

E-ELT Opportunities for Civil & Mechanical Engineering Companies

Alistair McPherson PM E-ELT

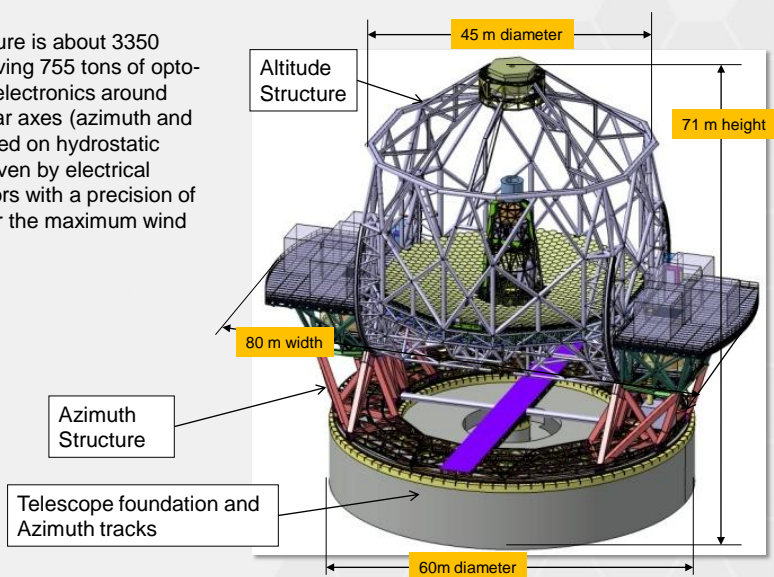


E-ELT Programme

Main Structure Design

General Overview

The Main Structure is about 3350 tons of steel moving 755 tons of opto-mechanics and electronics around two perpendicular axes (azimuth and altitude) supported on hydrostatic bearings and driven by electrical direct drive motors with a precision of 0.3 arcsec under the maximum wind disturbance.





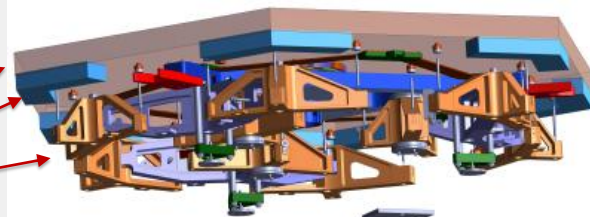
E-ELT Programme

E-ELT Primary Mirror

Segment Assembly (x1148)

[Movable and exchangeable part]

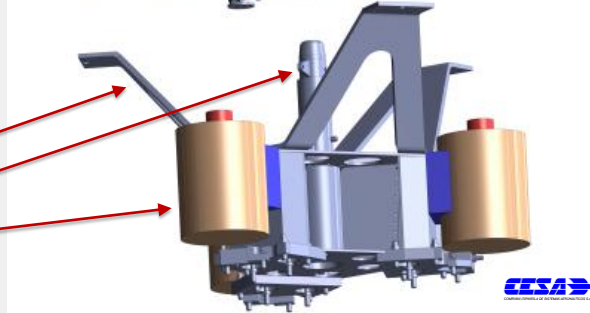
- Segment
- Edge sensors
- Segment Support (& Warping Harness)



Subcell (x984)

[Permanently attached to Main Structure]

- Fixed Frame
- Extractor
- Position Actuators



Note :

