



Science drivers

- Planets in other stellar systems**
 - Imaging *and* spectroscopy
 - The quest for Earth-like exo-planets*
- Stellar populations**
 - In galaxies inaccessible today (e.g. ellipticals in Virgo cluster)
 - Across the whole history (i.e. extent) of the Universe
- Cosmology**
 - The first stars/galaxies
 - Direct measure of deceleration
 - Evolution of cosmic parameters
 - Dark matter, dark energy
 - Tests of GR around black holes
- The unknown**
 - Open new parameter space



Science → Requirements

- **Diameter:** $\geq 39\text{m}$ (area $\geq 1000\text{ m}^2$)
 - Alt-Az, F/15 to F/18, fully steerable (0-360,0-90). Operational ZD: 0-70
- **Adaptive telescope**
 - GLAO correction (≥ 5 arcmin, 90% sky, 80% time)
 - better than 2x FWHM improvement for median seeing conditions
 - Post-focal: SCAO, MCAO, LTAO, ExAO, MOAO, ...
- **Science field of view:**
 - 10 arcmin unvignetted. Diffraction limited by design
 - 5 arcmin unobscured by guide probes
- **Wavelength range:** 0.3 – 24 μm
- **Transmission @Nasmyth:**
 - $>50\%$ at $>0.35\text{ }\mu\text{m}$, $>60\%$ at $>0.4\text{ }\mu\text{m}$, $>70\%$ at $0.7\text{ }\mu\text{m}$, $>80\%$ at $>1\text{ }\mu\text{m}$
- **Focal stations**
 - Two Nasmyth (multiple instruments, including gravity invariant option)
 - At least one Coudé
 - Fixed instrumentation (fast switching: < 10 min same focus, < 20 otherwise)



Where ?

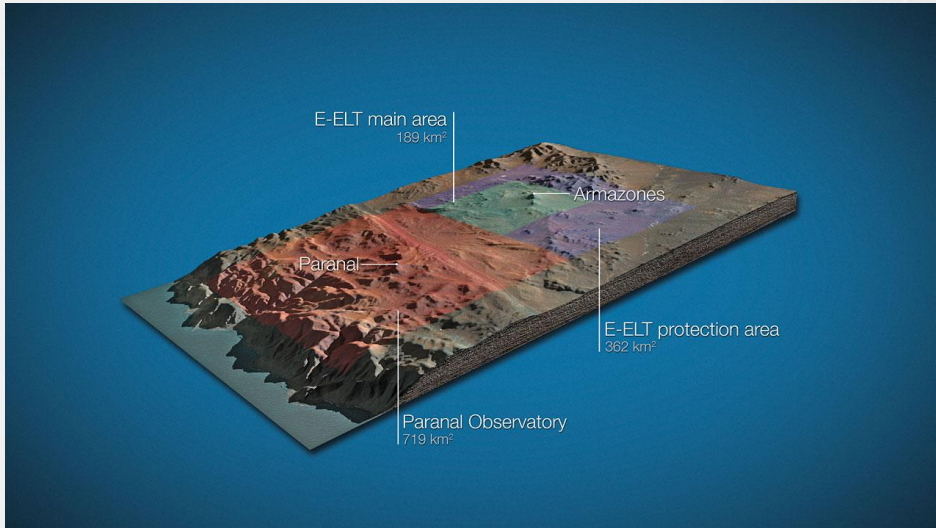
- Cerro Armazones, 2800 m, 25 km from Cerro Paranal [VLT]



E-ELT Design Status - November 2010 Slide 4



Cerro Armazones



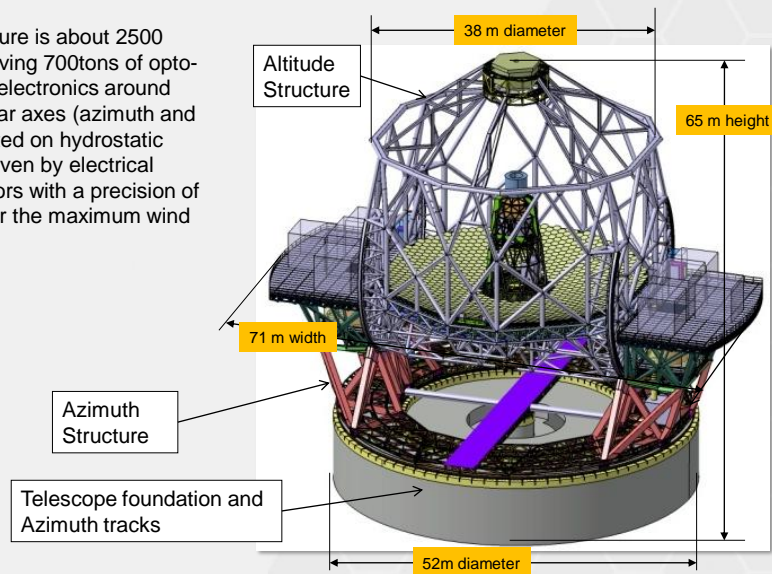
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Main Structure Design

