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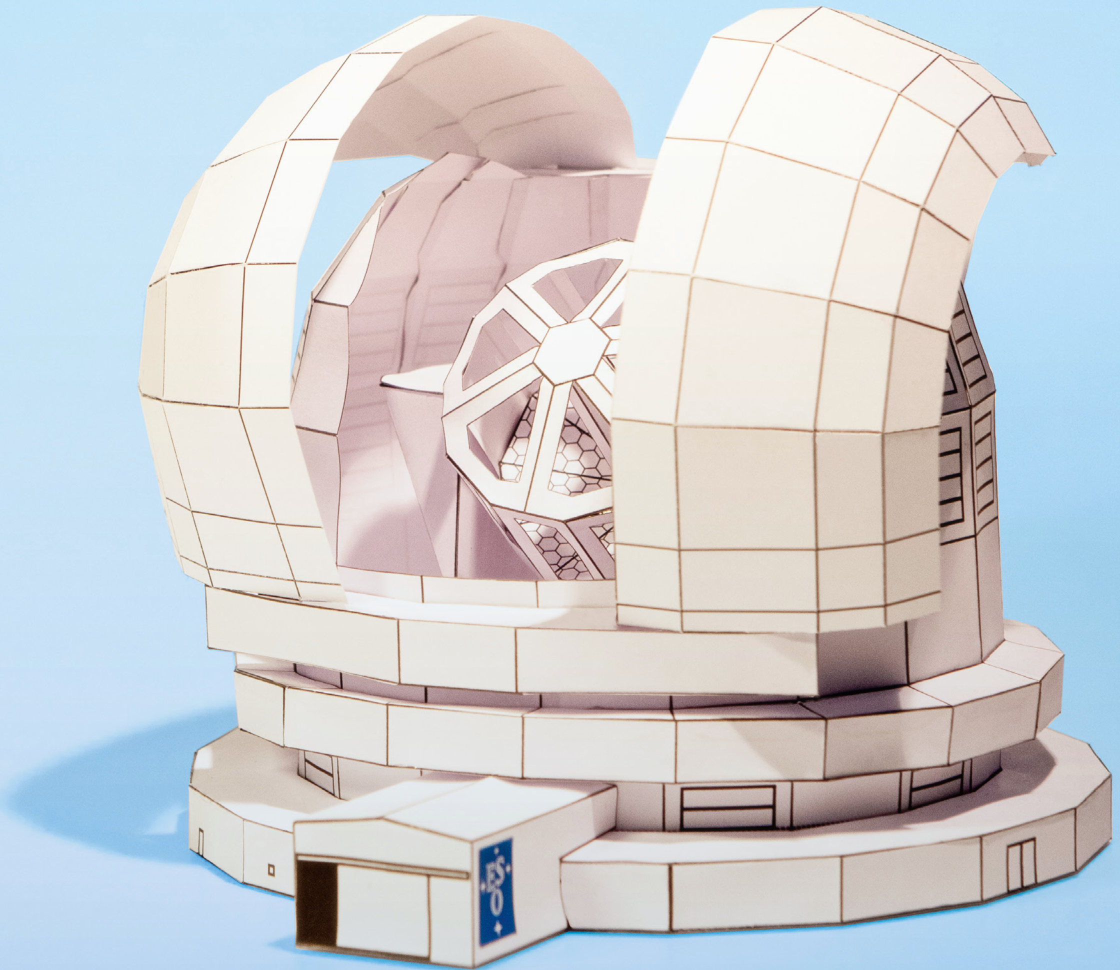


Paper model of ESO's Extremely Large Telescope (ELT)

Building instructions

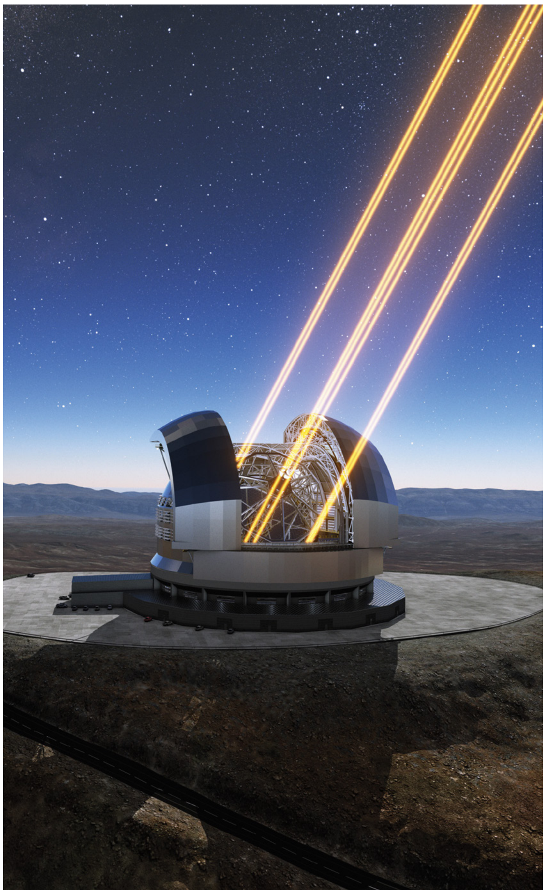
The European Southern Observatory

The European Southern Observatory (ESO) enables scientists worldwide to discover the secrets of the Universe for the benefit of all. We design, build and operate world-class observatories on the ground — which astronomers use to tackle exciting questions and spread the fascination of astronomy — and promote international collaboration in astronomy. An intergovernmental organisation supported by 16 Member States and two partner countries, ESO has headquarters in Germany and operates three observing sites in Chile.

A revolutionary telescope

The past decade has brought astronomical revelations that have excited people from all walks of life, from finding planets around Proxima Centauri, the nearest star to the Sun, to producing the first image of a black hole. On a mountain in the Atacama Desert in Chile, the European Southern Observatory (ESO) is building a telescope that will revolutionise astronomy for decades to come. ESO's Extremely Large Telescope (ELT) will dramatically change what we know about our Universe and make us rethink our place in the cosmos.

When it starts operating later this decade, the ELT will track down Earth-like planets around other stars, and could become the first telescope to find evidence of life outside of our Solar System. It will also probe the furthest reaches of the cosmos, revealing the properties of ancient galaxies and the nature of the dark Universe. On top of this, astronomers are expecting the unexpected with the ELT — there are many unimaginable discoveries that will push the boundaries of our knowledge of the cosmos.



ESO/L. Calçada

This artist's rendering shows a night view of the Extremely Large Telescope in operation on Cerro Armazones in northern Chile. The telescope is shown using lasers to create artificial stars high in the atmosphere.

