Earth 2.0

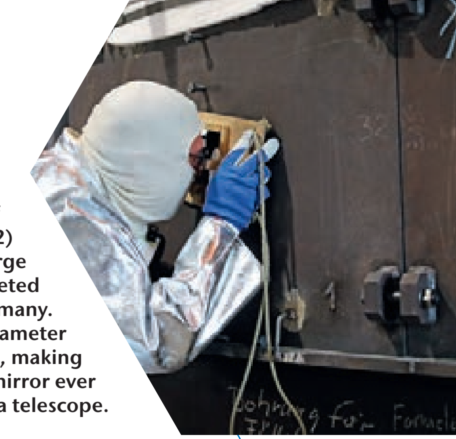
For astronomers, broadening horizons means reaching for the stars. The spectacular telescopes of the ESO enlighten the unknown of the universe.

By Michael Thiem

All pictures: ESO

Dawn at Cerro Armazones, site of the future Extremely Large Telescope.

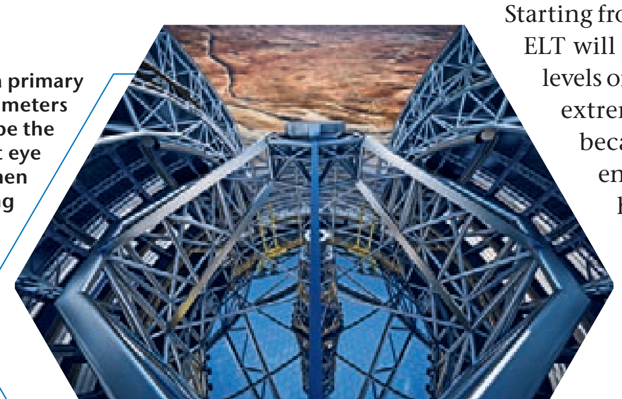
Visitors of the ESO's Supernova can marvel at an ELT segment made of ZERODUR® glass-ceramic.



In May 2017, the casting of the secondary mirror (M2) blank for ESO's Extremely Large Telescope (ELT) was completed by SCHOTT in Mainz, Germany. It is 4.2 meters in diameter and weighs 3.5 tonnes, making it the largest secondary mirror ever employed in a telescope.

The first things that visitors see are stars. Lots of them. At second glance, experts immediately recognize the Andromeda Galaxy, the Magellanic Clouds and, of course, the Southern Cross. The view is simply stunning. At the European Southern Observatory's (ESO) interactive center in Garching, outside Munich, Germany the glass dome in the entrance area to the "Supernova" has a 14-meter diameter and weighs almost 30 tons. Approximately 262 glass panels have been meticulously arranged to depict several constellations found in the Southern Hemisphere. The dome magically conjures up constellations and simulates the Milky Way as it can only be seen from Chile; the area has been dubbed the "Void," referring to how astronomers describe the empty space between two large structures. There is even lots of room to make new discoveries.

Open since summer 2018, the exhibition spans over 2,200 m² displaying multimedia installations covering thirteen fascinating astronomy topics. In an emotionally packed presentation, the center shares the knowledge scientists have been gaining over the years since ESO's founding back in 1962. Furthermore, they provide an astonishing view on the future research goals: How are galaxies formed? Why do stars twinkle? Is there life beyond our solar system? Financed by tax money and donations, the ESO counts sixteen member countries. The new "Supernova Planetarium and Visitor Center" builds the bridge between the newest astronomic findings and their impact on our everyday life. It is the unique opportunity to raise the fascination and appeal of astronomical research and involved technological innovations in a comprehensible manner. After all, generating advocacy and providing outreach to the public are almost as important for the ESO as discovering e.g. new black holes.