Same design for all Segment families

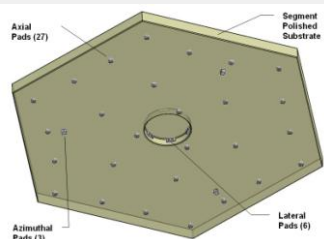


E-ELT Programme

E-ELT Primary Mirror

Segment

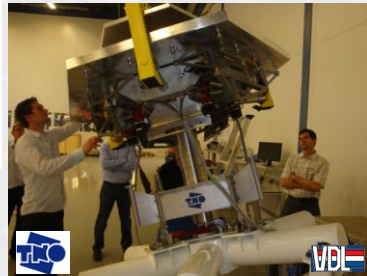
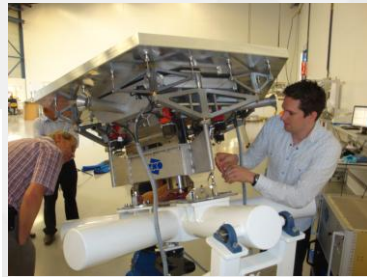
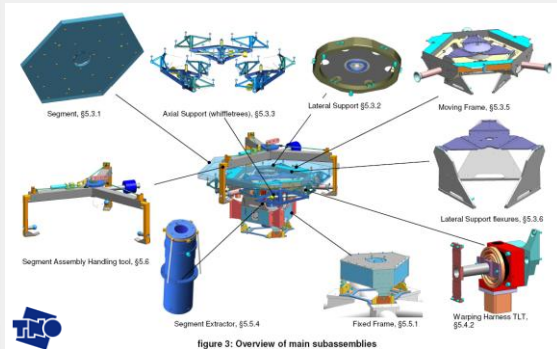
- Low CTE glass / glass ceramic
- 50 mm thick at center, back surface flat
- Back center hole $\phi 200$ mm, h 36 mm
- 27 axial invar pads
- 6 lateral invar pads
- 3 azimuthal invar pads
- Invar Pads Ni plated
- 12 Edge Sensor interfaces (Boron Nitride)
- Adhesive : Structural Epoxy and/or RTV





E-ELT Primary Mirror

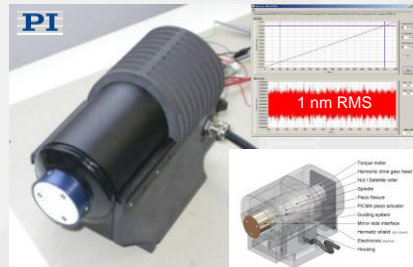
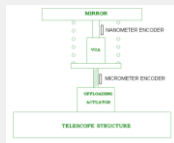
Segment Support - Alternative Design



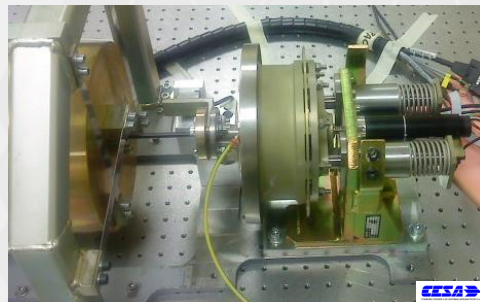
M1 Position actuators

Position Actuators

- Soft, 2 stage actuator
- Coarse Stage : brushless motor, gear box, lead screw
2 axial guides - Micron precision encoder – 15 mm stroke
- Fine Stage : voice coil actuator, two leaf springs
Nanometer precision encoder – +/- 5 micron stroke typical



Requirement	Unit	Spec
Stroke	mm	15
Stiffness [in 0-4 Hz range]	N/micron	12
Positioning error, tracking	nm RMS	1.7
Tracking velocity	$\mu\text{m} / \text{s}$	+/- 10
Slewing velocity	$\mu\text{m} / \text{s}$	+/- 250
Power consumption, average including electronics	W	< 2
Mass	kg	< 10
Bandwidth, update rate	Hz	30, 1000



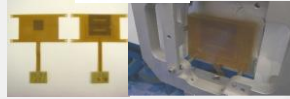


M1 Edge Sensors

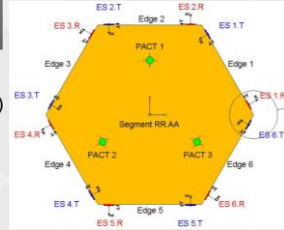
FOGALE nanotech

Edge Sensors

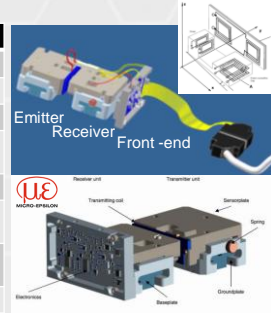
- 6 Emitters + 6 Receivers per Segment
- Inductive sensing technology :
Emitter & receiver Silver-palladium coils embedded in ceramic (Boron Nitride)
- Mechanics : casted low CTE Boron Nitride ceramic (metal free)
- Embedded low power (0.5W) front-end electronics for signal modulation, detection and digitization



Alternative coils engraved in Zerodur



Requirement	Piston		Gap & Shear
	Catching range	Measuring range	Measuring range
Range	± 1 mm	± 200 μ m	± 1 mm
Linearity	1 ± 10 %	1 ± 1 % (over ≤ 100 nm)	1 ± 1 % (over ≤ 1 mm)
Noise	-	≤ 1 nm/ $\sqrt{\text{Hz}}$ [goal 0.2]	≤ 1 μ m/ $\sqrt{\text{Hz}}$
Drift	-	< 10 nm/week [goal 2 nm]	< 10 μ m/week [goal 2 μ m]
Temperature sensitivity	-	$\Delta P/\Delta T \leq 5$ nm/ $^{\circ}\text{C}$	$\Delta G(S)/\Delta T \leq 5$ μ m/ $^{\circ}\text{C}$
Humidity sensitivity	-	$\Delta P/\Delta RH \leq 10$ nm/50%	$\Delta G(S)/\Delta RH \leq 10$ μ m/50%
Power dissipation	0.5 W / sensor max		