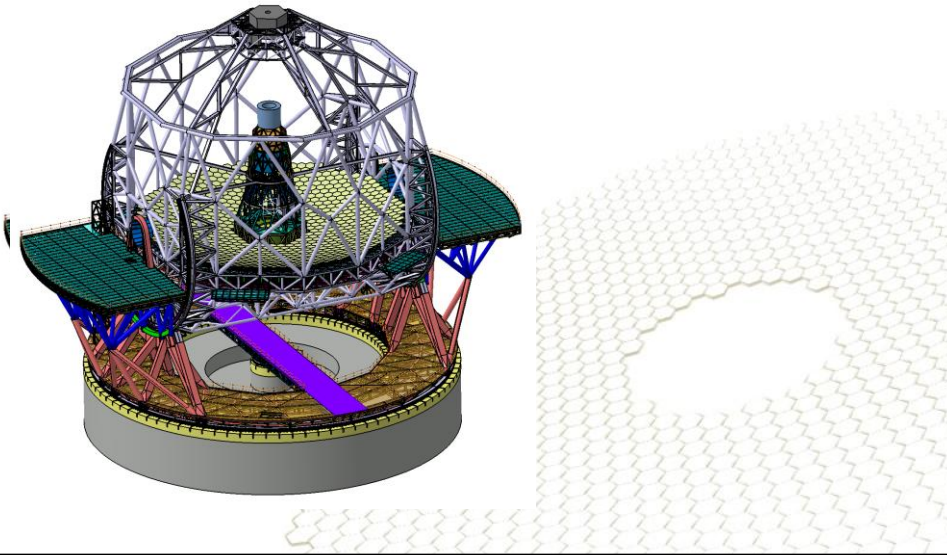
General Overview

The Main Structure is about 2500 tons of steel moving 700 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.





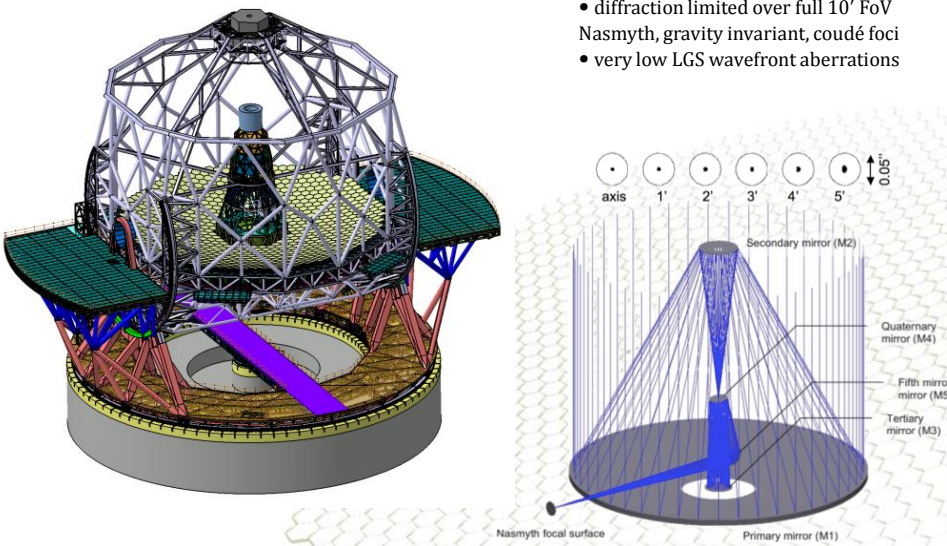
The E-ELT: overview



The E-ELT: overview

Optical design

- 3-mirror anastigmat on axis + 2 flats
- diffraction limited over full 10' FoV
- Nasmyth, gravity invariant, coudé foci
- very low LGS wavefront aberrations