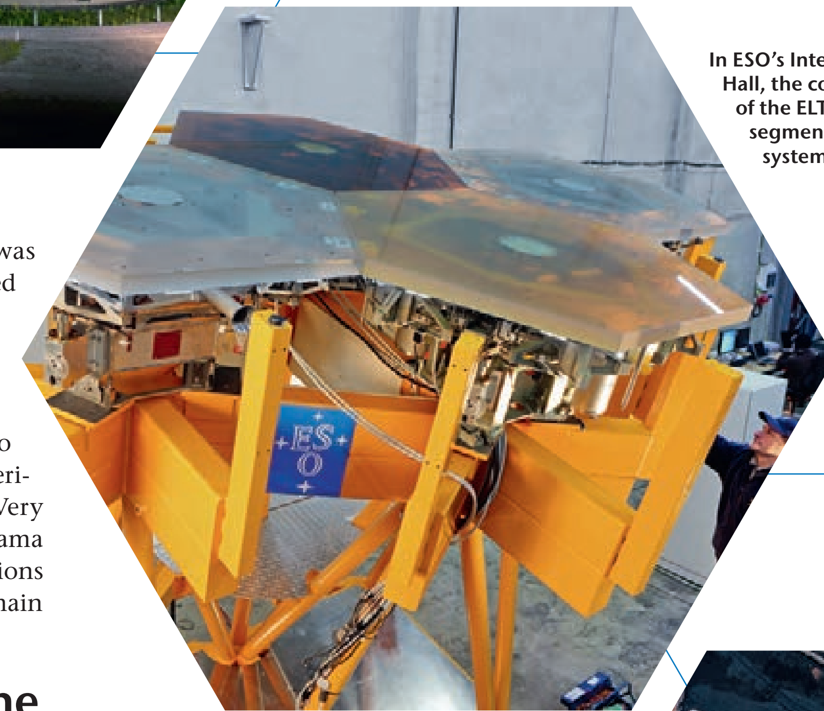


The ELT, with a primary mirror of 39 meters in diameter, will be the world's biggest eye on the sky when it starts operating in 2025.

The choice of the ELT construction site in Chile was obviously not random. Since 1979, ESO has been focused on the design, construction and operation of powerful ground based observing facilities for astronomy in South America. Roughly 300 of the ESO's 700 employees are continually working on site in Chile. In Garching, visitors to the new center have the possibility to step into the shoes of the astronomers working in Chile and experience the sky from their perspective. Since 1998, the Very Large Telescope (VLT) has been in operation in the Atacama Desert. Several photographs and astronomical visualizations in the ESO facilities were taken by the VLT. For the four main

"The sensors could pick up the growth of grass in real time"

mirrors – each with a diameter of 8.20 meters – SCHOTT manufactured the largest monolithic glass components ever built. Besides observing individually, the four telescopes can be coupled to form a gigantic interferometer. "Astronomers almost always set the impossible as their goal," notes Markus Kissler-Patig. He is a senior astronomer involved in the most spectacular ESO project of the last several years: the planning and building of the Extremely Large Telescope (ELT), which could be described as humankind's largest eye on the sky. Starting from 2025, and within sight of the VLT in Chile, the ELT will be ready to take the field of astronomy to next levels of discovery. Until then, lot of exhaustive effort and extremely hard work will have to be spent at ESO, because building the ELT is nothing short of an engineering masterpiece. "Everything we are doing has never been done before," explains Program Manager Roberto Tamai.



In ESO's Integration Hall, the construction of the ELT mirror segment support system is tested.

The construction of the foundations for the dome and telescope structure of the Extremely Large Telescope (ELT) started Early in 2018.

Kissler-Patig then adds, "We are essentially constructing a prototype, that has to be able to function immediately. And to achieve that, we find ourselves constantly pushing the limits of what is feasible." The ELT project team consists of roughly fifty engineers and scientists from ESO. When stepping into the Integration Hall in Garching, the incredible challenges faced by the team are clearly visible. One of them is the design of the instrument's primary mirror, which amounts to 39 meters in diameter. Using a prototype, ESO tests how seven mirror segments are constructed, maintained and operated so that the positioning accuracy is much smaller than the wavelength of the light required for the observation; this requires a maximum tolerance of several nanometers only. Several thousand sensors monitor the segment position fading actuators. The Herculean task becomes more evident when considering the performance of such sensors attached to each segment. Eventually, they will allow for up to 1,000 mirror corrections per second. "They are so powerful, they could theoretically register grass growing in real time," explains Kissler-Patig. The primary mirror is assembled from 798 ZERODUR® glass-ceramic segments. Including maintenance and spare parts, SCHOTT is manufacturing a total of 949 round discs. In the subsequent step, Safran REOSC, the optical department of the French Safran Group, is polishing and finally cutting the discs into hexagons. In the history of batch production for astronomical mirror substrates, no similar feat has ever been achieved. In 2019, the production of the primary mirror segment blanks at SCHOTT commenced in Mainz, Germany. It takes almost four months to complete the production of each segment blank. In peak periods, one ▶

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ELT MILESTONES

October 2011
Agreement with Chilean Government on the location of the ELT.

