tests and providing the relevant PA inputs
- Ensuring that cleanliness, contamination control and safety aspects are properly covered

13.4. SE0 - SYSTEM ENGINEERING

13.4.1. WP description

This WP describes the activities of the MORFEO System Engineer for the phase B.

The concerned product is the whole MORFEO system.

13.4.2. Resources

WP responsible	MARCO RIVA (INAF OAS)
WP resources	**FTE/year**
MARCO RIVA (MORFEO System Engineer, INAF OAB)	0.8
MATTEO GENONI (INAF OAB)	0.2
LORENZO BUSONI (INAF OAA)	0.2
ITALO FOPPIANI (INAF OAS)	0.2
SYLVAIN OBERTI (ESO)	0.1
CARMELO ARCIDIACONO (INAF OAPD)	0.1
DEMETRIO MAGRIN (INAF OAPD)	0.1
JACOPO FARINATO (INAF OAPD)	0.1
BERNARDO SALASNICH (INAF OAPD)	0.1
ENRICO CASCONE (INAF OACN)	0.1
VINCENZO DE CAPRIO (INAF OACN)	0.1
ZOLTAN HUBERT (CNRS/INSU)	0.1
PATRICK RABOU (CNRS/INSU)	0.1
MARCO BONAGLIA (INAF OAA)	0.1
GIANLUCA DI RICO (INAF OAAB)	0.1
MARCO XOMPERO (INAF OAA)	0.1
ANDREA BARUFFOLO (INAF OAPD)	0.1
GUIDO AGAPITO (INAF OAA)	0.1
EDOARDO REDAELLI (INAF OAB)	0.1
MATTEO ALIVERTI (INAF OAB)	0.1
ALEXANDER GONCHAROV (NUIG)	0.1
TOTAL	3.1

13.4.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO Compliance Matrix (E-MAO-000-INA-CMX-001)	MRI	DRD550
MORFEO Earthquake Analysis (E-MAO-000-INA-ANR-006)	MRI	D07
MORFEO System Budget Allocation (E-MAO-000-INA-TNO-003)	MRI	DRD270
MORFEO Wavefront Error Budget (E-MAO-SE0-INA-DER-005)	LBU	DRD270
MORFEO Astrometric Error Budget (E-MAO-SE0-INA-DER-006)	LBU	DRD270
System Design and Analysis Report (E-MAO-000-INA-DER-002)	MRI	D11
MORFEO-ELT Interface Control Document (E-MAO-000-INA-ICD-001)	MRI	D12
MORFEO-MICADO Interface Control Document (E-MAO-000-INA-ICD-002)	MRI	D12
MORFEO TEMPLATE MANUAL (DRAFT) (E-MA0-000-INA-MAN-001)	BSA	D25
MORFEO PAE TEST PLAN (DRAFT) (E-MAO-000-NUI-PLA-002)	AGO	D26
Sub-systems Requirements and Interfaces Requirements		
Sub-system Tech Spec :		
• Main structure	MRI	D13
• Thermal Control	MRI	D13
• Optical Design	MRI	D13
• Instrument Control Hardware	MRI	D13
• MORFEO Calibration Unit	MRI	D13
• MORFEO Test Unit	MRI	D13
• LGS WFS module (completed with AO WP)	MRI	D13
• LOR WFS module (completed with AO WP)	MRI	D13
• DM (completed with AO WP)	MRI	D13

13.4.4. System Engineering activities

The tasks of the System Engineering WP are:

- Ensuring the integration of the engineering activities in project
- Further developing the system architecture
- Definition and/or control of external and internal interfaces
- Maintenance of the system budgets
- Definition of sub-systems budgets
- Verification of design and performance against requirement

13.5. SA0 - SYSTEM ADAPTIVE OPTICS ENGINEERING

13.5.1. WP description

This WP contains the activities related to the definition of the AO aspects of the following MORFEO sub-systems:

- LOR WFS module;
- LGS WFS module;
- Real Time Computer;
- Deformable Mirrors.

This WP works in close coordination with the WP System Engineering and makes use of the results produced by WP End to End Simulations.

The tasks of this WP are:

- AO system analysis, design trade-offs verification, AO error budget development
- Contribute to the definition of requirements of AO-related components/sub-systems (WFS cameras, RTC, DMs, LGS WFS, NGS WFS)
- support user's requirements definition by WP ICS Software
- contribute to the definition of MORFEO AIV plan for AO aspects
- definition of AO control strategy including interaction with ELT and MICADO
- definition of AO calibration and operation strategy addressing in particular the following aspects:
  - reconstructor calibration strategies, measuring the interaction matrix via a calibration source, on sky or simulating it or part of it
  - pupil mis-registration strategies and algorithms
  - non-common path aberrations calibration strategies
  - operation strategy
  - acquisition strategy.

13.5.2. Resources

WP responsible	LORENZO BUSONI (INAF OAA)
WP resources	**FTE/yr**
LORENZO BUSONI (INAF OAA)	0.4
GUIDO AGAPITO (INAF OAA)	0.2
SIMONE ESPOSITO (INAF OAA)	0.2
CEDRIC PLANTET (INAF OAA)	0.2
CHRISTOPHE VERINAUD (ESO)	0.45
MISKA LE LOUARN (ESO)	0.2
TOTAL	**1.65**

13.5.3. Expected documents for the PDR

Documents	Owner	DRD
ADAPTIVE OPTICS DESIGN AND ANALYSIS REPORT E-MAO-SA0-INA-DER-001	LBU	D11

13.6. System AO Engineering activities

AO MANAGEMENT

- WP Management (Meeting, Schedule)
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan

AO ENGINEERING

- Flow-down of MORFEO requirements in AO subsystem
- Finalize Subsystems Technical Specifications
- Control of AO subsystem internal and external interfaces
- AO WFE budget
- Jitter budget
- Astrometric Error Budget
- Trade off study: 2DM vs 3DM, optimize number of actuators and pitch
- Sky coverage and tech FoV
- Trade-off and choice of algorithms for MCAO Reconstruction and control
- Choice of algorithms for slope computations
- Design Reference Sensor scheme
- Derotation scheme (how to keep sub-aps and actuators matched)
- Overall control and interaction between loops (AO RT loop, Reference, LGS guiding, all kind of offloads and secondary loop, telescope, pupil position control in WFSs, jitter stabilizations, …)
- Optimizing LGS WFS design and centroiding algorithm
- Study and quantify Telescope Effects on MORFEO

13.7. SM0 - SYSTEM MAIV ENGINEERING

13.7.1. WP description

This WP describes the MORFEO System AIV Engineering activities for the phase B.

The concerned product is the whole MORFEO system. The scope of this WP is the MAIV of the MORFEO system, starting from the MORFEO sub-systems.

13.7.2. Resources

WP responsible	JACOPO FARINATO (INAF OAPD)
WP resources	**FTE/year**
JACOPO FARINATO (AIV Engineer, INAF OAPD) GABRIELE RODEGHIERO (INAF OAS) MARIA BERGOMI (INAF OAPD) LUCA MARAFATTO (INAF OAPD) GIORGIO PARIANI (INAF OAB) VINCENZO DE CAPRIO (INAF OACN) VINCENZO CIANNIELLO (INAF OACN)	0.2 0.1 0.1 0.15 0.2 0.1 0.1
TOTAL	**0.95**

13.7.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO SYSTEM MAIV PLAN E-MAO-000-INA-PLA-010	JFA	D16
MORFEO COMMISSIONING PLAN (Draft) E-MAO-000-INA-PLA-008	JFA	D27

13.7.4. System MAIV Engineering activities

The tasks of the System MAIV Engineering WP are:

- Production of the MORFEO MAIV Plan, test and calibration procedures
- Verification of the sub-systems MAIV plans and procedures
- Production of the MORFEO Verification Control Document (VCD)
- Agreeing the MORFEO integration, test and verification procedures with ESO for the integration and commissioning of MORFEO with MICADO and the Telescope.
- MORFEO AIV tool design
- Definition of the requirements of any technical template needed for AIV only, therefore not part of the Template Manual, to be developed by ICS WP

13.8. SF0 - SYSTEM OPTICAL DESIGN

13.8.1. WP description

This WP describes the activities concerning the optical design at system level for phase B.

The product of this WP includes

- Main Path Optics, i.e. the optical relay which re-images the telescope focal plane to the exit ports for MICADO and the second instrument TBD; the Main Path Optics include the beam-splitter to separate the science path from the LGS path;
- LGS Objective, i.e. the set of optics downstream the beam-splitter to focus the LGS light for the LGS WFS module;
- Collaboration to handling and AIV tools design, whenever necessary.

The MORFEO Deformable Mirrors, which form the scope of a specific WP (section 4.17), are regarded in the present WP as rigid mirrors: the definition of their optical shape is the only relevant aspect here.

This WP, in addition to all the necessary activities for the development of the Post-Focal Relay Optics in the phase B, also includes the following tasks:

- agreeing the optical interfaces to ELT and MICADO;
- production and verification of the MORFEO optical model.

13.8.2. Resources

WP responsible	DEMETRIO MAGRIN (INAF OAPD)
WP resources	**FTE/yr**
DEMETRIO MAGRIN (INAF OAPD) ROBERTO RAGAZZONI (INAF OPAD) MATTEO MUNARI (INAF OACT) GIORGIO PARIANI (INAF OAB)	0.4 0.3 0.2 0.1
TOTAL	**1.00**

13.8.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO SYSTEM OPTICAL DESIGN AND ANALYSIS REPORT E-MAO-SF0-INA-DER-001	DMA	D11

13.8.4. System Optical Design activities

OPTICAL ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Agreeing the MORFEO optical interface (Telescope and MICADO)
- Define all MORFEO internal optical interfaces with the Consortium partners and suppliers
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- Preliminary Procurement Specification for Optical Components for cost estimation

OPTICAL DESIGN

- Refinement Main Path Optics Design baseline
- Refinement LGS Objective Design baseline
- Detailed tolerance analysis and thermo-elastic sensitivity
- Ghosts and straylight analysis
- Trade off of different designs

13.9. SC0 - SYSTEM CALIBRATION

13.9.1. WP description

This WP carries out the design and development of the MORFEO calibration strategy

13.9.2. Resources

WP responsible	SYLVAIN OBERTI (ESO)
WP resources	**FTE/year**
SYLVAIN OBERTI (ESO)	0.3
LORENZO BUSONI (INAF OAA)	0.1
DEMETRIO MAGRIN (INAF OAPD)	0.1
MARCO BONAGLIA (INAF OAA)	0.1
ZOLTAN HUBERT (INSU)	0.1
MARCO XOMPERO (INAF OAA)	0.1
TOTAL	**0.8**

13.9.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO INSTRUMENT CALIBRATION PLAN (Draft) E-MAO-000-ESO-PLA-001	SOB	DRD24

13.9.4. System Calibration activities

In agreement with the MORFEO system engineer and the AO system engineer, define an AO calibration, operation and acquisition strategy addressing in particular the following aspects:

- reconstructor calibration strategies, measuring the interaction matrix via a calibration source, on sky or simulating it or part of it
- pupil mis-registration strategies and algorithms
- non-common path aberrations calibration strategies
- online system optimization and telemetry processing
- operation strategy
- acquisition strategy

Define the calibration tasks of the following sub-systems:

- MORFEO optical relay and LGS objective
- The LOR WFS module
- The LGS WFS module
- The post-focal DM(s)

13.10. SS0 - SYSTEM SCIENCE OPERATIONS

13.10.1. WP description

This WP describes the scientific activities in the MORFEO project for the phase B.

The products of this WP consist of

- MORFEO Operational Concept Description;
- MORFEO Template Manual;
- Point Spread Functions, representing the MORFEO optical performance at the exit ports;
- TBC: auxiliary data and models to support the development of the MICADO Data Flow System and of the ELT Exposure Time Calculator; these sub-products have to be defined with MICADO and ESO.

13.10.2. Resources

WP responsible	CARMELO ARCIDIACONO (INAF OAPD)
WP resources	**FTE/year**
CARMELO ARCIDIACONO (INAF OAPD) MARCO GULLIEUSZIK (INAF OAPD) ELISA PORTALURI (INAF OAPD) MICHELE CANTIELLO (INAF OAAB)	0.50 0.20 0.35 0.30
TOTAL	**1.35**

13.10.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO OPERATIONAL CONCEPT DESCRIPTION (Draft) E-MAO-000-INA-MAN-002	CAR	DR30
MORFEO PSF DESCRIPTION E-MAO-SS0-INA-TNO-001 and E-MAO-SS0-INA-TNO-002	CAR	N/A

13.10.4. System Science Operations activities

The tasks of the MORFEO Science Operation WP are:

- verify that all scientific performance requirements are consistent with the design of MORFEO;
- perform scientific trade-offs on any design options in MORFEO to ensure that the scientific performance requirements are maintained;
- define requirements for MORFEO performance estimation tool in collaboration with MICADO
- chair the MORFEO Science Team.
- ensure a link between the Science Team and the Technical Work Packages
- define the preparation of the MORFEO Observations for the Template Manual
- define the Observation, Calibration and Maintenance Template

13.11. PC0 - END TO END SIMULATION CODE

13.11.1. WP description

This WP contains the end-to-end simulation activities to support the WP Adaptive Optics for the phase B.

The WP includes in particular

- development of dedicated numerical analysis tools and of an end-to-end code for the simulation of the MORFEO AO system;
- comparison of the end-to-end code with other existing codes, already in use in the framework of the project for other purposes, such as the OCTOPUS code at ESO and the MAO code at INAF OAS;
- performance of the simulations required by the WP Adaptive Optics

13.11.2. Resources

WP responsible	GUIDO AGAPITO (INAF OAA)
WP resources	**FTE/yr**
GUIDO AGAPITO (INAF OAA) CEDRIC PLANTET (INAF OAA)	0.5 0.5
TOTAL	**1.0**

13.11.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO AO SIMULATION REPORT E-MAO-PCO-INA-ANR-001	GAG	N/A

13.11.4. E2E simulation code activities

E2E SIMULATION MANAGEMENT

- WP Management (Meeting, Schedule)
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan

E2E SIMULATION DEVELOPMENT

- Development of sim tools to estimate sky coverage
- Evaluation of sky coverage
- Development of sim tools related to spot truncations and truth sensing
- Development of sim tools related to tomographic reconstruction
- Full system simulations to quantify optimal system parameters and final performances

13.12. PD0 - DEFORMABLE MIRRORS

13.12.1. WP description

This WP describes the activities concerning the MORFEO Deformable Mirrors for the phase B.

The Deformable Mirrors product consists of up to two adaptive mirrors units, with the following features:

- optical head, controlled in real-time by actuators;
- mechanical support, including interface to the MORFEO Main Structure and actuators for global positioning, whenever necessary;
- thermal control system for heat dissipation;
- control electronics;
- deterministic command interface to the Real Time Computer and non-deterministic command interface to the ICS Software;
- handling and AIV tools, whenever necessary.

13.12.2. Resources

WP responsible	MARCO XOMPERO (INAF OAA)
WP resources	**FTE/yr**
MARCO XOMPERO (INAF OAA)	0.30
RUNA BRIGUGLIO (INAF OAA)	0.30
GIORGIO PARIANI (INAF OAB)	0.10
EXTERNAL SUPPORT FROM FEASIBILITY STUDY	
TOTAL (excluding feasibility study)	**0.70**

13.12.3. Expected documents for the PDR

Documents	Owner	DRD
DEFORMABLE MIRRORS DESIGN REPORT E-MAO-PD0-INA-DER-001	MXO	D11/D14
DEFORMABLE MIRROR ANALYSIS REPORT E-MAO-PD0-INA-ANR-001	MXO	DRD220
DEFORMABLE MIRRORS INTERFACE CONTROL DOCUMENT E-MAO-PD0-INA-ICD-001	MXO	D15
DEFORMABLE MIRROR AIV PLAN E-MAO-PD0-INA-PLA-001	MXO	D17

13.12.4. Deformable Mirrors activities

DM ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Define internal Interface
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- Procurement Specification for Deformable Mirrors for cost estimation

DM Design

- DM update specification
- DM Design and Performance / Follow up Feasibility Study
- DM external Study Evaluation

13.13. PF0 - OPTOMECHANICS

13.13.1. WP description

This WP describes the activities concerning the Opto-mechanics for the phase B.

The Opto-mechanics product consists of

- mounts of the optical elements in the Main Path Optics and in the LGS Objective, the optical design of which is part of the WP Post-Focal Relay Optics
- mechanical interfaces of these mounts to the MORFEO Main Structure
- actuators and related control electronics, which are needed to position the optics with the required accuracy; the activities related to the design of the control electronics are included for convenience in WP Instrument Control Hardware
- handling and AIV tools, whenever necessary.

13.13.2. Resources

WP responsible	EDOARDO REDAELLI (INAF OABR)
WP resources	**FT/yr**
EDOARDO REDAELLI (INAF OAB) MATTEO ALIVERTI (INAF OAB) ANDREA BIANCO (INAF OAB)	0.7 0.3 0.2
TOTAL	**1.2**

13.13.3. Expected documents for the PDR

Documents	Owner	DRD
OPTMECHANICS DESIGN REPORT E-MAO-PF0-INA-DER-001	ERE	D11/D14
OPTOMECHANICS ANALYSIS REPORT E-MAO-PF0-INA-ANR-001	ERE	DRD 2020
OPTMECHANICS INTERFACE CONTROL DOCUMENT E-MAO-PF0-INA-ICD-001	ERE	D15
OPTMECHANICS AIV PLAN E-MAO-PF0-INA-PLA-001	ERE	D17

13.13.4. Optomechanics activities

OPTOMECHANICS ENGINEERING AND MANAGEMENT

WP Management (Meeting, Schedule)

- Define all optical mounts interfaces with the Consortium partners and suppliers
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- Procurement Specification for Optical Mounts Components for cost estimation

OPTOMECHANICS DESIGN

- Optimization of the baseline mount
- Interface to Bench Definition
- Electrical and Thermal Interface
- Input to MAIT
- Error Budget
- Integration Procedure

13.14. PH0 - INSTRUMENT CONTROL HARDWARE

13.14.1. WP description

This WP describes the activities concerning the Instrument Control Hardware (ICH) for the phase B. The ICH product

- consists of all controllers, power supplies, harnesses and other electronics components to control the MORFEO instrument at system level;
- requires services from the ELT Service connection points;
- receives commands from the ICS Software;
- it includes the controllers and all electrical / electronic components which are required to control the other MORFEO sub-systems: those components are part of the sub-systems themselves.
- includes handling and AIV tools, whenever necessary.

This WP, in addition to all the necessary activities for the development of the ICH in the phase B, also includes the following tasks:

- agreeing the MORFEO electrical and information protocol interfaces to ELT and MICADO;
- defining all MORFEO internal electrical and protocol interfaces and standards.

13.14.2. Resources

WP responsible	ENRICO CASCONE (INAF OACN)
WP resources	**FTE/yr**
ENRICO CASCONE (INAF OACN) CHRISTIAN EREDIA (INAF OACN) ITALO FOPPIANI (INAF OAS) GIUSEPPE COSENTINO (UNIBO) GIANLUCA DI RICO (INAF OAAB) DOMENICO D'AURIA SYLVAIN ROCHAT (CNRS/INSU) MECHATRONICS ENGINEER (TBH INAF OACN) ELECTRONIC ENGINEER (TBH, INAF OAS)	0.5 1.0 0.5 0.5 0.1 0.1 0.1
TOTAL	**2.80**

13.14.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO ICH DESIGN AND ANALYSIS REPORT E-MAO-PH0-INA-DER-001	ECA	D11/D14
MORFEO ICH ANALYSIS REPORT E-MAO-PH0-ANR-001	ECA	DRD220
MORFEO ICH INTERFACE CONTROL DOCUMENT E-MAO-PH0-ICD-001	ECA	D15
MORFEO ICH AIV PLAN E-MAO-PH0-PLA-001	ECA	D17

13.14.4. Instrument Control Hardware activities

The tasks of the MORFEO ICH WP are:

ICH ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Agreeing the MORFEO electrical and information protocol interface (Telescope and MICADO) Define all MORFEO internal electrical and protocol interfaces with the Consortium partners and suppliers
- Collaboration with PA manager for Product Assurance Issue regarding Instrument Control Hardware
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Procurement Specification for ICH components to be delivered to the MORFEO Project Office
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan

Instrument Control Electronics Design

- MORFEO Control Electronics : evaluating different solution for the control HW components
- Trading Off the optimal solution in respect the required input and deliverables
- Supply input to Instrument Control Hardware Sub system design and Analysis Report regarding Instrument Control Electronics
- Supply input to Instrument Control Hardware Sub system Interface Control Document regarding Instrument Control Electronics
- Supply input to Instrument Control Hardware Sub-system Manufacturing, Assembly, Integration and Test (MAIT) plan regarding Control Electronics
- Grounding Diagram Development
- Electrical Harness Design.

13.15. PL0 - LGS WFS MODULE

13.15.1. WP description

This WP describes the activities concerning the LGS WFS module for the phase B.

The LGS WFS module product consists of

- support structure, providing the mechanical interface to the MORFEO Main Structure;
- WFS probes and their positioning stages to pick the light of the LGSs
- handling and AIV tools, whenever necessary.

13.15.2. Resources

WP responsible	FRANCOIS HENAULT (CNRS/INSU)
WP resources	**FTE/yr**
PHILIPPE FEAUTRIER (CNRS/INSU)	0.5
ZOLTAN HUBERT (CNRS/INSU)	0.4
FRANCOIS HENAULT (CNRS/INSU)	0.5
PATRICK RABOU (CNRS/INSU)	0.3
JEAN-JACQUES CORREIA (CNRS/INSU)	0.4
MARIE-HELENE SZTEFEK (CNRS/INSU)	0.1
TOTAL	**2.2**

13.15.3. Items required to start

- MoU INAF/INSU
- All documentation mentioned in Project Management Plan
- Preliminary LGS WFS Module (LWM) technical specification document (including interface and verification requirements)

13.15.4. Expected documents for the PDR

Documents	Owner	DRD
LGS WFS MODULE DESIGN REPORT E-MAO-PL0-IPA-DER-012	PFE	D11/D14
LGS MODULE ANALYSIS REPORT E-MAO-PL0-IPA-ANR-013	PFE	DRD220
LGS WFS MODULE INTERFACE CONTROL DOCUMENT E-MAO-PL0-IPA-ICD-014	ZHU	D15
LGS WFS MODULE AIT PLAN E-MAO-PL0-IPA-PLA-015	ZHU	D17

13.15.5. LGS WFS Module activities

LGS MODULE MANAGEMENT AND PRODUCT ASSURANCE

- WP Management (Meeting, Schedule)
- LGS WFS Product Assurance
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- LGS Module Cost Estimation

LGS MODULE DESIGN

- LGS WFS System Engineering
- LGS WFS sub-system requirements and functional analysis
- LGS WFS Performance analysis and trade-offs
- LFS WFS BUDGET
- Interface Management
- LGS support mechanical design
- LGS WFS Probes Design
- LGS WFS AIT and Calibration Tools Design
- Support to user's requirements definition and functional specifications by WP ICS Software and WP Real Time

13.15.6. Excluded Task

- AO simulations
- Participation to alternative wave-front sensing concepts (other than Shack-Hartmann)
- Dichroic beam splitter design and costing
- Participation to relay optics design
- Participation to RTC development

13.16. PM0 - MAIN STRUCTURE

13.16.1. WP description

This WP describes the activities concerning the Main Structure for the phase B.

The Main Structure product includes

- a bench, supporting all the other MORFEO sub-systems with the exception of the LOR WFS module which is directly supported by MICADO;
- a support structure, providing the mechanical interface to the ELT Nasmyth platform;
- a cover, or enclosure, serving the function to create a suitable environment for the other sub-systems;
- the calibration unit assembly, the structure that support the calibration unit
- handling and AIV tools, whenever necessary.

13.16.2. Resources

WP responsible	VINCENZO DE CAPRIO (INAF OACN)
WP resources	**FTE/yr**
VINCENZO DE CAPRIO (INAF OACN) VINCENZO CIANNIELLO (INAF OACN) SUPPORT FROM EXTERNAL STUDY	0.3 0.9
TOTAL (excluding external support)	**1.2**

13.16.3. Expected documents for the PDR

Documents	Owner	DRD
MAIN STRUCTURE DESIGN REPORT E-MAO-PM0-INA-DER-001	VDC	D11/D14
MAIN STRUCTURE ANALYSIS REPORT E-MAO-PM0-INA-ANR-001	VDC	DRD2020
MAIN STRUCTURE INTERFACE CONTROL DOCUMENT E-MAO-PM0-INA-ICD-001	VDC	D15
MAIN STRUCTURE AIV PLAN E-MAO-PM0-INA-PLA-001	VDC	D17

13.16.4. Main Structure activities

The tasks of the MORFEO Main Structure Activities WP are:

MECHANICAL ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Agreeing the MORFEO mechanical interface (Telescope and MICADO)
- Define all MORFEO internal mechanical interfaces with the Consortium partners and suppliers
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan

Bench and CU Assembly Mechanical Design / External Study follow up

- Main Structure & CUA preliminary design / external study follow-up
- Auxiliary system design / external study follow-up
- Interface assembly drawings - 2D / external study follow-up
- Cables routing - preliminary design and interfaces / external study follow-up
- Auxiliary system design - CAD main drawings / external study follow-up
- Integration: subsystems mounting procedures
- Definition of the AIV activity
- External Study Evaluation

13.16.5. MECHANICAL EXTERNAL STUDY

An external study for the mechanical design is ongoing. The expected documents at the end of the study are

- 3D mechanical model
- 2D drawing for mechanical interface
- Preliminary numerical analysis for :
    - Mass estimation
    - Static Analysis
    - Modal Analysis
    - Earthquake analysis
    - Buckling analysis (if needed)
    - FEM analysis
    - Thermo-elastic model
- Preliminary Design Report
- Preliminary Analysis Report
- Preliminary MAIT plan
- Preliminary Feasibility, cost and manufacturing time assessment

13.17. PN0 - NGS WFS MODULE

13.17.1. WP description

This WP describes the activities concerning the LOR WFS module for the phase B.

