MO.R.AL
Alt-Azimuth one meter class mount for SLR

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MORAL

- MORAL (MOunt Robotic ALt-azimuth) is an Alt-Az mount designed to satisfy the needs of many applications that require high accuracy, precision and fast pointing of in-orbit objects:
  - ✓ Optical Observation
  - ✓ Laser Ranging

- Project drives:
  - ✓ Lightweight structure – 10000 N maximum load
  - ✓ <2 arcsec of mechanical axis pointing error
  - ✓ up to 30°/s slew rate
  - ✓ High torque (scalable)
  - ✓ 360° Free rotation in azimuth axis
  - ✓ Hollow shafts on both axis for laser path
  - ✓ Large clearance for large instruments
The requirements have been defined in order to obtain a high quality solution for observation of really fast objects in LEO dimensioned for space debris monitoring and tracking.

MORAL is a fully parametric and easy-adaptable product designed to withstand a large scale of loads (both mechanical and electrical) in which the level of the performance can be adjusted according to the needs.
MORAL

MORAL can mount instruments up to 1000 kg and over 1.3 m diameter.
MORAL exploits direct drive motors eliminating transmission hardware between the motor and telescope axes, with values of torque up to 600 Nm.

High resolution absolute optical encoders measure mount angular motion with an extreme precision, with a resolution of 0.01 arcsec directly on telescope axes.

High precision bearing units associated to an optimized mechanical design ensure excellent dimensional stability during operations.

The electrical hardware is already designed to provide and withstand higher level of velocity if required acting only on the software controlling system.

MORAL has been designed using aerospace methods and tools for structural optimization to ensure dynamic stiffness during operations.

A reference load of 10000 N has been considered for static dimensioning, ensuring positive margins of safety and limited displacement.
When operating at high performances loads can induce vibration and micro deformation on the structure that can alterate measures.

MORAL has been designed using aerospace methods and tools for structural optimization in order to achieve a lightweight structure and high performances in terms of stiffness.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Frequency [Hz]</th>
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<tbody>
<tr>
<td>1</td>
<td>23.3</td>
</tr>
<tr>
<td>2</td>
<td>23.5</td>
</tr>
<tr>
<td>3</td>
<td>106.9</td>
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<tr>
<td>4</td>
<td>139.2</td>
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The handling of the system has been studied in order to realize a product that can be easily inspected allowing a replacement of the main components avoiding the full disassembly of the system. This is important when MORAL is operating in harsh environment hardly accessible.

- Motors can be removed easily for inspection and maintenance.
- Encoders and controllers can be removed as well individually for maintenance.
- The braking system ensures that maintenance operations can be carried out in safe conditions.
CONTROL & OPERATIONS

- The controlling system is based on real time multi-axis control that allows really accurate and synchronous control of both axis.
- The control software has been built starting from ASCOM standards.
- Compatibility with commercial and compatibility with commercial astronomical equipment software control (e.g. ASCOM). and pointing model.
- Open communication protocol – TCP Server to send direct command to the mount
- GUI for standalone PC control
- Independent controlling Joystick
HIGH QUALITY STANDARDS

- Thanks to NPC experience and facilities it has been possible to ensure a high level of standards in terms of quality control before and during each step of integration.
CURRENT STATUS

- The first prototype is being manufactured and realized within facilities of the company NPC which can provide great expertise in terms of mechatronic and assembly of high precision mechanical components. The test campaign has been scheduled for December 2015.
Maximum telescope weight: 500 kg
Distance between support plates: 1410 mm
Lightweight: overall weight 700 kg
Mechanical Axes Error <2 Arcsec
Maximum speed: 30 deg/sec (settable)
Angle measurement resolution directly on the axes: 0.01 arcsec – accuracy 1 arcsec
High torque direct drive motors
ASCOM compliant communication protocol
First quality industrial standard components
Unlimited rotation in azimuth/elevation
Optimized design using aerospace derived analysis methods
Nasmyth – focus telescope compatible
MORAL has been designed exploiting parametric design philosophy that permits to rescale the system according to the needs (Custom data/power signals – Motors Performances – Dimensions)

A first approach design of a rescaled system has been studied for a potential customer.
OPTICS PROVIDER

Normand Fullum 1 METER f/2 PRIMARY MIRROR = 115KG
CARBON TRUSS STRUCTURE + UPPER CAGE = 20KG
PRIMARY STEEL CASE = 110KG
TOTAL = 245KG

60mm CORRECTED FLAT FIELD CIRCLE WITH WYMAN 4" 
0.1168 arcsec of resolution

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PROJECT MILESTONES

- September 2014 - April 2015 – Design
- April 2015 – August 2015 - Components supply/parts manufacturing
- September 2015 -November 2015 – Integration (on time)
- December 2015 - Begin of test campaign

THANKS FOR THE ATTENTION
VERSATILE OPERATIONAL APPROACH

- The philosophy adopted for the design of MORAL permits to modify the performance only changing few components. Drives and motors are designed to sustain higher voltage and in that way higher torques and velocity.
- All the components that can be switched according to requirements are integrated using flexible interfaces.
- The motion control components have been chosen in order to permit to reach the maximum value of power just changing the upstream power supply.
- The whole controlling chain can be modified in order to facilitate the use of specific software.
- Slip rings can be substituted with a different model offering more signal lines according to the required instruments.