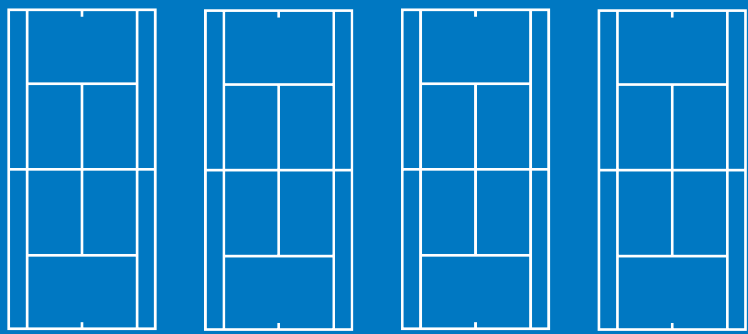
ELT facts

39 m
diameter

of the ELT’s main mirror, which is comparable to the height of the **Statue of Liberty** in New York, USA.

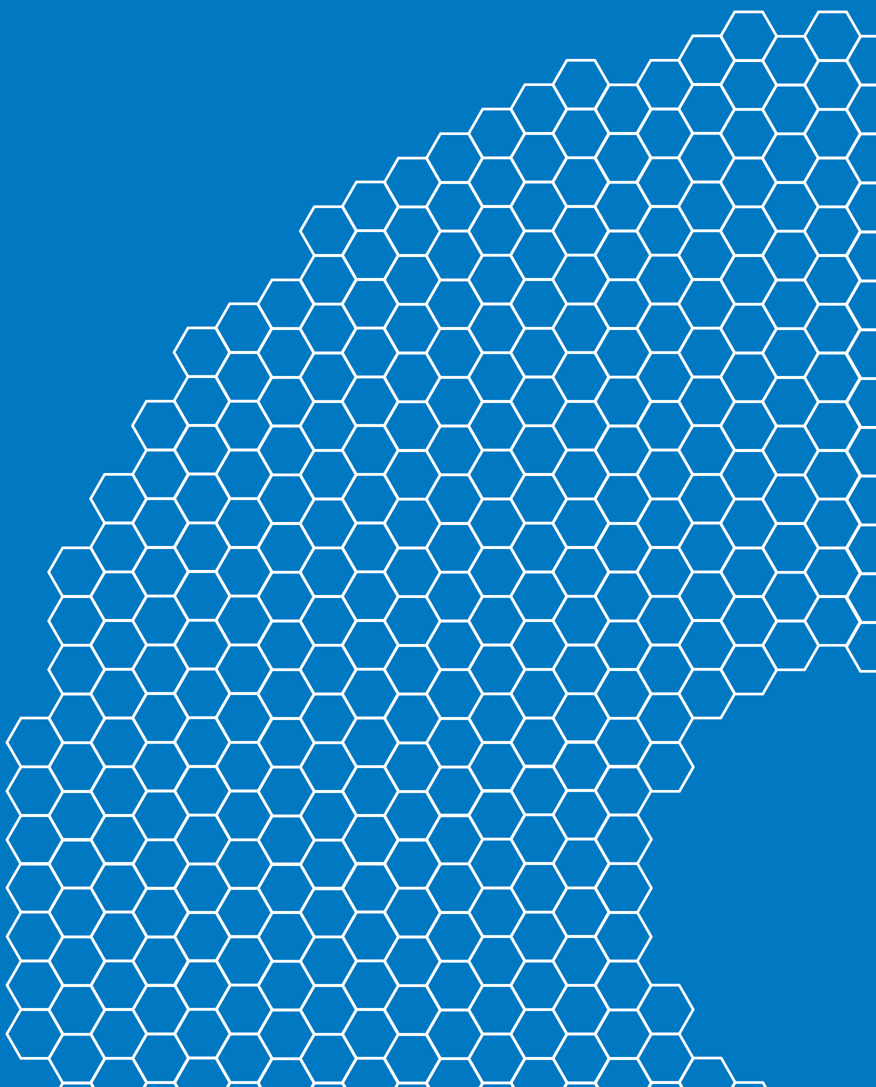
978 m^2
light-collecting area

of the telescope, which is comparable to that of **four tennis courts**.



798

Number of **hexagonal segments** making up the main mirror.



0.00000001 m

Precision level at which the segments will be aligned across the entire 39 m diameter. This is **10 000 times thinner than a human hair**.

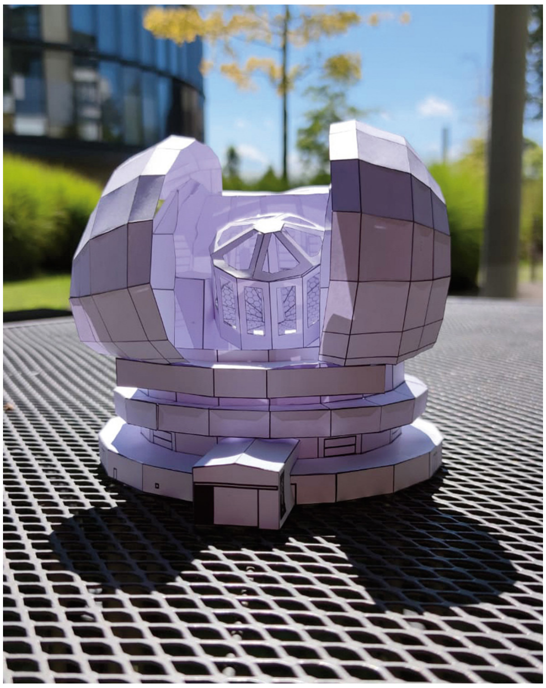
It will collect

100 million times more light

than the human eye.

Designing a paper model of the ELT

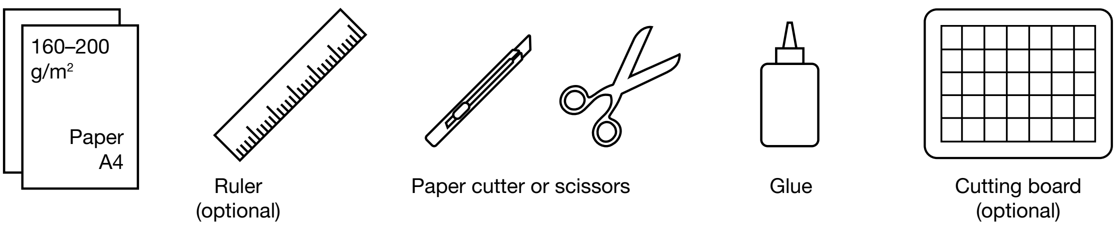
To transform a complex telescope like the ELT into a paper model, Martin Graf (edition 8x8) started simple. “I started by building some Platonic solids,” he says. “After this I went to more complex polyhedrons and found the Hectohexecontadihedron, which reminded me of the construction of the ELT. This was the starting point of the model.”