The LOR WFS module product consists of

- support structure, providing the mechanical interface to MICADO, onto which the LOR WFS module is mounted;
- WFS probes and their positioning stages to pick the light of the NGSs over the patrol FoV;
- handling and AIV tools, whenever necessary.

13.17.2. Resources

WP responsible	MARCO BONAGLIA (INAF OAA)
WP resources	**FTE/yr**
MARCO BONAGLIA (INAF OAA) SIMONE ESPOSITO (INAF OAA) PAOLO GRANI (INAF OAA)	0.5 0.1 0.2
TOTAL	**0.8**

13.17.3. Expected documents for the PDR

Documents	Owner	DRD
LOR WFS MODULE DESIGN REPORT E-MAO-PN0-INA-DER-001	MBO	D11/D14
LOR WFS MODULE ANALYSIS REPORT E-MAO-PN0-INA-ANR-001	MBO	DRD220
LOR WFS MODULE INTERFACE CONTROL DOCUMENT E-MAO-PN0-INA-ICD-001	MBO	D15
LOR WFS MODULE AIV PLAN E-MAO-PN0-INA-PLA-001	MBO	D17

13.17.4. NGS WFS Module activities

LOR MODULE ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Agreeing the LOR MODULE Interface with Telescope (ESO project office) and MICADO project office
- Define Internal Interface
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan

LOR MODULE DESIGN

- LOR support structure design
- LOR WFS unit design
- LOR module test and calibration tools design
- Support to user's requirements definition and functional specifications by WP ICS Software and WP Real Time
- LOR Module Cost Estimation
- LOR WFS Performance analysis and trade-offs
- LOR WFS BUDGET

13.18. PR0 - REAL TIME COMPUTER

13.18.1. WP description

This WP describes the activities concerning the Real Time Computer for the phase B.

The Real Time Computer product

- consists of hardware and software components;
- controls all AO real-time functions in MORFEO;
- receives data from the WFS cameras and sends commands to the actuators, which are the MORFEO DMs and the ELT actuators (M4, M5, etc.);
- provides the real-time interface of MORFEO to the ELT Centralised Control System;
- this WP is interfaced with the ICS Software ;
- includes handling and AIV tools, whenever necessary.

13.18.2. Resources

WP responsible	ANDREA BARUFFOLO (INAF OAPD)
WP resources	**FTE/yr**
ANDREA BARUFFOLO (INAF OAPD) ITALO FOPPIANI (INAF OAS) IVANO BARONCHELLI (INAF OAPD) EXTERNAL SUPPORT FROM FEASIBILITY STUDY	0.4 0.1 0.2
TOTAL (excluding feasibility study)	**0.7**

13.18.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO Adaptive Optics Real-Time Computer User Requirement Document E-MAO-PR0-INA-SPE-001	ABA	D13
MORFEO RTC Design Report and Analysis Report E-MAO-PR0-INA-DER-001	ABA	D14

13.18.4. Real Time Computer activities

RTC ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Define all MORFEO internal RTC interfaces with the Consortium partners and suppliers
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- Procurement Specification for RTC Components for cost estimation

RTC DESIGN

- Collect requirements and document them in RTC URD.
- Follow-up technical part of RTC external study.
- Contribute to the definition of interfaces, where applicable, and their documentation in ICDs.
- Provide input concerning RTC to AO Sub-system Manufacturing, Assembly, Integration and Test (MAIT) plan.
- Prepare preliminary design and document for RTC Design and Analysis Report.

13.19. PS0 – INSTRUMENT CONTROL SOFTWARE

13.19.1. WP description

This WP describes the activities concerning the ICS Software for the phase B.

The ICS Software product

- controls all the functions of the MORFEO instrument, with the exception of the AO real-time functions, which are controlled by the Real-Time Computer sub-system;
- provides software interfaces to ELT and MICADO.

The activities related to the control software of LGS, LOR and Calibration Unit sub-systems are part of the ICS Software WP.

13.19.2. Resources

WP responsible	BERNARDO SALASNICH (INAF OAPD)
WP resources	**FTE/year**
BERNARDO SALASNICH (INAF OAPD) DANIELA FANTINEL (INAF OAPD) ANDREA BALESTRA (INAF OAPD) LAURENCE GLUCK (CNRS/INSU) ALFIO PUGLISI (INAF OAA) GIANLUCA DI RICO (INAF OAAB)	0.6 0.3 0.6 0.2 0.2 0.1
TOTAL	**2.00**

13.19.3. Expected documents for the PDR

Documents	Owner	DRD
ICS SW Management Plan E-MAO-PS0-INA-PLA-001	BSA	D08
ICS User Requirement Specification E-MAO-PS0-INA-SPE-002	BSA	D08
ICS Functional Specification E-MAO-PS0-INA-SPE-003	BSA	D08
ICD btw MORFEO ICS SW and RTC E-MAO-PS0-INA-ICD-001	ABA	D15
MORFEO Instrumentation Software Quality Assurance Plan E-MAO-PS0-INA-PLA-002	BAA	D08
ICD btw MORFEO and MICADO ICS SW	MICHAEL WEGNER (MICADO)	D12
ICD btw MORFEO and SCAO ICS SW	FABRICE VIDAL (MICADO)	D12

13.19.4. Instrument Control Software activities

ICS ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Coordinate the software activities of LGS, LOR, and CU sub-systems
- Define all MORFEO internal ICS interfaces with the Consortium partners and suppliers
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis

ICS ACTIVITIES

- Formulation of the software requirements
- Analysis of the requirements and production of the software specifications
- Preparation of the quality assurance plan for the ICS software
- Definition of the software architecture
- Definition of the control network architecture
- Definition of the software interface with the Real Time Computer
- Collaboration to the definition of the interface between MORFEO ICS and SCAO ICS
- Collaboration to the definition of the interface between MORFEO ICS and MICADO ICS

13.20. PT0 - THERMAL CONTROL SYSTEM

13.20.1. WP description

This WP describes the activities concerning the Thermal Control System for the phase B.

The Thermal Control System product includes

- thermal control harness
- heat dissipation system
- mirror ventilation system
- air filtering system
- vacuum system
- ducts conduits
- motors, pumps and metrology for the ventilation, air filtering and vacuum systems
- handling and AIV tools, whenever necessary.

The activities related to the design of the control electronics for the Thermal Control System are included for convenience in WP Instrument Control Hardware.

This WP, in addition to all the necessary activities for the development of the Thermal Control System in the phase B, also includes the following tasks:

- agreeing the thermal interfaces to ELT and MICADO;
- production and verification of the MORFEO thermal model;
- development of the low-level software needed to actively control the electronic components of the thermal system (ventilation, pumps, vacuum system etc). The high level software will interface with the low-level to monitor the status of the components.
- definition of the interface with high level software
- definition of the software requirements for high level software

13.20.2. Resources

WP responsible	MATTEO ALIVERTI (INAF OAB)
WP resources	**FTE/yr**
MATTEO ALIVERTI (INAF OAB)	0.5
EDOARDO REDAELLI (INAF OAB)	0.1
TOTAL	**0.6**

13.20.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO THERMAL DESIGN REPORT E-MAO-PT0-INA-DER-001	MAL	D11/D14
MORFEO THERMAL ANALYSIS REPORT E-MAO-PT0-INA-ANR-001	MAL	DRD220
MORFEO THERMAL INTERFACE CONTROL DOCUMENT E-MAO-PT0-INA-ICD-001	MAL	D15
MORFEO THERMAL AIV PLAN E-MAO-PT0-INA-PLA-001	MAL	D17

13.20.4. Thermal Control System activities

THERMAL ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Agreeing the MORFEO thermal interface (Telescope and MICADO)
- Define all MORFEO internal thermal interfaces with the Consortium partners and suppliers
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- Procurement Specification for Thermal Components for cost estimation

THERMAL DESIGN

- HEAT DISSIPATION SYSTEM DESIGN
- MIRROR VENTILATION SYSTEM DESIGN
- THERMAL CONTROL HARNESS DESIGN

13.21. PU0 - CALIBRATION UNIT

13.21.1. WP description

This WP describes the activities concerning the Calibration Unit for the phase B.

The Calibration Unit product consists of

- one or more modules containing light sources to emulate NGS and LGS;
- actuators for the fine adjustment of the modules if required
- handling and AIV tools, whenever necessary.

13.21.2. Resources

WP responsible	GIANLUCA DI RICO (INAF OAAB)
WP resources	**FTE/yr**
GIANLUCA DI RICO (INAF OAAB) MAURO DOLCI (INAF OAAB) IVAN DI ANTONIO (INAF OAAB) AMICO DI CIANNO (INAF OAAB) ANGELO VALENTINI (INAF OAAB) GABRIELE RODEGHIERO (INAF OAS) Collaboration with OPTICAL WP for Optical Design of CU	0.4 0.3 0.7 0.1 0.1 0.1
TOTAL	**1.7**

13.21.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO CALIBRATION UNIT DESIGN REPORT E-MAO-PU0-INA-DER-001	GDR	D11/D14
MORFEO CALIBRATION UNIT ANALYSIS REPORT E-MAO-PU0-INA-ANR-001	GDR	DRD220
MORFEO CALIBRATION UNIT INTERFACE CONTROL DOCUMENT E-MAO-PU0-INA-ICD-001	GDR	D15
MORFEO CALIBRATION UNIT AIV PLAN E-MAO-PU0-INA-PLA-001	MDO	D17

13.21.4. Calibration Unit activities

CALIBRATION UNIT ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Define internal Interface
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- Preliminary Procurement Specification for CU Components to be delivered to the MORFEO Project Office
- Procurement Specification for CTU Components
- Calibration Unit Cost Estimation

CALIBRATION UNIT DESIGN

- Functional Analysis (provide Functional Requirements and Technical Specifications)
- Mechanical Design
- Control Electronics Design
- Mechanical Interface Definition
- Electronics Interface Definition
- Harness Definition
- Handling Tool Design and Interface Definition
- Manufacturing, Assembly, Integration and Test (MAIT) Preliminary Plan
- Performance Analysis
- Support to user’s requirements definition and functional specifications by WP ICS Software and WP Real Time

13.22. PV0 - Test Unit

13.22.1. WP DESCRIPTION

The scope of this WP is to develop a test unit to be used at PAE to verify the MORFEO AO performances.

The Test Unit must provide functionality to verify the MORFEO performances to a level commensurate with the projected project cost. Within this WP the AO verification plan must be developed.

The Test Unit is not meant to provide functionality to calibrate the system. The test Unit will be used at PAE and will not be integrated at the telescope although can be used also in Chile prior to mounting MORFEO on the platform, if needed

13.22.2. Resources

WP responsible	ALEXANDER GONCHAROV (NUIG)
WP resources	**FTE/yr**
ALEXANDER GONCHAROV (NUIG)	0.3
NICHOLAS DEVANEY (NUIG)	0.4
LORENZO BUSONI (INAF OAA)	0.1
SYLVAIN OBERTI (ESO)	0.1
TOTAL	**0.9**

13.22.3. Expected documents for the PDR

Documents	Owner	DRD
MORFEO TEST UNIT DESIGN REPORT E-MAO-PV0-NUI-DER-001	AGO	D11/D14
MORFEO TEST UNIT ANALYSIS REPORT E-MAO-PV0-NUI-ANR-001	AGO	DRD220
MORFEO TEST UNIT INTERFACE CONTROL DOCUMENT E-MAO-PV0-NUI-ICD-001	AGO	D15
MORFEO TEST UNIT AIV PLAN E-MAO-PV0-NUI-PLA-001	AGO	D17

13.22.4. Test Unit activities

TEST UNIT ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Define internal Interface
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan, Commissioning Plan
- Procurement Specification for Test Unit Components
- Test Unit Cost Estimation
- Test Unit Schedule

TEST UNIT DESIGN

- Functional Analysis (provide Functional Requirements and Technical Specifications)
- Mechanical Design
- Control Electronics Design
- Mechanical Interface Definition
- Electronics Interface Definition
- Performance Analysis

13.23. Phase-B Closure

Phase B was officially closed on February 22, 2023, after all the PDR Critical Action Items were completely resolved and the MOREFO consortium delivered the finalized post-PDR package.

The following sections provide a concise overview of the pending and upcoming tasks for Phase C, organized by each relevant Work Package.

13.23.1. Overall FTE effort

Below is a table summarizing the overall FTE effort for Phase B, measured in person-months:

	PHASE B	
WPs \ Effort	Initially planned effort in Phase B (Person Months)	Spent effort in Phase B (Person Months)
MA0 - PI Activities	24,8	31,6
MB0 - Project Management	31,0	39,5
MC0 - PA Management	31,0	39,5
MP0 - Procurement	0,0	0,0
SE0 - System Engineering	96,0	122,4
SA0 - System AO Engineering	51,1	65,1
SM0 - System MAIV Engineering	29,4	37,5
SF0 - System Optical Design	31,0	39,5
SC0 - System Calibration	24,8	31,6
SS0 - System Science Operations	41,8	53,3
PC0 - E2E Simulation Code	31,0	39,5
PD0 - Deformable Mirrors	21,7	27,6
PF0 - Optomechanics	37,2	47,4
PH0 - Instrument Control Hardware	86,7	110,5
PL0 - LGS WFS Module	68,1	86,9
PM0 - Main Structure	37,2	47,4
PN0 - NGS WFS Module	24,8	31,6
PR0 - Real Time Computer	21,7	27,6
PS0 - Instrument Control Software	61,9	79,0
PT0 - Thermal Control	18,6	23,7
PU0 - Calibration Unit	52,7	67,1
PV0 - Test Unit	27,9	35,5
PW0 - WFS Cameras	0,0	0,0
Total	**850,1**	**1.083,7**

13.23.2. Pending/To-Do for Phase-C

- Project Management & Documentation: Consolidate work packages for all phases, complete and maintain the CIDL (MAO-1034), and implement the MORFEO identification scheme once ESO finalizes the standard (MAO-1052)
- System Engineering & Interfaces: Strengthen requirement traceability, finalize all ICDs with MICADO/Telescope, and define the strategy for structural load and earthquake analyses (MAO-145) before advancing to FDR
- AO Performance and Simulations: Finalize the DM stroke budget, including plate-scale modes, low-order corrections, and offload strategies (critical MAO-1055 still open), complete the remaining bias-mitigation and algorithm-verification work, formalize the integrated control strategy with Telescope and MICADO (open actions like MAO-885, MAO-1053, and MAO-1054), and confirm that the LGS WFS meets the required flux performance while resolving the outstanding SONY-detector issues
- Optical Design: Complete the detailed design and trade-off studies for the large optical mounts (open actions from MAO-1048 to MAO-1061) , finalize the alignment and thermo-mechanical stability procedures (open ESO action MAO-1005), and close the MORFEO–MICADO optical interface documentation by consolidating all previous cross-verification results
- Wavefront Sensors: Clarify whether MORFEO must ensure plate-scale stability within single or consecutive MICADO exposures (and update LOR WFS/PFDM requirements accordingly), reassess NGS mechanical stability including the Focus Compensator (critical action MAO-838), finalize and justify the Reference WFS strategy with bias-mitigation, and simply document the completed LGS WFS de-rotation and thermo-mechanical/vibration analyses
- Instrument Control Software and RTC: Complete the remaining software and RTC requirements (including fast re-acquisition, NGS acquisition, degraded modes, data processing, and alarms), deliver a detailed RTC prototyping plan with clear resourcing, finalize timing and latency analyses for the soft-real-time cluster, and establish both the RTC obsolescence plan and the updated construction effort split between design and build phases
- Science Operations: Clarify and document the allocation of calibration time (MAO-1021), resolving overlaps with maintenance (MAO-1023) and initiate studies to quantify the impact of daytime vibrational noise on calibration activities (MAO-959, MAO-960, and MAO-1030 still open)
- Mechanical & Thermal Design: Further validate the Nasmyth spherical-joint interface and refine the thermal strategy, reassess enclosure geometry for simplification, verify crane-height and IAA-to-Nasmyth transport constraints (MAO-1463 still open), and finalize both the AO Test Plan (MAO-1466) and the optical-alignment and quality verification procedures to ensure full robustness for commissioning
- Calibration Unit/Test Unit: Expand the TU preliminary design report with the selected WFS model, clarified TAC (Test/Alignment Camera) design choices, and

defined mechanical/electrical interfaces, while documenting mitigation strategies for throughput, alignment, and ghost/stray-light risks and producing a single consolidated set of CU/TU user requirements with prioritized calibration, characterization, and testing needs

- Instrument Control Hardware: Update the list to include missing information on the Cal Units positioner and fill in any remaining TBD entries related to the optomechanics and deformable mirrors
- RAMS: Deliver the full Product Tree early in final design (MAO-1461), perform a system-wide hazard and failure analysis, finalize degraded modes and the spare-parts strategy, and reassess critical items such as Calibration Unit's impact on availability and the trade-offs related to the large LOR WFS assembly now identified as a whole LRU.

14. ANNEX 2 - WORK PACKAGES DESCRIPTION FOR PHASE C

The MORFEO WBS for the Phase-C with the name of all the WP manager is reported in Figure 13-1 The MORFEO Phase-C WBS

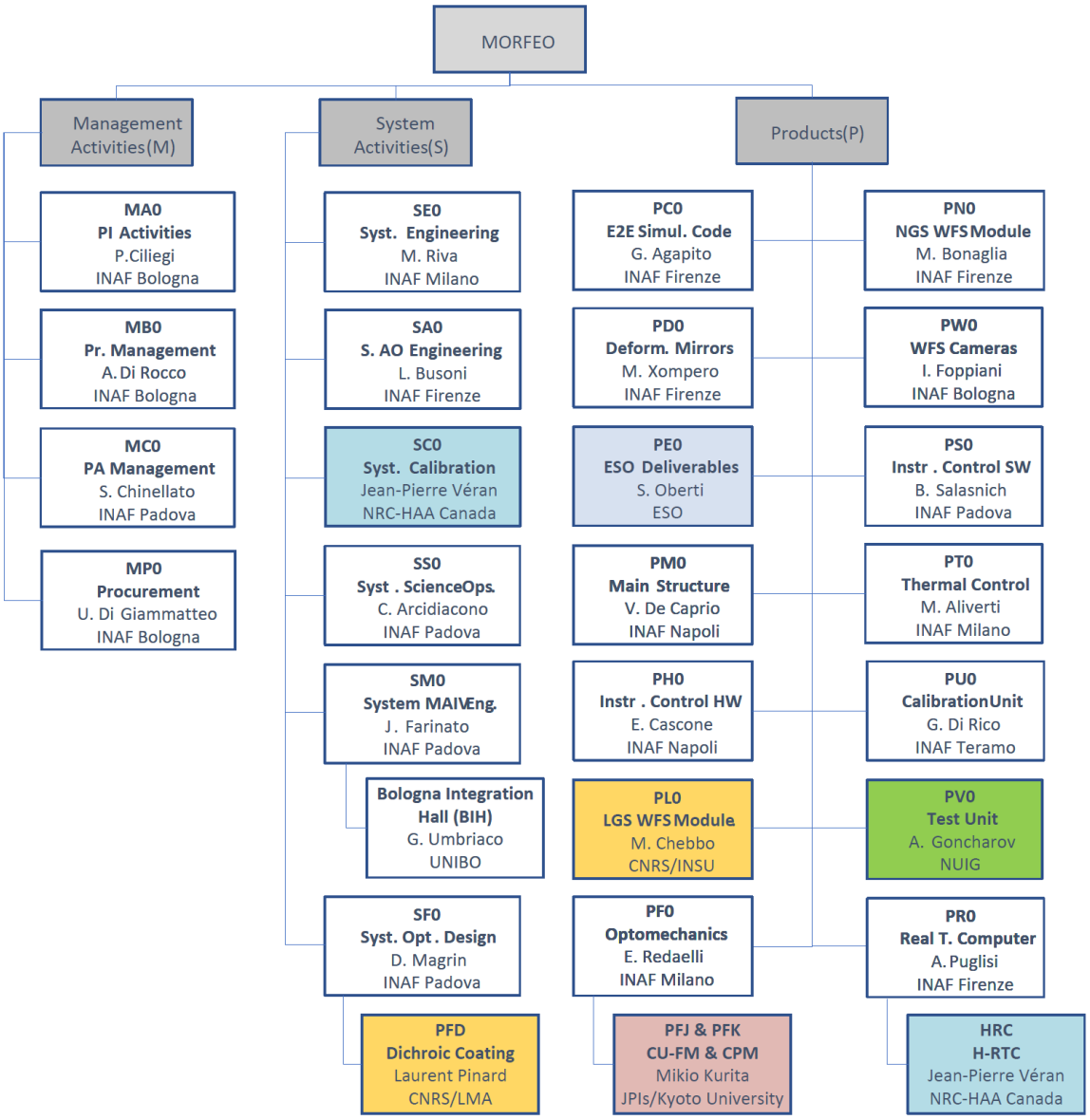


Figure 13-1 The MORFEO Phase-C WBS (First Level)

For each WP we report in the following sections:

- WP Manager
- Resources
- List of expected documents for the FDR
- Description of activities

The WBS of Phase C is slightly different from the one of Phase-B, since it includes the management of procurement and the adoption of a SONY-based camera for the LGS WFS Unit.

Additionally, with the introduction of new partners into the MOREFO Consortium, designated sub-packages have been established to define the responsibilities assigned to them.

The relative weight of the different WPs will be different in this Phase and the level of design detail will be much higher than the one of Phase-B.

At the end of Phase-C the documentation must contain all the elements necessary to start the manufacturing of the various Subsystems.

In the following we report the description of Phase-C Work Packages with the information available at this moment.

14.1. MA0 - PRINCIPAL INVESTIGATOR ACTIVITIES

14.1.1. WP description

This WP describes the activities of the MORFEO Principal Investigator for phase C.

The concerned product is the whole MORFEO system.

14.1.2. Resources

WP responsible: PAOLO CILIEGI (INAF OAS)

WP resources	FTE/year
PAOLO CILIEGI (INAF OAS)	0.7
TOTAL	**0.7**

14.1.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO EXECUTIVE SUMMARY E-MAO-000-INA-PLA-005	PCI	D02
MORFEO SYSTEM OVERVIEW E-MAO-000-INA-DER-001	PCI	D10

14.1.4. Principal Investigator activities

The tasks of the Principal Investigator are:

- Maintain on overview of the MORFEO system
- Provide the functions of the formal single point of contact to ESO
- Report the Consortium activities to the MORFEO Steering Committee
- Represent the MORFEO Consortium towards ESO in all Project Reviews
- Represent the MORFEO Consortium in all Progress Meetings of ESO
- Represent the MORFEO Consortium towards ESO in all ELT Reviews
- Manage MORFEO out-reach activities
- Approve all scientific, technical and programmatic documentation of MORFEO
- Manage the funding distribution to the Consortium partners
- Manage the GTO interface to ESO for MORFEO

14.2. MB0 - PROJECT MANAGEMENT

14.2.1. WP description

This WP describes the activities of the MORFEO Project Manager for Phase C.

The concerned product is the whole MORFEO system.

14.2.2. Resources

WP responsible: ANDREA DI ROCCO (INAF OAS)

WP resources	FTE/year
ANDREA DI ROCCO (INAF OAS)	1.0
LUDOVICO TEODORI (INAF OAS)	1.0
TOTAL	**2.0**

14.2.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO PROJECT MANAGEMENT PLAN E-MAO-000-INA-PLA-001	ADR	D01
MORFEO CONFIGURATION ITEM DATA LIST E-MAO-000-INA-CIDL-001	ADR	DRD150
MORFEO CONFIGURATION MANAGEMENT PLAN E-MAO-000-INA-PLA-002	LTE	DRD100
MORFEO RISK REGISTER E-MAO-000-INA-RRR-001	ADR	D03

14.2.4. Project Management activities

The tasks of the Project Management WP are:

- Define and maintain the overall schedule of MORFEO development and milestones in conformity with the requirements of ESO
- Approve the schedules of the MORFEO Consortium suppliers and those of the direct suppliers
- Maintain the MORFEO Document Tree
- Monitor the activities of the Consortium partners and direct suppliers taking all actions necessary to achieve the project milestones
- Manage MORFEO Consortium Working Meetings
- Define the Project Reviews and meetings necessary to ensure the success of the program
- Support and prepare all ESO reviews of MORFEO required by ESO
- Control and support all reviews of the activities of the MORFEO Consortium partners and direct suppliers performed by the MORFEO Engineering System Team
- Prepare and support all Progress Meetings required by ESO
- Perform all Progress Meetings with Consortium partners and direct suppliers
- Manage and maintain the configuration control of the project
- Monitor and control the costs of the program
- Prepare, update and approve the programmatic documentation of the project
- Provide support to the MORFEO PI for Consortium Management
- Time Management, Cost Management, Prepare, update and approve the programmatic documentation of the project (that is approved by the PI, too).

14.3. MC0 - PRODUCT ASSURANCE MANAGEMENT

14.3.1. WP description

This WP describes the Product Assurance activities for phase C.

The concerned product is the whole MORFEO system.

