EUROPEAN SOUTHERN OBSERVATORY

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral

Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

VLT PROGRAMME

# VERY LARGE TELESCOPE

## INSTRUMENTATION DIVISION

**Technical Specification and Statement of Work**

**for the MACAO Tip-Tilt Mount**

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CHANGE RECORD

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## 1. Scope

This document describes the technical specifications of the Tip-Tilt Mounts that will be used for MACAO-VLTI and MACAO-Sinfoni/Crires.

It describes the activities that have to be undertaken and the items to be delivered with respect to the development, manufacturing, test, and documentation of the deliverables. In the following, we will refer to the Tip-Tilt Mount (TTM) unit meaning the TTM itself including the drive electronics.

## Applicable documents

| | |
|---|---|
| **AD 1** | VLT-SPE-ESO-10000-0004, VLT Environmental Specifications, Issue 6.0 |

# 2. MACAO-VLTI Tip-Tilt Mount technical specifications

The Tip-Tilt Mount for MACAO-VLTI will have to hold a curvature deformable mirror. However, the technical specification of the Tip-Tilt mount specified in this document refers to the performance of the mount itself assumed to have a dummy mirror of the same dimension and weight of the deformable mirror.

## *2.1 MACAO-VLTI optical specifications*

- Pupil geometry on the mounted DM: oval
- Pupil diameter on the DM: ~100mm
- DM diameter: ~150mm (without the DM mount)
- DM diameter with mount: 180mm (goal 170mm)
- Flatness of the DM while the TT Mount is performing the correction: best effort

## *2.2 MACAO-VLTI mechanical specifications*

- DM weight: <750g (goal 500g)
- Maximum dimension of the TT Mount with the DM mounted: 290mm (drawing will be provided)
- In order to reduce to a minimum the piston produced by the tip-tilt action we issue the following alignment specifications. In the following, we define a X axis as the tip axis, Y axis as the tilt axis and Z axis as perpendicular the the X-Y plane. The optical surface of the DM coincides with the X-Y plane. In the X-Y plane, the intersection of the tip-tilt axes and the DM surface center should correspond to +/-0.2mm (goal 0.05mm) along the Z axis, the intersection of the tip-tilt axes and the DM surface should correspond to +/-1mm the mechanical I/F of the TT mount defines a plane parallel with the X-Y plane. The DM surface should be parallel to this plane to +/-0.1 degree.
  The above specifications are indicated on fig. 1
  These specifications are for the assembly DM-TTM and it is acceptable to divide these figures by two in order to have a specification for the TTM alone, or the DM alone.