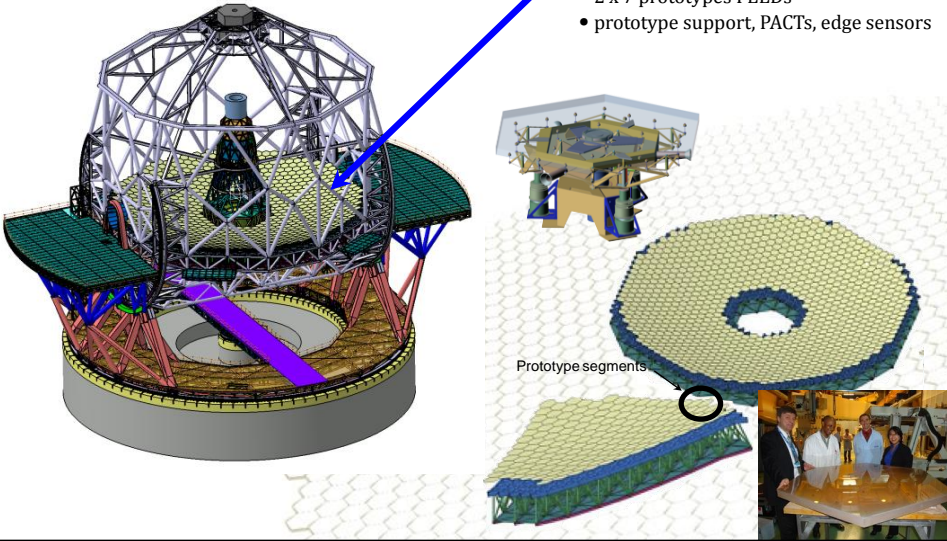




The E-ELT: overview

39m Primary Mirror

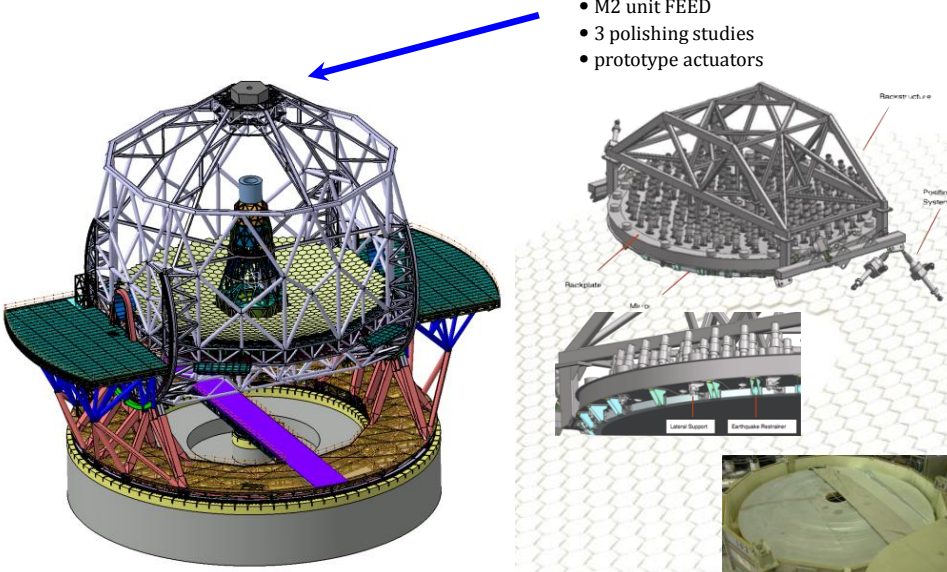
- 786 segments mirror +1/family
- 2 x 7 prototypes FEEDs
- prototype support, PACTs, edge sensors