14.3.2. Resources

WP responsible: SIMONETTA CHINELLATO (INAF OAPD)

WP resources	FTE/year
SIMONETTA CHINELLATO (INAF OAPD)	0.4
ROSANNA SORDO (INAF OAPD)	0.5
MINA SIBALIC (IANF OACN) (since Dec 2025)	0.3 TBC
NATALIA AURICCHIO (INAF OAS) (since Nov 2025)	0.2
DOMENICO D'AURIA (INAF OACN) (until Feb 2025)	1
ENRICO GIRO (INAF OAPD) (until June 2024)	0.6
ANDREA BALESTRA (INAF OAPD)	0.3
TOTAL	**3.3**

14.3.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO PRODUCT ASSURANCE PLAN E-MAO-000-INA-PLA-003	SCH	DRD110
MORFEO HAZARD LIST AND ANALYSIS E-MAO-000-INA-ANR-003	SCH	D04
MORFEO HAZARDOUS MATERIAL LIST E-MAO-000-INA-LIS-004	SCH	DRD180
MORFEO RELIABILITY ANALYSIS E-MAO-000-INA-ANR-002	SCH	DRD160

Documents	Owner	DRD
MORFEO FMECA E-MAO-000-INA-ANR-001	SCH	DRD160
MORFEO PARTS LIST/BILL OF MATERIALS (Draft) E-MAO-000-INA-BOM-001	SCH	D32/D33
MORFEO SPARE PARTS LIST (Draft) E-MAO-000-INA-LIS-005	SCH	DRD260
MORFEO MAINTENANCE MANUALI (Draft) E-MAO-000-INA-MAN-007	SCH	D31
MORFEO SW QUALITY ASSURANCE PLAN E-MAO-MC0-INA-PLA-001	BAA	D02

14.3.4. Product Assurance Management activities

The tasks of the MORFEO Product Assurance WP in Phase C are:

- Implementing the MORFEO Product Assurance Plan
- Liaising with and advising PA Managers of the MORFEO Consortium partners
- Carrying out PA surveillance and control of MORFEO Consortium institutes including audits and acceptance of items
- Define a project NCR and waiver system including sub-contractor and supplier NCR's convening and chairing Non-conformity Review Boards (NRB). Monitor Change Requests (CRE), Request for Deviation (RFD), Request for Waiver (RFW).
- Attend to Test Readiness Reviews (TRR), Test Review Boards (TRB), Integration review Boards (IRR), Qualification Status Review (QSR) for all qualification and verification tests
- Ensuring Reliability; Availability and Maintainability (RAM) assurance activities are analysis is properly carried out
- Agreeing and approving the necessary documentation in the form of Log Books and Acceptance Data Packages
- Attending all major reviews and tests and providing the relevant PA inputs

Ensuring that cleanliness, contamination control and safety aspects are properly coveredFor what concerns SQA tasks in phase C these consists in checking the correct application of SQA Plan with particular attention to:

- Review of software documentation.
- Checking for traceability from requirements to design elements.
- Ensuring developers follow coding guidelines (naming conventions, documentation).
- Ensuring tools for SQA workflow are properly implemented.

14.4. MP0 - PROCUREMENT

14.4.1. WP description

This WP describes the procurement activities to be carried out in phase C.

The concerned product is the whole MORFEO system.

14.4.2. Resources

WP responsible: UGO DI GIAMMATTEO (INAF OAS)

WP resources	FTE/year
UGO DI GIAMMATTEO (INAF OAS)	0.1
PAOLO CILIEGI (INAF OAS)	0.1
SIMONETTA CHINELLATO (INAF OAPD)	0.1
ROSANNA SORDO (INAF OAPD)	0.1
Administrative personnel of local INAF offices	TBD
TOTAL	**0.4**

14.4.3. Expected documents for the FDR

Documents	Owner	DRD
Calls for Tender documentation	UDG	N.A.
Auxiliary Documentation	UDG	N.A.
Contracts with external providers	UDG	N.A.

14.4.4. Procurement activities

The tasks of the MORFEO Procurement WP are:

- Identify the procurement needs and define the relevant process
- Define schedule and needed resources for the procurement process in close collaboration with PI, PM and PA-QA Manager.
- Supervise the procurement process and ensure its coherence with the objectives of the project
- Monitor and control times, resources and costs of the procurement

An external company supports MORFEO personnel in the selection of the best procurement instruments and in the management of the Calls.

14.5. SE0 - SYSTEM ENGINEERING

14.5.1. WP description

This WP describes the activities of the MORFEO System Engineer for phase C.
The concerned product is the whole MORFEO system.

14.5.2. Resources

WP responsible: MARCO RIVA (INAF OAB)

WP resources	FTE/year
MARCO RIVA (MORFEO System Engineer, INAF OAB)	0.8
MARCELLO SCALERA (INAF OAB)	0.3
MATTEO GENONI (INAF OAB)	0.2
LORENZO BUSONI (INAF OAA)	0.2
FOPPIANI (INAF OAS)	0.1
SYLVAIN OBERTI (ESO)	0.2
CARMELO ARCIDIACONO (INAF OAS)	0.1
DEMETRIO MAGRIN (INAF OAPD)	0.1
JACOPO FARINATO (INAF OAPD)	0.1
BERNARDO SALASNICH (INAF OAPD)	0.1
ENRICO CASCONE (INAF OACN)	0.1
VINCENZO DE CAPRIO (INAF OACN)	0.1
ZOLTAN HUBERT / LAURENT JOCOU (CNRS/INSU)	0.1
PATRICK RABOU / EDGAR RENAUT (CNRS/INSU)	0.1
MARCO BONAGLIA (INAF OAA)	0.1
GIANLUCA DI RICO (INAF OAAB)	0.1
MARCO XOMPERO (INAF OAA)	0.1
ANDREA BARUFFOLO (INAF OAPD)	0.1

WP resources	FTE/year
GUIDO AGAPITO (INAF OAA)	0.1
EDOARDO REDAELLI (INAF OAB)	0.1
MATTEO ALIVERTI (INAF OAB)	0.1
ALEXANDER GONCHAROV / NICHOLAS DEVANEY (NUIG)	0.1
GABRIELE RODEGHIERO (INAF.OAS)	0.2
ANDREA BALESTRA (INAF OAPD)	0.1
TOTAL	**3.7**

14.5.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO COMPLIANCE MATRIX E-MAO-000-INA-CMX-001	MRI	DRD550
MORFEO EARTHQUAKE ANALYSIS E-MAO-000-INA-ANR-006	MRI	D07
MORFEO SYSTEM BUDGET ALLOCATION E-MAO-SE0-INA-SPE-002	MRI	DRD270
MORFEO SYSTEM DESIGN AND ANALYSIS REPORT E-MAO-000-INA-DER-002	MRI	D11
MORFEO-ELT INTERFACE CONTROL DOCUMENT E-MAO-000-INA-ICD-001	MRI	D12
MORFEO INTERFACE DRAWINGS E-MAO-SE0-INA-LIS-002	MRI	D21
MORFEO MANUFACTURING DRAWINGS E-MAO-SE0-INA-LIS-003	MRI	D22
MORFEO OPERATIONS MANUAL (Draft) E-MAO-000-INA-MAN-003	MRI	D700
Sub-system Specifications		
MORFEO MAIN STRUCTURE TECHNICAL SPECIFICATIONS E-MAO-PM0-INA-SPE-003	MRI	D13
MORFEO THERMAL CONTROL TECHNICAL SPECIFICATIONS E-MAO-PT0-INA-SPE-003	MRI	D13

Documents	Owner	DRD
MORFEO POST FOCAL RELAY OPTICS TECHNICAL SPECIFICATIONS E-MAO-PF0-INA-SPE-003	MRI	D13
MORFEO ICH TECHNICAL SPECIFICATIONS E-MAO-PH0-INA-SPE-003	MRI	D13
MORFEO CALIBRATION UNIT TECHNICAL SPECIFICATIONS E-MAO-PU0-INA-SPE-003	MRI	D13
MORFEO TEST UNIT TECHNICAL SPECIFICATIONS E-MAO-PV0-INA-SPE-003	MRI	D13
MORFEO LGS WFS TECHNICAL SPECIFICATIONS E-MAO-PL0-INA-SPE-002	MRI	D13
MORFEO LGS WFS CAMERAS TECHNICAL SPECIFICATIONS E-MAO-PW0-INA-SPE-001	MRI	D13
MORFEO NGS WFS TECHNICAL SPECIFICATIONS E-MAO-PN0-INA-SPE-003	MRI	D13
MORFEO DMs TECHNICAL SPECIFICATIONS E-MAO-PD0-INA-SPE-003	MRI	D13

14.5.4. System Engineering activities

The tasks of the System Engineering WP are:

- Ensuring the integration of the engineering activities in project
- Agreeing on a system architecture
- Definition and/or control of external and internal interfaces
- Maintenance of the system budgets
- Definition of sub-systems budgets
- Verification of design and performance against requirements.

14.6. SA0 - SYSTEM ADAPTIVE OPTICS ENGINEERING

14.6.1. WP description

This WP contains the activities related to the definition of the AO aspects of the following MORFEO sub-systems:

- LOR WFS module;
- LGS WFS module;
- Real Time Computer;
- Deformable Mirrors.

This WP works in close coordination with the WP System Engineering and makes use of the results produced by WP End to End Simulations.

The tasks of this WP are:

- AO system analysis, design trade-offs verification, AO error budget development
- Contribute to the definition of requirements of AO-related components/sub-systems (WFS cameras, RTC, DMs, LGS WFS, NGS WFS)
- support user's requirements definition by WP ICS Software
- contribute to the definition of MORFEO AIV plan for AO aspects
- definition of AO control strategy including interaction with ELT and MICADO
- definition of AO calibration and operation strategy addressing in particular the following aspects:
  - reconstructor calibration strategies, measuring the interaction matrix via a calibration source, on sky or simulating it or part of it
  - pupil mis-registration strategies and algorithms
  - non-common path aberrations calibration strategies
  - operation strategy
  - acquisition strategy.

14.6.2. Resources

WP responsible: LORENZO BUSONI (INAF OAA)

WP resources	FTE/year
LORENZO BUSONI (INAF OAA)	0.4
GUIDO AGAPITO (INAF OAA)	0.2
SIMONE ESPOSITO (INAF OAA)	0.2

WP resources	FTE/year
CEDRIC PLANTET (INAF OAA)	0.2
GIULIA CARLA' (INAF OAA)	0.6
JEAN-PIERRE VERAN (NRC)	0.4
TOTAL	**2**

14.6.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO ADAPTIVE OPTICS SYSTEM DESIGN AND ANALYSIS REPORT E-MAO-SA0-INA-DER-001	LBU	D11
MORFEO WAVEFRONT FLUX BUDGET E-MAO-SA0-INA-TNO-005	LBU	DRD270
MORFEO WAVEFRONT ERROR BUDGET E-MAO-SA0-INA-TNO-008	LBU	DRD270
MORFEO ASTROMETRIC ERROR BUDGET	LBU	DRD270
MORFEO IMPACT OF PLATESCALE CONTROL ON LO STROKE OF PFDMs AND ON POINTING STABILITY E-MAO-SA0-INA-TNO-004	LBU	D11
PROPAGATION OF OPTICAL ELEMENTS ABERATIONS IN THE AO LOOP AND THEIR CORRECTION BY THE REFERENCE LOOP E-MAO-SA0-INA-TNO-004	LBU	D11

14.6.4. System AO Engineering activities

AO MANAGEMENT

- WP Management (Meeting, Schedule)
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan

AO ENGINEERING

- Flow-down of MORFEO requirements in AO subsystem
- Finalize Subsystems Technical Specifications
- Control of AO subsystem internal and external interfaces
- AO WFE budget
- Jitter budget
- Astrometric Error Budget
- Trade off study: 2DM vs 3DM, optimize number of actuators and pitch
- Sky coverage and tech FoV
- Trade-off and choice of algorithms for MCAO Reconstruction and control
- Choice of algorithms for slope computations
- Design Reference Sensor scheme
- Derotation scheme (how to keep sub-aps and actuators matched)
- Overall control and interaction between loops (AO RT loop, Reference, LGS guiding, all kinds of offloads and secondary loop, telescope, pupil position control in WFSs, jitter stabilizations, …)
- Optimizing LGS WFS design and centroiding algorithm
- Study and quantify Telescope Effects on MORFEO

14.7. SM0 - SYSTEM MAIT/V ENGINEERING

14.7.1. WP description

This WP describes the MORFEO System AIV Engineering activities for phase C.

The concerned product is the whole MORFEO system. The scope of this WP is the MAIV of the MORFEO system, starting from the MORFEO sub-systems.

14.7.2. Resources

WP responsible: JACOPO FARINATO (INAF OAPD)

WP resources	FTE/year
JACOPO FARINATO (AIV Engineer, INAF OAPD)	0.2
GABRIELE RODEGHIERO (INAF OAS)	0.4
MARIA BERGOMI (INAF OAPD)	0.3
LUCA MARAFATTO (INAF OAPD)	0.3
GIORGIO PARIANI (INAF OAB)	0.2
VINCENZO DE CAPRIO (INAF OACN)	0.1
VINCENZO CIANNIELLO (INAF OACN)	0.1
SIMONE DI FILIPPO (INAF OAPD)	0.2
FEDERICO BATTAINI (INAF OAPD)	0.2
GABRIELE UMBRIACO (INAF OAS)	0.5
ZOLTAN HUBERT / LAURENT JOCOU (CNRS/INSU)	0.1
TOTAL	**2.6**

14.7.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO SYSTEM MAIT STRATEGY E-MAO-000-INA-PLA-010	JFA	D16
MORFEO SYSTEM AI PLAN E-MAO-000-INA-PLA-020	JFA	D16

Documents	Owner	DRD
MORFEO SYSTEM TEST PLAN E-MAO-000-INA-PLA-021	JFA	D16
MORFEO HANDLING TOOLS AND SUPPORT EQUIPMENT DESIGN REPORT E-MAO-SM0-INA-DER-001	JFA	D14
MORFEO HANDLING TOOLS AND SUPPORT EQUIPMENT ANALYSIS REPORT E-MAO-SM0-INA-ANR-001	JFA	D14
MORFEO HANDLING TOOLS AND SUPPORT EQUIPMENT INTERFACE CONTROL DOCUMENT E-MAO-SM0-INA-ICD-001	JFA	D15
MORFEO HANDLING TOOLS AND SUPPORT EQUIPMENT MAIT PLAN E-MAO-SM0-INA-PLA-001	JFA	D17
MORFEO HANDLING TOOLS AND SUPPORT EQUIPMENT INTERFACE DRAWINGS E-MAO-SM0-INA-LIS-001	JFA	D21
MORFEO HANDLING TOOLS AND SUPPORT EQUIPMENT MANUFACTURING DRAWINGS E-MAO-SM0-INA-LIS-002	JFA	D22
MORFEO PAE TEST PLAN E-MAO-000-INA-PLA-014	JFA	D26
MORFEO SHIPMENT PLAN (Draft)	JFA	D310
MORFEO IAA AIV PLAN	JFA	DRD400
MORFEO AND MICADO AIV PLAN	JFA and MICADO	DRD400

14.7.4. System MAIT/V Engineering activities

The tasks of the System MAIV Engineering WP are:

- Production of the MORFEO MAIV Plan, test and calibration procedures
- Verification of the sub-systems MAIV plans and procedures
- Production of the MORFEO Verification Control Document (VCD)
- Agreeing the MORFEO integration, test and verification procedures with ESO for the integration and commissioning of MORFEO with MICADO and the Telescope.
- MORFEO AIV tool design

- Definition of the requirements of any technical template needed for AIV only, therefore not part of the Template Manual, to be developed by ICS WP

14.8. SF0 - SYSTEM OPTICAL DESIGN

14.8.1. WP description

This WP describes the activities concerning the optical design at system level for the phase C.

The product of this WP includes

- Main Path Optics, i.e. the optical relay which re-images the telescope focal plane to the exit ports for MICADO and the second instrument TBD; the Main Path Optics include the beam-splitter to separate the science path from the LGS path;
- LGS Objective, i.e. the set of optics downstream the beam-splitter to focus the LGS light for the LGS WFS module;
- Collaboration to handling and AIV tools design, whenever necessary.

The MORFEO Deformable Mirrors, which form the scope of a specific WP (section 4.17), are regarded in the present WP as rigid mirrors: the definition of their optical shape is the only relevant aspect here.

This WP, in addition to all the necessary activities for the development of the Post-Focal Relay Optics in the phase B, also includes the following tasks:

- agreeing the optical interfaces to ELT and MICADO;
- production and verification of the MORFEO optical model.

14.8.2. Resources

WP responsible: DEMETRIO MAGRIN (INAF OAPD)

WP resources	FTE/year
DEMETRIO MAGRIN (INAF OAPD)	0.5
LUCA OGGIONI (INAF OAB)	0.3
MATTEO MUNARI (INAF OACT)	0.3
GIORGIO PARIANI (INAF OAB)	0.3
ANDREA BIANCO (INAF OAB)	0.2
DAVIDE GREGGIO (INAF OAPD)	0.1
ALESSANDRO BALLONE (INAF OAPD)	0.2
TOTAL	**1.9**

14.8.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO SYSTEM OPTICAL DESIGN AND ANALYSIS REPORT E-MAO-SF0-INA-DER-001	DMA	D11

14.8.4. System Optical Design activities

OPTICAL ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Agreeing the MORFEO optical interface (Telescope and MICADO)
- Define all MORFEO internal optical interfaces with the Consortium partners and suppliers
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- Preliminary Procurement Specification for Optical Components for cost estimation
- DEC (Direttore dell'Esecuzione del Contratto) responsibility and related activities for the Opto-mechanical contracts

OPTICAL DESIGN

- Refinement Main Path Optics Design baseline
- Refinement LGS Objective Design baseline
- Detailed tolerance analysis and thermo-elastic sensitivity
- Ghosts and straylight analysis
- Trade off of different designs

14.9. SC0 - SYSTEM CALIBRATION

14.9.1. WP description

This WP carries out the design and development of the MORFEO calibration strategy

14.9.2. Resources

WP responsible: SYLVAIN OBERTI (ESO)

WP resources	FTE/year
SYLVAIN OBERTI (ESO) / JEAN PIERRE VERAN (NRC)	0.3
LORENZO BUSONI (INAF OAA)	0.1
DEMETRIO MAGRIN (INAF OAPD)	0.1
MARCO BONAGLIA (INAF OAA)	0.1
ALFIO PUGLISI (INAF OAA)	0.1
ZOLTAN HUBERT / LAURENT JOCOU (CNRS/INSU)	0.1
TOTAL	**0.8**

14.9.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO INSTRUMENT CALIBRATION PLAN E-MAO-SC0-ESO-PLA-001	JPV	D24

14.9.4. System Calibration activities

In agreement with the MORFEO system engineer and the AO system engineer, define an AO calibration, operation and acquisition strategy addressing in particular the following aspects:

- reconstructor calibration strategies, measuring the interaction matrix via a calibration source, on sky or simulating it or part of it
- pupil mis-registration strategies and algorithms
- non-common path aberrations calibration strategies
- online system optimization and telemetry processing
- operation strategy
- acquisition strategy

Define the calibration tasks of the following sub-systems:

- MORFEO optical relay and LGS objective
- The LOR WFS module
- The LGS WFS module
- The post-focal DM(s)

14.10. SS0 - SYSTEM SCIENCE OPERATIONS

14.10.1. WP description

This WP describes the scientific activities in the MORFEO project for the phase C.

The products of this WP consist of

- MORFEO Operational Concept Description;
- MORFEO Template Manual;
- Point Spread Functions, representing the MORFEO optical performance at the exit ports;
- TBC: auxiliary data and models to support the development of the MICADO Data Flow System and of the ELT Exposure Time Calculator; these sub-products have to be defined with MICADO and ESO.

14.10.2. Resources

WP responsible:CARMELO ARCIDIACONO (INAF OAPD)

WP resources	FTE/year
CARMELO ARCIDIACONO (INAF OAPD)	0.4
MARCO GULLIEUSZIK (INAF OAPD)	0.3
ELISA PORTALURI (INAF OAPD)	0.4
MICHELE CANTIELLO (INAF OAAB)	0.3
TOTAL	**1.4**

14.10.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO OPERATIONAL CONCEPT DESCRIPTION E-MAO-000-INA-MAN-002	CAR	D30
MORFEO PSF DESCRIPTION E-MAO-SS0-INA-TNO-001 and E-MAO-SS0-INA-TNO-002	CAR	N.A.
MORFEO USER MANUAL (DRAFT) E-MAO-000-INA-MAN-004	CAR	D29

Documents	Owner	DRD
MORFEO COMMISSIONING PLAN E-MAO-000-INA-PLA-016	CAR	D27

14.10.4. System Science Operations activities

The tasks of the MORFEO Science Operation WP are:

- verify that all scientific performance requirements are consistent with the design of MORFEO;
- perform scientific trade-offs on any design options in MORFEO to ensure that the scientific performance requirements are maintained;
- define requirements for MORFEO performance estimation tool in collaboration with MICADO
- active participation in the MORFEO Science Team.
- ensure a link between the Science Team and the Technical Work Packages
- support the definition of the preparation process for MORFEO observations in the Template Manual.
- support the definition of the Observation, Calibration and Maintenance Template

14.11. PC0 - END TO END SIMULATION CODE

14.11.1. WP description

This WP contains the end-to-end simulation activities to support the WP Adaptive Optics for the phase C.

The WP includes in particular

- development of dedicated numerical analysis tools and of an end-to-end code for the simulation of the MORFEO AO system;
- comparison of the end-to-end code with other existing codes, already in use in the framework of the project for other purposes, such as the OCTOPUS code at ESO and the MAO code at INAF OAS;
- performance of the simulations required by the WP Adaptive Optics

14.11.2. Resources

WP responsible: GUIDO AGAPITO (INAF OAA)

WP resources	FTE/year
GUIDO AGAPITO (INAF OAA)	0.5
CEDRIC PLANTET (INAF OAA)	0.5
TOTAL	**1.0**

14.11.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO AO SIMULATION ANALYSIS REPORT E-MAO-PC0-INA-ANR-001	GAG	D11
MORFEO FOCUS CONTROL STRATEGY	GAG	D11
MORFEO SKY COVERAGE COMPUTATION	GAG	D11
MORFEO PETALING MITIGATION STRATEGY	GAG	D11

14.11.4. E2E simulation code activities

E2E SIMULATION MANAGEMENT

- WP Management (Meeting, Schedule)
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan

E2E SIMULATION DEVELOPMENT

- Development of sim tools to estimate sky coverage
- Evaluation of sky coverage
- Development of sim tools related to spot truncations and truth sensing
- Development of sim tools related to tomographic reconstruction
- Full system simulations to quantify optimal system parameters and final performances

14.12. PD0 - DEFORMABLE MIRRORS

14.12.1. WP description

This WP describes the activities concerning the MORFEO Deformable Mirrors for the phase C.

The Deformable Mirrors product consists of up to two adaptive mirrors units, with the following features:

- optical head, controlled in real-time by actuators;
- mechanical support, including interface to the MORFEO Main Structure and actuators for global positioning, whenever necessary;
- thermal control system for heat dissipation;
- control electronics;
- deterministic command interface to the Real Time Computer and non-deterministic command interface to the ICS Software;
- handling and AIV tools, whenever necessary.

14.12.2. Resources

WP responsible:MARCO XOMPERO (INAF OAA)

WP resources	FTE/year
MARCO XOMPERO (INAF OAA)	0.5
NICOLO' AZZAROLI (INAF OAA)	0.25
EXTERNAL SUPPORT	
TOTAL (excluding external support)	**1.0**

14.12.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO DEFORMABLE MIRRORS DESIGN REPORT E-MAO-PD0-INA-DER-001	MXO	D14
MORFEO DEFORMABLE MIRRORS ANALYSIS REPORT E-MAO-PD0-INA-ANR-001	MXO	D14

Documents	Owner	DRD
MORFEO DEFORMABLE MIRRORS INTERFACE CONTROL DOCUMENT E-MAO-PD0-INA-ICD-001	MXO	D15
MORFEO DEFORMABLE MIRRORS MAIT PLAN E-MAO-PD0-INA-PLA-001	MXO	D17
MORFEO DEFORMABLE MIRRORS INTERFACE DRAWINGS E-MAO-PD0-INA-LIS-001	MXO	D21
MORFEO DEFORMABLE MIRRORS MANUFACTURING DRAWINGS E-MAO-PD0-INA-LIS-002	MXO	D22

14.12.4. Deformable Mirrors activities

DM ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Define internal Interface
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- Procurement Specification for Deformable Mirrors for cost estimation

DM Design

- DM update specification
- DM Design and Performance / Follow up Feasibility Study
- DM external Study Evaluation

14.13. PF0 - OPTOMECHANICS

14.13.1. WP description

This WP describes the activities concerning the Opto-mechanics for the phase C.

The Opto-mechanics product consists of

- mounts of the optical elements in the Main Path Optics and in the LGS Objective, the optical design of which is part of the WP Post-Focal Relay Optics
- mechanical interfaces of these mounts to the MORFEO Main Structure
- actuators and related control electronics, which are needed to position the optics with the required accuracy; the activities related to the design of the control electronics are included for convenience in WP Instrument Control Hardware
- handling and AIV tools, whenever necessary.