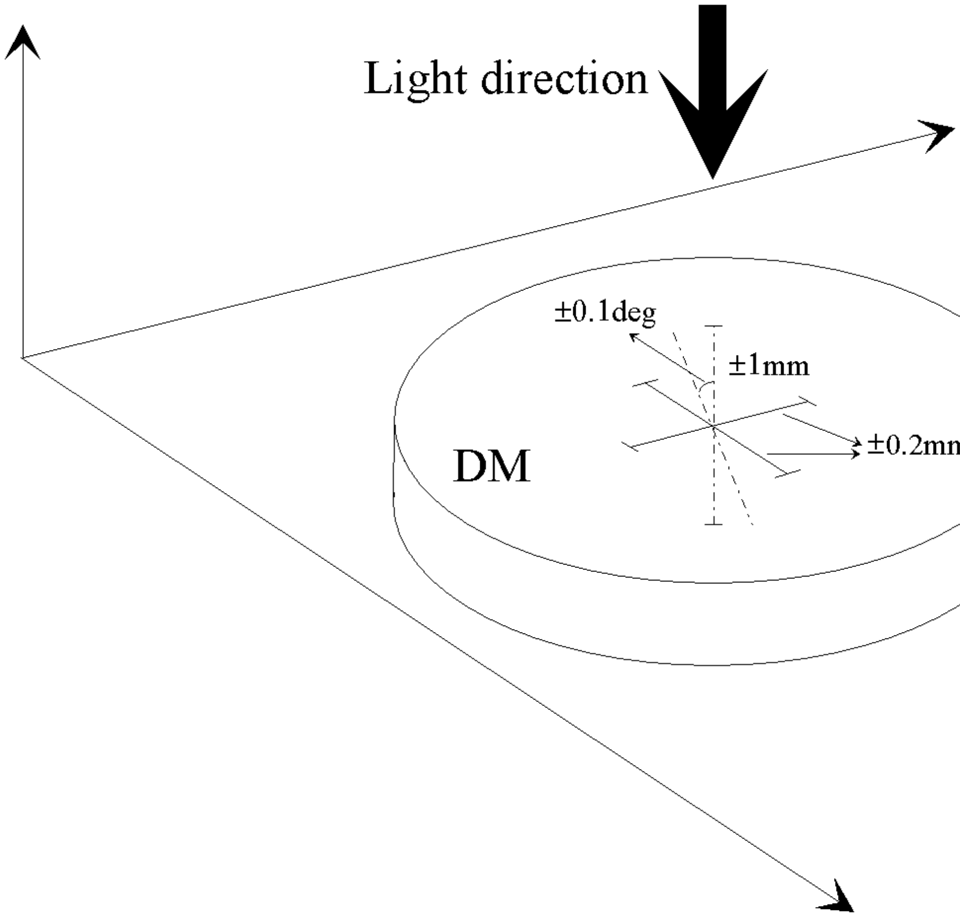


**Fig. 1**

## *2.3 MACAO-VLTI tip-tilt correction specifications*

- Mechanical tilt angle range for each axis: > ± 120" (which corresponds to a tilt angle range on the sky >±3" for each axis)
- Mechanical tilt angle resolution for each axis: < 40mas RMS (which corresponds to a tilt angular resolution on the sky <1mas RMS for each axis)
- Mechanical positioning accuracy for each axis: < ± 40mas (which corresponds to a positioning accuracy on the sky < ± 1mas)
- Overall transfer function:
  - effective bandwidth at - 3 dB: >100Hz and <400Hz in local closed loop
  - phase lag: <-20$^{o}$ up to 15Hz in local closed loop
  - cross talk: <0.5% up to 15Hz

- The local closed loop should be tuneable in order to avoid possible interference between the Tip-Tilt loop performed by the mount and the DM loop.

### *2.4 MACAO-VLTI tip-tilt mirror electrical sub-assembly specification*

- Channel assignment: each channel simultaneously and individually addressable
- Analog signal: ±10V
- Inter channel cross-talk: <0.1%
- Output monitoring for each channel: position sensor output voltage (10V)
- Cable length: 18m
- Maximum power dissipation of the TTM (not including the DM power dissipation): 5W

## 3. MACAO-Sinfoni/Crires Tip-Tilt Mount technical specifications

The Tip-Tilt Mount for MACAO-Sinfoni will have to hold a curvature deformable mirror. However, the technical specification of the Tip-Tilt mount specified in this document refers to the performance of the mount itself assumed to have a dummy mirror of the same dimension and weight of the deformable mirror.

### *3.1 MACAO-Sinfoni/Crires optical specifications*

- Pupil geometry on the mounted DM: circular
- Pupil diameter on the DM: ~50.6mm
- DM diameter: ~100mm (without the DM mount)
- DM diameter with mount: 130mm (goal 120mm)
- Flatness of the DM while the TT Mount is performing the correction: best effort

### *3.2 MACAO-Sinfoni/Crires mechanical specifications*

- DM weight: <400g (goal 300g)
- Maximum dimension of the TT Mount with the DM mounted: 250mm (drawing will be provided)

### *3.3 MACAO-Sinfoni/Crires tip-tilt correction specifications*

- Mechanical tilt angle range for each axis: > ± 240" (which corresponds to a tilt angle range on the sky >±3" for each axis)
- Mechanical tilt angle resolution for each axis: <80mas RMS (which corresponds to a tilt angular resolution on the sky <1mas RMS for each axis)

- Mechanical positioning accuracy for each axis: < ± 80mas (which corresponds to a positioning accuracy on the sky < ± 1mas)
- Overall transfer function:
  - effective bandwidth at - 3 dB: >100Hz and <400Hz in local closed loop
  - phase lag: <-20$^o$ up to 15Hz in local closed loop
  - cross talk: <0.5% up to 15Hz
- The local closed loop should be tuneable in order to avoid possible interference between the Tip-Tilt loop performed by the mount and the DM loop.