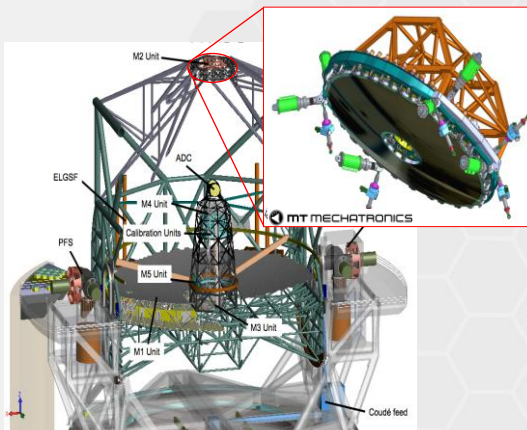


M2 unit

F/1.2 Convex Mirror 6-m diameter

- **Active positioning** – 5 DoF
Slewing
Step tracking
 Δz 0.7 mm for Gravity Invariant (GI)
- **Active shaping**
Correction for optical surface errors
No shape change for GI > M3
- **Polishing spec** : 30 nm RMS WFE (in active mode)

Characteristic	Value
Radius of curvature	-14488 mm
Conic constant	-2.564187
Useful area, outer	5692 mm
Useful area, inner	1561 mm
Aspheric departure	2.06 mm





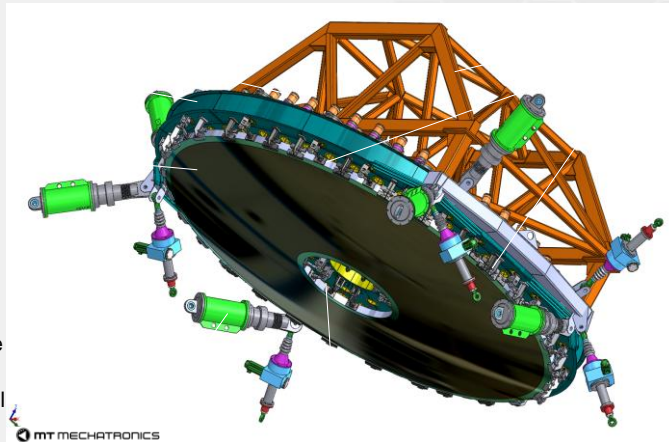
M2 unit

M2 Mirror

- Thin meniscus
- 6000 mm diameter
- 1700 mm centre hole
- 100 mm thick
- Interface with tripods

M2 Cell

- Hexapod Support
- Steel Backbeam Structure
- CFRP Box type mirror backplate
- Mirror Support :
 - 162 Pneumatic + Voice Coil actuators
 - 24 + 8 pneumatic lateral support
 - 24 Safety restrainers



mt MECHATRONICS

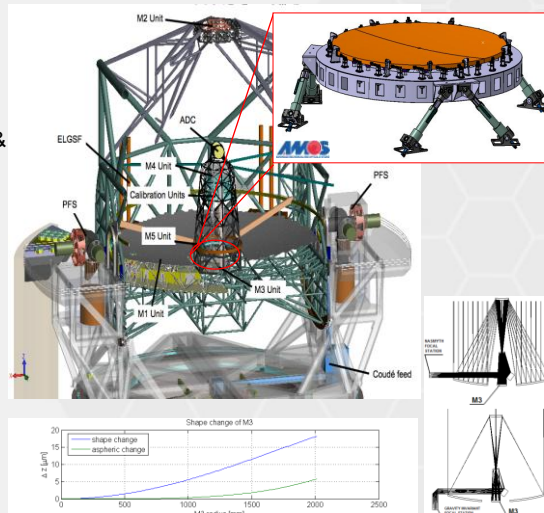


M3 unit

F/2.7 Concave Mirror 4-m diameter

- **Active positioning** – 5 DoF
Slewing, Tracking, Telescope control
 Δz 166 mm for Gravity Invariant (GI)
- **Active shaping**
Correction for optical surface errors & Telescope control
Change $< 20 \mu\text{m}$ PV for GI
- **Polishing spec** : 30 nm RMS WFE (in active mode)

Characteristic	Value
Radius of curvature	22120 mm
Conic constant	2 aspheric terms (r^4+r^6)
Useful area, outer	4032 mm
Useful area, inner	250 mm
Aspheric departure	0.04 mm