14.13.2. Resources

WP responsible:EDOARDO REDAELLI (INAF OAB)

WP resources	FTE/year
EDOARDO REDAELLI (INAF OAB)	0.7
MATTEO ALIVERTI (INAF OAB)	0.1
ANDREA BIANCO (INAF OAB) / GIUSEPPE DE LUCA (INAF OAB)	0.4
MATTEO D'AMBROGIO (INAF-OAB)	0.7
HOSSEIN MAHMOODZADEH (INAF OAB)	0.1
TOTAL	**2.0**

14.13.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO ASPHERICAL MIRRORS (M7, M8) DESIGN REPORT E-MAO-PF0-INA-DER-001	ERE	D14
MORFEO ASPHERICAL MIRRORS (M7, M8) ANALYSIS REPORT E-MAO-PF0-INA-ANR-001	ERE	D14

Documents	Owner	DRD
MORFEO ASPHERICAL MIRRORS (M7, M8) INTERFACE CONTROL DOCUMENT E-MAO-PF0-INA-ICD-001	ERE	D15
MORFEO ASPHERICAL MIRRORS (M7, M8) MAIT PLAN E-MAO-PF0-INA-PLA-001	ERE	D17
MORFEO ASPHERICAL MIRRORS (M7, M8) INTERFACE DRAWINGS E-MAO-PF0-INA-LIS-001	ERE	D21
MORFEO ASPHERICAL MIRRORS (M7, M8) MANUFACTURING DRAWINGS E-MAO-PF0-INA-LIS-002	ERE	D22
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) DESIGN REPORT E-MAO-PF0-INA-DER-002	ERE	D14
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) ANALYSIS REPORT E-MAO-PF0-INA-ANR-002	ERE	D14
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) INTERFACE CONTROL DOCUMENT E-MAO-PF0-INA-ICD-002	ERE	D15
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) MAIT PLAN E-MAO-PF0-INA-PLA-002	ERE	D17
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) INTERFACE DRAWINGS E-MAO-PF0-INA-LIS-003	ERE	D21
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) MANUFACTURING DRAWINGS E-MAO-PF0-INA-LIS-004	ERE	D22
MORFEO CALIBRATION UNIT FOLDING MIRROR DESIGN REPORT E-MAO-PFJ-JPI-DER-001	ERE	D14
MORFEO CALIBRATION UNIT FOLDING MIRROR ANALYSIS REPORT E-MAO-PFJ-JPI-ANR-001	ERE	D14
MORFEO CALIBRATION UNIT FOLDING MIRROR INTERFACE CONTROL DOCUMENT E-MAO-PFJ-JPI-ICD-001	ERE	D15
MORFEO CALIBRATION UNIT FOLDING MIRROR MAIT PLAN E-MAO-PFJ-JPI-PLA-001	ERE	D17
MORFEO CALIBRATION UNIT FOLDING MIRROR INTERFACE DRAWINGS	ERE	D21

Documents	Owner	DRD
E-MAO-PFJ-JPI-LIS-001		
MORFEO CALIBRATION UNIT FOLDING MIRROR MANUFACTURING DRAWINGS E-MAO-PFJ-JPI-LIS-002	ERE	D22
MORFEO CORRECTIVE PLATE DESIGN REPORT E-MAO-PFK-JPI-DER-001	ERE	D14
MORFEO CORRECTIVE PLATE ANALYSIS REPORT E-MAO-PFK-JPI-ANR-001	ERE	D14
MORFEO CORRECTIVE PLATE INTERFACE CONTROL DOCUMENT E-MAO-PFK-JPI-ICD-001	ERE	D15
MORFEO CORRECTIVE PLATE MAIT PLAN E-MAO-PFK-JPI-PLA-001	ERE	D17
MORFEO CORRECTIVE PLATE INTERFACE DRAWINGS E-MAO-PFJ-JPI-LIS-001	ERE	D21
MORFEO CORRECTIVE PLATE MANUFACTURING DRAWINGS E-MAO-PFK-JPI-LIS-002	ERE	D22
MORFEO DICHROIC PLATE DESIGN REPORT E-MAO-PFD-INA-DER-001	ERE	D14
MORFEO DICHROIC PLATE ANALYSIS REPORT E-MAO-PFD-INA-ANR-001	ERE	D14
MORFEO DICHROIC PLATE INTERFACE CONTROL DOCUMENT E-MAO-PFD-INA-ICD-001	ERE	D15
MORFEO DICHROIC PLATE MAIT PLAN E-MAO-PFD-INA-PLA-001	ERE	D17
MORFEO DICHROIC INTERFACE DRAWINGS E-MAO-PFD-INA-LIS-001	ERE	D21
MORFEO DICHROIC MANUFACTURING DRAWINGS E-MAO-PFD-INA-LIS-002	ERE	D22

14.13.4. Optomechanics activities

OPTOMECHANICS ENGINEERING AND MANAGEMENT

WP Management (Meeting, Schedule)

- Define all optical mounts interfaces with the Consortium partners and suppliers
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- Procurement Specification for Optical Mounts Components for cost estimation

OPTOMECHANICS DESIGN

- Optimization of the baseline mount
- Interface to Bench Definition
- Electrical and Thermal Interface
- Input to MAIT
- Error Budget
- Integration Procedure

14.14. PH0 - INSTRUMENT CONTROL HARDWARE

14.14.1. WP description

This WP describes the activities concerning the Instrument Control Hardware (ICH) for the phase C. The ICH product

- consists of all controllers, power supplies, harnesses and other electronics components to control the MORFEO instrument at system level;
- requires services from the ELT Service connection points;
- receives commands from the ICS Software;
- It includes the controllers and all electrical / electronic components which are required to control the other MORFEO sub-systems: those components are part of the sub-systems themselves.
- includes handling and AIV tools, whenever necessary.

This WP, in addition to all the necessary activities for the development of the ICH in the phase C, also includes the following tasks:

- agreeing the MORFEO electrical and information protocol interfaces to ELT and MICADO;
- defining all MORFEO internal electrical and protocol interfaces and standards.

14.14.2. Resources

WP responsible:ENRICO CASCONE (INAF OACN)

WP resources	FTE/year
ENRICO CASCONE (INAF OACN)	0.4
CHRISTIAN EREDIA (INAF OACN)	1.0
DOMENICO D'AURIA (INAF OACN) / MAHSHID SHIRI (INAF OACN)	0.5
External support	
TOTAL	1.9

14.14.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO INSTRUMENT CONTROL HARDWARE DESIGN REPORT E-MAO-PH0-INA-DER-001	ECA	D14

Documents	Owner	DRD
MORFEO INSTRUMENT CONTROL HARDWARE ANALYSIS REPORT E-MAO-PH0-INA-ANR-001	ECA	D14
MORFEO INSTRUMENT CONTROL HARDWARE INTERFACE CONTROL DOCUMENT E-MAO-PH0-INA-ICD-001	ECA	D15
MORFEO INSTRUMENT CONTROL HARDWARE MAIT PLAN E-MAO-PH0-INA-PLA-001	ECA	D17
MORFEO INSTRUMENT CONTROL HARDWARE INTERFACE DRAWINGS E-MAO-PH0-INA-LIS-001	ECA	D21
MORFEO INSTRUMENT CONTROL HARDWARE MANUFACTURING DRAWINGS E-MAO-PH0-INA-LIS-002	ECA	D22

14.14.4. Instrument Control Hardware activities

The tasks of the MORFEO ICH WP are:

ICH ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Agreeing the MORFEO electrical and information protocol interface (Telescope and MICADO) Define all MORFEO internal electrical and protocol interfaces with the Consortium partners and suppliers
- Collaboration with PA manager for Product Assurance Issue regarding Instrument Control Hardware
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Procurement Specification for ICH components to be delivered to the MORFEO Project Office
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan

Instrument Control Electronics Design

- MORFEO Control Electronics : evaluating different solution for the control HW components
- Trading Off the optimal solution in respect the required input and deliverables
- Supply input to Instrument Control Hardware Sub system design and Analysis Report regarding Instrument Control Electronics
- Supply input to Instrument Control Hardware Sub system Interface Control Document regarding Instrument Control Electronics
- Supply input to Instrument Control Hardware Sub-system Manufacturing, Assembly, Integration and Test (MAIT) plan regarding Control Electronics
- Grounding Diagram Development
- Electrical Harness Design

14.15. PL0 - LGS WFS MODULE

14.15.1. WP description

This WP describes the activities concerning the LGS WFS module for the phase C.

The LGS WFS module product consists of

- support structure, providing the mechanical interface to the MORFEO Main Structure;
- WFS probes and their positioning stages to pick the light of the LGSs
- handling and AIV tools, whenever necessary.

14.15.2. Resources

WP responsible:MANAL CHEBBO (CNRS/INSU)

WP resources	FTE/year
PHILIPPE FEAUTRIER / MANAL CHEBBO (CNRS/INSU)	0.5
ZOLTAN HUBERT / LAURENT JOCOU (CNRS/INSU)	0.4
PATRICK RABOU / EDGAR RENAUT (CNRS/INSU)	0.3
JEAN-JACQUES CORREIA (CNRS/INSU)	0.4
DAVID MOUILLET (CNRS/INSU)	0.2
THIBAUT MOULIN (CNRS/INSU)	0.3
SEBASTIAN SOLER (CNRS/INSU)	0.5
YVES MAGNARD (CNRS/INSU)	0.5
SYLVAIN ROCHAT (CNRS/INSU)	0.5
VINCENT LEAL / LUIS BARBIER (CNRS/INSU)	0.5
LAURENCE MICHARD (CNRS/INSU)	0.1
LAURENCE GLUCK (CNRS/INSU)	0.1
TOTAL	4.3

14.15.3. Items required to start

- MoU INAF/INSU
- All documentation mentioned in Project Management Plan
- Preliminary LGS WFS Module (LWM) technical specification document (including interface and verification requirements)

14.15.4. Expected documents for the FDR

Documents	Owner	DRD
MORFEO LGS WFS MODULE DESIGN REPORT E-MAO-PL0-IPA-DER-001	MCH	D14
MORFEO LGS WFS MODULE ANALYSIS REPORT E-MAO-PL0-IPA-ANR-001	MCH	D14
MORFEO LGS WFS MODULE INTERFACE CONTROL DOCUMENT E-MAO-PL0-IPA-ICD-001	MCH	D15
MORFEO LGS WFS MODULE MAIT PLAN E-MAO-PL0-IPA-PLA-001	MCH	D17
MORFEO LGS WFS MODULE INTERFACE DRAWINGS E-MAO-PL0-IPA-LIS-001	MCH	D21
MORFEO LGS WFS MODULE MANUFACTURING DRAWINGS E-MAO-PL0-IPA-LIS-002	MCH	D22

14.15.5. LGS WFS Module activities

LGS MODULE MANAGEMENT AND PRODUCT ASSURANCE

- WP Management (Meeting, Schedule)
- LGS WFS Product Assurance
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- LGS Module Cost Estimation

LGS MODULE DESIGN

- LGS WFS System Engineering
- LGS WFS sub-system requirements and functional analysis
- LGS WFS Performance analysis and trade-offs
- LFS WFS BUDGET
- Interface Management
- LGS support mechanical design
- LGS WFS Probes Design
- LGS WFS AIT and Calibration Tools Design
- Support to user's requirements definition and functional specifications by WP ICS Software and WP Real Time

14.15.6. Excluded Task

- AO simulations
- Participation to alternative wave-front sensing concepts (other than Shack-Hartmann)
- Dichroic beam splitter design and costing
- Participation to relay optics design
- Participation to RTC development

14.16. PM0 - MAIN STRUCTURE

14.16.1. WP description

This WP describes the activities concerning the Main Structure for phase C.

The Main Structure product includes

- a bench, supporting all the other MORFEO sub-systems with the exception of the LOR WFS module which is directly supported by MICADO;
- a support structure, providing the mechanical interface to the ELT Nasmyth platform;
- a cover, or enclosure, serving the function to create a suitable environment for the other sub-systems;
- the calibration unit assembly, the structure that support the calibration unit
- handling and AIV tools, whenever necessary.

14.16.2. Resources

WP responsible: VINCENZO DE CAPRIO (INAF OACN)

WP resources	FTE/year
VINCENZO DE CAPRIO (INAF OACN)	0.4
VINCENZO CIANNIELLO (INAF OACN)	0.9
TBH (INAF OACN)	0.4
SUPPORT FROM EXTERNAL STUDY	
TOTAL (excluding external support)	1.7

14.16.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO MAIN STRUCTURE DESIGN REPORT E-MAO-PM0-INA-DER-001	VDC	D14
MORFEO MAIN STRUCTURE ANALYSIS REPORT E-MAO-PM0-INA-ANR-001	VDC	D14
MORFEO MAIN STRUCTURE INTERFACE CONTROL DOCUMENT E-MAO-PM0-INA-ICD-001	VDC	D15

Documents	Owner	DRD
MORFEO MAIN STRUCTURE MAIT PLAN E-MAO-PM0-INA-PLA-001	VDC	D17
MORFEO MAIN STRUCTURE INTERFACE DRAWINGS E-MAO-PM0-INA-LIS-001	VDC	D21
MORFEO MAIN STRUCTURE MANUFACTURING DRAWINGS E-MAO-PM0-INA-LIS-002	VDC	D22

14.16.4. Main Structure activities

The tasks of the MORFEO Main Structure Activities WP are:

MECHANICAL ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Agreeing the MORFEO mechanical interface (Telescope and MICADO)
- Define all MORFEO internal mechanical interfaces with the Consortium partners and suppliers
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan

Bench and CU Assembly Mechanical Design / External Study follow up

- Main Structure & CUA preliminary design / external study follow-up
- Auxiliary system design / external study follow-up
- Interface assembly drawings - 2D / external study follow-up
- Cables routing - preliminary design and interfaces / external study follow-up
- Auxiliary system design - CAD main drawings / external study follow-up
- Integration: subsystems mounting procedures
- Definition of the AIV activity
- External Study Evaluation

14.16.5. MECHANICAL EXTERNAL STUDY

An external study for mechanical design is ongoing. The expected documents at the end of the study are

- 3D mechanical model
- 2D drawing for mechanical interface
- Preliminary numerical analysis for :
    - Mass estimation
    - Static Analysis
    - Modal Analysis
    - Earthquake analysis
    - Buckling analysis (if needed)
    - FEM analysis

    - Thermo-elastic model
- Preliminary Design Report
- Preliminary Analysis Report
- Preliminary MAIT plan
- Preliminary Feasibility, cost and manufacturing time assessment

14.17. PN0 - NGS WFS MODULE

14.17.1. WP description

This WP describes the activities concerning the LOR WFS module for phase C.

The LOR WFS module product consists of

- support structure, providing the mechanical interface to MICADO, onto which the LOR WFS module is mounted;
- WFS probes and their positioning stages to pick the light of the NGSs over the patrol FoV;
- handling and AIV tools, whenever necessary.

14.17.2. Resources

WP responsible: MARCO BONAGLIA (INAF OAA)

WP resources	FTE/year
MARCO BONAGLIA (INAF OAA)	0.5
SIMONE ESPOSITO (INAF OAA)	0.2
PAOLO GRANI (INAF OAA) / BERNARDO SALASNICH (INAF OPAD)	0.2
TOMMASO LAPUCCI (INAF OAA)	0.5
EDOARDO REDAELLI (INAF OAA)	0.4
GIORGIO PARIANI (INAF OAB)	0.3
DHEERAJ MALIK (INAF OAA)	0.3
TOTAL	2.4

14.17.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO LOR WFS DESIGN REPORT E-MAO-PN0-INA-DER-001	MBO	D14
MORFEO LOR WFS MODULE ANALYSIS REPORT E-MAO-PN0-INA-ANR-001	MBO	D14

Documents	Owner	DRD
MORFEO LOR WFS MODULE INTERFACE CONTROL DOCUMENT E-MAO-PN0-INA-ICD-001	MBO	D15
MORFEO LOR WFS MODULE MAIT PLAN E-MAO-PN0-INA-PLA-001	MBO	D17
MORFEO LOR WFS MODULE INTERFACE DRAWINGS E-MAO-PN0-INA-LIS-001	MBO	D21
MORFEO LOR WFS MODULE MANUFACTURING DRAWINGS E-MAO-PN0-INA-LIS-002	MBO	D22

14.17.4. NGS WFS Module activities

LOR MODULE ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Agreeing the LOR MODULE Interface with Telescope (ESO project office) and MICADO project office
- Define Internal Interface
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan

LOR MODULE DESIGN

- LOR support structure design
- LOR WFS unit design
- LOR module test and calibration tools design
- Support to user's requirements definition and functional specifications by WP ICS Software and WP Real Time
- LOR Module Cost Estimation
- LOR WFS Performance analysis and trade-offs
- LOR WFS BUDGET

14.18. PR0 - REAL TIME COMPUTER

14.18.1. WP description

This WP describes the activities concerning the Real Time Computer for phase C.

The Real Time Computer product

- consists of hardware and software components;
- controls all AO real-time functions in MORFEO;
- receives data from the WFS cameras and sends commands to the actuators, which are the MORFEO DMs and the ELT actuators (M4, M5, etc.);
- provides the real-time interface of MORFEO to the ELT Centralised Control System;
- this WP is interfaced with the ICS Software ;
- includes handling and AIV tools, whenever necessary.

14.18.2. Resources

WP responsible: ANDREA BARUFFOLO (INAF OAPD) / ALFIO PUGLISI (INAF OAA)

WP resources	FTE/year
ANDREA BARUFFOLO (INAF OAPD) / ALFIO PUGLISI (INAF OAA)	0.5
ITALO FOPPIANI (INAF OAS)	0.1
IVANO BARONCHELLI / SALVATORE LAMPITELLI (INAF OAPD)	1.0
GIULIO CAPASSO (INAF OACN)	0.1
SALVATORE SAVARESE (INAF OCAN)	0.3
CHIARA DI PROSPERO (INAF OAPD)	1.0
AMEDEO PETRELLA (INAF OAPD)	0.1
DANILO SELVESTREL (INAF OAPD)	0.1
EDWARD CHAPIN (NRC)	0.5
JEAN-PIERRE VERAN (NRC)	0.3
DAN KERLEY (NRC)	0.3
MALCOM SMITH (NRC)	0.2
LIANNE MUELLER(NRC)	0.3

WP resources	FTE/year
EXTERNAL SUPPORT FROM FEASIBILITY STUDY	
TOTAL (excluding feasibility study)	4.8

14.18.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO RTC USER REQUIREMENTS DOCUMENT E-MAO-PR0-INA-SPE-001	APU	D13
MORFEO RTC DESIGN AND ANALYSIS REPORT E-MAO-PR0-INA-DER-001	APU	D14
MORFEO RTC TECHNICAL SPECIFICATIONS AND VERIFICATION MATRIX E-MAO-PR0-INA-SPE-003	APU	D13
MORFEO RTC ICS INTERFACE CONTROL DOCUMENT E-MAO-000-INA-ICD-003	APU	D15
MORFEO RTC ACCEPTANCE TEST PLAN E-MAO-PR0-INA-PLA-002	APU	N.A.
MORFEO RTC DEVELOPMENT PLAN	APU	DRD600

14.18.4. Real Time Computer activities

RTC ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Define all MORFEO internal RTC interfaces with the Consortium partners and suppliers
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- Procurement Specification for RTC Components for cost estimation

RTC DESIGN

- Collect requirements and document them in RTC URD.
- Follow-up technical part of RTC external study.
- Contribute to the definition of interfaces, where applicable, and their documentation in ICDs.
- Provide input concerning RTC to AO Sub-system Manufacturing, Assembly, Integration and Test (MAIT) plan.
- Prepare preliminary design and document for RTC Design and Analysis Report.

14.19. PS0 – INSTRUMENT CONTROL SOFTWARE

14.19.1. WP description

This WP describes the activities concerning the ICS Software for the phase C.

The ICS Software product

- controls all the functions of the MORFEO instrument, with the exception of the AO real-time functions, which are controlled by the Real-Time Computer sub-system;
- provides software interfaces to ELT and MICADO.

The activities related to the control software of LGS, LOR and Calibration Unit sub-systems are part of the ICS Software WP.

14.19.2. Resources

WP responsible: BERNARDO SALASNICH (INAF OPAD)

WP resources	FTE/year
BERNARDO SALASNICH (INAF OAPD)	0.5
ANDREA BARUFFOLO (INAF OAPD)	0.1
DANIELA FANTINEL (INAF OAPD)	0.3
SYLVAIN GUIEU (CNRS/INSU)	0.1
BENEDETTA DI FRANCESCO (INAF OAAB)	0.1
FULVIO LAUDISIO (INAF OAPD)	0.8
ELIA COSTA (INAF OAPD)	0.2
DAPHNE DIRETTO (INAF OAPD)	1.0
FABRICE PANCHER (CNRS/INSU)	0.25
MIRKO COLAPIETRO (INAF OACN)	0.2
PIETRO SCHIPANI (INAF OACN)	0.05
TOTAL	3.6

14.19.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO ICS SW MANAGEMENT PLAN E-MAO-PS0-INA-PLA-001	BSA	D08
MORFEO ICS USER REQUIREMENT SPECIFICATION E-MAO-PS0-INA-SPE-002	BSA	D08
MORFEO ICS FUNCTIONAL SPECIFICATION E-MAO-PS0-INA-SPE-003	BSA	D08
MORFEO TEMPLATE MANUAL E-MA0-000-INA-MAN-001	DFA	D25
MORFEO ICS SW DESIGN DOCUMENT E-MAO-PS0-INA-DER-001	BSA	D08/DRD610
MORFEO ICS ACCEPTANCE TEST PLAN E-MAO-PS0-INA-PLA-003	BSA	D08
MORFEO SW USER MANUAL E-MAO-PS0-INA-MAN-001	BSA	DRD720

14.19.4. Instrument Control Software activities

ICS ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Coordinate the software activities of LGS, LOR, and CU sub-systems
- Define all MORFEO internal ICS interfaces with the Consortium partners and suppliers

ICS ACTIVITIES

- Update and consolidation of the software requirements
- Analysis of the requirements and production of the software specifications
- Definition of the software architecture
- Collaboration to the definition of the control network architecture
- Collaboration to the definition of the software interface with the Real Time Computer
- Collaboration to the definition of the interface between MORFEO ICS and SCAO ICS
- Collaboration to the definition of the interface between MORFEO ICS and MICADO ICS
- Design of special devices
- Implementation of the SW Skeleton (standard devices only)
- Implementation of the TwinCAT solution (standard devices only)

14.20. PT0 - THERMAL CONTROL SYSTEM

14.20.1. WP description

This WP describes the activities concerning the Thermal Control System for the phase C.

The Thermal Control System product includes

- thermal control harness
- heat dissipation system
- mirror ventilation system
- air filtering system
- vacuum system
- ducts conduits
- motors, pumps and metrology for the ventilation, air filtering and vacuum systems
- handling and AIV tools, whenever necessary.

The activities related to the design of the control electronics for the Thermal Control System are included for convenience in WP Instrument Control Hardware.

This WP, in addition to all the necessary activities for the development of the Thermal Control System in the phase B, also includes the following tasks:

- agreeing the thermal interfaces to ELT and MICADO;
- production and verification of the MORFEO thermal model;
- development of the low-level software needed to actively control the electronic components of the thermal system (ventilation, pumps, vacuum system etc). The high level software will interface with the low-level to monitor the status of the components.
- definition of the interface with high level software
- definition of the software requirements for high level software

14.20.2. Resources

WP responsible: MATTEO ALIVERTI (INAF OAB)

WP resources	FTE/year
MATTEO ALIVERTI (INAF OAB)	0.5
EDOARDO REDAELLI (INAF OAB)	0.2
TOTAL	**0.7**

14.20.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO THERMAL CONTROL DESIGN REPORT E-MAO-PT0-INA-DER-001	MAL	D14
MORFEO THERMAL CONTROL ANALYSIS REPORT E-MAO-PT0-INA-ANR-001	MAL	D14
MORFEO THERMAL CONTROL INTERFACE CONTROL DOCUMENT E-MAO-PT0-INA-ICD-001	MAL	D15
MORFEO THERMAL CONTROL MAIT PLAN E-MAO-PT0-INA-PLA-001	MAL	D17
MORFEO THERMAL CONTROL INTERFACE DRAWINGS E-MAO-PT0-INA-LIS-001	MAL	D21
MORFEO THERMAL CONTROL MANUFACTURING DRAWINGS E-MAO-PT0-INA-LIS-002	MAL	D22

14.20.4. Thermal Control System activities

THERMAL ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Agreeing the MORFEO thermal interface (Telescope and MICADO)
- Define all MORFEO internal thermal interfaces with the Consortium partners and suppliers
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- Procurement Specification for Thermal Components for cost estimation

THERMAL DESIGN

- HEAT DISSIPATION SYSTEM DESIGN
- MIRROR VENTILATION SYSTEM DESIGN
- THERMAL CONTROL HARNESS DESIGN

14.21. PU0 - CALIBRATION UNIT

14.21.1. WP description

This WP describes the activities concerning the Calibration Unit for phase C.

The Calibration Unit product consists of:

- one or more modules containing light sources to emulate NGS and LGS;
- actuators for the fine adjustment of the modules if required
- handling and AIV tools, whenever necessary.

This WP does not include the calibration unit selector, the structure that supports the calibration unit, which is included in the Main Structure WP.

14.21.2. Resources

WP responsible: GIANLUCA DI RICO (INAF OAAB)

WP resources	FTE/year
GIANLUCA DI RICO (INAF OAAB)	0.4
MAURO DOLCI (INAF OAAB)	0.1
IVAN DI ANTONIO (INAF OAAB)	0.5
AMICO DI CIANNO (INAF OAAB)	0.1
ANGELO VALENTINI (INAF OAAB)	0.3
GABRIELE RODEGHIERO (INAF OAS)	0.1
BENEDETTA DI FRANCESCO (INAF OAAB)	0.5
TOTAL	**2.0**

14.21.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO CALIBRATION UNIT DESIGN REPORT E-MAO-PU0-INA-DER-001	GDR	D14
MORFEO CALIBRATION UNIT ANALYSIS REPORT E-MAO-PU0-INA-ANR-001	GDR	D14
MORFEO CALIBRATION UNIT INTERFACE CONTROL DOCUMENT E-MAO-PU0-INA-ICD-001	GDR	D15
MORFEO CALIBRATION UNIT MAIT PLAN E-MAO-PU0-INA-PLA-001	GDR	D17
MORFEO CALIBRATION UNIT INTERFACE DRAWINGS E-MAO-PU0-INA-LIS-001	GDR	D21
MORFEO CALIBRATION UNIT MANUFACTURING DRAWINGS E-MAO-PU0-INA-LIS-002	GDR	D22

14.21.4. Calibration Unit activities

CALIBRATION UNIT ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Define internal Interface
- Collaboration with PA manager for Product Assurance Issue
- Collaboration with System Engineering for System Budget Allocation and Risk Analysis
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan Commissioning Plan
- Preliminary Procurement Specification for CU Components to be delivered to the MORFEO Project Office
- Procurement Specification for CTU Components
- Calibration Unit Cost Estimation

CALIBRATION UNIT DESIGN

- Functional Analysis (provide Functional Requirements and Technical Specifications)
- Mechanical Design
- Control Electronics Design
- Mechanical Interface Definition
- Electronics Interface Definition
- Harness Definition
- Handling Tool Design and Interface Definition
- Manufacturing, Assembly, Integration and Test (MAIT) Preliminary Plan
- Performance Analysis
- Support to user's requirements definition and functional specifications by WP ICS Software and WP Real Time

14.22. PV0 - Test Unit

14.22.1. WP DESCRIPTION

The scope of this WP is to develop a test unit to be used at PAE to verify the MORFEO AO performances.