Building the model was, however, not simple: Martin only had 3D renders of the telescope as a reference, and it’s not always easy to understand from these computer graphics what the different parts of the ELT look like. The fact that the dome of the telescope is round was an added challenge: “This is difficult to do in paper,” he says. But in the end, Martin succeeded in creating a paper model of the telescope. His favourite part? “The inner structure, which is the heart of the ELT.”

Basic instructions

Tools:



Step 1: Print the model. Cut out all the parts in the right order and make slits and holes with a paper cutter (or scissors) where marked.

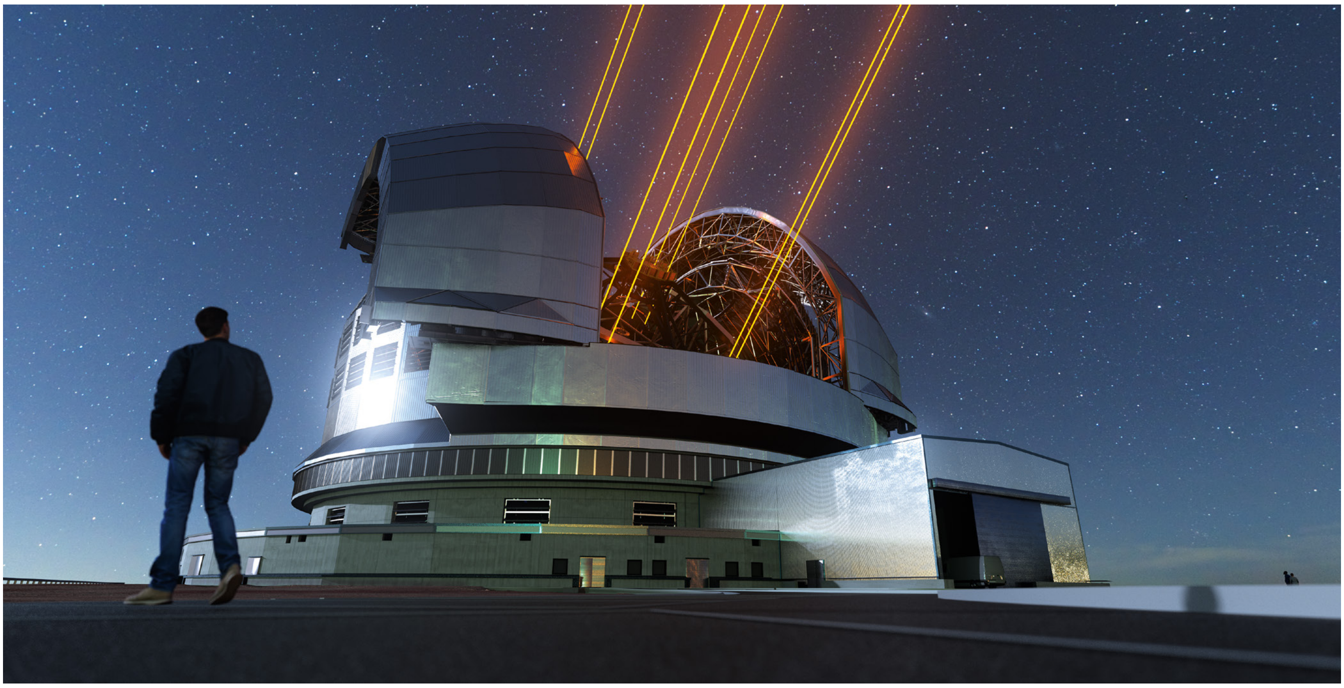
Step 2: Fold or crease the paper pieces along the solid lines.

Step 3: Glue the different pieces together as indicated in the diagrams in the next pages.

Step 4: Have fun!

Estimated assembly time: 15 hours.

The base



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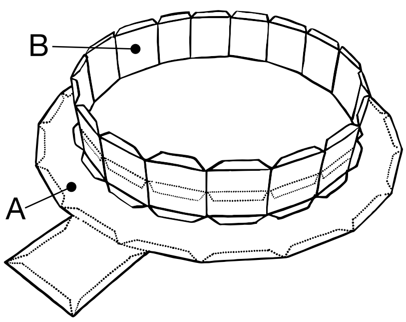

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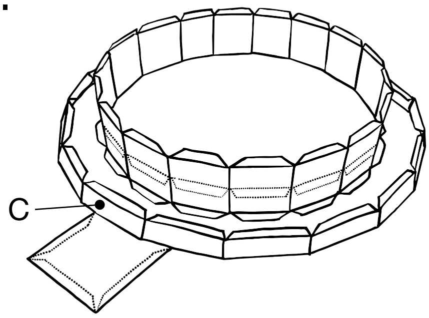

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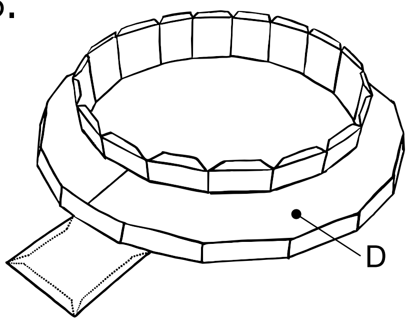

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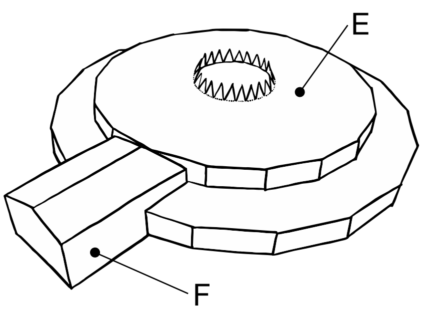
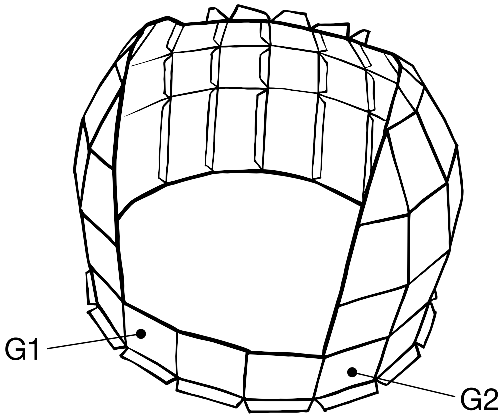


The dome

The ELT dome is a giant, extending about 80 meters from the ground and measuring 88 metres in diameter.

The rotating enclosure, once fully equipped and finished, will have a mass of around 6100 tons, and it will rotate on 36 stationary trolleys mounted above the pier at a height of 11 m from the ground. The structure itself consists of a round girder with a special track at its bottom that rests on the wheels of the trolleys. The primary structure of the enclosure is completed by three structural arches resting on the round girder, one at each side of the slit and one at the back. The enclosure structure, which will be bolted together on site, is closed by a number of secondary beams which will allow the assembly of the insulated aluminum cladding. A complex series of accesses inside the structure and the slit doors allows engineers to reach all mechanisms of the doors, ventilation louvers, and installed equipment.

