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 acceleration
- Evolution of cosmic parameters
- Dark matter, dark energy
- Tests of GR around black holes

The unknown
- Open new parameter space
Science ➔ Requirements

- Diameter: ≥39m (area ≥ 1000 m²)
  - 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 μm, >60% at >0.4 μm, >70% at 0.7 μm, >80% at > 1 μm
- 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]
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

Telescope foundation and Azimuth tracks

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.

Main Structure Design
General Overview

Altitude Structure
Azimuth Structure
Telescope foundation and Azimuth tracks

38 m diameter
71 m width
65 m height
52 m diameter
The E-ELT: overview

39m Primary Mirror
- 786 segments mirror +1/family
- 2 x 7 prototypes FEEDs
- prototype support, PACTs, edge sensors

Prototype segments

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

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Unit</th>
<th>Spec</th>
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</thead>
<tbody>
<tr>
<td>Stroke</td>
<td>mm</td>
<td>15</td>
</tr>
<tr>
<td>Stiffness [in 0-4 Hz range]</td>
<td>N/micron</td>
<td>12</td>
</tr>
<tr>
<td>Positioning error, tracking</td>
<td>mm RMS</td>
<td>1.7</td>
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<tr>
<td>Tracking velocity</td>
<td>μm / s</td>
<td>+/- 10</td>
</tr>
<tr>
<td>Slewing velocity</td>
<td>μm / s</td>
<td>+/- 250</td>
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<tr>
<td>Power consumption, average</td>
<td>W</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>including electronics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>kg</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Bandwidth, update rate</td>
<td>Hz</td>
<td>30, 1000</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Piston</th>
<th>Gap &amp; Shear</th>
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</thead>
<tbody>
<tr>
<td>Catching range</td>
<td>± 1 mm</td>
<td>± 1 mm</td>
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<tr>
<td>Measuring range</td>
<td>± 200 μm</td>
<td>± 1 mm</td>
</tr>
<tr>
<td>Linearity</td>
<td>1 ± 10 %</td>
<td>1 ± 1 % (over ≤100 nm)</td>
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<tr>
<td></td>
<td>± 1 mm/√Hz</td>
<td>± 1 μm/√Hz (goal 0.2)</td>
</tr>
<tr>
<td>Noise</td>
<td>-</td>
<td>≤ 10 nm/week (goal 2 nm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 10 μm/week (goal 2 μm)</td>
</tr>
<tr>
<td>Temperature sensitivity</td>
<td>-</td>
<td>ΔPI/ΔT ≤ 5 nm/°C</td>
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<tr>
<td></td>
<td></td>
<td>ΔG(S)/ΔT ≤ 5 μm/°C</td>
</tr>
<tr>
<td>Humidity sensitivity</td>
<td>-</td>
<td>ΔP/ΔRH ≤ 10 mm/50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ΔG(S)/ΔRH ≤ 10 μm/50%</td>
</tr>
<tr>
<td>Power dissipation</td>
<td></td>
<td>0.5 W / sensor max</td>
</tr>
</tbody>
</table>

The E-ELT: overview

4 m Secondary Mirror
- M2 unit FEED
- 3 polishing studies
- Prototype actuators
The E-ELT: overview

Central tower
- ADC volume
- Adaptive M4
- Fieldstabilization 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

Remainder tip tilt < 1" rms

Telescope w/M2

After M5

Low frequency, high stroke

After M5+ M4

High frequency, low stroke
The E-ELT: overview

Prefocal station
- preliminary design concluded

Instrumentation
- 8 instrument concepts Phase A concluded
- 2 post-focal AO modules Phase A concluded
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.
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 (4m diameter class)
  - 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

Areas of Interest for Industry

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

- Road Construction And Platform Preparation
- Final Design and Construction of Dome
- Final Design and Construction of Main Structure
- Procurement of 6000 Edge Sensors
- Procurement of 3000 Primary Mirror Segment Actuators
- Procurement of Power Supply