The Test Unit must provide functionality to verify the MORFEO performances to a level commensurate with the projected project cost. Within this WP the AO verification plan must be developed.

The Test Unit is not meant to provide functionality to calibrate the system. The test Unit will be used at PAE and will not be integrated at the telescope although can be used also in Chile prior to mounting MORFEO on the platform, if needed

14.22.2. Resources

WP responsible: ALEXANDER GONCHAROV (NUIG)

WP resources	FTE/year
ALEXANDER GONCHAROV (NUIG)	0.3
NICHOLAS DEVANEY (NUIG)	0.4
LORENZO BUSONI (INAF OAA)	0.1
JEAN PIERRE VERAN (NRC)	0.1
SYLVAIN OBERTI (ESO)	0.1
MATTEO D'AMBROGIO (INAF OAB)	0.2
TOTAL	**1.2**

14.22.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO TEST UNIT DESIGN REPORT E-MAO-PV0-NUI-DER-001	NDA	D14
MORFEO TEST UNIT ANALYSIS REPORT E-MAO-PV0-NUI-ANR-001	NDA	D14
MORFEO TEST UNIT INTERFACE CONTROL DOCUMENT E-MAO-PV0-NUI-ICD-001	NDA	D15
MORFEO TEST UNIT MAIT PLAN E-MAO-PV0-NUI-PLA-001	NDA	D17
MORFEOTEST UNIT INTERFACE DRAWINGS E-MAO-PV0-NUI-LIS-001	GDR	D21
MORFEO TEST UNIT MANUFACTURING DRAWINGS E-MAO-PV0-NUI-LIS-002	GDR	D22

14.22.4. Test Unit activities

TEST UNIT ENGINEERING AND MANAGEMENT

- WP Management (Meeting, Schedule)
- Define internal Interface
- Collaboration for Instrument Calibration Plan, Template Manual, PAE Test Plan, Commissioning Plan
- Procurement Specification for Test Unit Components
- Test Unit Cost Estimation
- Test Unit Schedule

TEST UNIT DESIGN

- Functional Analysis (provide Functional Requirements and Technical Specifications)
- Mechanical Design
- Control Electronics Design
- Mechanical Interface Definition
- Electronics Interface Definition
- Performance Analysis

14.23. PW0 – WFS Cameras

14.23.1. WP DESCRIPTION

The scope of this WP comprises all activities needed to ensure the smooth insertion of a SONY-based camera in the LGS WFS Unit.

This implies the need to implement the full interfacing of the camera with its operational environment (mechanical, electronical, data transfer, thermal).

A development phase is needed in order to implement these interfaces, followed by a demonstration phase by means of a prototype.

Once demonstrated the proper functioning of the camera, the series production can be started.

14.23.2. Resources

WP responsible: ITALO FOPPIANI (INAF OAS)

WP resources	FTE/year
ITALO FOPPIANI (INAF OAS)	0.6
GIUSEPPE COSENTINO (DIFA)	0.6
FULVIO GIANOTTI (INAF OAS)	0.05
ALESSANDRO TACCHINI (INAF OAS)	0.05
TOTAL	**1.3**

14.23.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO LGS WFS CAMERA REQUIREMENTS E-MAO-PW0-INA-SPE-003	IFO	D13
MORFEO LGS WFS CAMERA COMPLIANCE MATRIX E-MAO-PW0-INA-CMX-001	FLI/AN DOR	DRD100
MORFEO LGS WFS CAMERA DESIGN REPORT E-MAO-PW0-INA-DER-001	IFO	D14
MORFEO LGS WFS CAMERA INTERFACE CONTROL DOCUMENT E-MAO-PW0-INA-ICD-001	IFO	D15
MORFEO LGS WFS CAMERA PROTOTYPE TEST REPORT E-MAO-PW0-INA-TRP-001	IFO	DRD540/545

14.23.4. LGS FWS camera activities

LGS WFS camera preparatory activities

- Informal consultation of companies to assess the status of existing solutions. This task aims at clarifying the technical details of the LGS WFS cameras in particular for what concerns the adaptation of commercial cameras to the MORFEO environment
- Study of software, electronic and mechanical interfaces of LGS WFS cameras. In this task all interfaces of the LGS WFS cameras are analysed and refined in order to ensure the integration
- Definition of detailed requirements for LGS WFS cameras. The technical annex of the call for tender is prepared with the necessary levekl of detail, in order to allow interested companies to submit an offer

Technical Support to procurement

- Even though all specific procurement activities are carried out in the dedicated WP, this WP will provide technical support to the procurement

Customisation and prototyping

- The selected company carries out the customisation of the camera and prepares a prototyping
- MORFEO personnel provide support to customisation and to prototype testing. Once the testing is successfully completed and the FDR is accepted, the production of all needed LGS WFS cameras can start.

15. ANNEX 3 - WORK PACKAGES DESCRIPTION FOR PHASE D

The MORFEO WBS for the Phase-C with the name of all the WP manager is reported in Figure 13-1 The MORFEO Phase-C WBS

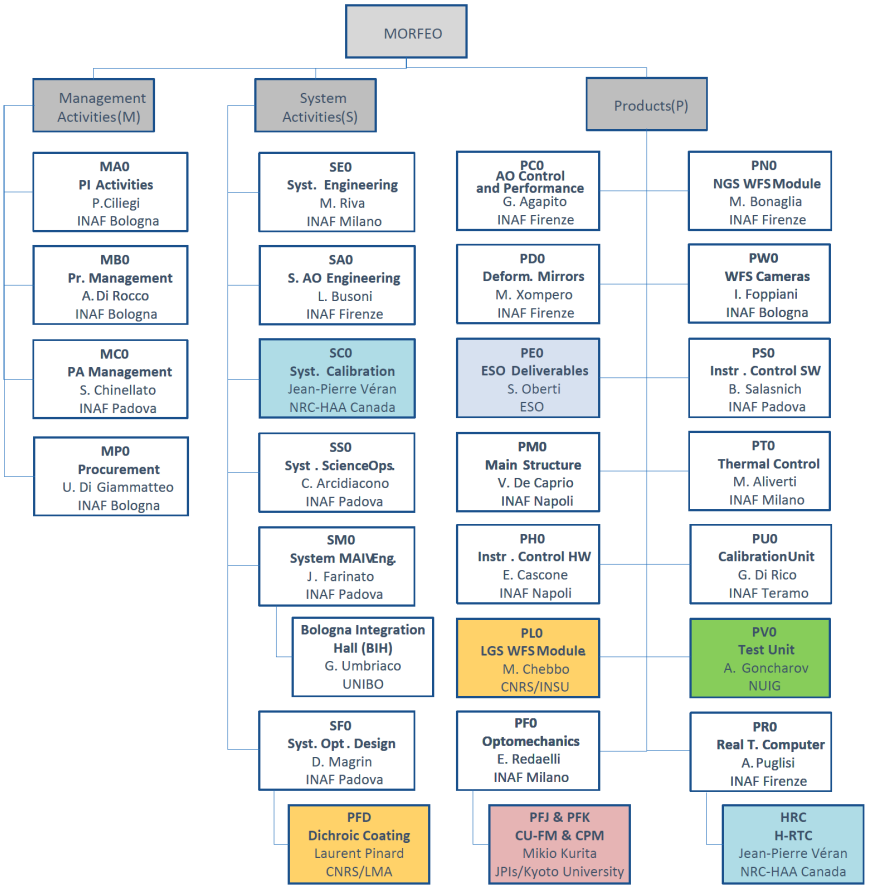


Figure 9-1 The MORFEO Phase-D WBS

For each WP we report in the following sections:

- WP Manager
- Resources
- List of expected deliverables for PhaseD
- Description of activities

The Work Breakdown Structure (WBS) of Phase D remains unchanged from Phase C, with the sole exception of the PE0 Work Package, which is renamed **"AO Control and Performance"** to better reflect the activities foreseen in this phase.

At the end of Phase D, each Work Package is expected to deliver the complete set of documentation required to support the final acceptance of the Subsystems, including evidence of successful integration, verification, and compliance with the applicable requirements. In particular, the System Work Packages shall provide the full suite of documents necessary to demonstrate the final acceptance of the overall system.

In the following, we provide the description of the Phase D Work Packages based on the information currently available.

15.1. MA0 - PRINCIPAL INVESTIGATOR ACTIVITIES

15.1.1. WP DESCRIPTION

The Principal Investigator WP provides overall scientific and strategic leadership during Phase-D, ensuring that MORFEO's integration and verification activities remain aligned with the project's scientific objectives and ESO requirements. The PI supervises the execution of the work packages at a high level, represents the Consortium in interactions with ESO, and provides guidance on priorities, risk management, and compliance.

This WP also ensures that scientific performance goals are maintained throughout MAIT and PAE, and that project decisions reflect both technical feasibility and long-term operational needs.

15.1.2. Resources

WP responsible: PAOLO CILIEGI (INAF OAS)

WP resources	FTE/year
PAOLO CILIEGI (INAF OAS)	0.7
TOTAL	**0.7**

15.1.3. Expected documents for the PAE

Documents	Owner	DRD
MORFEO SYSTEM OVERVIEW (UPDATE) E-MAO-000-INA-DER-001	PCI	D10

15.1.4. Principal Investigator Activities

The tasks of the Principal Investigator are:

- Maintain on overview of the MORFEO system
- Provide the functions of the formal single point of contact to ESO
- Report the Consortium activities to the MORFEO Steering Committee
- Represent the MORFEO Consortium towards ESO in all Project Reviews
- Represent the MORFEO Consortium in all Progress Meetings of ESO
- Represent the MORFEO Consortium towards ESO in all ELT Reviews
- Manage MORFEO out-reach activities
- Approve all scientific, technical and programmatic documentation of MORFEO
- Manage the funding distribution to the Consortium partners
- Manage the GTO interface to ESO for MORFEO

15.2. MB0 - PROJECT MANAGEMENT

15.2.1. WP DESCRIPTION

The Project Management WP coordinates Phase D execution by maintaining the project schedule, managing configuration control, and ensuring milestone alignment across all WPs. MB0 supports integration planning, risk mitigation, and internal reporting, and prepares the management deliverables required for ESO acceptance.

15.2.2. Resources

WP responsible: ANDREA DI ROCCO (INAF OAS)

WP resources	FTE/year
ANDREA DI ROCCO (INAF OAS)	1.0
LUDOVICO TEODORI (INAF OAS)	1.0
TOTAL	**2.0**

15.2.3. Expected Deliverables for the PAE

Documents	Owner	DRD
MORFEO CONFIGURATION ITEM DATA LIST (UPDATE) E-MAO-000-INA-CIDL-001	ADR	DRD150

Documents	Owner	DRD
MORFEO RISK REGISTER (UPDATE) E-MAO-000-INA-RRR-001	ADR	D03

15.2.4. Project Management Activities

The main tasks of the Project Management WP are:

- Define and maintain the overall schedule of MORFEO development and milestones in conformity with the requirements of ESO
- Approve the schedules of the MORFEO Consortium suppliers and those of the direct suppliers
- Maintain the MORFEO Document Tree
- Monitor the activities of the Consortium partners and direct suppliers taking all actions necessary to achieve the project milestones
- Manage MORFEO Consortium Working Meetings
- Define the Project Reviews and meetings necessary to ensure the success of the program
- Support and prepare all ESO reviews of MORFEO required by ESO
- Control and support all reviews of the activities of the MORFEO Consortium partners and direct suppliers performed by the MORFEO Engineering System Team
- Prepare and support all Progress Meetings required by ESO
- Perform all Progress Meetings with Consortium partners and direct suppliers
- Manage and maintain the configuration control of the project
- Monitor and control the costs of the program
- Prepare, update and approve the programmatic documentation of the project
- Provide support to the MORFEO PI for Consortium Management
- Time Management, Cost Management, Prepare, update and approve the programmatic documentation of the project (that is approved by the PI, too).

15.3. MC0 - PRODUCT ASSURANCE MANAGEMENT

15.3.1. WP DESCRIPTION

The Product Assurance Management WP oversees quality assurance and compliance during Phase D by verifying that MAIT activities, documentation, and verification results

meet defined standards. MC0 is also responsible for managing all change requests, both internal and those submitted to ESO. MC0 supports RAMS finalization, ensures traceability of non-conformances, and validates the Maintenance Manual and safety documentation for PAE

15.3.2. Resources

WP responsible: SIMONETTA CHINELLATO (INAF OAPD)

WP resources	FTE/year
SIMONETTA CHINELLATO (INAF OAPD)	0.6
ROSANNA SORDO (INAF OAPD)	0.5
NATALIA AURICCHIO (INAF OAS)	0.2
MINA SIBALIC (INAF OACN)	0.3 TBC
ANDREA BALESTRA (INAF OAPD)	0.3
TOTAL	**1.9**

15.3.3. Expected Deliverables for the PAE

Documents	Owner	DRD
MORFEO HAZARD LIST AND ANALYSIS E-MAO-000-INA-ANR-003 (UPDATE)	SCH	D04
MORFEO HAZARDOUS MATERIAL LIST E-MAO-000-INA-LIS-004 (UPDATE)	SCH	DRD180
MORFEO RELIABILITY ANALYSIS E-MAO-000-INA-ANR-002 (UPDATE)	SCH	DRD160
MORFEO FMECA (UPDATE) E-MAO-000-INA-ANR-001	SCH	DRD160
MORFEO PARTS LIST/BILL OF MATERIALS (Draft) E-MAO-000-INA-BOM-001 (UPDATE)	SCH	D32/D33
MORFEO SPARE PARTS LIST (Draft) E-MAO-000-INA-LIS-005 (UPDATE)	SCH	DRD260
MORFEO MAINTENANCE MANUALI (Draft) E-MAO-000-INA-MAN-007	SCH	D31
SAFETY FILE	SCH	D05

Documents	Owner	DRD
E-MAO-000-INA-SAF-0001		
DECLARATION OF CONFORMITY E-MAO-000-INA-CER-001	SCH	D06
NON CONFORMITY REPORT E-MAO-000-INA-NRC-001	SCH	DRD120
CHANGE REQUESTS	SCH	DRD130
REQUESTS FOR DEVIATION	SCH	DRD140
REQUESTS FOR WAIVER	SCH	DRD140
SOFTWARE VERIFICATION REPORTs	BAA	N.A.

15.3.4. Product Assurance Activities

The main tasks of the MORFEO Product Assurance WP are:

- Implementing the MORFEO Product Assurance Plan
- Liaising with and advising PA Managers of the MORFEO Consortium partners
- Carrying out PA surveillance and control of MORFEO Consortium institutes including audits and acceptance of items
- Manage an NCR and waiver system including sub-contractor and supplier NCR's convening and chairing Non-conformity Review Boards (NRB).
- Monitor and Manage Change Requests (CRE), Requests for Deviation (RFD), Requests for Waiver (RFW), both internal and ESO-directed, ensuring traceability, impact analysis, and formal approval workflows.
- Attend to Test Readiness Reviews (TRR), Test Review Boards (TRB), Integration review Boards (IRR), Qualification Status Review (QSR) for all qualification and verification tests
- Attending all major reviews and tests and providing the relevant PA inputs
- Ensuring Reliability; Availability and Maintainability (RAM) activities are analysis is the reliability assurance activities are properly carried out
- Ensuring that cleanliness, contamination control and safety aspects are properly covered
- Agreeing and approving providing the necessary documentation in the form of Log Books and Acceptance Data Packages
- Verify QA standards during subsystem MAIT
- Monitor traceability and conformity during BIH integration
- Support acceptance testing and non-conformance resolution
- Finalize RAMS analysis based on integrated system configuration

- Support safety assessments for BIH operations and PAE readiness
- Update and finalize the Maintenance Manual based on verified procedures and integration experience

For what concerns SQA activities, these will concern the full and correct application of the SQA plan with specific attention to:

- Static analysis of the code.
- Verification of proper execution of unit and integration tests.
- Monitoring of Software Tickets.
- Insuring proper quality of regular deliveries to ESO.
- Production of regular reports towards ESO.

15.4. MP0 - PROCUREMENT

15.4.1. WP DESCRIPTION

The Procurement WP provides oversight and strategic guidance on procurement activities during Phase D. While not directly involved in subsystem-level procurement, MPO supervises and advises on procurement-specific issues, defines procurement strategies, and ensures compliance with institutional and ESO requirements. It plays a key role in supervising major procurements realized through public tenders and provides legal and contractual advice to support the Consortium in managing procurement risks and obligations.

15.4.2. Resources

WP responsible: UGO DI GIAMMATTEO (INAF OAS)

WP resources	FTE/year
UGO DI GIAMMATTEO (INAF OAS)	0.1
PAOLO CILIEGI (INAF OAS)	0.1
SIMONETTA CHINELLATO (INAF OAPD)	0.1
ROSANNA SORDO (INAF OAPD)	0.1
Administrative personnel of local INAF offices	-
TOTAL	**0.4**

15.4.3. Expected Deliverables for the PAE

N/A

15.4.4. Procurement Activities

The main tasks of the Procurement WP in Phase D are:

- Maintain procurement strategy for major acquisitions
- Supervise procurement processes conducted via public tenders, ensuring compliance with applicable regulations
- Advise MB0 and subsystem WPs on procurement-specific issues (e.g., supplier qualification, risk mitigation)
- Provide legal and contractual advice related to procurement and tendering processes
- Ensure traceability and documentation of procurement decisions for ESO reporting
- Monitor supplier performance and contractual obligations for major procurements
- Support resolution of procurement-related disputes or non-conformances in coordination with MC0
- Interface with ESO and institutional stakeholders on procurement compliance and reporting

15.5. SE0 - SYSTEM ENGINEERING

15.5.1. WP DESCRIPTION

The System Engineering WP in phase D maintains the system architecture and configuration baseline, coordinates the execution of system-level verification in alignment with the Verification Matrix, and validates subsystem interfaces during BIH integration.

SE0 ensures traceability of requirements, manages change control, and consolidates system-level verification evidence for PAE

15.5.2. Resources

WP responsible: MARCO RIVA (INAF OAB)

WP resources	FTE/year
MARCO RIVA (MORFEO System Engineer, INAF OAB)	0.8
MARCELLO SCALERA (INAF OAB)	0.3
MATTEO GENONI (INAF OAB)	0.2
LORENZO BUSONI (INAF OAA)	0.2
FOPPIANI (INAF OAS)	0.1
JEAN PIERRE VERAN (NRC)	0.2
CARMELO ARCIDIACONO (INAF OAS)	0.1
DEMETRIO MAGRIN (INAF OAPD)	0.1

WP resources	FTE/year
JACOPO FARINATO (INAF OAPD)	0.1
BERNARDO SALASNICH (INAF OAPD)	0.1
ENRICO CASCONE (INAF OACN)	0.1
VINCENZO DE CAPRIO (INAF OACN)	0.1
LAURENT JOCOU (CNRS/INSU)	0.1
EDGAR RENAUT (CNRS/INSU)	0.1
MARCO BONAGLIA (INAF OAA)	0.1
GIANLUCA DI RICO (INAF OAAB)	0.1
MARCO XOMPERO (INAF OAA)	0.1
ANDREA BARUFFOLO (INAF OAPD)	0.1
GUIDO AGAPITO (INAF OAA)	0.1
EDOARDO REDAELLI (INAF OAB)	0.1
MATTEO ALIVERTI (INAF OAB)	0.1
NICHOLAS DEVANEY (NUIG)	0.1
GABRIELE RODEGHIERO (INAF.OAS)	0.2
ANDREA BALESTRA (INAF OAPD)	0.1
TOTAL	**3.7**

15.5.3. Expected Deliverables for the PAE

Documents	Owner	DRD
MORFEO COMPLIANCE MATRIX (UPDATE) E-MAO-000-INA-CMX-001	MRI	DRD550
MORFEO EARTHQUAKE ANALYSIS (UPDATE) E-MAO-000-INA-ANR-006	MRI	D07
MORFEO SYSTEM BUDGET ALLOCATION (UPDATE) E-MAO-SE0-INA-SPE-002	MRI	DRD270
MORFEO SYSTEM DESIGN AND ANALYSIS REPORT (UPDATE) E-MAO-000-INA-DER-002	MRI	D11

Documents	Owner	DRD
MORFEO-ELT INTERFACE CONTROL DOCUMENT (UPDATE) E-MAO-000-INA-ICD-001	MRI	D12
MORFEO AS-BUILT DRAWINGS	MRI	D23
MORFEO OPERATIONS MANUAL	MRI	D700
Sub-system Specifications		
MORFEO MAIN STRUCTURE TECHNICAL SPECIFICATIONS E-MAO-PM0-INA-SPE-003 (UPDATE)	MRI	D13
MORFEO THERMAL CONTROL TECHNICAL SPECIFICATIONS (UPDATE) E-MAO-PT0-INA-SPE-003	MRI	D13
MORFEO POST FOCAL RELAY OPTICS TECHNICAL SPECIFICATIONS (UPDATE) E-MAO-PF0-INA-SPE-003	MRI	D13
MORFEO ICH TECHNICAL SPECIFICATIONS (UPDATE) E-MAO-PH0-INA-SPE-003	MRI	D13
MORFEO CALIBRATION UNIT TECHNICAL SPECIFICATIONS (UPDATE) E-MAO-PU0-INA-SPE-003	MRI	D13
MORFEO TEST UNIT TECHNICAL SPECIFICATIONS (UPDATE) E-MAO-PV0-INA-SPE-003	MRI	D13
MORFEO LGS WFS TECHNICAL SPECIFICATIONS (UPDATE) E-MAO-PL0-INA-SPE-002	MRI	D13
MORFEO LGS WFS CAMERAS TECHNICAL SPECIFICATIONS (UPDATE) E-MAO-PW0-INA-SPE-001	MRI	D13
MORFEO NGS WFS TECHNICAL SPECIFICATIONS (UPDATE) E-MAO-PN0-INA-SPE-003	MRI	D13
MORFEO DMs TECHNICAL SPECIFICATIONS (UPDATE) E-MAO-PD0-INA-SPE-003	MRI	D13
MORFEO ICSS TECHNICAL SPECIFICATIONS (UPDATE) E-MAO-PS0-INA-SPE-003	MRI	D13
MORFEO RTC TECHNICAL SPECIFICATIONS (UPDATE) E-MAO-PR0-INA-SPE-003	MRI	D13

15.5.4. System Engineering Activities

The tasks of the System Engineering WP are:

- Ensuring the integration of the engineering activities in project
- Verification of performance against requirements.
- Validate subsystem interfaces during integration
- Update system budgets and configuration baseline
- Manage system-level change control and configuration updates during MAIT
- Oversee the execution of the system-level verification
- Maintain system architecture and interface control documentation
- Support SM0 in planning and executing the integration sequence
- Provide technical oversight and coordination during anomaly resolution, requirement deviations, or test non-conformances
- Consolidate verification evidence and compliance documentation for ESO's Preliminary Acceptance Europe (PAE)
- Collaborate with MB0 and MC0 on risk mitigation and compliance

15.6. SA0 - SYSTEM ADAPTIVE OPTICS ENGINEERING

15.6.1. WP DESCRIPTION

The System Adaptive Optics Engineering WP ensures that MORFEO's Adaptive Optics (AO) system is correctly integrated, calibrated, and validated during Phase D, and that its performance is traceable to system-level requirements and ESO acceptance criteria.

Giulia Carlà (INAF OAA) sub-WP responsible for:

- assessing optical alignment impacts on AO performance in cooperation with SF0
- supporting SS0 in interpreting AO outputs for science validation, including PSF quality and field uniformity
- providing AO telemetry and performance data for ESO's Preliminary Acceptance Europe (PAE)

Cedric Plantet (INAF OAA) sub-WP responsible for:

- supporting AO loop closure testing during BIH integration
- validating AO control algorithms, reconstructor matrices, and real-time loop behavior under operational conditions

Jean Pierre Veran responsible for AO calibration and verification, ensuring calibration procedures (e.g. pupil registration, reference source alignment) as also SC0 responsible and supporting AO performance verification.

15.6.2. Resources

WP responsible: LORENZO BUSONI (INAF OAA)

WP resources	FTE/year
LORENZO BUSONI (INAF OAA)	0.4
GUIDO AGAPITO (INAF OAA)	0.2
SIMONE ESPOSITO (INAF OAA)	0.2
CEDRIC PLANTET (INAF OAA)	0.2
GIULIA CARLA' (INAF OAA)	0.6
JEAN-PIERRE VERAN (NRC)	0.4
TOTAL	**2**

15.6.3. Expected Deliverables for the PAE

Documents	Owner	DRD
MORFEO ADAPTIVE OPTICS SYSTEM DESIGN AND ANALYSIS REPORT (UPDATE) E-MAO-SA0-INA-DER-001	LBU	D11
MORFEO WAVEFRONT ERROR BUDGET (UPDATE) E-MAO-SA0-INA-TNO-008	LBU	DRD270
MORFEO FLUX BUDGET (UPDATE) E-MAO-SA0-INA-TNO-005	LBU	DRD270
MORFEO ASTROMETRIC ERROR BUDGET (UPDATE)	LBU	DRD270

15.6.4. System AO Engineering Activities

The main tasks of the System AO Engineering WP are:

- Support AO loop closure testing during BIH integration
- Validate AO control algorithms, reconstructor matrices, and real-time loop behavior under operational conditions
- Provide AO telemetry and performance data for ESO's Preliminary Acceptance Europe (PAE)

- Interface with SC0 to ensure calibration procedures (e.g. pupil registration, reference source alignment) support AO performance verification
- Collaborate with SF0 to assess optical alignment impacts on AO performance
- Support SS0 in interpreting AO outputs for science validation, including PSF quality and field uniformity
- Contribute to the Verification Matrix by linking AO requirements to test results and verification methods
- Document AO performance traceability, including test conditions, environmental factors, and configuration dependencies
- Ensure AO subsystem readiness and compliance with system-level integration procedures

15.7. SM0 - SYSTEM MAIT/V ENGINEERING

15.7.1. WP DESCRIPTION

The MAIT work packages coordinate the integration, testing and verification of the MORFEO instrument at the system level in accordance with the MAIT Plan, including mechanical assembly, optical alignment, and functional testing.
While subsystem-level MAIT activities are primarily carried out by the respective provider teams under their own local work packages, SM0 is in charge of supervising these activities at sub-system level, and of performing the Acceptance Readiness Review.

