Challenges to the construction of the WSS for the METIS/ELT

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INTRODUCTION

METIS is one of the first generation instruments for the ELT. The instrument consists of two separate units (imager and spectrograph) encased, together with the AO wavefront sensor and fore-optics, in a cryostat to maintain the stable low temperatures required for good mid-infrared performance. To achieve diffraction-limited performance, METIS will use a single conjugate adaptive optics system to compensate for atmospheric turbulence. The wavefront will be measured inside METIS, and this information will be used to control the M4 adaptive mirror of the ELT[1].

The METIS collaboration consists of 10 European institutions plus an institution from Taiwan and the USA. The Portuguese contribution to METIS is the construction of the support structure and access (Warm Support Structure; WSS) to the METIS instrument, which consists of 3 main components (Fig. 1):

- Elevation Platform (**ELP**) - Connected to the Nasmyth platform, and holds the **CAS** and **RIG**.
- Cryostat Alignment Structure (**CAS**) - Movable hexapod holding the cryostat and attached instruments, and used for cryostat alignment.
- Instrument Access Platform (**RIG**) - Allows personnel to access METIS for maintenance purposes.

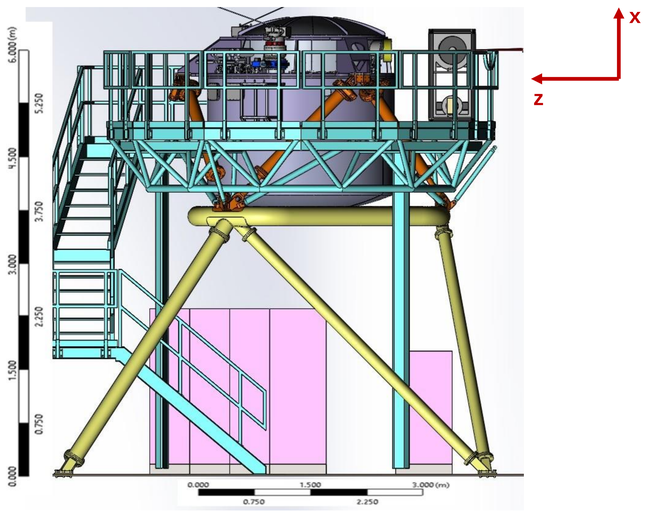

Fig. 1 - The WSS design (@ Nov. 2020) with scale, and its 3 substructures: RIG (cyan), CAS (orange) and ELP (yellow). The staircase support structure is not included.

REQUIREMENTS

The need to meet stringent functional requirements, while keeping the mass low, drives the general design of the WSS. Below, several of the key requirements are presented.

- **Design Volume** – The location of the pre-focal station, support cabinets (in pink; Fig. 1), the corridor access, and the volume allocated to future instruments determine the volume to be occupied by the WSS.
- **Loads** – The ELP and CAS are designed to support a mass (cryostat plus instruments) of 9 tons (11 with margin). The RIG is designed to support the mass of two people simultaneously on the platform plus tools and equipment. In addition, the RIG must also support SLAO, the 1 ton adaptive optics system, to be positioned on the RIG in front of the ELT beam. The entire WSS must further withstand earthquake quasi-static accelerations of 3 g in the y and z, and 2.16 g in the x (reference in red; Fig. 1) direction.
- **Height** – Due to the location of the ELT beam, the access platform of the RIG and the ELP plus CAS are designed to be at a height of ~6 m from the Nasmyth platform (Fig. 1).
- **Accuracy** – The CAS (Fig. 2) alignment accuracy and quasi-static stability requirements (<3 h) are 1 mm for x, y and z. The CAS alignment accuracy, quasi-static stability requirements (<3 h) rms dynamic stability requirements (<15 s) are 0.2 arcmin, 0.5 arcmin and 0.05 in Rx and Ry, and 6 arcmin, 7.5 arcmin and 1.5 in Rz. The alignment range is 50, 60 and 60 mm in x, y, and z, and 1.2, 1.3 and 1.3º in Rx, Ry and Rz.

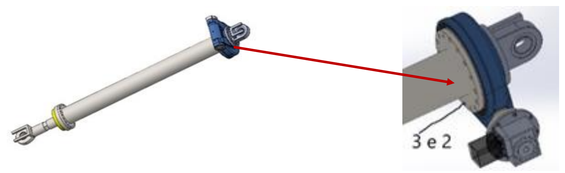

Fig. 2 – One arm of the CAS (movable hexapod) with detail of the indexation mechanism, gearbox and stepper motor.

- **Safety** – Additional safety requirements have been put in place. These include handrails on the stairway and access platform, foot protection, fixation points for safety harnesses, the fixation of tools and equipment, lifting eyes and clamps, fastener attachments to holding components, all complying with the European safety norms for staircases and walkways[2,3].

CHALLENGES

The 3 WSS substructures will be first separately assembled at each manufacturer location, then partially assembled in Lisbon. They will then be transported to The Netherlands, where a partial assembly/integration (without the ELP legs) of the WSS with METIS will take place. Finally, the WSS will be transported, along with the rest of the METIS components, to Chile, where a full METIS assembly/integration will take place.

Due to its large dimensions, its support load, as well as the long distances that need to be travelled, the WSS poses unique safety and engineering challenges.

- **Mass –** To keep the mass low, the RIG access structure will be built in aluminum. The asymmetric 7 leg ELP solution was found to be the sturdiest, least massive configuration. In addition, a significant part of the CAS arms consist of custom-made components, which brings down the mass.
- **Transport –** The stiff middle ring (~4 m side) will have to be transported in an oversized container. In addition, all the WSS substructure components need to be fixed to their containers, as well as have shock absorption that can withstand transport vibrations, 20 cm falls, and 1.3 g quasi-static earthquakes.
- **Assembly –** The cryostat and instruments must be hoisted above the CAS (>3 m) and lowered into position.
- **Integration** - The complete assembly of METIS requires an integration hall of at least 8 m height.

CONCLUSIONS

The Portuguese contribution to METIS is the construction of the support structure to the instrument, as well as access to the instrument for maintenance purposes. Coordinating the assembly and integration of the WSS onto METIS requires adopting extreme safety measures to protect the WSS itself, to protect the instruments that the WSS supports, as well as the protection of personnel that will be involved in the process.

REFERENCES

1. https://metis.strw.leidenuniv.nl/
2. EN-ISO 1422-2
3. EN-ISO 1422-3