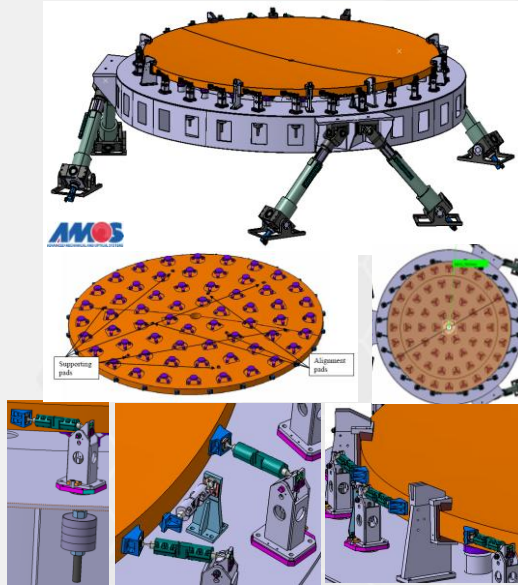
M3 unit

M3 Mirror

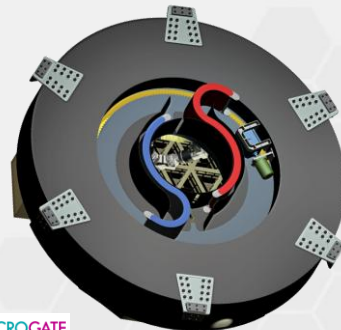
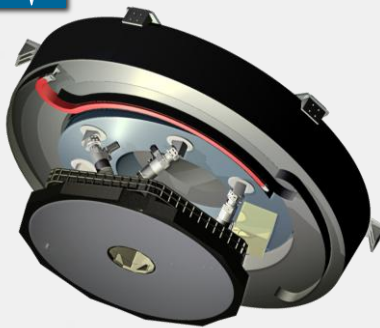
- Thin meniscus
- 4200 mm diameter
- 100 centre hole
- 100 mm thick
- Interface with tripods

M3 Cell

- Hexapod Support
- Steel Box type mirror backplate
- Mirror Support :
- 57 Pneumatic actuators
- 24 lateral astatic levers
- Fixed points (3axial, 3 lateral)
- 10 Safety restrainers – Radial & axial [Brackets, outer edge, 0.5 mm Gap]



M4 - Design 1



- 5928 contactless actuators in optical area
- 160 μm stroke
- 31.5 mm pitch, triangular pattern
- Segmented Zerodur 2mm thin shell (6 petals)
- External membrane frame
- Lightweighted CFRP Backplate
- Removable Actuator Brick design (228 bricks)
- On board M4 Adaptive Mirror electronics
- Remote M4 Control System electronics
- Flex joint hexapods for M4 Positioning System
- Large bearing + cable wrap for Nasmyth selector
- Mass: 9.9 tons
- Power: 8.4 kW



M4 – Design 1

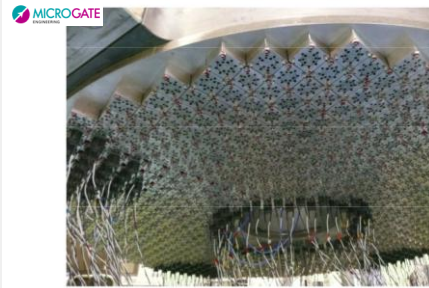
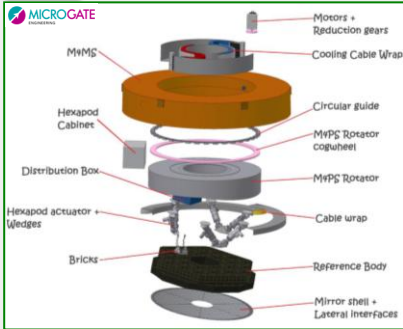
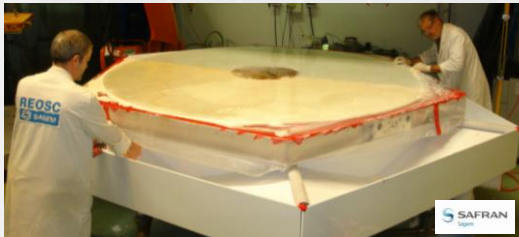
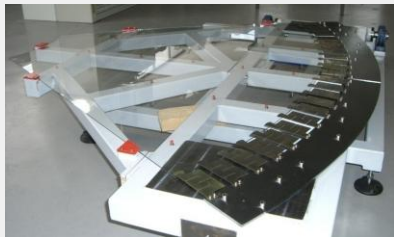