Upon successful local acceptance, these units are logistically prepared and transferred, with specialized packaging and coordinated handling protocols, to the main Integration Hall in Bologna.

At the Bologna facility, the MAIT teams assume full responsibility for receiving, inspecting, and functionally verifying each incoming subsystem, ensuring their integrity post-transport. Following verification, the subsystems are progressively integrated into the MORFEO system architecture, adhering to defined mechanical, optical, and software interfaces.
Furthermore, SM0 manages the integration schedule, facility operations, and AIV tooling, and ensures that test and verification procedures (whenever possible) are implemented correctly and documented for PA.

The WP then coordinates and executes the system-level testing campaign, culminating in the PAE (Preliminary Acceptance Europe) process in collaboration with ESO. Upon acceptance, the instrument is carefully disassembled, packaged, and shipped to Chile, with the MAIT teams again overseeing all outbound logistics to ensure readiness for reintegration and commissioning at the observatory site.

15.7.2. Resources

WP responsible: JACOPO FARINATO (INAF OAPD)

WP resources	FTE/year
JACOPO FARINATO (INAF OAPD)	0.2
GABRIELE RODEGHIERO (INAF OAS)	0.4
MARIA BERGOMI (INAF OAPD)	0.3
LUCA MARAFATTO (INAF OAPD)	0.3
GIORGIO PARIANI (INAF OAB)	0.2
VINCENZO DE CAPRIO (INAF OACN)	0.1
VINCENZO CIANNIELLO (INAF OACN)	0.1
SIMONE DI FILIPPO (INAF OAPD)	0.2
FEDERICO BATTAINI (INAF OAPD)	0.2
GABRIELE UMBRIACO (INAF OAS)	0.5
LAURENT JOCOU (CNRS/INSU)	0.1
TBH MAIV (INAF OAPD)	0.6
TBH (INAF OAS)	0.5
TBH (INAF OAS)	0.5
TOTAL	**4.0**

15.7.3. Expected Deliverables for the PAE

Documents	Owner	DRD
MORFEO SHIPMENT PLAN	JFA	D310
TEST AND INSPECTION REPORTS	JFA	DRD540/545
INSTRUMENT PERFORMANCE REPORT	JFA	D28
MORFEO PAE TEST PLAN (UPDATE) E-MAO-000-INA-PLA-014	JFA	D26
MORFEO IAA AIV PLAN (UPDATE)	JFA	DRD400
MORFEO AND MICADO AIV PLAN (UPDATE)	JFA	DRD400
MORFEO HANDLING TOOLS AND SUPPORT EQUIPMENT AS-BUILT DRAWINGS	JFA	D23

Documents	Owner	DRD
Equipment	**Owner**	**DRD**
INTEGRATION/ALIGNMENT/MAINTENANCE TOOLS AND SUPPORT EQUIPMENT	JFA	N.A.
HANDLING AND TRANSPORT EQUIPMENT	JFA	N.A.
TRANSPORT CONTAINERS	JFA	N.A.

15.7.4. MAIT Activities

The main tasks of the System MAIT/V Engineering WP are:

- Supervise MAIT/V activities at sub-system level and perform the ARR for each of them
- Develop and maintain the System MAIT Plan, detailing integration sequences, tooling, environmental conditions, and test protocols
- Coordinate the execution of system-level integration activities at the BIH, including mechanical assembly, electrical interfacing, and optical alignment
- Manage the Verification Matrix, ensuring that each system requirement is verified through appropriate methods
- SM0 oversees and technically supervises the full MAIT workflow carried out by the supplier for the realization of the MORFEO AIV Tools
- Oversee the deployment and use of AIV tools, including alignment fixtures, calibration sources, and environmental monitoring system
- Interface with ESO for test readiness and PAE protocol compliance
- Manage BIH Facility Operations, including access control, infrastructure, and safety procedures
- Coordinate Logistics, including delivery tracking, customs, unpacking, and staging of subsystems
- Track sub-system delivery status and readiness for integration, ensuring alignment with the system MAIT sequence
- Incorporate feedback from subsystem MAIT into the system-level MAIT plan
- Support the execution of system-level functional tests, calibration procedures, and performance validation campaigns
- Contribute to the final test report and verification evidence package for ESO acceptance
- Perform the PAE review
- Oversees final disassembly, shipment preparation, and transfer of the instrument to Chile

15.8. SF0 - SYSTEM OPTICAL ENGINEERING

15.8.1. WP DESCRIPTION

The System Optical Engineering WP supports integration of MORFEO in BIH by validating optical alignment, straylight control, and internal interface compliance. SF0 contributes to system-level verification by assessing optical tolerances, reviewing test results, and supplying configuration data for the final optical baseline and PAE documentation

15.8.2. Resources

WP responsible: DEMETRIO MAGRIN (INAF OAPD)

WP resources	FTE/year
DEMETRIO MAGRIN (INAF OAPD)	0.5
MATTEO MUNARI (INAF OACT)	0.3
GIORGIO PARIANI (INAF OAB)	0.2
ANDREA BIANCO (INAF OAB)	0.2
DAVIDE GREGGIO (INAF OPAD)	0.2
ALESSANDRO BALLONE (INAF OPAD)	0.5
MARIA BERGOMI (INAF OPAD)	0.1
TOTAL	**2.0**

15.8.3. Expected documents for the PAE

Documents	Owner	DRD
MORFEO SYSTEM OPTICAL DESIGN AND ANALYSIS REPORT (UPDATE) E-MAO-SF0-INA-DER-001	DMA	D11

15.8.4. System Optical Design Activities

The main tasks of the System Optical Design WP are:

- Support SM0 during BIH integration by advising on optical alignment procedures and tolerances
- Assist SA0 in verifying AO-related optical paths and wavefront error contributions
- Contribute to straylight and ghosting test definition, execution, and interpretation
- Review mechanical tolerances and thermal sensitivities affecting optical performance
- Provide diagnostic feedback on optical anomalies during system testing

15.9. SC0 - SYSTEM CALIBRATION

15.9.1. WP DESCRIPTION

The System Calibration WP implements and validates MORFEO's calibration strategy during system integration and testing at BIH, ensuring that all calibration procedures, tools, and data products meet performance and traceability requirements.

15.9.2. Resources

WP responsible: JEAN PIERRE VERAN (NRC)

WP resources	FTE/year
JEAN PIERRE VERAN (NRC)	0.3
LORENZO BUSONI (INAF OAA)	0.1
DEMETRIO MAGRIN (INAF OAPD)	0.1
MARCO BONAGLIA (INAF OAA)	0.1
ALFIO PUGLISI (INAF OAA)	0.1
LAURENT JOCOU (CNRS/INSU)	0.1
TOTAL	**0.8**

15.9.3. Expected documents for the PAE

Documents	Owner	DRD
MORFEO INSTRUMENT CALIBRATION PLAN (UPDATE) E-MAO-SC0-ESO-PLA-001	JPV	D24

15.9.4. System Calibration Activities

The main tasks of the System Calibration WP are:

- Define and execute system-level calibration procedures for AO subsystems
- Validate calibration templates and acquisition protocols
- Support SA0 and SM0 during calibration-related test campaigns at BIH
- Provide support during subsystem MAIT phases when early calibration procedures or tests are performed
- Monitor calibration stability across environmental conditions and integration phases
- Provide calibration inputs to the Verification and Compliance Matrix, linking procedures to requirement verification

- Contribute to the final calibration baseline for PAE, including template definitions, calibration sequences, and expected performance metrics
- Interface with SS0 to ensure calibration outputs support science validation and PSF reconstruction

15.10. SS0 - SYSTEM SCIENCE OPERATION

15.10.1. WP DESCRIPTION

The System Science Operation WP ensures that MORFEO delivers scientifically valid outputs by verifying image quality, PSF characteristics, and operational readiness. SS0 bridges technical performance with science usability, supporting both internal validation and ESO acceptance.

15.10.2. Resources

WP responsible:CARMELO ARCIDIACONO (INAF OAPD)

WP resources	FTE/year
CARMELO ARCIDIACONO (INAF OAPD)	0.4
MARCO GULLIEUSZIK (INAF OAPD)	0.3
ELISA PORTALURI (INAF OAPD)	0.4
MICHELE CANTIELLO (INAF OAAB)	0.3
TOTAL	**1.4**

15.10.3. Expected documents for the PAE

Documents	Owner	DRD
MORFEO OPERATIONAL CONCEPT DESCRIPTION (UPDATE) E-MAO-000-INA-MAN-002	CAR	D30
MORFEO PSF DESCRIPTION (UPDATE) E-MAO-SS0-INA-TNO-001 and E-MAO-SS0-INA-TNO-002	CAR	N.A.
MORFEO USER MANUAL E-MAO-000-INA-MAN-004	CAR	D29
MORFEO COMMISSIONING PLAN (UPDATE) E-MAO-000-INA-PLA-016	CAR	D27

15.10.4. System Science Operation Activities

The main tasks of the System Science Operation WP are:

- Validate PSF outputs against science requirements, including shape, stability, and field uniformity
- Support SA0 and SC0 in interpreting AO and calibration data from a science performance perspective
- Define and execute science validation tests during BIH integration, using simulated or internal sources
- Update the User Manual with verified observing templates, user constraints and science use cases.
- Provide science performance metrics and validation results for ESO's Preliminary Acceptance Europe (PAE)
- Contribute to the Verification Matrix by linking science requirements to test results and validation procedures
- Review and validate operational scenarios, including acquisition, calibration, and observation sequences

15.11. PC0 - AO CONTROL AND PERFORMANCE

15.11.1. WP DESCRIPTION

The AO Control and Performance Work Package covers the development, verification, and optimization of the adaptive optics (AO) control algorithms and the performance estimation tools for MORFEO during Phases D.

The activities include the definition, implementation support, and verification of AO control strategies and performance estimation methods within the Real-Time Computer (RTC) environment.

The WP ensures the consistency between simulated and real system performance throughout the integration, test and commissioning phases, providing the algorithmic reference for control and performance monitoring.

15.11.2. Resources

WP resources	FTE/year
GUIDO AGAPITO (INAF OAA)	0.5
CEDRIC PLANTET (INAF OAA)	0.5
TOTAL	**1.0**

15.11.3. Expected documents for the PAE

Documents	Owner	DRD
MORFEO AO SIMULATION ANALYSIS REPORT E-MAO-PC0-INA-ANR-001 (UPDATE)	GAG	D11

15.11.4. AO Control and Performances Activities

- Definition, update, and optimization of AO control algorithms, including their formalization in pseudo-code for RTC implementation.
- Development of algorithms for performance estimation using system telemetry and sensor image data.
- Continuous refinement of AO performance models through comparison between simulated and measured data, both during integration and tests in Europe (Bologna) and at the telescope (Chile).
- Validation of control and performance algorithms through simulation campaigns using PASSATA, Specula, and TIPTOP, including maintenance, upgrade, and documentation of these tools.
- Support and coordination with the RTC team for software integration, implementation, and verification in the RTC environment.
- Use of simulation tools for validation, calibration activities, and preparation of performance-related system documentation (Operational Manual).

15.12. PD0 - DEFORMABLE MIRROS

15.12.1. WP DESCRIPTION

The Manufacturing, Assembly, Integration, and Test (MAIT) phase for the MORFEO DM1 and DM2 units encompasses a coordinated sequence of tasks managed jointly by ADOPTICA (Join Venture between ADS and Microgate) and oversight by INAF.

The process involves the procurement and inspection of mechanical and electronic components, the integration and calibration of actuators and control boards, the application of critical coatings and bonding processes, and comprehensive in-process and final verifications.

Activities include both hardware assembly and software implementation, leveraging specialized infrastructure such as climatic chambers, metrology tools, and cleanroom facilities. The objective is to deliver fully validated deformable mirror assemblies, aligned with ESO technical standards and project milestones.

15.12.2. Resources

WP responsible: MARCO XOMPERO (INAF OAA)

WP resources	FTE/year
MARCO XOMPERO (INAF OAA)	0.50
NICOLO' AZZAROLI (INAF OAA)	0.25
TOTAL	**0.75**

15.12.3. Expected Deliverables for the PAE

Documents	Owner	DRD
DEFORMABLE MIRRORS (DM1 and MD2) DESIGN REPORT E-MAO-PD0-INA-DER-001 (UPDATE)	MXO	D14
DEFORMABLE MIRRORS (DM1 and MD2) ANALYSIS REPORT E-MAO-PD0-INA-ANR-001 (UPDATE)	MXO	DRD220
DEFORMABLE MIRRORS INTERFACE CONTROL DOCUMENT E-MAO-PD0-INA-ICD-001 (UPDATE)	MXO	D15
DEFORMABLE MIRRORS (DM1 and MD2) TEST AND INSPECTION REPORT	MXO	DRD540/545
DEFORMABLE MIRRORS (DM1 and MD2) AS-BUILT DRAWING	MXO	D23
DEFORMABLE MIRRORS (DM1 and MD2) ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	MXO	D19
DEFORMABLE MIRRORS (DM1 and MD2) SHEET OF COMMERCIAL COMPONENTS	MXO	D18
Equipment	**Owner**	**DRD**
FULLY ASSEMBLED & TESTED DEFORMABLE MIRRORS (DM1 and MD2)	MXO	N.A.
INTEGRATION/ALIGNMENT/MAINTENANCE TOOLS AND SUPPORT EQUIPMENT	MXO	N.A.
HANDLING AND TRANSPORT EQUIPMENT	MXO	N.A.
TRANSPORT CONTAINERS	MXO	N.A.
SPARE PARTS	MXO	N.A.

15.12.4. Deformable Mirrors activities

INAF RESPONSIBILITIES

- Contractual oversight of MAIT execution according to technical and scheduling obligations.
- Coordination with subcontractors (ADS, Microgate, others) to ensure alignment with project objectives and milestones.
- Participation in design and verification reviews, including IRRs, and FARs.
- Approval of test procedures and inspection criteria defined by the consortium.
- Review and approval of deliverables, including mechanical and software assemblies, calibration datasets, and documentation.
- Assessment and logging of non-conformances and follow-up on corrective actions.
- Interface with ESO or project stakeholders for reporting, compliance assurance, and milestone acceptance.

ADOPTICA (ADS) RESPONSIBILITIES

- Procurement and dimensional verification of mechanical components
- Electro-mechanical integration and testing of actuators
- Integration and validation of auxiliary equipment
- Calibration of HP linear actuators
- Coating processes (optical and mechanical surfaces)
- Opto-mechanical and crates assembly and testing
- Transfer of integrated assemblies to Microgate for electronics

ADOPTICA (MICROGATE) RESPONSIBILITIES

- Electronics procurement, integration, functional validation, and calibration
- Visual and functional inspection of soldered and assembled boards
- System-level functional verification and environmental testing
- Integration within dedicated cleanroom and thermal facilities
- Implementation and verification of embedded control software
- Arrange insurance, transport monitoring, and logistics for shipping to Bologna Integration Hall

15.13. PF0 - OPTOMECHANICS

15.13.1. WP DESCRIPTION

The Manufacturing, Assembly, Integration, and Test (MAIT) phase for the MORFEO optical elements—including mirrors (Aspherical and Flat), Corrective Plate, the LGS objective and the dichroic —covers the full sequence of optical and mechanical production activities performed by the industrial partners and research institutes under INAF oversight.

The workflow encompasses the procurement and inspection of optical blanks, the preparation and qualification of grinding and polishing tools, and the complete surface-generation and finishing processes appropriate for each optical type. Optical performance is verified through dedicated metrology and environmental tests, ensuring compliance with surface-quality, wavefront-error, alignment, and stability requirements. Mechanical activities include the manufacturing of mounts, cells, barrels, and auxiliary equipment, as well as the integration of each optic into its support structure, followed by dimensional and functional checks.

Across all optical families, the MAIT phase concludes with coating and cleaning operations, integration into the corresponding mechanical assemblies, Factory Acceptance Tests (FAT), On-site Acceptance Tests (OAT), and the compilation of the full technical documentation package.

The objective is to deliver fully validated optical assemblies meeting MORFEO technical specifications and delivered in accordance with the overall project schedule.

15.13.2. Resources

WP responsible:EDOARDO REDAELLI (INAF OAB)

WP resources	FTE/year
EDOARDO REDAELLI (INAF OAB)	0.7
MATTEO ALIVERTI (INAF OAB)	0.1
ANDREA BIANCO (INAF OAB) / GIUSEPPE DE LUCA (INAF OAB)	0.4
MATTEO D'AMBROGIO (INAF-OAB)	0.7
HOSSEIN MAHMOODZADEH (INAF OAB)	0.1
TOTAL	**2.0**

15.13.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO ASPHERICAL MIRRORS (M7, M8) DESIGN REPORT E-MAO-PFB-INA-DER-001 (UPDATE) E-MAO-PFC-INA-DER-001 (UPDATE)	ERE	D14
MORFEO ASPHERICAL MIRRORS (M7, M8) ANALYSIS REPORT E-MAO-PFB-INA-ANR-001 (UPDATE) E-MAO-PFC-INA-DER-001 (UPDATE)	ERE	D14
MORFEO ASPHERICAL MIRRORS (M7, M8) INTERFACE CONTROL DOCUMENT E-MAO-PFB-INA-ICD-001 (UPDATE) E-MAO-PFC-INA-ICD-001 (UPDATE)	ERE	D15
MORFEO ASPHERICAL MIRRORS (M7, M8) TEST AND INSPECTION REPORT	ERE	DRD540/545
MORFEO ASPHERICAL MIRRORS (M7, M8) AS-BUILT DRAWINGS	ERE	D23

Documents	Owner	DRD
MORFEO ASPHERICAL MIRRORS (M7, M8) ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	ERE	D19
MORFEO ASPHERICAL MIRRORS (M7, M8) DATA SHEET OF COMMERCIAL COMPONENTS	ERE	D18
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) DESIGN REPORT E-MAO-PFA-INA-DER-002 (UPDATE) E-MAO-PFEA-INA-DER-002 (UPDATE) E-MAO-PFF-INA-DER-002 (UPDATE) E-MAO-PFG-INA-DER-002 (UPDATE) E-MAO-PFI-INA-DER-002 (UPDATE)	ERE	D14
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) ANALYSIS REPORT E-MAO-PFA-INA-ANR-002 (UPDATE) E-MAO-PFE-INA-ANR-002 (UPDATE) E-MAO-PFF-INA-ANR-002 (UPDATE) E-MAO-PFG-INA-ANR-002 (UPDATE) E-MAO-PFI-INA-ANR-002 (UPDATE)	ERE	D14
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) INTERFACE CONTROL DOCUMENT E-MAO-PFA-INA-ICD-002 (UPDATE) E-MAO-PFEA-INA-ICD-002 (UPDATE) E-MAO-PFF-INA-ICD-002 (UPDATE) E-MAO-PFG-INA-ICD-002 (UPDATE) E-MAO-PFI-INA-ICD-002 (UPDATE)	ERE	D15
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) TEST AND INSPECTION REPORT	ERE	DRD540/545
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) AS-BUILT DRAWINGS	ERE	D23
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	ERE	D19
MORFEO FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3) DATA SHEET OF COMMERCIAL COMPONENTS	ERE	D18
MORFEO LGS OBJECTIVE DESIGN REPORT E-MAO-PFH-INA-DER-002 (UPDATE)	ERE	D14
MORFEO LGS OBJECTIVE ANALYSIS REPORT E-MAO-PFH-INA-ANR-002 (UPDATE)	ERE	D14
MORFEO LGS OBJECTIVE INTERFACE CONTROL DOCUMENT E-MAO-PFH-INA-ICD-002 (UPDATE)	ERE	D15
MORFEO LGS OBJECTIVE TEST AND INSPECTION REPORT	ERE	DRD540/545

Documents	Owner	DRD
MORFEO LGS OBJECTIVE AS-BUILT DRAWINGS	ERE	D23
MORFEO LGS OBJECTIVE ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	ERE	D19
MORFEO LGS OBJECTIVE DATA SHEET OF COMMERCIAL COMPONENTS	ERE	D18
MORFEO CALIBRATION UNIT FOLDING MIRROR DESIGN REPORT E-MAO-PFJ-JPI-DER-001 (UPDATE)	ERE	D14
MORFEO CALIBRATION UNIT FOLDING MIRROR ANALYSIS REPORT E-MAO-PFJ-JPI-ANR-001 (UPDATE)	ERE	D14
MORFEO CALIBRATION UNIT FOLDING MIRROR INTERFACE CONTROL DOCUMENT E-MAO-PFJ-JPI-ICD-001 (UPDATE)	ERE	D15
MORFEO CALIBRATION UNIT FOLDING MIRROR TEST AND INSPECTION REPORT	ERE	DRD540/545
MORFEO CALIBRATION UNIT FOLDING MIRROR AS-BUILT DRAWINGS	ERE	D23
MORFEO CALIBRATION UNIT FOLDING MIRROR ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	ERE	D19
MORFEO CALIBRATION UNIT FOLDING MIRROR DATA SHEET OF COMMERCIAL COMPONENTS	ERE	D18
MORFEO CORRECTIVE PLATE DESIGN REPORT E-MAO-PFK-JPI-DER-001 (UPDATE)	ERE	D14
MORFEO CORRECTIVE PLATE ANALYSIS REPORT E-MAO-PFK-JPI-ANR-001 (UPDATE)	ERE	D14
MORFEO CORRECTIVE PLATE INTERFACE CONTROL DOCUMENT E-MAO-PFK-JPI-ICD-001 (UPDATE)	ERE	D15
MORFEO CORRECTIVE PLATE TEST AND INSPECTION REPORT	ERE	DRD540/545
MORFEO CORRECTIVE PLATE AS-BUILT DRAWINGS	ERE	D23
MORFEO CORRECTIVE PLATE ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	ERE	D19
MORFEO CORRECTIVE PLATE DATA SHEET OF COMMERCIAL COMPONENTS	ERE	D18
MORFEO DICHROIC DESIGN REPORT E-MAO-PFD-INA-DER-001 (UPDATE)	ERE	D14

Documents	Owner	DRD
MORFEO DICHROIC ANALYSIS REPORT E-MAO-PFD-INA-ANR-001 (UPDATE)	ERE	D14
MORFEO DICHROIC INTERFACE CONTROL DOCUMENT E-MAO-PFD-INA-ICD-001 (UPDATE)	ERE	D15
MORFEO DICHROIC TEST AND INSPECTION REPORT	ERE	DRD540/545
MORFEO DICHROIC AS-BUILT DRAWINGS	ERE	D23
MORFEO DICHROIC ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	ERE	D19
MORFEO DICHROIC DATA SHEET OF COMMERCIAL COMPONENTS	ERE	D18
Equipment	**Owner**	**DRD**
FULLY ASSEMBLED & TESTED ASPHERICAL MIRRORS (M7M, M8M)	ERE	N.A.
FULLY ASSEMBLED & TESTED FLAT MIRRORS (M6, M11, M12, LGSO-FM1, LGSO-FM3)	ERE	N.A
FULLY ASSEMBLED & TESTED LGS OBJECTIVE	ERE	N.A
FULLY ASSEMBLED & TESTED CALIBRATION UNIT FOLDING MIRROR	ERE	N.A
FULLY ASSEMBLED & TESTED CORRECTIVE PLATE	ERE	N.A
FULLY ASSEMBLED & TESTED DICHROIC	ERE	N.A
INTEGRATION/ALIGNMENT/MAINTENANCE TOOLS AND SUPPORT EQUIPMENT	ERE	N.A.
HANDLING AND TRANSPORT EQUIPMENT	ERE	N.A.
TRANSPORT CONTAINERS	ERE	N.A.
SPARE PARTS	ERE	N.A.

15.13.4. Optomechanics Activities

- Optical blank procurement and reception inspection
- Preparation and qualification of grinding, lapping, and polishing tools
- Surface generation and fine polishing of the optical element
- Production and verification of tooling, supports, fixtures, and test equipment
- Optical metrology and performance verification using appropriate test methods
- Environmental and operational verification, including temperature-dependent performance checks
- Coating operations appropriate for each optical type, followed by final cleaning and controlled handling

- Manufacturing and integration of mechanical interfaces, including mounts, barrels, cells, and auxiliary hardware
- Verification and testing of the integrated assembly, including dimensional checks, dedicated test rigs, and Factory Acceptance Test (FAT) execution
- Packing, transport, delivery,carried out according to handling and protection requirements
- On-site Acceptance testing (OAT) at the delivery location, followed by release of final compliance and documentation.

15.14. PH0 - INSTRUMENT CONTROL HARDWARE

15.14.1. WP DESCRIPTION

The MAIT phase for Instrument Control Hardware encompasses the complete workflow required to manufacture, assemble, integrate, verify, and qualify all electronics cabinets, control units, power-distribution hardware, and cabling infrastructure serving the MORFEO subsystems.
It includes the delivery of fully assembled and tested hardware compliant with electrical-safety rules, grounding and EMC/EMI requirements, thermal constraints, vibration tolerance, and the defined electrical interfaces for control electronics, sensors, interlocks, and power distribution.
Activities cover the installation of power-distribution elements, protection devices (fuses, breakers, SPDs), filtering components, grounding schemes, cable terminations, and the required control or monitoring hardware.
The process also includes internal wiring, routing and labelling, the implementation of safety and protection logic, and the verification of electrical performance, EMC behaviour, grounding continuity, and proper power delivery to all MORFEO subsystems.
The MAIT phase concludes with functional tests of power-up sequences, protection response, correct voltage/current levels, and interface continuity, followed by delivery to the MORFEO integration team.
All activities must comply with the electrical, electromagnetic, safety, and interface requirements provided by the MORFEO consortium.