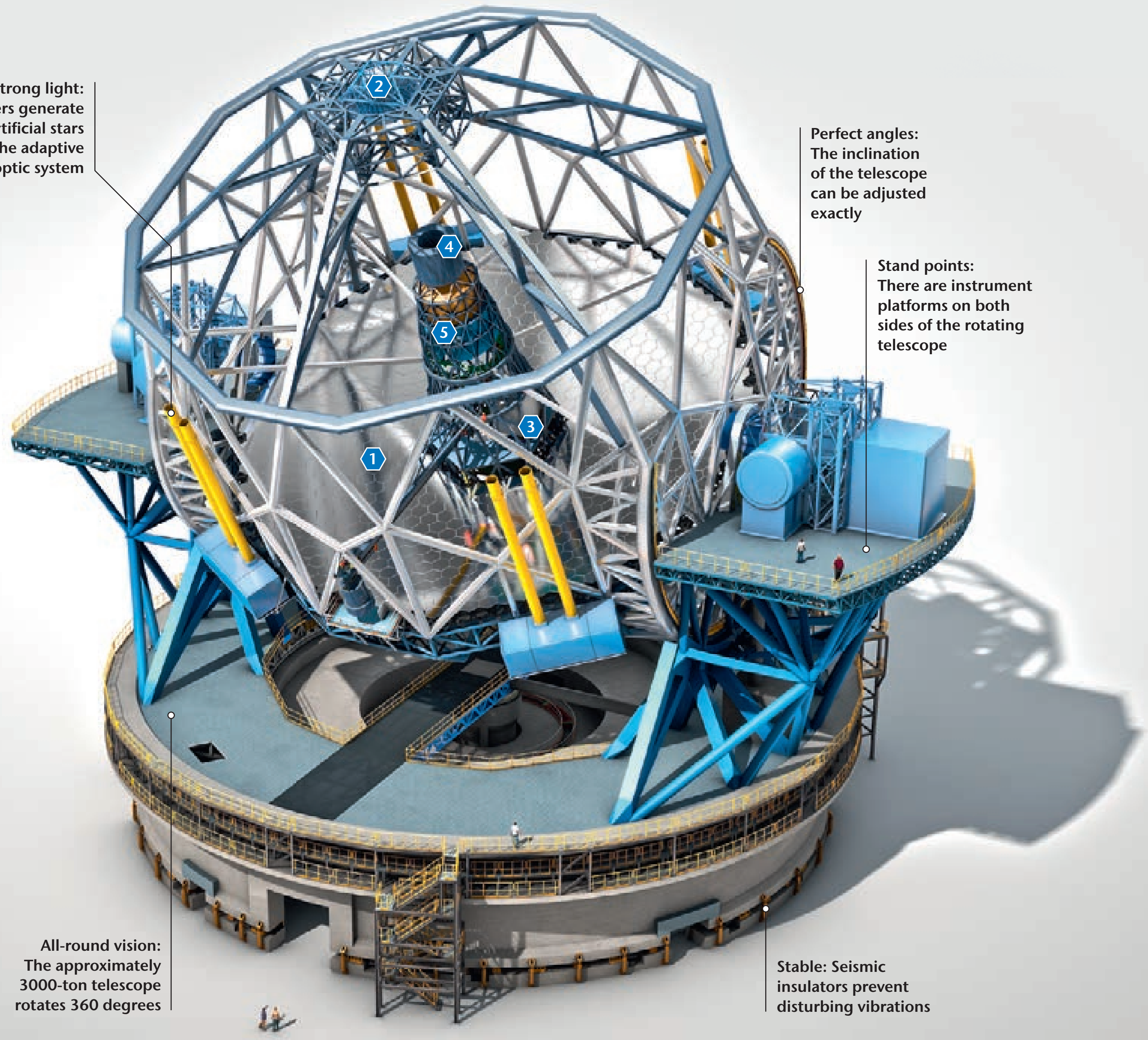
June 2014
Groundbreaking ceremony and beginning of constructions.

May 2017
Signing of the contracts for primary mirror and first stone ceremony.