Figure 11: HV voltage cables connected to the active actuators (back side of the mirror)



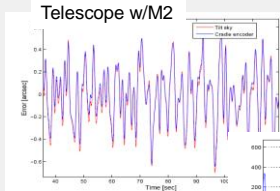
M5 Unit

Tip/Tilt flat mirror 3.0 x 2.5 m

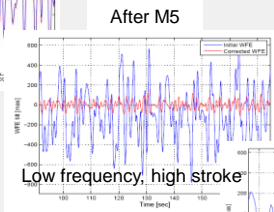
Incoming disturbance with 1" rms residual tip tilt

- Residual after M5 stabilisation, on sky tip-tilt:
 - < 0.07" rms (goal 0.06") over entire frequency range
 - < 0.004" rms for [9Hz to ∞] all peaks < 2σ

Telescope main axes control

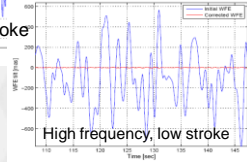


Remaining tip tilt < 1" rms

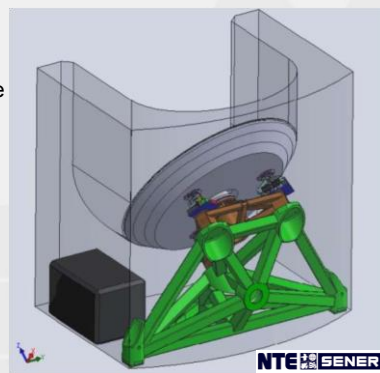


After M5

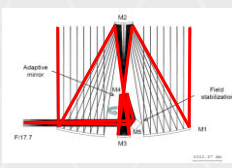
Low frequency, high stroke



High frequency, low stroke



After M5+ M4





E-ELT Programme

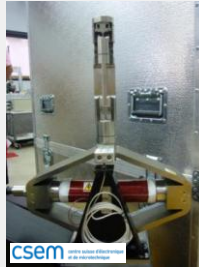
M5 Unit

Electromechanical Unit

3 axial pzt actuators 0.5 mm range – Membrane lateral support (membrane)



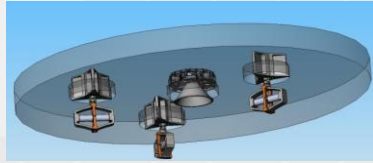
Scale 1 demonstrator



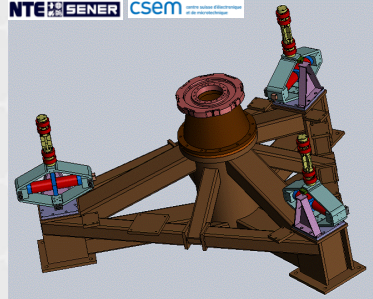
Axial support



Lateral support



Mirror and support system



Mounting frame



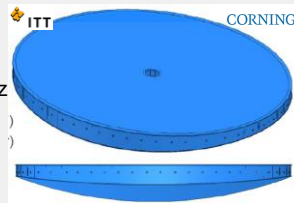
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M5 Unit

Mirror

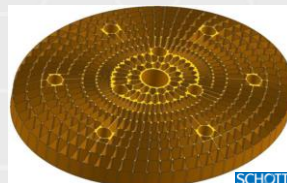
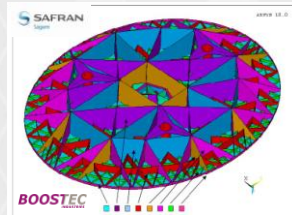
Monolithic - Ultra lightweight 60 kg/m² – 300 Hz

Requirement	Specified value
Mechanical	
Dimensions (clear ap.)	2388 x 2978 mm
Central hole (clear ap.)	151 x 183 mm
Thickness	300 mm (TBC wrt design)
Areal density	90 kg/m ² , 60 kg/m ² goal
First Eigenfrequency	~ 300 Hz
Optical (WFE)	
Optical quality (scale > 40 mm)	< 1 μm P-V
Static mode distortion (scale > 40 mm) (Additional : thermal, gravity)	< 500 nm RMS
Obs. mode distortion (scale > 40 mm)	< 200 nm RMS
Optical quality (scale < 40 mm)	<15 nm RMS



Closed-back ULE® Mirror with Abrasive Water Jet (AWJ) Lightweight Square Core – Low temperature fusion

SiC brazed petals with CVD SiC layer



Ultralightweight machined Zerodur® Substrate



Pre-focal Stations

2 Prefocal Stations

➤ Selection of focal station :