The E-ELT: overview

4m Secondary Mirror

- M2 unit FEED
- 3 polishing studies
- prototype actuators

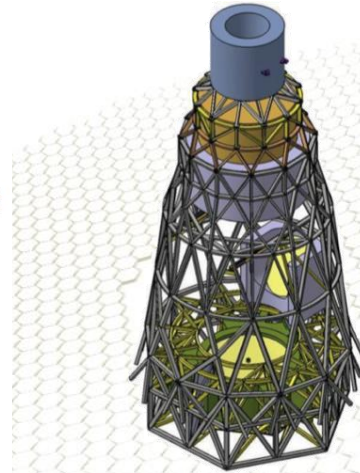
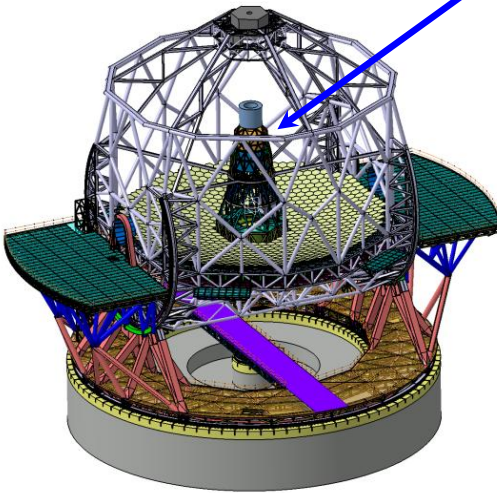




The E-ELT: overview

Central tower

- ADC volume
- Adaptive M4
- Field stabilization M5
- M3



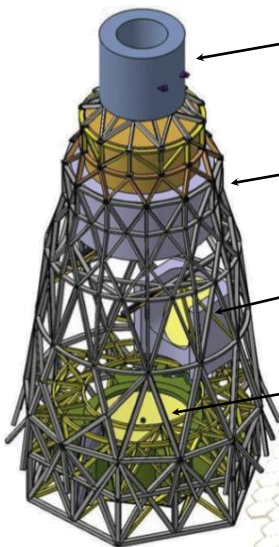
The E-ELT: overview

ADC volume

M4 mirror

M5 mirror

M3 mirror

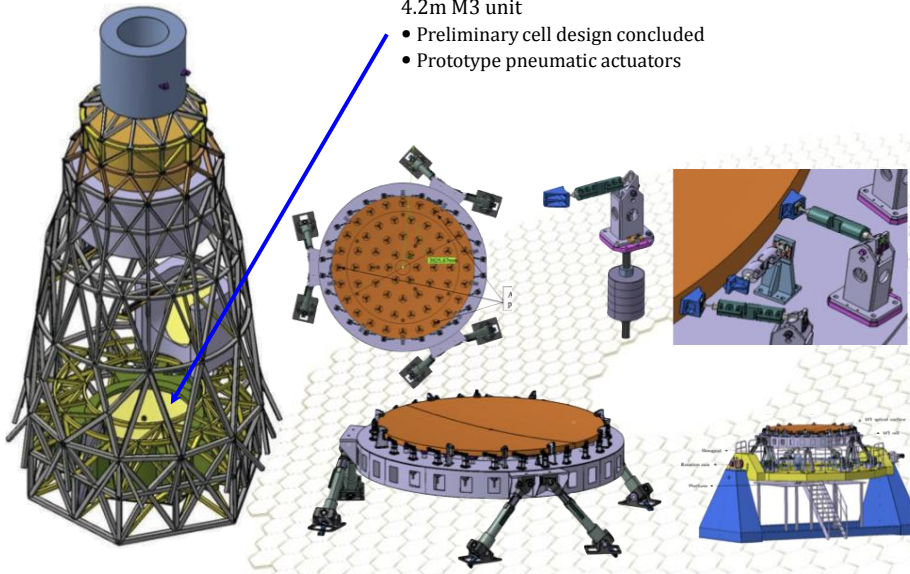




The E-ELT: overview

4.2m M3 unit

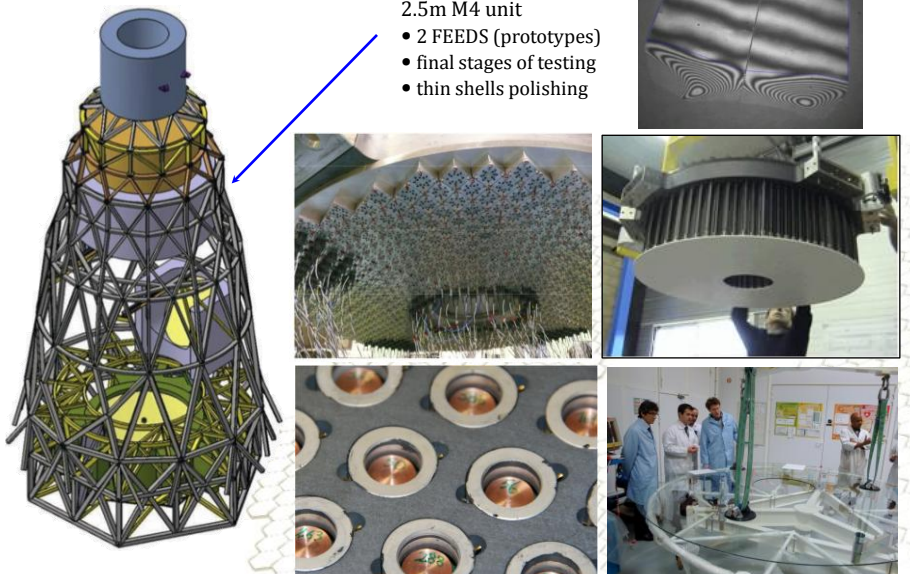
- Preliminary cell design concluded
- Prototype pneumatic actuators