### *3.4 MACAO-Sinfoni/Crires tip-tilt mirror electrical sub-assembly specification*

- Channel assignment: each channel simultaneously and individually addressable
- Analog signals: 10V
- Inter channel cross-talk: <0.1%
- Output monitoring for each channel: position sensor output voltage (10V)
- Cable length: 5m (TBC)
- Maximum Power dissipation of the TTM (not including the DM power dissipation): 5W

## 4 Environmental specifications

All the specifications given in this document shall be met under the environmental conditions described in AD1.
However, particular care shall be given to the following conditions:

| | |
|---|---|
| • Functional air temperature range: | -10$^o$C to +30$^o$C |
| • Operational air temperature range: | 0$^o$C to +15$^o$C |
| • Typical air temperature gradient at night: | -0.9 / +0.5 $^o$C/hour |
| • Operating altitude: | 0-2700m a.s.l. |
| • Humidity: | <95% non condensing |

The Maximum Likely Earthquake (MLE) which the system has to survive to without major damages is defined in AD1.

# 5 Statement of work

## *5.1 Deliverables*

### 5.1.1 Hardware

The elements to be supplied by the contractor are:

- 1 MACAO-VLTI TTM prototype, including the drive electronics
- 4 MACAO-VLTI TTM units
- 1 Sinfoni/Crires TTM prototype, including the drive electronics
- 2 Sinfoni/Crires TTM units
- 2 full drive electronics spare
- 4 linear motors (magnet and coils) spares

### 5.1.2 Documentation

Two separate sets of documents should be supplied: the first set for MACAO-VLTI (5 units) and the second one for MACAO-Sinfoni/Crires (3 units). The following documents shall be provided as part of each sets of documents:

- A Design Report document, describing the overall unit design
- Test procedure report
- Test report for each unit
- The User/Maintenance Manual, describing how to use and maintain the system
- “As built” drawings and electronics schematics

All the documents shall be in English.

## *5.2 Acceptance Procedure*

The Contractor shall propose a test procedure demonstrating the conformance to the present specifications. This procedure shall be submitted to ESO for approval.

The acceptance test shall be performed at the contractor premises.

The following specifications shall be measured and checked: local close loop performances, hardware mechanical interfaces.

The Contractor shall provide the dummy mirror of the DM with same weight, dimensions and centre of gravity - without any wires and connectors - to be used for the tests.

### *5.3 Responsibility of the Contractor and of ESO*

The Contractor is responsible for the design, hardware procurement, manufacturing, integration and testing of the MACAO-VLTI and MACAO-Sinfoni/Crires TTM prototypes units + one full drive electronic spare. It is also responsible for the design, manufacturing, integration and testing of four MACAO-VLTI and two MACAO-Sinfoni/Crires TTM units.

ESO is responsible for the hardware procurement of four MACAO-VLTI and two MACAO-Sinfoni/Crires TTM units + one full drive electronic spare. ESO will also provide support for the dynamic FEM analysis.

The Contractor shall provide manpower support for the integration at ESO of the TTM with the DM (the performances of the two systems together will be anyway best effort).

### *5.4 Project definition*

5.4.1 MACAO-VLTI Phase Definition

- **Phase 1: Design Phase**

  During this phase, the Contractor shall perform a detailed design of the MACAO-VLTI TTM units. The fulfilment of all the specified requirements shall be demonstrated on the design.
  The test procedure report shall be submitted to ESO for approval.
  The design phase ends with the design verification.

- **Phase 2: Manufacturing and testing of the MACAO-VLTI prototype unit.**

  During this phase, the Contractor shall procure, manufacture, assemble and test the MACAO-VLTI prototype unit. This phase ends with the acceptance test at the Contractor premises of the prototype. The Contractor will also provide support for the integration at ESO of the TTM with the DM (the performances of the two systems together will be anyway best effort). Only after ESO approval, the Contractor shall start the manufacturing of the four MACAO-VLTI units.