5.



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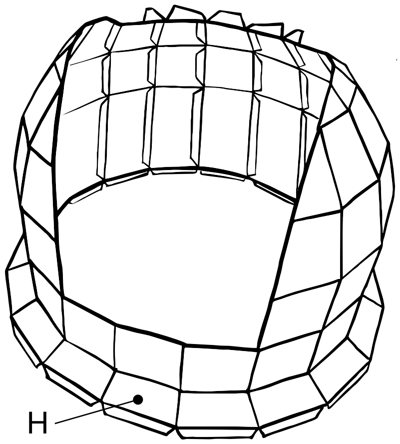

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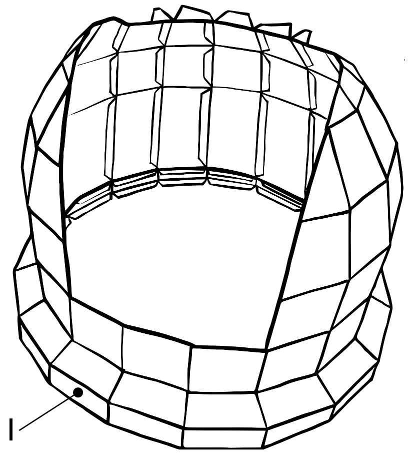

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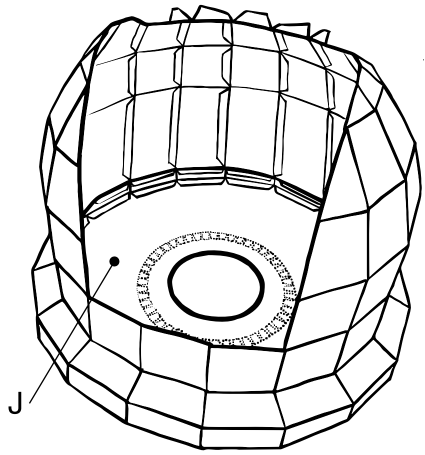

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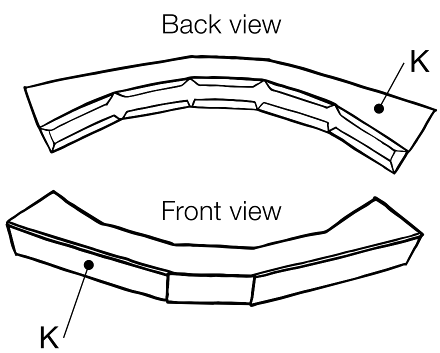

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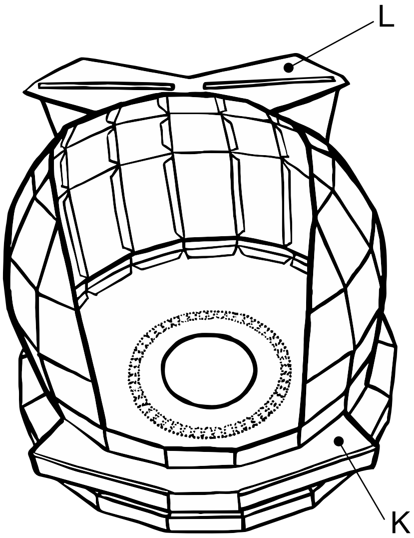
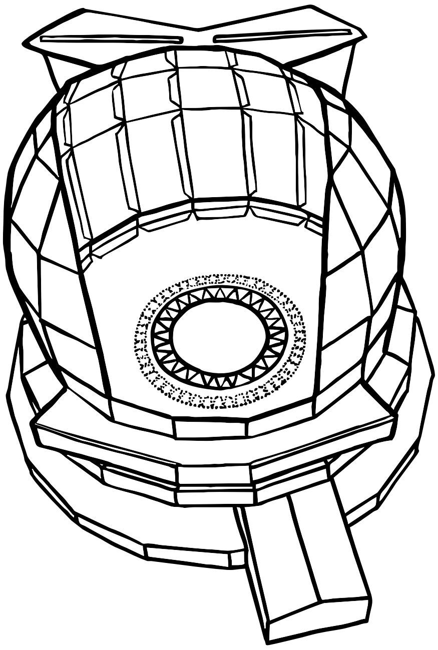


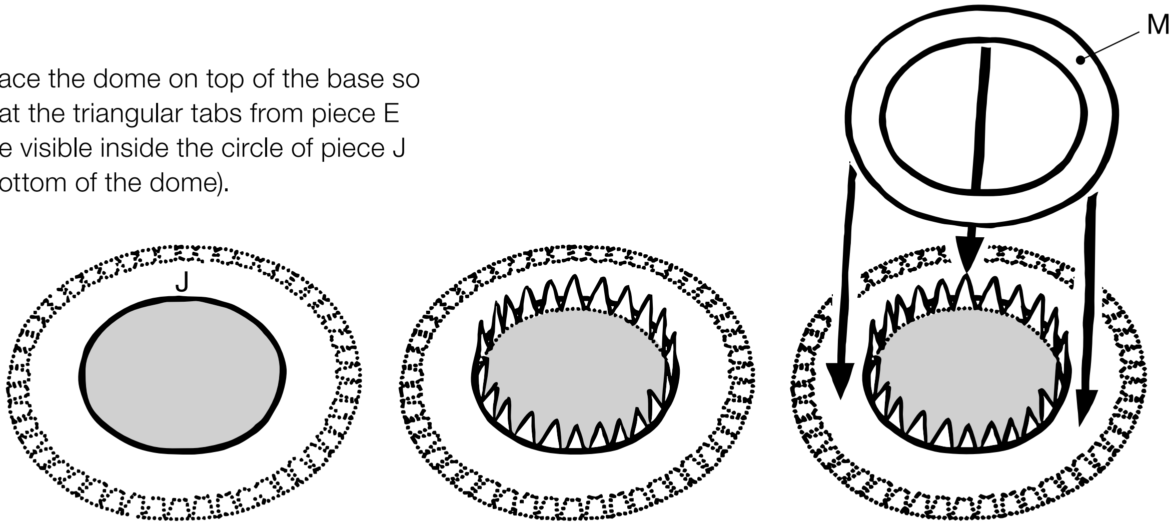
Connecting the base and the dome

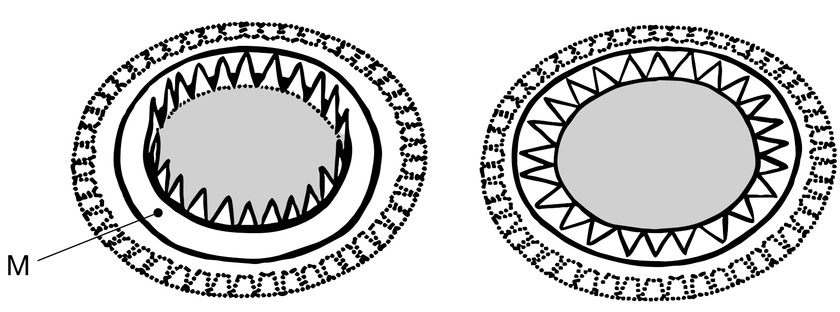


11. Combine the dome and the base as described in the next steps.

b. Place ring M on top of J as indicated.

a. Place the dome on top of the base so that the triangular tabs from piece E are visible inside the circle of piece J (bottom of the dome).





c. Glue the tabs from E on top of M.