The E-ELT: overview

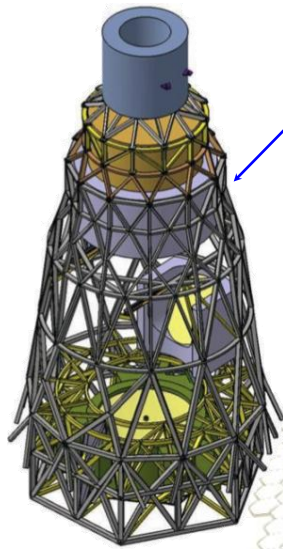
2.5m M4 unit

- 2 FEEDS (prototypes)
- final stages of testing
- thin shells polishing





The E-ELT: overview



2.4m x 3m M5 unit

- scale-1 electromechanical prototype FEED
- final stages of testing
- 4 mirror polishing studies (including heavy option)



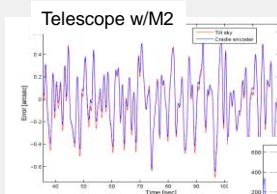
M5 Unit

Tip/Tilt flat mirror 3.0 x 2.5 m

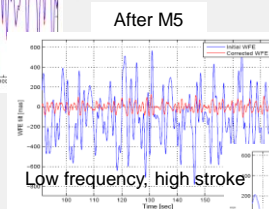
Incoming disturbance with 1" rms residual tip tilt