15.14.2. Resources

WP responsible:ENRICO CASCONE (INAF OACN)

WP resources	FTE/year
ENRICO CASCONE (INAF OACN)	0.4
CHRISTIAN EREDIA (INAF OACN)	1.0
MAHSHID SHIRI (INAF OACN)	1.0
External support	
TOTAL	2.4

15.14.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO INSTRUMENT CONTROL HARDWARE DESIGN REPORT E-MAO-PH0-INA-DER-INA-001 (UPDATE)	ECA	D14
MORFEO INSTRUMENT CONTROL HARDWARE ANALYSIS REPORT E-MAO-PH0-ANR-INA-001 (UPDATE)	ECA	D14
MORFEO INSTRUMENT CONTROL HARDWARE INTERFACE CONTROL DOCUMENT E-MAO-PH0-INA-ICD-001 (UPDATE)	ECA	D15
MORFEO INSTRUMENT CONTROL HARDWARE TEST AND INSPECTION REPORT	ECA	DRD540/545
MORFEO INSTRUMENT CONTROL HARDWARE AS-BUILT DRAWINGS	ECA	D23
MORFEO INSTRUMENT CONTROL HARDWARE ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	ECA	D19
MORFEO INSTRUMENT CONTROL HARDWARE DATA SHEET OF COMMERCIAL COMPONENTS	ECA	D18
Equipment	**Owner**	**DRD**
FULLY ASSEMBLED & TESTED INSTRUMENT CONTROL HARDWARE	ECA	N.A.
INTEGRATION/MAINTENANCE TOOLS AND SUPPORT EQUIPMENT	ECA	N.A.
HANDLING AND TRANSPORT EQUIPMENT	ECA	N.A.
TRANSPORT CONTAINERS	ECA	N.A.
SPARE PARTS	ECA	N.A.

15.14.4. Instrument Control Hardware Activities

- Procurement of electrical components required for the PDC: breakers, RCD/SPD units, filters, terminals, connectors, cabling, sensors, and monitoring elements
- Mechanical preparation of the Power Distribution Cabinet, including mounting plates, DIN rails, ventilation and integration of protection hardware.
- Installation of distribution and protection elements (main switches, circuit breakers, surge protection, filtering blocks)
- Internal wiring and routing of power lines, protective earth, neutral bars, and shield terminations according to grounding and EMC rules
- Implementation of safety and protection logic, including emergency shut-off lines, thermal limiters (if assigned), access protection and interlock wiring where applicable

- Labelling, documentation and traceability of all cables, terminals, and components inside the cabinet
- Verification of electrical interfaces between PH0 hardware and all other MORFEO subsystems receiving power from the PDC
- Continuity, insulation and grounding tests to verify correct bonding, shielding, and protective-earth performance
- EMC-related checks, such as correct segregation of sensitive lines, application of shielding rules and filtering
- Functional power-up and power-down tests, including validation of voltage levels, current limits, protection tripping behaviour, and recovery
- Integration support during MORFEO's electrical integration phase at BIH
- Preparation for acceptance, including test reports, cabinet diagrams, and electrical configuration information.

15.15. PL0 - LGS WFS MODULE

15.15.1. WP DESCRIPTION

This MAIT phase encompasses all work required to deliver a fully assembled, aligned and validated LGS WFS sub-system ready for system-level integration. It consists of:

- Qualification of integration and test facilities (cleanrooms, tents, etc.)
- manufacturing of handling, assembly, integration, alignment and test tools procured externally or developed in-house
- Manufacturing and Procurement of optics, mechanics, actuators, sensors and electronics, with custom production for critical components and acceptance tests to ensure compliance
- assembly and testing of electronic cabinets, assembly, alignment and testing of optical and mechanical parts, using dedicated benches, handling tools, and metrology for functional and optical verification
- system-level integration and alignment, combining all subsystems, using dedicated handling and metrology tools
- a functional and performance test campaign spanning tip-tilt and wavefront stability, back focal distance, differential focus, mounting repeatability, yielding a compliance matrix and an acceptance report
- disassembly, packaging and transport of LGS WFS from IPAG premises to BIH
- reassembly and alignment of major parts, with beam alignment, asterism and differential focus checks, leading to final connection, testing, and readiness for MORFEO integration.

15.15.2. Resources

WP responsible: MANAL CHEBBO CNRS/INSU)

WP resources	FTE/year
MANAL CHEBBO (CNRS/INSU)	0.7
DAVID MOUILLET	0.2

WP resources	FTE/year
FABRICE PANCHER	0.2
SYLVAIN ROCHAT	0.3
JEAN-JACQUES CORREIA	0.4
PATRICK RABOU/EDGARE RENAULT	0,4
SYLVAIN GUIEU	0.1
THIBAUT MOULIN	0.3
YVES MAGNARD[2]	0.4
LAURENT JOCOU	0.4
LAURENCE MICHAUE	0.2
LAURENCE GLUCK	0.2
SÉBASTIEN SOLER[3]	0.1
LOUIS BARBIER[4]	0.1
TO BE HIRED (AIT expert)	*0.4[5]*
TO BE HIRED (AIT expert)	*0.4[6]*
TO BE HIRED (electronics expert)	*0.2[7]*
TOTAL	**4.9**

15.15.3. Expected Deliverables for the PAE

Documents	Owner	DRD
MORFEO LGS WFS MODULE DESIGN REPORT E-MAO-PL0-IPA-DER-001 (UPDATE)	MCH	D14
MORFEO LGS WFS MODULE ANALYSIS REPORT E-MAO-PL0-IPA-ANR-001 (UPDATE)	MCH	DRD220

[2] involved in LGS MAIT activities only during 2025-2027
[3] involved in LGS MAIT activities only in 2025
[4] involved in LGS MAIT activities only in 2025
[5] it refer to the years 2026–2030, as it is planned for the hiring
[6] it refer to the years 2026–2030, as it is planned for the hiring
[7] it refer to the years 2026–2030, as it is planned for the hiring

Documents	Owner	DRD
MORFEO LGS WFS MODULE INTERFACE CONTROL DOCUMENT E-MAO-PL0-IPA-ICD-001 (UPDATE)	MCH	D15
MORFEO LGS WFS TEST AND INSPECTION REPORT	MCH	DRD540/545
MORFEO LGS WFS AS-BUILT DRAWINGS	MCH	D23
MORFEO LGS WFS ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	MCH	D19
DATA SHEETS OF COMMERCIAL COMPONENTS	MCH	D18
Equipment	**Owner**	**DRD**
FULLY ASSEMBLED & TESTED LGS WFS MODULE	MCH	N.A.
INTEGRATION/ALIGNMENT/MAINTENANCE TOOLS AND SUPPORT EQUIPMENT	MCH	N.A.
HANDLING AND TRANSPORT EQUIPMENT	MCH	N.A.
TRANSPORT CONTAINERS	MCH	N.A.
LGS WFS MODULE SPARE PARTS	MCH	N.A.

15.15.4. LGS WFS Module Activities

FACILITIES AND TOOLS PREPARATION

- Configuration of the clean-room and integration hall (ISO 7/8, temp./humidity control, air-filtration).
- Procurement/manufacturing of handling, alignment, integration and test tools (lifting tool, probe benches, validation benches, laser tracker).

MANUFACTURING AND PROCUREMENT

- Optics (MLA, optical train, NBPF) outsourced with contractor certification + in-house verification
- Mounts/mechanical parts (interface frame, rotator, support structure, lifting tool, dummy load) procured externally with acceptance tests
- Motion control (motors, stages, encoders, limit switches) and sensors (LGS cameras) mainly COTS, tested for integrated and tuning
- Electronics (commercial controllers and drivers) integrated into custom racks, assembled in-house at IPAG (cabinets provided by INAF)
- Procurement strategy:off-the-shelf preferred; custom production only if needed.
- Acceptance: inspection, metrology (laser tracker), optical tests, compliance documentation.

COMPONENT-LEVEL ASSEMBLY, ALIGNMENT AND TEST

- Translation: assembly of welded frame with rails, ball screw, motor/encoder; alignment and stroke/precision tests
- Rotator: assembly of guiding structure, bearings, torque motor/encoder, probe flange; wobble and motor control tests
- Calibration Unit (CU): assembly of frame, XY stages, fibers, tip-tilt platform; alignment and stability tests.
- LDM: assembly of the relay, MLA, and camera (ISO7 clean room); optical alignment and characterization.
- Probes: PSM alignment (w/ PAB benches), pupil/throughput checks, probe FoV and noise tests.
- Cabinets: assembly of two racks with PLC/ELT software; functional tests.

MODULE-LEVEL INTEGRATION AND ALIGNMENT

- Co-align translation and rotator axes with the incoming beam, align CU, and minimize probe differential focus.
- Install assemblies with lifting tools/crane on telescope simulator (translation, CU, rotator, probes)
- Perform beam alignment (folding mirror, CU tip-tilt, laser tracker, AIT camera)
- Define 6-LGS asterism with reference plate/fibers; mount and align probes on rotator flange
- Integrate electronic cabinets in parallel for motor/control support.

MODULE-LEVEL TESTS

- Compliance tests: performance, rotator speed/accuracy, tip-tilt and wavefront stability, differential focus (static/dynamic), repeatability, alignment accuracy, environmental and thermal performance, safety and EMC.

DIS-MOUNTING AND SHIPPING

- Dis-assemble LGS WFS module (translation, CU, rotator, probes, cable wrap, dummy, cabinets, AIT tools)
- Pack into wooden crates and boxes (ISPM-15 compliant) with humidity and shock protection and flight cases (Pelicase, with foam)
- Handling via lifting tools/cranes by trained staff
- Arrange insurance, transport monitoring, and logistics to Bologna Integration Hall.

RE-MOUNTING AND INTEGRATION IN THE MORFEO SYSTEM

- Reassembly on SST at INAF following IPAG procedures (translation, CU, rotator, probes)
- Verify assemblies (rotator/probes functional and optical checks, asterism alignment)
- Integrate under MORFEO structure: connect services, functional verification, fine alignment with folding mirror and calibration beam, finalize locking and reference positions.

15.16. PM0 - MAIN STRUCTURE

15.16.1. WP DESCRIPTION

The MAIT phase for the MORFEO Main Structure covers the complete mechanical workflow required to manufacture, assemble, integrate, and verify all structural elements that support and interface the instrument with the ELT Nasmyth platform.
This scope includes the Main Support Structure (MSS), the CU Selector assembly, the Thermal Enclosures, the MAOMIC thermal duct.

All structural components are manufactured by the contractor, who performs the full assembly in-house and executes Factory Tests using representative payload dummies supplied by the Consortium. These tests validate interfaces, stiffness, handling operations, and installation procedures.

This phase is governed by formal milestones: the Integration Readiness Review, Factory Acceptance, and INAF On-Site Acceptance.

The MAIT phase ends with delivery to the INAF Bologna Integration Hall (BIH) for preliminary integration, followed by preparation for packing and shipment to Chile, in full compliance with ESO transport and safety requirements.
All activities must meet MORFEO's functional, mechanical, thermal, and safety specifications.

15.16.2. Resources

WP responsible: VINCENZO DE CAPRIO (INAF OACN)

WP resources	FTE/year
VINCENZO DE CAPRIO (INAF OACN)	0.4
VINCENZO CIANNIELLO (INAF OACN)	0.9
TBH (INAF OACN)	1
SUPPORT FROM EXTERNAL STUDY	
TOTAL (excluding external support)	2.3

15.16.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO MAIN STRUCTURE DESIGN REPORT E-MAO-PM0-INA-DER-001 (UPDATE)	VDC	D14

Documents	Owner	DRD
MORFEO MAIN STRUCTURE ANALYSIS REPORT E-MAO-PM0-INA-ANR-001 (UPDATE)	VDC	D14
MORFEO MAIN STRUCTURE INTERFACE CONTROL DOCUMENT E-MAO-PM0-INA-ICD-001 (UPDATE)	VDC	D15
MORFEO MAIN STRUCTURE TEST AND INSPECTION REPORT	VDC	DRD540/545
MORFEO MAIN STRUCTURE AS-BUILT DRAWINGS	VDC	D23
MORFEO MAIN STRUCTURE ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	VDC	D19
MORFEO MAIN STRUCTURE DATA SHEET OF COMMERCIAL COMPONENTS	VDC	D18
Equipment	**Owner**	**DRD**
FULLY ASSEMBLED & TESTED MAIN STRUCTURE	VDC	N.A.
FULLY ASSEMBLED & TESTED HANDLING TOOLS	VDC	N.A.
TRANSPORT CONTAINERS	VDC	N.A.
SPARE PARTS	VDC	N.A.

15.16.4. Main Structure Activities

- Procurement of materials and components for the Main Structure
- Mechanical fabrication and structural manufacturing for the Main Support Structure, thermal enclosures, and thermal duct
- Full structural assembly of the Main Support Structure, CU Selector, Enclosures, and thermal duct at the contractor's premise
- Pre-integration with representative payload dummies (matching CoG, interfaces, geometry) delivered by the Consortium
- Verification of mechanical, thermal, and electrical interfaces with the extended Opto-Mechanical Support Structures and the Nasmyth platform flanges
- Execution of Factory Tests on the Main Structure, including functional checks, handling operations, and verification of AIV procedures
- Validation of installation and removal procedures using payload dummies, Handling Tools, and Support Equipment
- Dimensional inspections and metrology of structural interfaces and critical reference surfaces
- Preparation of the Integration Readiness Review (IRR) and resolution of non-conformities
- Delivery of the Main Structure with related documentation to the Bologna Integration Hall (INAF-BIH), followed by preliminary integration and European On-Site Acceptance (OA)

- Disassembly, packing, and preparation for shipment to Chile, in compliance with ESO packing requirements..

15.17. PN0 - NGS WFS MODULE

15.17.1. WP DESCRIPTION

This MAIT phase encompasses all work required to deliver a fully assembled, aligned and validated LOR WFS sub-system ready for system-level integration. It consists of:

- certifying clean-room and integration facilities, commissioning cranes, metrology instruments and support stands, and completing safety training
- Procurement of optics, mechanical mounts, actuators and electronics. Delivered items are then screened against drawings and performance criteria, with any deviations resolved before release to assembly.
- Under controlled-environment benches, sub-assemblies are installed, shim-aligned by coordinate metrology and mounted to the primary support structure using an on-axis alignment simulator.
- A structured test campaign, spanning static characterization, closed-loop control demonstrations and field-dependent acquisition routines, yields a compliance matrix and acceptance report.
- The sub-system and tooling are then de-integrated, packed in reusable climate-sealed crates and shipped to BIH for hand-over to system-level integration.

15.17.2. Resources

WP responsible: MARCO BONAGLIA (INAF OAA)

WP resources	FTE/year
MARCO BONAGLIA (INAF OAA)	0.6
EDOARDO REDAELLI (INAF OAA)	0.4
GIORGIO PARIANI (INAF OAB)	0.1
DHEERAJ MALIK (INAF OAA)	0.6
LORENZO BUSONI (INAF OAA)	0.1
MIMMA LAURIA (INAF OAA)	0.1
GIULIA CARLÀ (INAF OAA)	0.4
GUIDO AGAPITO (INAF OAA)	0.1
CEDRIC PLANTET (INAF OAA)	0.1

WP resources	FTE/year
RUNA BRIGUGLIO (INAF OAA)	0.1
ALFIO PUGLISI (INAF OAA)	0.4
LUCA CARBONARO (INAF OAA)	0.2
TO BE HIRED	*0.6*
TOTAL	**3.8**

15.17.3. Expected Deliverables for the PAE

Documents	Owner	DRD
MORFEO LOR WFS MODULE DESIGN REPORT E-MAO-PN0-INA-DER-001 (UPDATE)	MBO	D14
MORFEO LOR WFS MODULE ANALYSIS REPORT E-MAO-PN0-INA-ANR-001 (UPDATE)	MBO	DRD220
MORFEO LOR WFS MODULE INTERFACE CONTROL DOCUMENT E-MAO-PN0-INA-ICD-001 (UPDATE)	MBO	D15
MORFEO LOR WFS TEST AND INSPECTION REPORT	MBO	DRD540/545
MORFEO LOR WFS AS-BUILT DRAWINGS	MBO	D23
MORFEO LOR WFS ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	MBO	D19
DATA SHEETS OF COMMERCIAL COMPONENTS	MBO	D18
Equipment	**Owner**	**DRD**
FULLY ASSEMBLED & TESTED LOR WFS MODULE	MBO	N.A.
INTEGRATION/ALIGNMENT/MAINTENANCE TOOLS AND SUPPORT EQUIPMENT	MBO	N.A.
HANDLING AND TRANSPORT EQUIPMENT	MBO	N.A.
TRANSPORT CONTAINERS	MBO	N.A.
LOR WFS MODULE SPARE PARTS	MBO	N.A.

15.17.4. NGS WFS Module activities

FACILITY & TOOLING PREPARATION

- Configure clean-room and integration hall (ISO 7/8, temperature/humidity control, air-filtration).
- Procure, commission and verify handling devices, support stands, laser tracker, interferometers, 3D arm, climatic chamber

MANUFACTURING & PROCUREMENT

- Optics: flats, dichroics, lenses, ADC prisms, lenslets (outsourced with factory-certified acceptance).

- Mech. mounts & support structure (COTS for PI actuators; custom machining for mounts/structure).
- Electronics: sub-racks, motor controllers, Beckhoff terminals, cabling (bench acceptance + functional/consumption checks).

BOARD-LEVEL ASSEMBLY & INTERNAL ALIGNMENT

- Mount optics in their mechanical supports; glue cure; stress/WFE verification.
- Integrate optics & stages onto breadboard: CMM/laser-tracker shimming to achieve prescribed tolerances.

MODULE-LEVEL INTEGRATION

- Install three WFS units (FREDA/ALICE) onto Support Structure (LSS).
- Align on-axis AO simulator (LAOS) for common reference beam.
- Adjust Acquisition Stages (planarity), Pupil Steering Mirror (pupil centering), Focus Compensator (defocus nulling).
- Verify interfaces to MICADO via alignment to mechanical pads.

SUB-SYSTEM TESTING AND INSPECTION

- Characterization: plate scale, FoV, frame-rate, wavelength band, sensitivity, internal WFE.
- Internal loops: pupil stabilization, focus compensation, ADC correction, anti-collision logic.
- Field tests: NGS acquisition, blind pointing, non-sidereal offsets, motion-time, observing efficiency
- Inspections: number of LOR units, patrolling field, vignetting constraint, S-H sensors configuration, light separation between LO and Ref, tools availability.

DE-INTEGRATION & SHIPPING

- Disassemble into three transport kits: optomechanics, electronics, tooling.
- Pack in marine-ply crates (foam/spring trays, barrier film, shock/tilt indicators).
- Arrange insurance, transport monitoring, and logistics to Bologna Integration Hall.

15.18. PR0 - REAL-TIME COMPUTER

15.18.1. WP DESCRIPTION

This MAIT phase encompasses all activities required to deliver an integrated and validated Real-Time Computer (RTC) system, including both hardware and software components, ready for system-level integration. It consists of:

- Development and testing of SRTC prototypes at INAF OAPd and HRTC prototypes at NRC
- Integration and testing of SRTC and HRTC final prototypes at INAF OAPd
- Intermediate milestones to support other WPs and to ensure timely delivery and testing of final hardware in advance of the PAE milestone.
- Iterative SW release and review to verify functionality, quality, and completeness
- Procurement of final SRTC and HRTC hardware, integration and testing at BIH
- Final integration and testing of RTC, ICSS and ICH at BIH
- System test campaign including the complete RTC, all WFS cameras and a test DM as preparation for PAE.

15.18.2. Resources

WP responsible: ALFIO PUGLISI (INAF OAA)

WP resources	FTE/year
ANDREA BARUFFOLO (INAF OAPD) / ALFIO PUGLISI (INAF OAA)	0.5
ITALO FOPPIANI (INAF OAS)	0.1
SALVATORE LAMPITELLI (INAF OAPD)	1.0
GIULIO CAPASSO (INAF OACN)	0.1
SALVATORE SAVARESE (INAF OACN)	0.3
CHIARA DI PROSPERO (INAF OAPD)	1.0
AMEDEO PETRELLA (INAF OAPD)	0.1
DANILO SELVESTREL (INAF OAPD)	0.1
EDWARD CHAPIN (NRC)	0.4
JEAN-PIERRE VERAN (NRC)	0.3
DAN KERLEY (NRC)	0.4
MALCOM SMITH (NRC)	0.3
LIANNE MUELLER (NRC)	0.2

WP resources	FTE/year
EXTERNAL SUPPORT FROM FEASIBILITY STUDY	
TOTAL (excluding feasibility study)	4.8

15.18.3. Expected Deliverables for the PAE

Documents	Owner	DRD
MORFEO RTC DEVELOPMENT PLAN (UPDATE) E-MAO-PR0-INA-PLA-001	APU	DRD600
MORFEO RTC USER REQUIREMENTS DOCUMENT (UPDATE) E-MAO-PR0-INA-SPE-001	APU	D13
MORFEO RTC DESIGN AND ANALYSIS REPORT (UPDATE) E-MAO-PR0-INA-DER-001	APU	D14
MORFEO RTC TECHNICAL SPECIFICATIONS AND VERIFICATION MATRIX (UPDATE) E-MAO-PR0-INA-VMX-001	APU	DRD550
MORFEO RTC ICS INTERFACE CONTROL DOCUMENT (UPDATE) E-MAO-000-INA-ICD-003	APU	D15
MORFEO RTC TEST REPORT	APU	DRD540
DATA SHEETS OF COMMERCIAL COMPONENTS	APU	D18
Equipment	**Owner**	**DRD**
FULLY ASSEMBLED & TESTED RTC	APU	N.A.
INTEGRATION/ALIGNMENT/MAINTENANCE TOOLS AND SUPPORT EQUIPMENT	APU	N.A.
HANDLING AND TRANSPORT EQUIPMENT	APU	N.A.
TRANSPORT CONTAINERS	APU	N.A.
RTC SPARE PARTS	APU	N.A.

15.18.4. Real-Time Computer activities

Activities at INAF premises

- Procurement of SRTC and scaled-down HRTC prototype hardware

- SRTC SW developmnet, installation and testing
- Installation of SW simulators in place of connections to cameras and DM together with realistic data stream for local testing
- SRTC SW/HW drops for NGS to test NGS functionalities during its AIT phase
- SRTC and HRTC SW periodic installation, full system HW integration and testing
- Periodical delivery of SRTC SW to NRC for local testing
- Early procurement of final SRTC servers and delivery to BIH at the beginning of AI phase in BIH

Activities at NRC premises

- Procurement of HRTC ans scaled-down SRTC prototype hardware
- HRTC SW developmnet, installation and testing
- HRTC SW drop and delivery to INAF for NGS to test NGS functionalities during its AIT phase
- SRTC and HRTC SW periodic installation, full system HW integration and testing
- Periodical delivery of HRTC SW to INAFfor local testing
- HRTC final acceptance test
- Early procurement of final HRTC servers and delivery to INAF OAS at the beginning of AI phase in BIH

Activities at BIH

- Integration of final SRTC and HRTC
- Integration of final RTC with ICS and ICH
- Implementation of RTC SW modifications if required by the MORFEO system integration and testing activities.

15.19. PS0 - INSTRUMENT CONTROL SOFTWARE

15.19.1. WP DESCRIPTION

The MAIT phase of WP PS0 covers the integration, configuration, verification, and test execution of the MORFEO Instrument Control System Software (ICSS), following the User Requirements and Functional Specifications. During this phase, the software components produced in Phase C/D (e.g. Function Control Software, Detector Control Software), maintenance tools, simulators, auxiliary loops, device interfaces, safety logic, GUIs, and templates, are deployed on the production hardware and validated against all MORFEO subsystems (LGS, NGS, PFRO, CU, ICH, RTC).
Throughout subsystem-level MAIT, dedicated ICSS releases are generated to support testing of motors, sensors, actuators, control loops and assemblies, enabling early functional validation during local integration.
The MAIT software deliverables include all alignment, integration and system-test tools, providing the control and diagnostic capabilities required for system-level verification of MORFEO.
The phase concludes with the preparation of PAE deliverables: test reports, documentation, updated ICSS packages, and support to subsystem and system integration campaigns.

15.19.2. Resources

WP responsible: BERNARDO SALASNICH (INAF OPAD)

WP resources	FTE/year
BERNARDO SALASNICH (INAF OAPD)	0.5
ANDREA BARUFFOLO (INAF OAPD)	0.1
DANIELA FANTINEL (INAF OAPD)	0.3
SYLVAIN GUIEU (CNRS/INSU)	0.1
BENEDETTA DI FRANCESCO (INAF OAAB)	0.1
FULVIO LAUDISIO (INAF OAPD)	0.8
ELIA COSTA (INAF OAPD)	0.2
DAPHNE DIRETTO (INAF OAPD)	1.0
FABRICE PANCHER (CNRS/INSU)	0.25
MIRKO COLAPIETRO (INAF OACN)	0.2
PIETRO SCHIPANI (INAF OACN)	0.05
TOTAL	3.6

15.19.3. Expected documents for the FDR

Documents	Owner	DRD
MORFEO TEMPLATE MANUAL E-MA0-000-INA-MAN-001 (UPDATE)	DFA	D25
MORFEO ICS SW DESIGN DOCUMENT E-MAO-PS0-INA-DER-001 (UPDATE)	BSA	D08/DRD610
MORFEO SW USER MANUAL E-MAO-PS0-INA-MAN-001 (UPDATE)	BSA	DRD720
MORFEO ICSS TEST REPORT	BSA	DRD540
SOFTWARE CONFIGURATION AND RELEASES NOTES	BSA	DRD620
SOFTWARE TRANSFER DOCUMENT	BSA	DRD630

15.19.4. Instrument Control Software Activities

- Deployment of ICSS components on LCUs, workstations and PLC
- Preparation of dedicated ICSS releases to test motors, sensors, actuators and assemblies for each subsystem (LGS, NGS, PFRO, CU, ICH, RTC)
- Generation of the ICSS release for MORFEO system-level integration, including all software tools required for alignment, integration and system tests in the Bologna Integration Hall
- Configuration of devices, I/O maps, motorized functions and control assemblies
- Integration and verification of auxiliary loops, offloads and deterministic interfaces
- Validation of engineering modes, safety logic, alarms and interlocks
- Integration of GUIs (synoptic, NGS acquisition, AO panel) and user-station functions
- Execution of functional and performance tests defined in ISFS and ISURS
- Verification of interfaces with CCS, RTC (HRTC/SRTC), MICADO and THCS
- Preparation of installation packages, configuration files, templates, logging tools, MAIT documentation, test reports and acceptance data, plus support for subsystem and system integration.