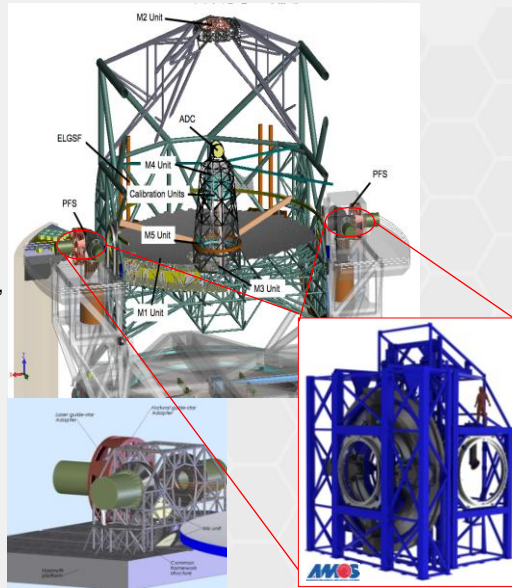
- Straight-through focus – 10 arcmin FoV
- Gravity Invariant focus - 10 arcmin FoV
- Lateral foci - 5 arcmin FoV
- Coudé focus – 20 arcsec FoV

➤ Wavefront sensing Natural Guide Stars :

- Fast high order WFS for adaptive optics, tracking, optical alignment & mirror shape control
- Slow high order WFS Segment Phasing and shape measurement

➤ Wavefront sensing Laser Guide Stars

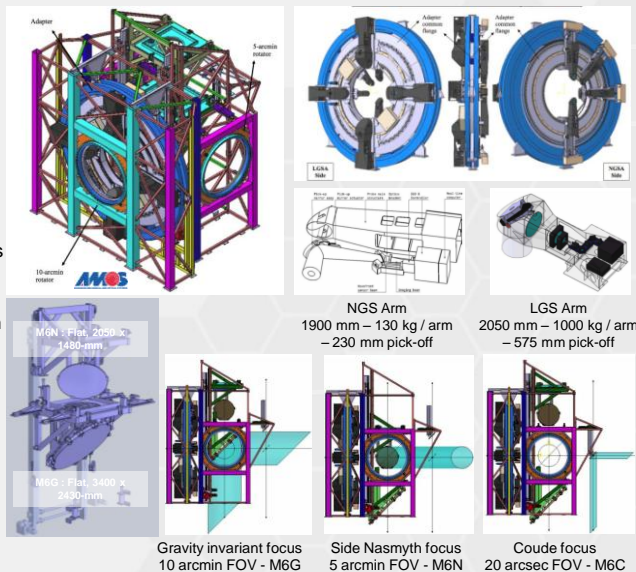
➤ Rotation of Instruments with weight up to 5 tons (4m x Ø 4m)



Pre-focal Stations

PFS Baseline

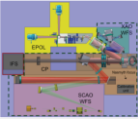
- Steel frame structure
- Two concentric adapters :
 - One for NGS – 4 arms (1+3)
 - One for LGS – 4 arms
- Instrument rotator on each port
- A folding mirror elevator for focus selection [M6G-M6N]
- A small Coudé folding mirror arm [M6C]
- Mass: approx. 55 t
- Total height 10.5 m
- Back focal distance : 750 mm



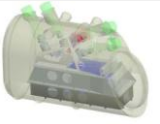


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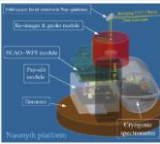
Platforms and Instruments



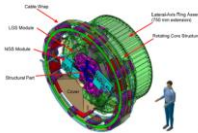
EPICS
Exo-planet imaging camera
and spectrograph



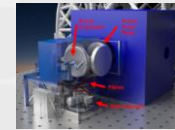
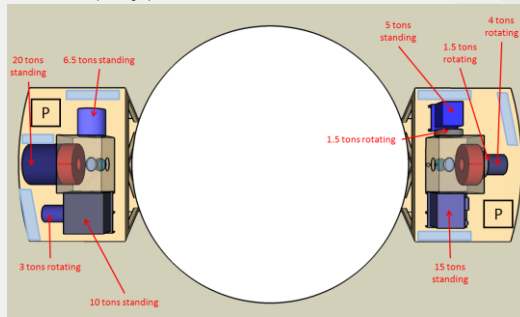
CODEX
high stability, high
resolution visible
spectrograph