- 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

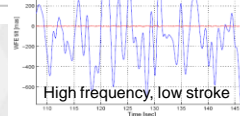
Telescope main axes control



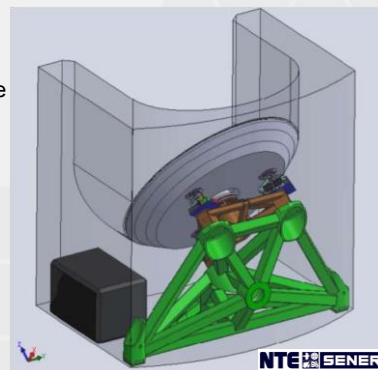
Remaining tip tilt < 1" rms



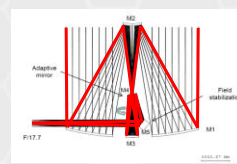
Low frequency, high stroke



High frequency, low stroke



After M5+ M4

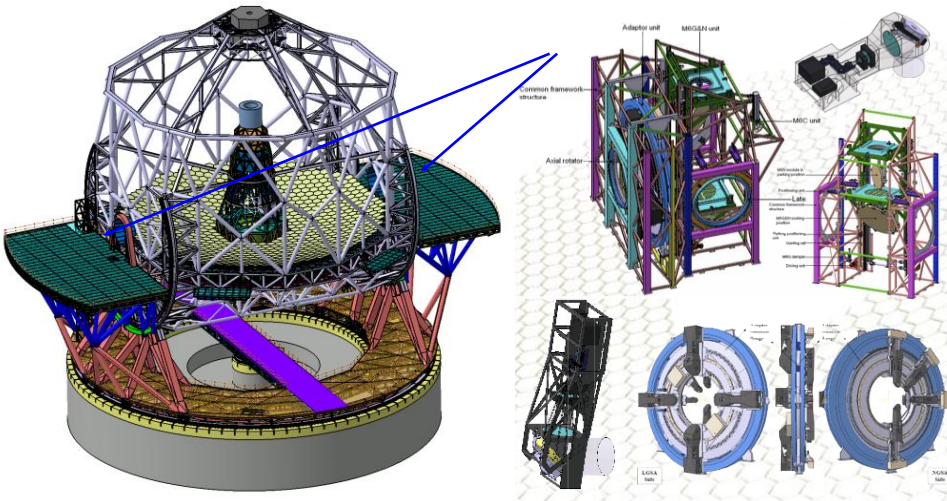




The E-ELT: overview

Prefocal station

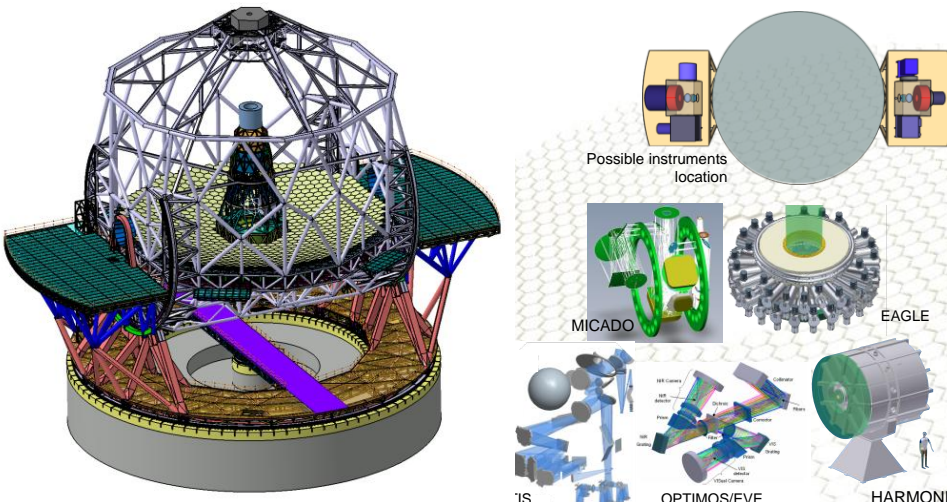
- preliminary design concluded



The E-ELT: overview

Instrumentation

- 8 instrument concepts Phase A concluded
- 2 post-focal AO modules Phase A concluded





The E-ELT: overview

Instrumentation

- 8 instrument concepts Phase A concluded
- 2 post-focal AO modules Phase A concluded

First Light Instruments

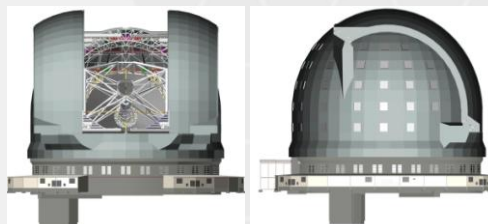


Dome

Scope

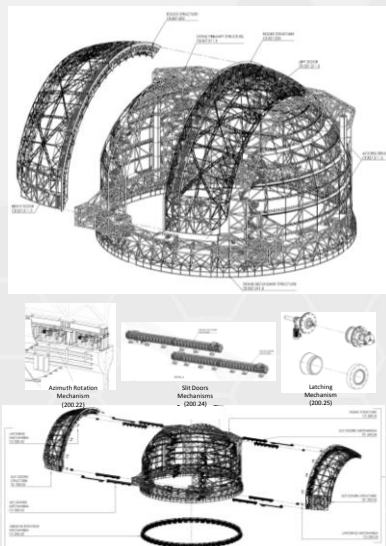
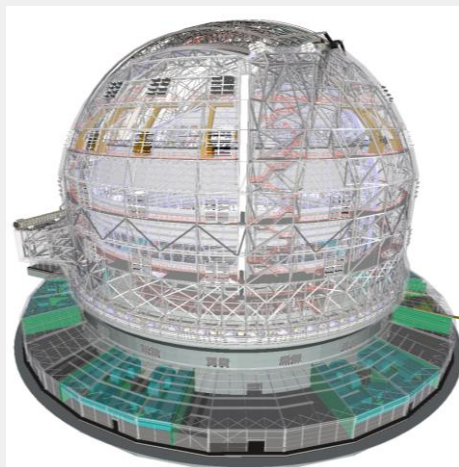
Dome contains:

- the primary and secondary steel structures
- the concrete foundations for the dome and the main structure
- all mechanisms for the rotation and operation
- louvers, windscreen, ventilation and air-conditioning
- storage areas required within the dome and general access facilities such as staircases, platforms, elevators, cranes etc.
- all auxiliary installation like electrical equipment, thermal control equipment, lighting facilities etc.
- the hardware and software for the local control of the dome functions.