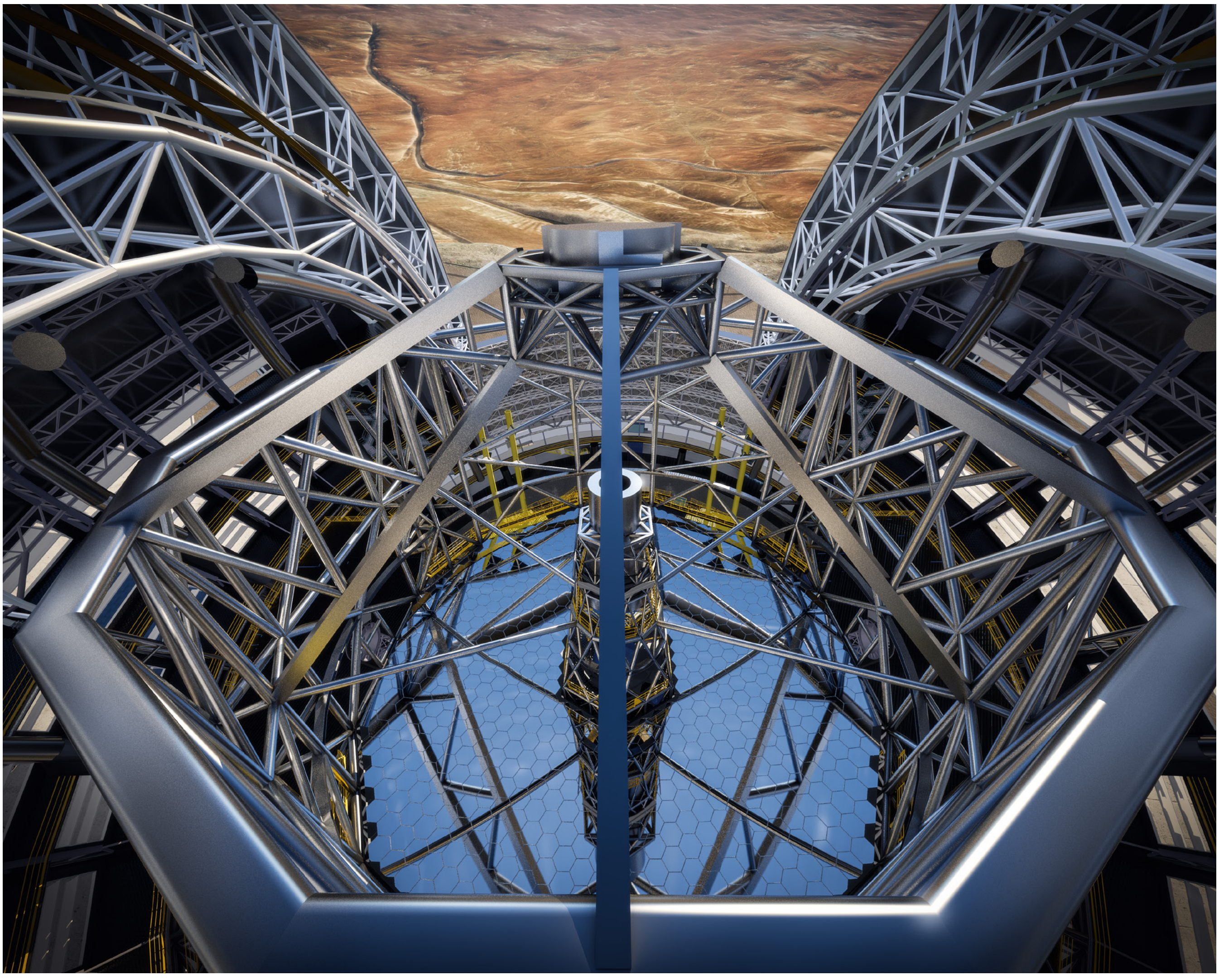
ATTENTION: Make sure the dome and the base of the building can still turn left and right.

The ELT is being built on Cerro Armazones in the Chilean Atacama Desert, at 3046 metres altitude and just 23 kilometres away from Cerro Paranal, the site of ESO's Very Large Telescope.

The mirrors and main structure

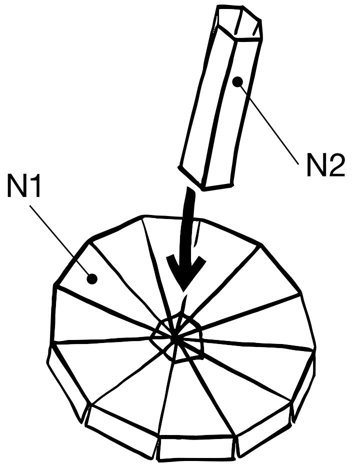
The ELT will have a pioneering five-mirror optical design that will allow it to unveil the Universe in unprecedented detail. The mirrors all have different shapes, sizes and roles but will work together seamlessly. The primary, M1, is the most spectacular: a giant 39-metre concave mirror that will collect light from the night sky and reflect it to the secondary mirror. The convex M2, the largest secondary mirror ever employed on a telescope, will hang above M1 and will reflect light back down to M3, which in turn will relay it to an adaptive flat mirror (M4) above it. This fourth mirror will adjust its shape a thousand times a second to correct for distortions caused by atmospheric turbulence, before sending the light to M5, a flat tiltable mirror that will stabilise the image and send it to the ELT instruments.

The main structure of the ELT telescope supports the optics and the instruments during astronomical observations and keeps the telescope stable under all conditions, including in high winds and during earthquakes.

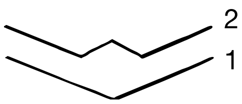


ESO/L. Calçada/ACe Consortium

12.



Before gluing N2 to N1, push the small hexagon of N1 upwards.