- **Phase 3: Manufacturing and testing of two of the four MACAO-VLTI units.**

  During this phase, ESO shall procure and the Contractor shall manufacture, assemble and test two MACAO-VLTI TTM units + one full drive electronic spare. This phase ends with the acceptance test at the Contractor premises of the two units tested one by one.

- **Phase 4: Manufacturing and Testing of the remaining two MACAO-VLTI units**

  During this phase, ESO shall procure and the Contractor shall manufacture, assemble and test the two remaining MACAO-VLTI TTM units. This phase ends with the acceptance test at the Contractor premises of the two units tested one by one.

- **Phase 5: Documentation Delivery**

  During this phase, the full documentation shall be delivered to ESO.
  This phase ends with the provisional acceptance of the units at ESO.

- **Phase 6: Final Acceptance**

  The final acceptance is performed after the guarantee period of 1 year.

5.4.2 MACAO-Sinfoni/Crires Phase Definition

- **Phase 1: Design Phase**

  During this phase, the Contractor shall perform a detailed design of the MACAO-Sinfoni/Crires TTM units. The fulfilment of all the specified requirements shall be demonstrated on the design. The test procedure report shall be submitted to ESO for approval. The design phase ends with the design verification.

- **Phase 2: Manufacturing and Testing of the MACAO-Sinfoni/Crires prototype unit.**

  During this phase, the Contractor shall procure, manufacture, assemble and test the MACAO-Sinfoni/Crires prototype unit. This phase ends with the acceptance test at the Contractor premises of the prototype. The Contractor will also provide support for the integration at ESO of the TTM with the DM (the performances of the two systems together will be anyway best effort). Only after ESO approval, the Contractor shall start the manufacturing of the two MACAO-Sinfoni/Crires units.

- **Phase 3: Manufacturing and Testing of the two MACAO-Sinfoni/Crires units**

  During this phase, ESO shall procure and the Contractor shall manufacture, assemble and test the two MACAO-Sinfoni/Crires TTM units + one full drive electronic spare. This phase ends with the acceptance test at the Contractor premises of the entire set of units, tested one by one.

- **Phase 4: Documentation Delivery**

  During this phase, the full documentation shall be delivered to ESO.
  This phase ends with the provisional acceptance of the units at ESO.

- **Phase 5: Final Acceptance**

  The final acceptance is performed after the warranty period of 1 year.

### *5.5 Delivery Schedule*

The Project Phases are described in Sec.5.4.1 and Sec.5.4.2

5.5.1 MACAO-VLTI Schedule

| **Milestone (MACAO-VLTI)** | **Date** |
|---|---|
| Contract Signature | $T_0$ |
| End of Phase 1 | $T_0$ + 2 months |
| End of Phase 2 | $T_0$ + 5 months |
| End of Phase 3 | $T_0$ + 11 months |
| End of Phase 4 | $T_0$ + 14 months |
| End of Phase 5 | $T_0$ + 16 months |
| End of Phase 6 | $T_0$ + 25 months |

5.5.2 MACAO-Sinfoni/Crires Schedule

| **Milestone (Sinfoni/Crires)** | **Date** |
|---|---|
| Contract Signature | $T_0$ |
| End of Phase 1 | $T_0$ + 6 months |
| End of Phase 2 | $T_0$ + 12 months |
| End of Phase 3 | $T_0$ + 15 months |
| End of Phase 4 | $T_0$ + 18 months |
| End of Phase 5 | $T_0$ + 26 months |

5.6 Payment Plan

| **Milestone** | **Amount** |
| --- | --- |
| Contract Signature | 30% |
| End of Phase 2 MACAO-VLTI | 40% |
| End of Phase 2 MACAO-Sinfoni/Crires | 20% |
| End of Phase 5 MACAO-VLTI and End of Phase 4 MACAO-Sinfoni/Crires | 10% |
| **Total** | **100%** |