Dome



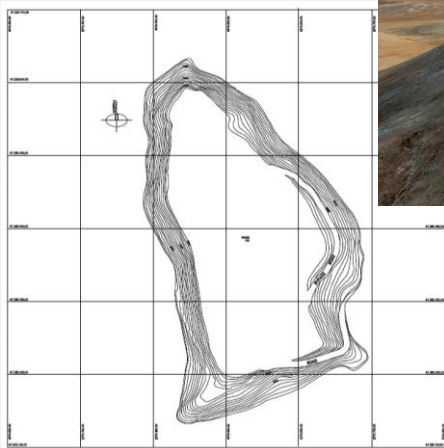
E-ELT Phase B Final Review, September 22nd 2010

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Areas of Interest for Industry

- Electronics and IT
 - Detectors
 - Control Electronics
 - Safety & Interlocks
 - Software
 - IT Hardware
- Infrastructure
 - 4 MW Stand-by Power Generation
 - Coating Plant for 1.4m segments
 - Coating facility for large mirrors (6m diameter)
 - Handling equipment





Areas of Interest for Industry

- Mechanical Engineering
 - Steel Structures
 - Actuation & Metrology
- Civil Engineering
 - Dome civil construction
 - Civil Works
 - Roads & Infrastructure
 - Consultancy
- Optics
 - Small Optics
 - Large Optics
 - Coatings

Slide 33



Areas of Interest for Industry

- Cryogenics & HVAC
 - Cryogenic storage and handling
 - Compressors & Cooling Engines
 - Vacuum Equipment

Slide 34



Up-coming Contracts

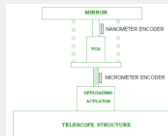
- Road Construction And Platform Preparation
- Final Design and Manufacture of M4 Unit
- Final Design and Construction of Dome
- Final Design and Construction of Main Structure
- Procurement of 5000 Edge Sensors
- Procurement of 2600 Primary Mirror Segment Actuators

Slide 35

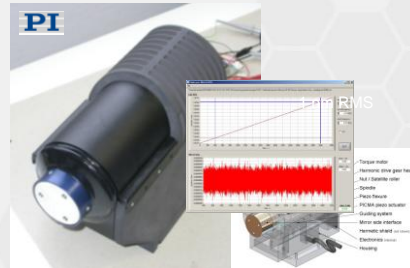


Position Actuators

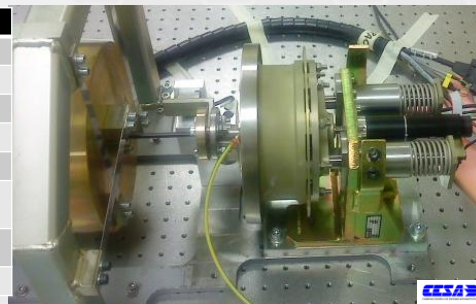
- Soft, 2 stage actuator
- Coarse Stage : brushless motor, gear box, lead screw
2 axial guides - Micron precision encoder – 15 mm stroke
- Fine Stage : voice coil actuator, two leaf springs
Nanometer precision encoder – +/- 5 micron stroke typical



M1 Position actuators



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

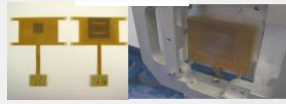




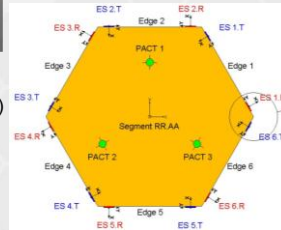
M1 Edge Sensors

Edge Sensors

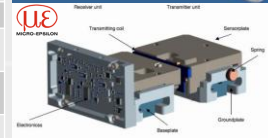
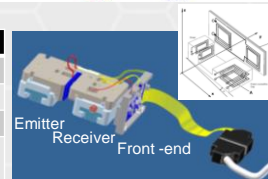
- 6 Emitters + 6 Receivers per Segment
- Inductive sensing technology :
Emitter & receiver Silver-palladium coils embedded in ceramic (Boron Nitride)
- Mechanics : casted low CTE Boron Nitride ceramic (metal free)
- Embedded low power (0.5W) front-end electronics for signal modulation, detection and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



- November 2010



Questions



Alistair McPherson PM E-ELT