15.20. PT0 - THERMAL CONTROL

15.20.1. WP DESCRIPTION

The MAIT phase for Thermal Control & Cooling System covers the complete workflow required to manufacture, assemble, integrate, and verify all hydraulic and thermo-control elements serving the MORFEO electronics cabinets.
It includes the production and qualification of the manifolds, the assembly of cooling loops (heat exchangers, valves, sensors, piping), and the integration of Beckhoff control modules responsible for monitoring and driving the thermal regulation functions.

The MAIT process for the cabinet-cooling section of THCS comprises the procurement of hydraulic and control components, the assembly of prototype cooling circuits, and their pressure and functional testing at Merate using the THCS control logic. Validated units are then integrated in Bologna into the MORFEO electronics cabinets, where heat exchangers, valves, piping and Beckhoff modules are mounted and connected to the system CPU. Once cabinet-level tests (EtherCAT communication, I/O mapping, thermal-loop response) are completed, the cooled cabinets are shipped to the corresponding subsystem integration sites for installation and verification.

The MAIT phase concludes with the delivery of fully integrated and tested cooling hardware—manifolds, cabinet-level assemblies, routing elements, and validated control logic—ready for MORFEO system integration and subsequent acceptance.
All activities must comply with the mechanical, thermal, electrical-interface, safety, and software-interface requirements defined by the MORFEO consortium and ESO.

15.20.2. Resources

WP responsible: MATTEO ALIVERTI (INAF OAB)

WP resources	FTE/year
MATTEO ALIVERTI (INAF OAB)	0.5
EDOARDO REDAELLI (INAF OAB)	0.2
TOTAL	**0.7**

15.20.3. Expected documents for the PAE

Documents	Owner	DRD
MORFEO THERMAL CONTROL DESIGN REPORT E-MAO-PT0-INA-DER-001 (UPDATE)	MAL	D14
MORFEO THERMAL CONTROL ANALYSIS REPORT E-MAO-PT0-INA-ANR-001 (UPDATE)	MAL	D14
MORFEO THERMAL CONTROL INTERFACE CONTROL DOCUMENT E-MAO-PT0-INA-ICD-001 (UPDATE)	MAL	D15
MORFEO THERMAL CONTROL TEST AND INSPECTION REPORT	MAL	DRD540/545
MORFEO THERMAL CONTROL AS-BUILT DRAWINGS	MAL	D23
MORFEO THERMAL CONTROL ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	MAL	D19
MORFEO THERMAL CONTROL DATA SHEET OF COMMERCIAL COMPONENTS	MAL	D18
Equipment	**Owner**	**DRD**
FULLY ASSEMBLED & TESTED THERMAL CONTROL SYSTEM	MAL	N.A.
INTEGRATION/MAINTENANCE TOOLS AND SUPPORT EQUIPMENT	MAL	N.A.
HANDLING AND TRANSPORT EQUIPMENT	MAL	N.A.
TRANSPORT CONTAINERS	MAL	N.A.
SPARE PARTS	MAL	N.A.

15.20.4. Thermal Control Activities

- Procurement of hydraulic and control components, including prototype manifold, valves, fittings, sensors, tubing, and ancillary cooling hardware

- Procurement of tools and installation equipment required for assembly and testing of the cooling circuits
- Manufacturing and completion of the final manifolds, including additional branch lines and configuration of the full cooling distribution system
- Mechanical assembly of cooling sub-circuits at Merate, integrating valves, sensors, heat exchangers, piping, brackets, and interface hardware
- Functional and pressure testing of hydraulic assemblies at Merate, including leak tests, sensor verification, valve behaviour checks, and THCS software loop validation with ICH/ICSS
- Boxing and shipment of validated cooling assemblies from Merate to Bologna for cabinet-level integration
- Integration of cooling hardware inside MORFEO electronics cabinets at Bologna, including mounting of heat exchangers, valves, piping, sensors and Beckhoff modules
- Cabinet-level functional tests, verifying EtherCAT communication, CPU interfacing, I/O mapping, sensor–actuator coherence and thermal-control response
- Multi-cabinet THCS system test, connecting all cooled cabinets in the final EtherCAT network to validate the integrated control logic
- Shipment of cooled and tested cabinets to the respective subsystem integration sites (e.g. Grenoble for LGS, Arcetri for NGS)
- Final integration and routing of THCS cooling lines to MORFEO subsystems (LOR, DM, etc.) once structures become available, performed in coordination with system-level integration activities.

15.21. PU0 - CALIBRATION UNIT

15.21.1. WP DESCRIPTION

The Manufacturing, Assembly, Integration, and Test (MAIT) phase of the MORFEO Calibration Unit (CU) opto-mechanical system covers the complete industrial production workflow performed by the Contractor. This includes the procurement of optical blanks, mechanical parts and COTS components; the polishing and coating of optical elements; the manufacturing of the CU tower, inner mechanical parts, and tools; and all incoming inspections and supplier-acceptance activities. The Contractor proceeds with the assembly of the optical components into their holders, the integration of mechanical and opto-mechanical elements, and the execution of preliminary and final alignment procedures. Functional verification, optical-performance tests and Factory Acceptance Tests (FAT) are carried out according to the approved verification plan. The phase concludes with packaging, shipment of the CU assembly and tools, execution of On-site Acceptance Tests (SAT), and the release of as-built data, inspection reports, and technical documentation.

Additional integration activities are performed by the MORFEO team. These include the installation and alignment of elements not supplied by the Contractor—such as the NGS and LGS masks, the Pupil Sources (PS) panel, the connectors panel, the Fiber Splitting Unit (FSU), and the Deformable Mirror (DM) when applicable. The MORFEO team also integrates the CU with the electronics and control systems (ICSS/ICH), performs the system-level commissioning of motion control and safety functions, and executes the CU integration within the broader MORFEO AIV workflow.

15.21.2. Resources

WP responsible: GIANLUCA DI RICO (INAF OAAB)

WP resources	FTE/year
GIANLUCA DI RICO (INAF OAAB)	0.4
MAURO DOLCI (INAF OAAB)	0.1
IVAN DI ANTONIO (INAF OAAB)	0.5
AMICO DI CIANNO (INAF OAAB)	0.1
ANGELO VALENTINI (INAF OAAB)	0.3
GABRIELE RODEGHIERO (INAF OAS)	0.1
BENEDETTA DI FRANCESCO (INAF OAAB)	0.5
TOTAL	**2.0**

15.21.3. Expected documents for the PAE

Documents	Owner	DRD
MORFEO CALIBRATION UNIT DESIGN REPORT E-MAO-PU0-INA-DER-001 (UPDATE)	GDR	D14
MORFEO CALIBRATION UNIT ANALYSIS REPORT E-MAO-PU0-INA-ANR-001 (UPDATE)	GDR	D14
MORFEO CALIBRATION UNIT INTERFACE CONTROL DOCUMENT E-MAO-PU0-INA-ICD-001 (UPDATE)	GDR	D15
MORFEO CALIBRATION UNIT TEST AND INSPECTION REPORT	GDR	DRD540/545
MORFEO CALIBRATION UNIT AS-BUILT DRAWINGS	GDR	D23
MORFEO CALIBRATION UNIT ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	GDR	D19
MORFEO CALIBRATION UNIT DATA SHEET OF COMMERCIAL COMPONENTS	GDR	D18
Equipment	**Owner**	**DRD**

Documents	Owner	DRD
FULLY ASSEMBLED & TESTED CALIBRATION UNIT	GDR	N.A.
INTEGRATION/MAINTENANCE TOOLS AND SUPPORT EQUIPMENT	GDR	N.A.
HANDLING AND TRANSPORT EQUIPMENT	GDR	N.A.
TRANSPORT CONTAINERS	GDR	N.A.
SPARE PARTS	GDR	N.A.

15.21.4. Calibration Unit Activities

CONTRACTOR RESPONSABILITIES

- Procurement of optical blanks, mechanical parts, COTS items, and raw materials
- Incoming inspections, supplier follow-up, and part-acceptance meetings
- Optical polishing, metrology definition, optical testing, and release of as-built optical data
- Coating processes, specification review, supplier selection, and coating-durability inspections
- Manufacturing of the CU tower, inner mechanical components, and tools, with geometrical testing
- Preliminary inspection of the CU mechanical assembly, interfaces, alignment devices, and tools
- Assembly of optical components into their holders and preliminary alignment
- Integration of mechanical and opto-mechanical subsystems into the full CU assembly
- Final alignment, functional verification, optical-performance tests, and FAT execution
- Packaging, shipment, On-site Acceptance Tests (SAT), and delivery of all documentation.

INAF RESPONSABILITIES

- Contractual oversight of MAIT execution according to technical and scheduling obligations
- Coordination with subcontractors to ensure alignment with project objectives and milestones
- Participation in design and verification reviews, including IRRs, and FARs
- Approval of test procedures and inspection criteria defined by the consortium
- Review and approval of deliverables, including mechanical and optical assemblies, calibration datasets, and documentation
- Assessment and logging of non-conformances and follow-up on corrective actions
- Interface with ESO or project stakeholders for reporting, compliance assurance, and milestone acceptance
- Installation and alignment of NGS masks and LGS masks, not supplied by the Contractor
- Integration of the Pupil Sources (PS) panel, connectors panel and Fiber Splitting Unit (FSU)

- Installation and alignment of the Deformable Mirror (DM) when used instead of the Pupil Mirror (PM)
- Integration of the CU with the ICSS/ICH electronics and control system, not part of the Contractor supply
- Execution of system-level software commissioning, motion-control verification, and safety-function checks
- Integration of the CU into the MORFEO AIV flow, including system-level alignment and calibration activities.

15.22. PV0 - TEST UNIT

15.22.1. WP DESCRIPTION

The MAIT activities for PV0 encompass the full manufacturing, assembly, integration, and verification of the Test Unit, combining the TAC (Test and Alignment Cameras) subsystem with the NACO-based deformable-mirror chain. The TAC provides the optical and mechanical backbone needed to perform PSF imaging, pupil analysis, alignment verification, and stability assessments during MORFEO subsystem and system-level tests. This includes the procurement and characterisation of cameras and opto-mechanical components, the integration of multiple optical branches (pupil, imaging, off-axis, WFS, photodiode), and the assembly, alignment, and calibration of translational and rotational stages. Verification covers focusing performance, co-alignment of the five imaging channels, repeatability, and overall stability of the TAC platform prior to integration in the Bologna facility.

In parallel, the Test Unit focuses on preparing, integrating, and validating the deformable mirror chain and associated electronics required for early optical testing. Activities include the selection and procurement of the commercial DAC that drives the NACO DM, the verification of mechanical and electrical interfaces inherited from legacy hardware, and the definition of representative test cases supporting RTC interaction during early integration phases. The MAIT phase also involves cabling validation and the preparation of appropriate power and infrastructure elements for stable DM operation.

Together, the TAC subsystem and the NACO DM chain ensure that the Test Unit is fully prepared to support system-level testing and alignment activities in the Bologna Integration Hall (BIH).

15.22.2. Resources

WP responsible: ALEXANDER GONCHAROV (NUIG)

WP resources	FTE/year
ALEXANDER GONCHAROV (NUIG)	0.3
NICHOLAS DEVANEY (NUIG)	0.4
LORENZO BUSONI (INAF OAA)	0.1

WP resources	FTE/year
JEAN PIERRE VERAN (NRC)	0.1
SYLVAIN OBERTI (ESO)	0.1
MATTEO D'AMBROGIO (INAF OAB)	0.2
TOTAL	**1.2**

15.22.3. Expected documents for the PAE

Documents	Owner	DRD
MORFEO TEST UNIT DESIGN REPORT E-MAO-PV0-NUI-DER-001 (UPDATE)	NDA	D14
MORFEO TEST UNIT ANALYSIS REPORT E-MAO-PV0-NUI-ANR-001 (UPDATE)	NDA	D14
MORFEO TEST UNIT INTERFACE CONTROL DOCUMENT E-MAO-PV0-NUI-ICD-001 (UPDATE)	NDA	D15
MORFEO TEST UNIT TEST AND INSPECTION REPORT	NDA	DRD540/545
MORFEO TEST UNIT AS-BUILT DRAWINGS	NDA	D23
MORFEO TEST UNIT ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	NDA	D19
MORFEO TEST UNIT DATA SHEET OF COMMERCIAL COMPONENTS	NDA	D18
Equipment	**Owner**	**DRD**
FULLY ASSEMBLED & TESTED TESTUNIT	NDA	N.A.

15.22.4. Test Unit Activities

- Select and technically specify the commercial DAC for NACO DM actuation, including interfaces with RTC
- Verify the mechanical interfaces and as-built condition of the NACO DM, ensuring compatibility with the Calibration Unit design
- Validate cable lengths, routing paths, and infrastructure (ducts, chains) required for DAC-HVA-DM connectivity
- Execute the DM functional tests defined during the design phase, including command application, shape verification and interface checks with the control software

- Prepare the low-voltage power distribution and ancillary electronics needed to operate the DAC chain inside the Test Unit.
- Procurement, inspection, and characterisation of cameras (GoldEye/Ninox/Owl) and opto-mechanical components.
- Assembly and integration of the optical branches (pupil, imaging, WFS, off-axis, photodiode) and associated filter wheel.
- Integration, alignment, and calibration of XY and Z stages, including load verification and focusing range characterisation.
- Full functional verification: PSF imaging, pupil capture, co-focus alignment of the five cameras, and TAC stability characterisation.
- Preparation of verification documentation and readiness for system-level integration at Bologna.

15.23. PW0 - LGS WFS CAMERAS

15.23.1. WP DESCRIPTION

The MAIT phase for the MORFEO LGS WFS Cameras and their dedicated Camera Adapters covers the complete chain from procurement of the six cameras, three adapter units, and associated spare parts, to their verification, integration, and acceptance before delivery to the subsystem-level AIT phase.

Following the completion of the prototyping activities,including latency measurements and functional validation on the prototype C-BLUE2 camera as received from the camera supplier, and the mechanical/electrical integration tests of the adapter performed with the adapter supplier, the final units undergo a structured MAIT workflow at INAF. This workflow includes incoming inspections, functional checks, and verification of compliance with specifications (e.g. the latency requirement). Each camera is integrated with its adapter, connected to the required power, cooling and timing networks, and tested for full operability under the expected MAIT conditions. Latency and functional tests are executed on all delivered cameras and adapters

Upon successful qualification, all validated cameras and adapters are packed and shipped by INAF to IPAG, where they enter the integration flow of the LGS WFS module and the subsequent subsystem-level MAIT activities.

15.23.2. Resources

WP responsible: ITALO FOPPIANI (INAF OAS)

WP resources	FTE/year
ITALO FOPPIANI (INAF OAS)	0.6
GIUSEPPE COSENTINO (DIFA)	0.6
FULVIO GIANOTTI (INAF OAS)	0.05
ALESSANDRO TACCHINI (INAF OAS)	0.05

WP resources	FTE/year
TOTAL	**1.3**

15.23.3. Expected documents for the PAE

Documents	Owner	DRD
MORFEO LGS WFS CAMERA TESTS REPORT E-MAO-PW0-INA-TNO-001 (UPDATE)	IFO	DRD540
MORFEO LGS WFS CAMERA DESIGN REPORT E-MAO-PW0-INA-DER-001 (UPDATE)	IFO	D14
MORFEO LGS WFS CAMERA INTERFACE CONTROL DOCUMENT E-MAO-PW0-INA-ICD-001 (UPDATE)	IFO	D15
MORFEO LGS WFS CAMERA AS-BUILT DRAWINGS	IFO	D23
MORFEO LGS WFS CAMERA ACCEPTANCE REPORT OF MANUFACTURED COMPONENTS	IFO	D19
MORFEO LGS WFS CAMERA DATA SHEET OF COMMERCIAL COMPONENTS	IFO	D18
Equipment	**Owner**	**DRD**
FULLY ASSEMBLED & TESTED LGS WFS CAMERA	IFO	N.A.
INTEGRATION AND MAINTENANCE TOOLS	IFO	N.A.
TRANSPORT CONTAINERS	IFO	N.A.
SPARE PARTS	IFO	N.A.

15.23.4. LGS WFS Cameras Activities

- Incoming inspection and interface verification (e.g. visual and mechanical checks of cameras, adapters and accessories)
- Assembly and connection of the camera with its adapter, including network, triggering, and timing
- Functional and operational testing (e.g configuration access, monitoring, alarms) Performance and latency verification
- Preparation of test and acceptance reports of fully qualified units
- Packing, and shipment from INAF to IPAG for integration into the LGS WFS module.

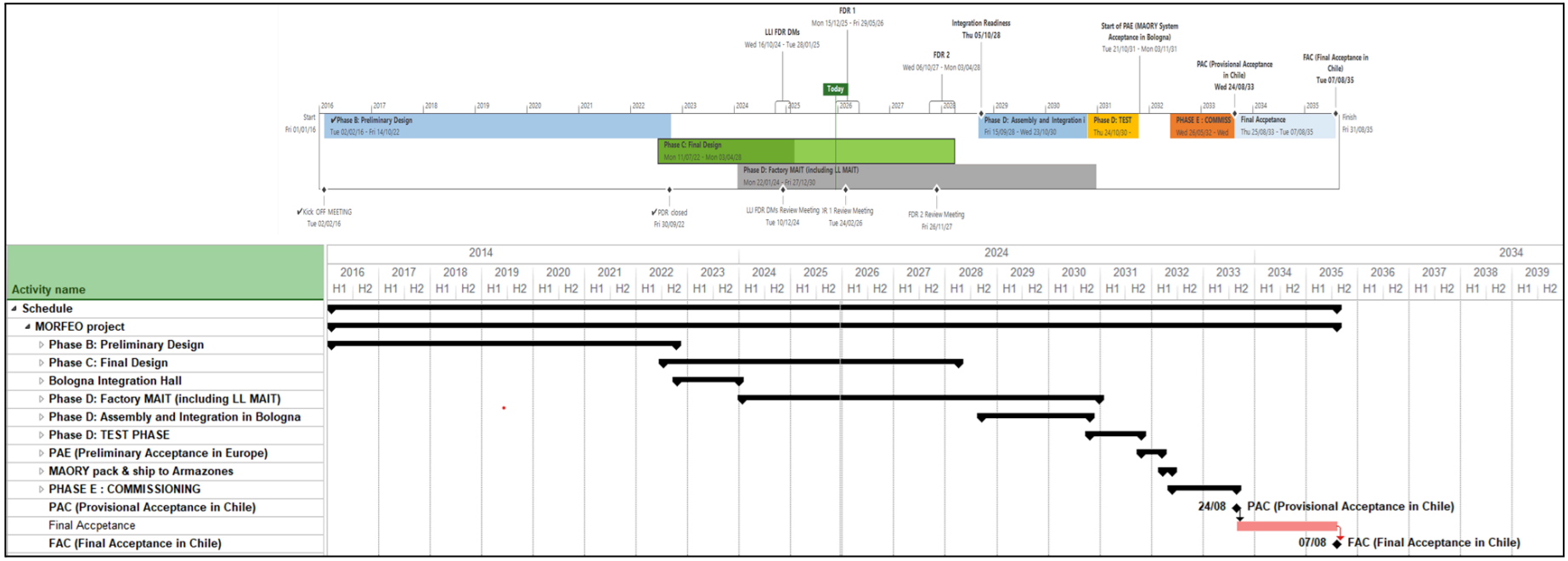
16. ANNEX 4 - WORK PACKAGES DESCRIPTION FOR PHASE E

TBD (to be defined prior to FDR2)

17. ANNEX 5 –MORFEO Overall Schedule

In the following a synthetic view of the schedule, in tabular and graphical form:

Name	Start	Finish
Phase B: Preliminary Design	Tue 02/02/16	Fri 14/10/22
Phase C: Final Design	Mon 11/07/22	Mon 03/04/28
Bologna Integration Hall	Mon 17/10/22	Fri 29/12/23
Phase D: Factory MAIT (including LL MAIT)	Mon 22/01/24	Fri 27/12/30
Phase D: Assembly and Integration in Bologna	Fri 15/09/28	Wed 23/10/30
Phase D: TEST PHASE	Thu 24/10/30	Mon 20/10/31
PAE (Preliminary Acceptance in Europe)	Tue 21/10/31	Thu 18/03/32
MAORY pack & ship to Armazones	Fri 19/03/32	Tue 25/05/32
PHASE E : COMMISSIONING	Wed 26/05/32	Wed 24/08/33
PAC (Provisional Acceptance in Chile)	Wed 24/08/33	Wed 24/08/33
Final Accpetance	Thu 25/08/33	Tue 07/08/35
FAC (Final Acceptance in Chile)	Tue 07/08/35	Tue 07/08/35


FDR 1
Mon 15/12/25 - Fri 29/05/26
LLI FDR DMs
Wed 16/10/24 - Tue 28/01/25
Integration Readiness
Thu 05/10/28
FDR 2
Wed 06/10/27 - Mon 03/04/28
Start of PAE (MAORY System Acceptance in Bologna)
Tue 21/10/31 - Mon 03/11/31
PAC (Provisional Acceptance in Chile)
Wed 24/08/33
FAC (Final Acceptance in Chile)
Tue 07/08/35
Today
Start
Fri 01/01/16
✔Phase B: Preliminary Design
Tue 02/02/16 - Fri 14/10/22
Phase C: Final Design
Mon 11/07/22 - Mon 03/04/28
Phase D: Factory MAIT (including LL MAIT)
Mon 22/01/24 - Fri 27/12/30
Phase D: Assembly and Integration i
Fri 15/09/28 - Wed 23/10/30
Phase D: TEST
Thu 24/10/30 -
PHASE E : COMMISS
Wed 26/05/32 - Wed
Final Acceptance
Thu 25/08/33 - Tue 07/08/35
Finish
Fri 31/08/35
✔Kick OFF MEETING
Tue 02/02/16
✔PDR closed
Fri 30/09/22
LLI FDR DMs Review Meeting
Tue 10/12/24
IR 1 Review Meeting
Tue 24/02/26
FDR 2 Review Meeting
Fri 26/11/27
Activity name
Schedule
MORFEO project
Phase B: Preliminary Design
Phase C: Final Design
Bologna Integration Hall
Phase D: Factory MAIT (including LL MAIT)
Phase D: Assembly and Integration in Bologna
Phase D: TEST PHASE
PAE (Preliminary Acceptance in Europe)
MAORY pack & ship to Armazones
PHASE E : COMMISSIONING
PAC (Provisional Acceptance in Chile)
Final Accpetance
FAC (Final Acceptance in Chile)
24/08 PAC (Provisional Acceptance in Chile)
07/08 FAC (Final Acceptance in Chile)

17.1. Critical path analysis

17.1.1. Introduction

The critical path of the MORFEO project identifies those activities whose timely completion is essential to safeguard the overall schedule and the achievement of major milestones. Any shift in these activities produces a direct impact on subsequent phases, including Assembly, Integration, and Testing, and ultimately affects the Preliminary Acceptance in Europe (PAE). The analysis highlights the subsystems and work packages that constrain the project timeline and establishes the basis for monitoring and mitigation throughout Phase C and Phase D.

17.1.2. Phase C

In Phase C the critical path is defined by the **Main Structure, LGSO, Calibration Unit** and the **Flat Mirrors**, listed in order of their impact on the overall schedule. These work packages are positioned on the critical path because their procurement and design activities directly determine the readiness of the system for integration and testing.

- The Main Structure is the most critical element, as it provides the foundation for initiating integration activities in Bologna. To mitigate risks, the procurement strategy incorporates a reference design to guide suppliers and evaluation criteria that award additional points for proposals offering shorter schedules.
- The LGSO is essential to complete integration and enable the start of the testing phase. Its procurement plan allows suppliers to begin acquiring blanks prior to the final design review, reducing exposure to schedule constraints. A reference design, resulting from the Main Optics FDR already concluded, is also provided, and evaluation criteria incentivise shorter delivery schedules.
- The Calibration Unit is positioned on the critical path due to its procurement and design activities, which drive the schedule toward the next milestone sequence.
- The Flat Mirrors are included on the critical path as a result of their current procurement status, which directly influences the scheduling of subsequent integration steps.

With the decision to arrange earlier Final Design Reviews (FDR1) for the **NGS WFS**, **LGS WFS**, and the **RTC**, these work packages are no longer positioned on the critical path. Their schedules retain sufficient margin to avoid constraining the overall milestone sequence.

17.1.3. Phase D

In Phase D the critical path is driven by the delivery and integration of externally manufactured subsystems. The **Main Structure**, **LGSO**, **Calibration Unit**, and **Flat Mirrors** are positioned on the critical path. Any shift in these elements results in a corresponding impact on Assembly and Integration in Bologna and on subsequent activities through the PAE.

- The **Main Structure** remains the most critical driver, as its installation is the prerequisite for initiating integration in Bologna.
- The **LGSO** is equally essential, as its completion is required to finalise integration and enable the testing phase.
- The **Calibration Unit** continues to be critical, but its impact has been partially mitigated. An alternative alignment method has been defined, allowing integration activities to proceed even before the final unit is delivered.
- The **Flat Mirrors** remain critical, as their procurement and integration activities are necessary to maintain the overall schedule similar to the LGSO.

17.1.4. Contingency and Risk Management

A contingency of six months has been embedded in Phase D for all systems on the critical path to absorb unplanned risks.

Procurement strategies for the Main Structure and LGSO reduce exposure by providing reference designs and incentivising shorter schedules in supplier evaluation. For the LGSO, the procurement plan allows the acquisition of blanks prior to the final design review. For the Calibration Unit, the alternative alignment method ensures integration can proceed independently of final delivery.

***** End of document ***