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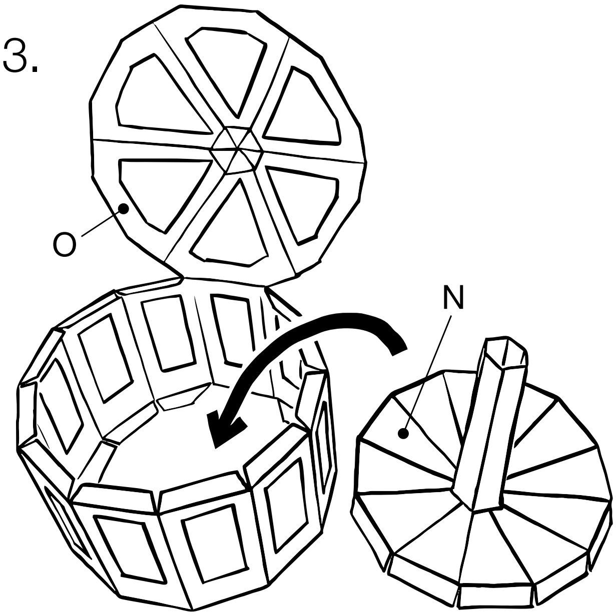

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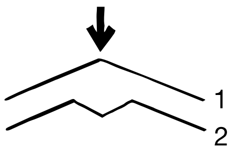
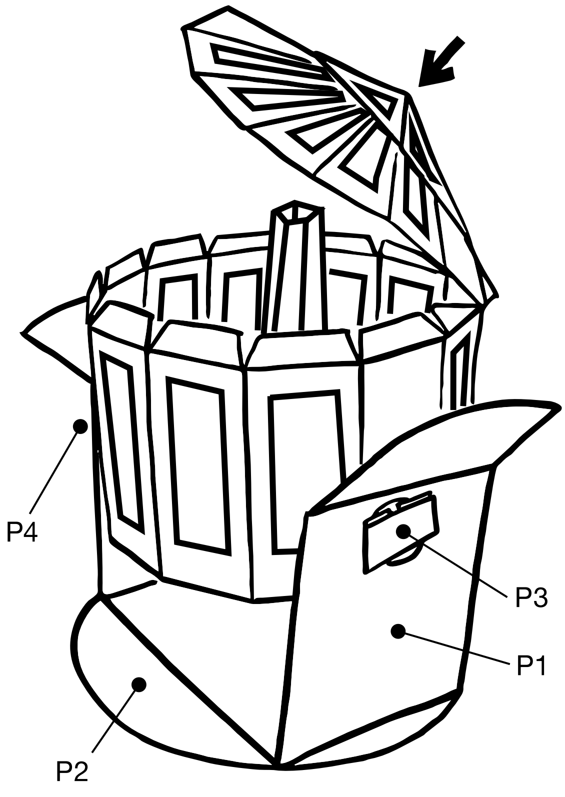


Before closing the upper part of piece O, push the small hexagon downwards.



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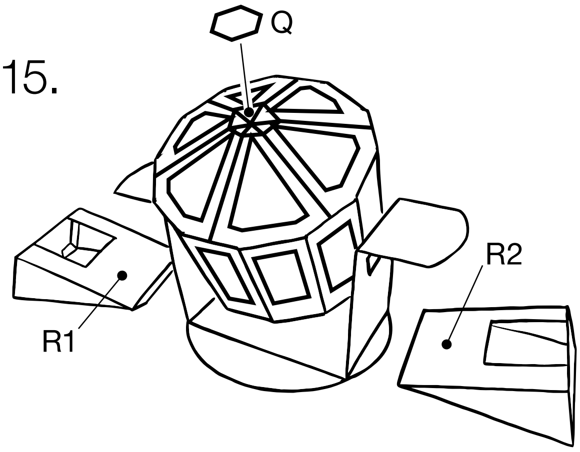

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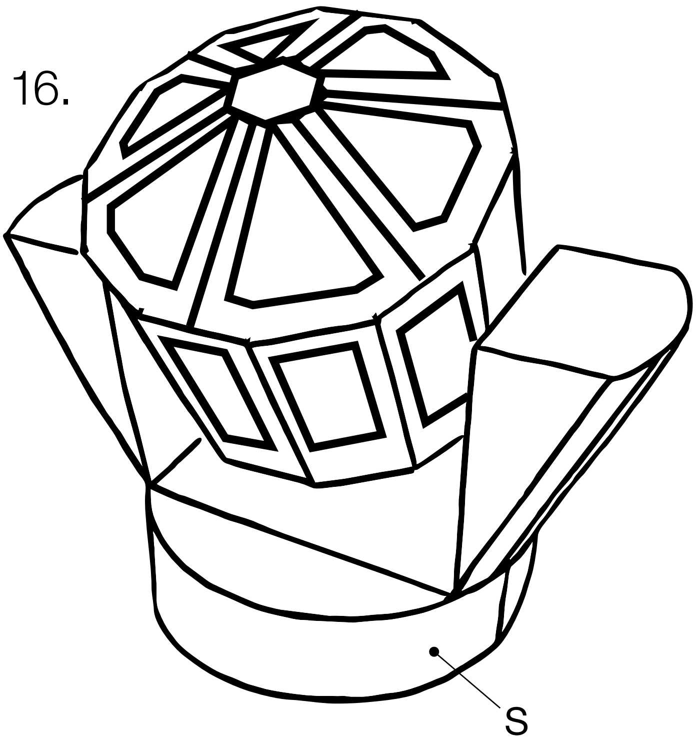
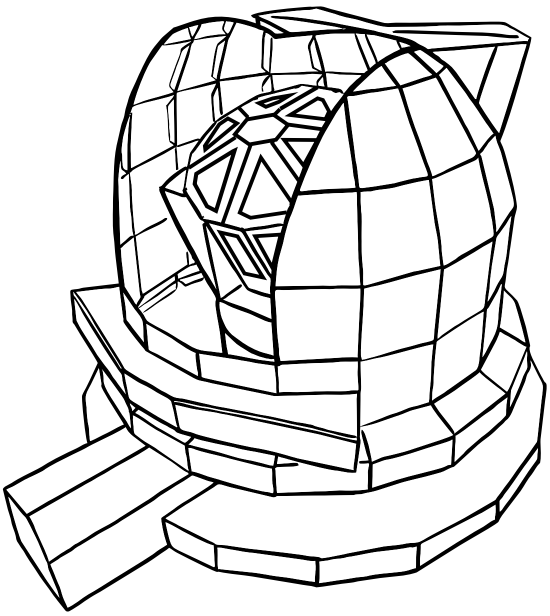
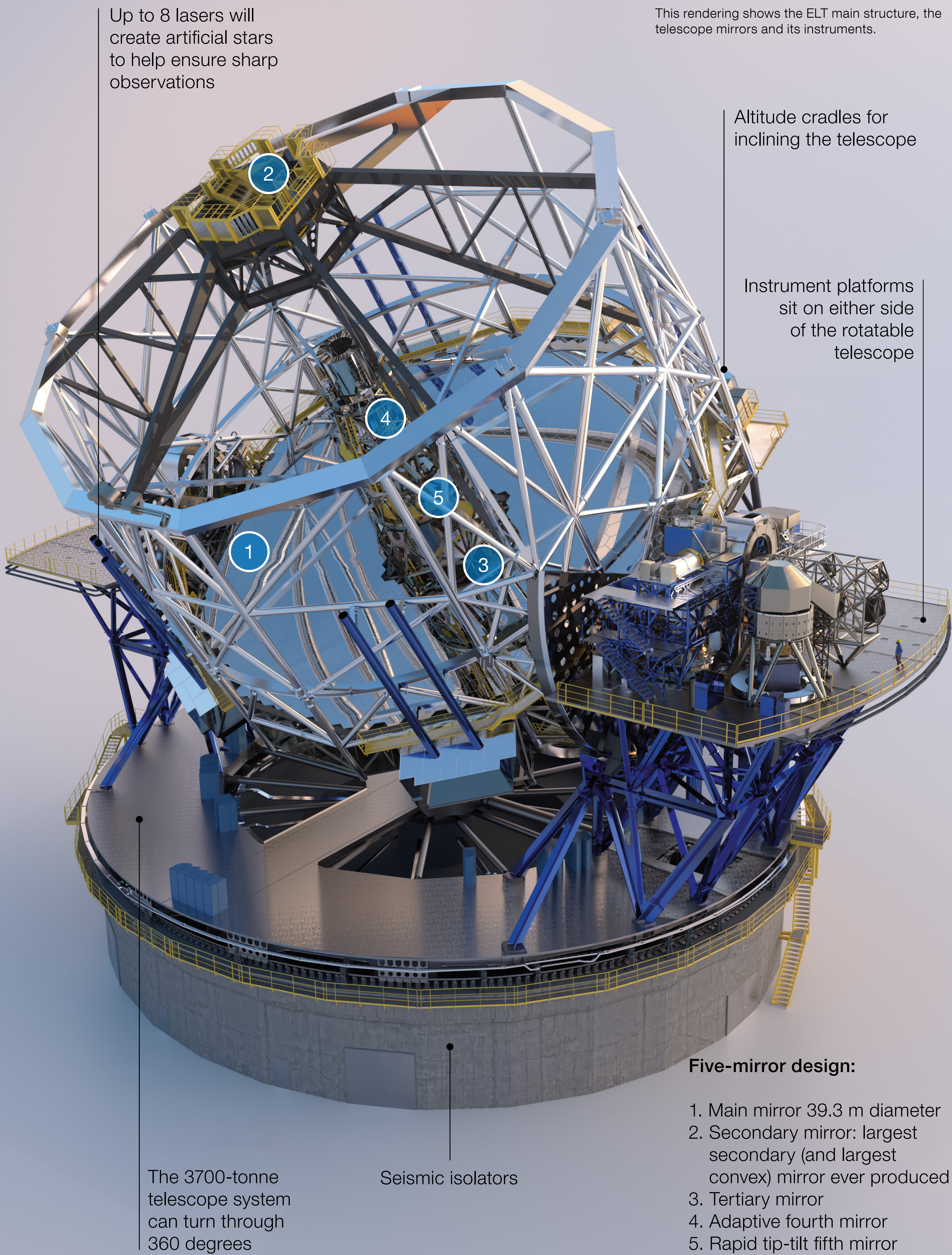


