Building a Giant

On a mountain in the Atacama Desert in northern Chile, ESO, the European Southern Observatory, is constructing the Extremely Large Telescope (ELT). It will be the largest telescope of its kind ever built.

The telescope’s main mirror will have a diameter almost half the length of a soccer pitch. The ELT will on its own gather more light than all the existing large research telescopes on the planet combined, and 100 million times more light than the human eye. It will provide images 15 times sharper than those from the NASA/ESA Hubble Space Telescope.

The ELT will be housed in a huge dome the size of a stadium. But it differs from a stadium in important ways — not only does it have to open and close, but it also has to rotate with high accuracy to track celestial objects.

The ELT, with a main mirror 39.3 metres in diameter, will be by far the largest optical/near-infrared telescope in the world, and will dwarf all other telescopes, either existing, under construction or planned for the next decade.
The Extremely Large Telescope is being built on Cerro Armazones in the Atacama Desert, at 3046 metres altitude and just 23 kilometres from the site of ESO’s Very Large Telescope (VLT) at Paranal.
The World’s Biggest Eye on the Sky

The ELT has an unusual optical design based on a novel five-mirror scheme that results in exceptional image quality coupled with a wide field of view (one third of the width of the full Moon).

Adaptive mirrors, as components of both the telescope and its instruments, will compensate for the fuzziness in images introduced by atmospheric turbulence. One of these, the telescope’s fourth mirror, or M4, will be very thin and supported by more than 5000 actuators that adjust its shape up to a thousand times a second.

The telescope will be equipped with giant instruments to analyse the light that it captures. They are currently under development at institutes around Europe and will be mounted on a platform so big it could support one of the Unit Telescopes of the Very Large Telescope.

The contract for the ELT telescope and dome is the largest ever placed for a ground-based telescope.
Five-mirror design:

1. Main mirror 39.3 metres diameter.
2. Secondary mirror. Largest secondary (and largest convex) mirror ever produced.
3. Tertiary mirror.
4. Adaptive fourth mirror.
5. Rapid tip-tilt fifth mirror.

First-generation instruments:

HARMONI, an integral-field spectrograph used to explore galaxies in the early Universe, study the constituents of the local Universe and characterise exoplanets in great detail.

MAORY, an adaptive-optics module designed to help compensate for distortions caused by turbulence in the Earth’s atmosphere.

METIS, a mid-infrared imager and spectrograph, will focus on exoplanets, protoplanetary discs, Solar System bodies, active galactic nuclei, and high-redshift galaxies.

MICADO, the first dedicated imaging camera for the ELT, will be comparable to the James Webb Space Telescope, but with six times the resolution.
Preparing for a Revolution

Milestones

- October 2011: Agreement with Chilean Government on land for the ELT.
- June 2012: ELT Programme approved by ESO Council.
- June 2014: Ground-breaking ceremony.
- September 2015: Agreements for first-generation instruments.
- May 2016: Contract for dome and telescope structure.
- May 2017: First stone ceremony on Cerro Armazones.
2017: Contracts for main mirror.

2020: First main mirror segment completed.

2023: Dome and telescope structure complete.

2024: Last segment of main mirror completed.

Late 2024: First light of ELT.

2025: First light of science instruments.

The highest mountain in this spectacular landscape is Cerro Armazones, future home of the Extremely Large Telescope.
Thinking Big. Aiming High.

With first light targeted for late 2024, the Extremely Large Telescope will address many of the most pressing unsolved questions in astronomy. Thanks to its size and suite of front-line instruments, it may eventually revolutionise our perception of the Universe, much as Galileo’s telescope did 400 years ago.
## ELT Facts

<table>
<thead>
<tr>
<th>Name</th>
<th>Extremely Large Telescope</th>
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<tbody>
<tr>
<td>Site</td>
<td>Cerro Armazones, northern Chile</td>
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<tr>
<td>Altitude</td>
<td>3046 metres</td>
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<tr>
<td>Enclosure</td>
<td>Hemispherical dome</td>
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<tr>
<td>Type</td>
<td>Optical/near-infrared giant segmented-mirror telescope</td>
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<tr>
<td>Optical design</td>
<td>Five-mirror design — three-mirror on-axis anastigmat + two mirrors used for adaptive optics</td>
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| Diameter. Primary M1  | 39.3 metres (798 hexagonal 1.4-metre segments, with 4608 edge sensors — the most accurate sensors ever in a telescope (a few nanometres accuracy) |
| Diameter. Secondary M2| 4.2 metres                |
| Diameter. Third M3    | 4.0 metres                |
| Diameter. Fourth M4   | 2.40-metre thin adaptive mirror with more than 5000 actuators |
| Diameter. Fifth M5    | 2.7 × 2.1-metre rapid tip-tilt mirror |
| Laser Guide Stars     | Up to 8                   |
| Mount                 | Altazimuth fork mount     |
| First Light date      | Late 2024                 |
| Telescope weight      | 3000 tonnes               |
| Dimensions of dome    | 80 metres high × 85 metres wide |
The ELT may be the first telescope to enable us to identify life beyond the Solar System, at long last answering one of humanity’s most fundamental questions.

The ELT will discover and study planets with masses as low as the Earth’s in the habitable zone, by making precise measurements of the wobbling motion of stars perturbed by the planets in orbit around them. The ELT will also be able to obtain direct images of larger planets and via high-resolution spectroscopy characterise the atmospheres of transiting planets — and possibly find the telltale biomarkers indicating that there may be life present on those planets.

The ELT’s suite of instruments will allow astronomers to probe the earliest stages in the formation of planetary systems and to study protoplanetary discs around stars in the making.
The First Objects in the Universe

By probing the most distant objects the ELT will provide vital clues to help us understand the formation of the first objects in the Universe — primordial stars, primordial galaxies and black holes — and learn how they are related.

Studies of extreme objects like black holes will benefit from the power of the ELT to provide greater insight into time-dependent phenomena.

The ELT is designed to carry out detailed studies of the first galaxies and to follow their evolution through cosmic time.

The ELT will be a unique tool for making an inventory of the changing abundances of the elements in the Universe with time, and for understanding the history of star formation in galaxies.

The ELT has the potential to make a direct measurement of the acceleration of the Universe’s expansion, a measurement that would have a major impact on our understanding of the Universe.

The ELT will also search for possible variations with time of the fundamental physical constants. An unambiguous detection of such variations would have far-reaching consequences for the basic laws of physics.
ESO, the European Southern Observatory, carries out an ambitious programme focused on the design, construction and operation of powerful observing facilities for astronomy to enable discoveries at the forefront of science. ESO, which is supported by 16 countries, operates the La Silla Observatory, the Paranal Observatory and the Atacama Large Millimeter/submillimeter Array (ALMA) (with intercontinental partners in North America, and East Asia). Publication statistics show that ESO is the most productive ground-based observatory in the world.