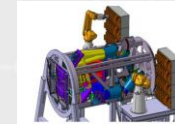
SIMPLE
high resolution NIR
spectrograph



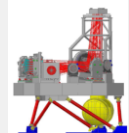
ATLAS: Laser Tomography AOA
module



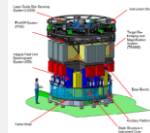
OPTIMOS-EVE
optical-Hband fibre MOS



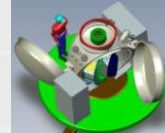
OPTIMOS-DIORAMAS
a wide field imaging multi-slit
spectrograph



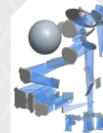
MAORY
Multi-conjugate AO



EAGLE
Wide-field multi-IFU
AO assisted NIR
spectrograph



MICADO
Diffraction-limited NIR
Camera



METIS
Mid-infrared ELT
Imager and
Spectrograph



HARMONI
Single field, wide
band IFU, NIR
spectrometer



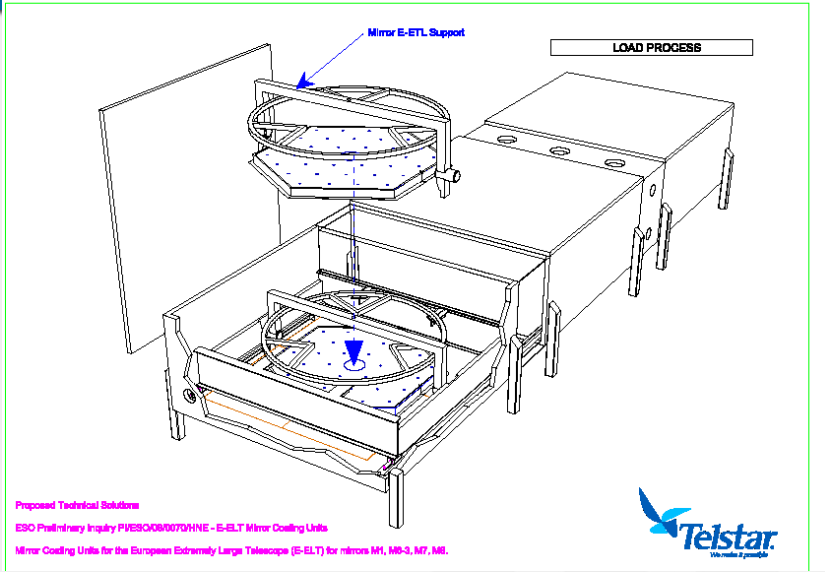
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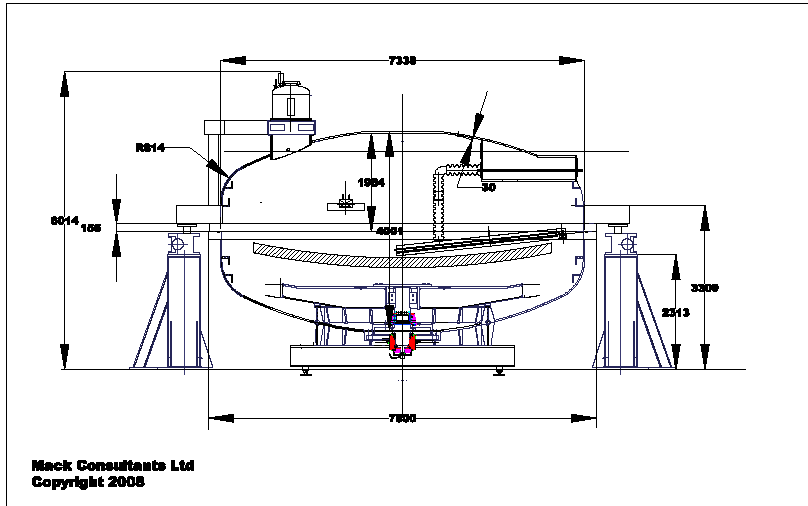
Coating Plants

- Primary Mirror Segments
- M2 – 6m
- M3 – 4m
- M5 2.5 * 3m
- M4 Segments
- M6.....