17. Glue the main structure inside the dome as shown in the picture.

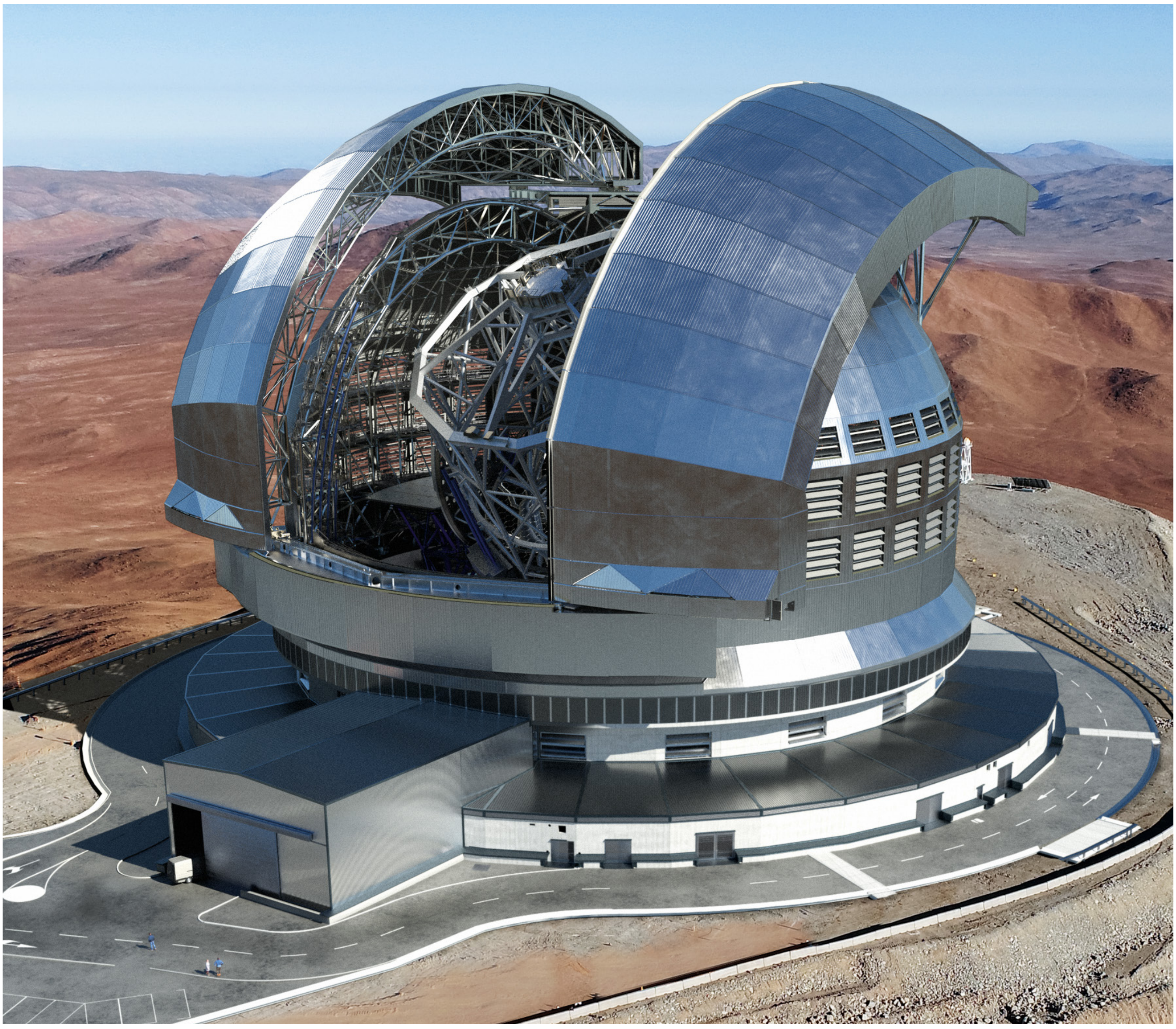



This rendering shows the ELT main structure, the telescope mirrors and its instruments.
Up to 8 lasers will create artificial stars to help ensure sharp observations
Altitude cradles for inclining the telescope
Instrument platforms sit on either side of the rotatable telescope
2
4
5
1
3
The 3700-tonne telescope system can turn through 360 degrees
Seismic isolators
Five-mirror design:
1. Main mirror 39.3 m 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

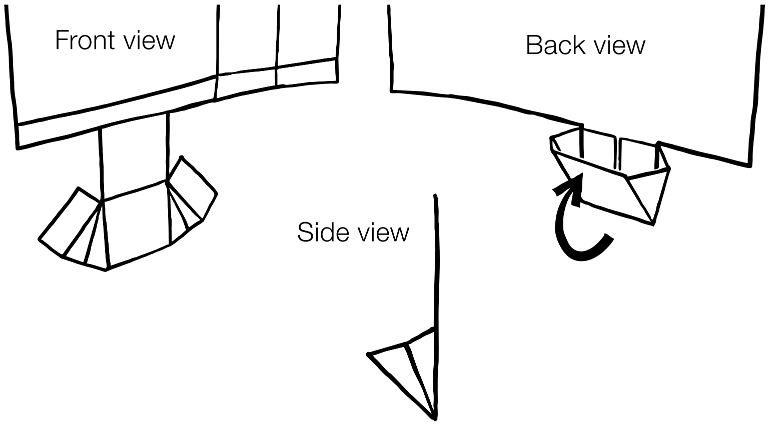
The slit doors

The enclosure's slit doors, which open to allow observations of the night sky, move on three rails each, one at the round girder and two at the top. The doors provide an aperture of 41 m when open, and their system motors have sufficient redundancy to ensure the doors can be closed when needed, in all conditions. In addition, the doors will be equipped with latching mechanisms to achieve structural continuity and with special inflatable seals to guarantee environmental tightness when closed.

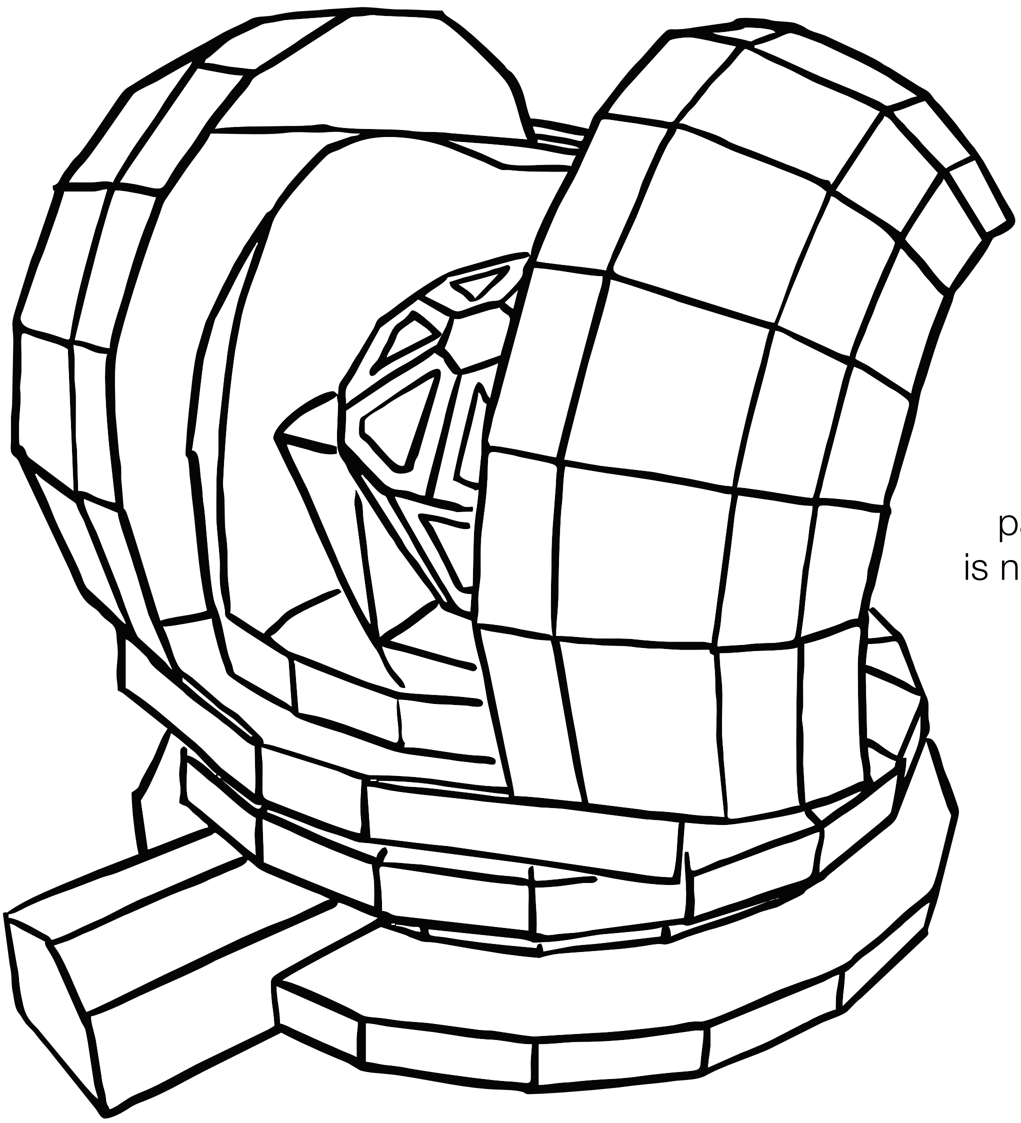
Engineers have carried out wind tunnel tests to compute the pressure forces acting on the structure in operational conditions (doors open) as well as in survival conditions (doors closed). The structure has also been tested against earthquakes and snow loads.



18. The two model slit doors slide on the top and bottom rails, with small "pockets" holding them in place. Fold and glue the pockets as shown.



19. Insert the pockets on the top and bottom rail slits (L and K).



Your ELT
paper model
is now complete!

"With the ELT we're going to see things that were impossible to see before. We're going to see things and we're going to be surprised!"

Didier Queloz, Nobel Prize Laureate,
Professor at the Universities of Cambridge, UK, and Geneva, Switzerland

European Southern Observatory

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