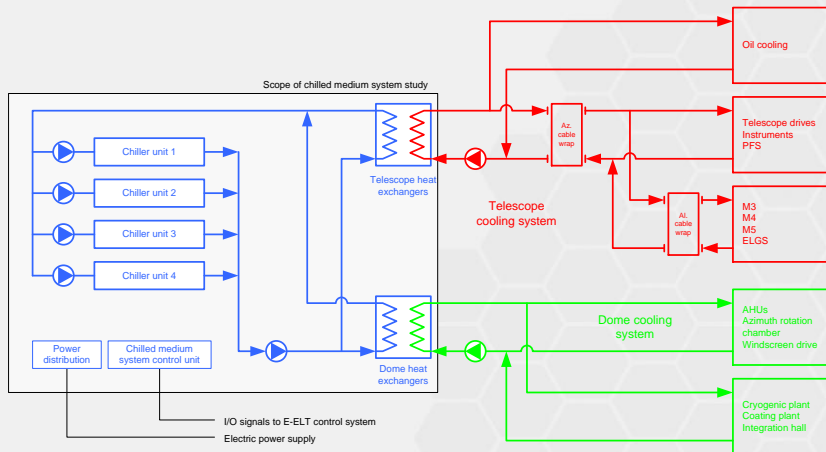


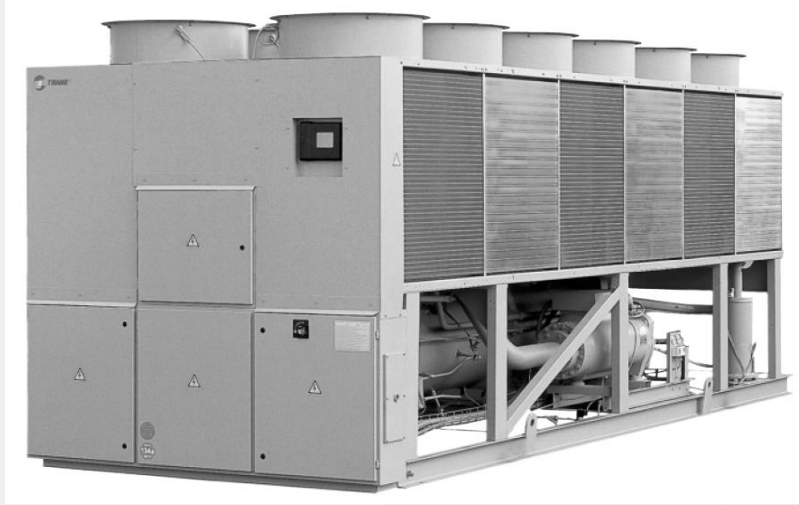
Coating Plants



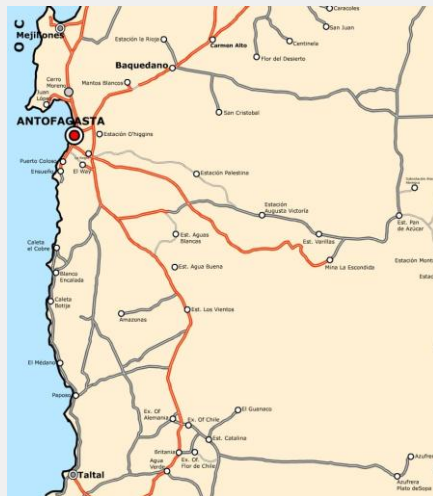


Chillers





Slide 29





Paranal



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Slide 32



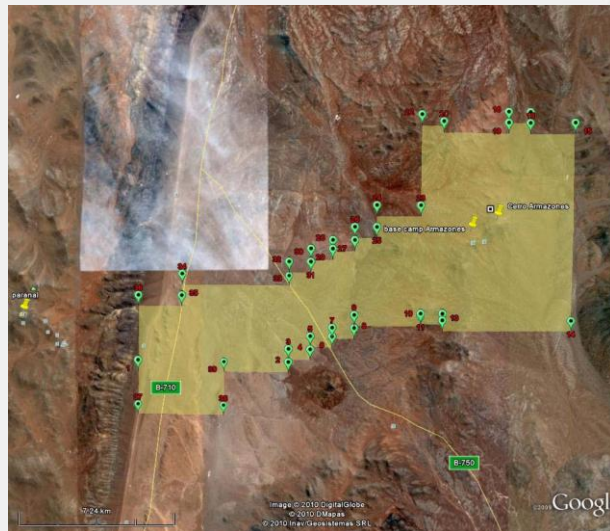
Power System

- Power from Grid
- Stand-by Power
- Distribution within Site

Slide 33



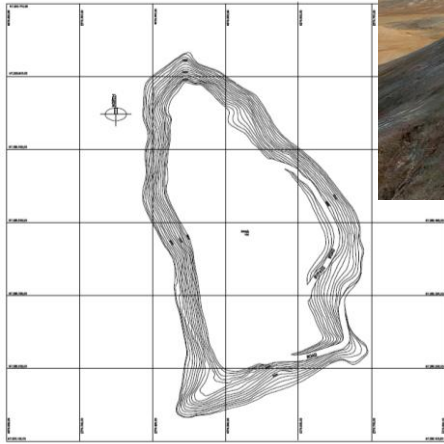
Route of Road



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E-ELT Programme



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