2020
Completion of first primary mirror segment.

2024
Completion of last primary mirror segment. First light of ELT late 2025.

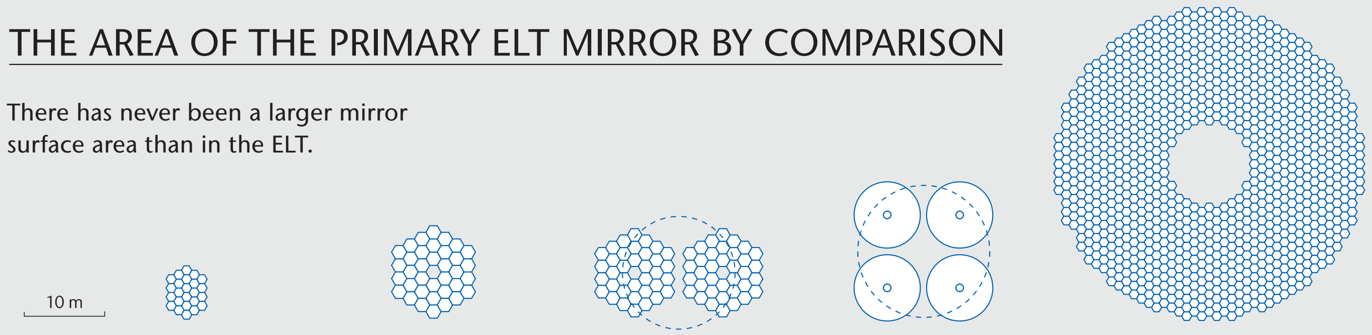
The Extremely Large Telescope (ELT)



Graphic: ESO

THE AREA OF THE PRIMARY ELT MIRROR BY COMPARISON

There has never been a larger mirror surface area than in the ELT.



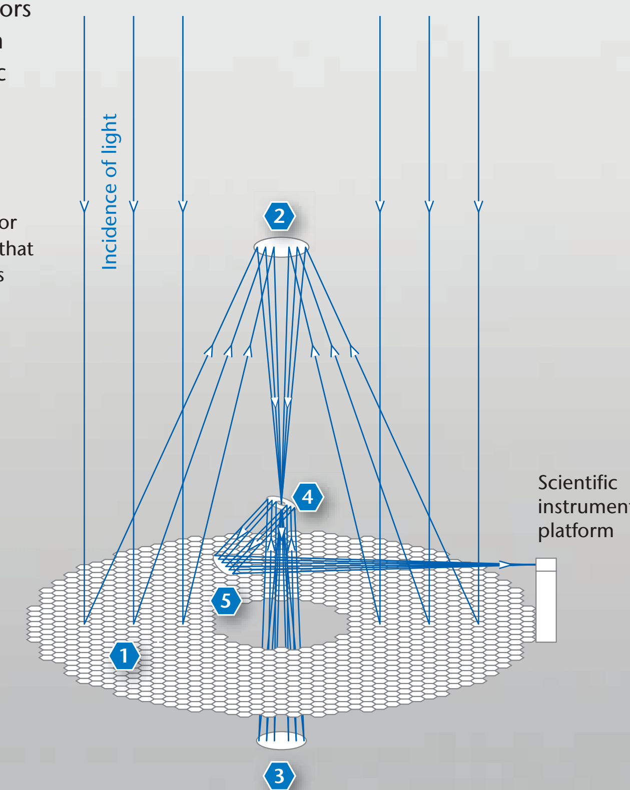
THE HEIGHT OF THE ELT BUILDING BY COMPARISON

The ELT has an height of 85 meters.

THE ELT

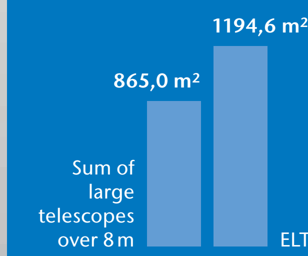
Four of the ELT's five mirrors were manufactured with ZERODUR® glass-ceramic from SCHOTT.

1. **M1:** Active concave mirror 39.3 meters in diameter that consists of 798 hexagons
2. **M2:** Convex mirror 4.2 meters in diameter
3. **M3:** Concave mirror 4.0 meters in diameter
4. **M4:** Adaptive mirror 2.4 meters in diameter
5. **M5:** Flat, tiltable mirror 2.7 x 2.1 meters in size, Silicon Carbide



? Did you know, that ...

... the ELT mirror surface area is larger than all of the large telescopes exceeding eight meters in diameter combined? Accordingly, its capacity for gathering light is significantly higher.



segment will be completed each day. “A project like the ELT would not be possible if a material as ZERODUR® with these properties did not exist,” says Kissler-Patig. “When it comes to the ELT, every step is about making pioneering efforts,” admits Jean-Louis Lizon, who supports the construction of the prototype and who also holds the ESO record for the most visits to Chile: Since 1981, he has stayed in the Atacama Desert 132 times. Kissler-Patig is quick to point out what that piece of trivia reveals. Scientific work done at 3,046 meters above sea level is like “working on the moon.” Nearly 200 individuals are currently busy at the VLT on the Cerro Paranal Mountain. The telescope is in operation every day of the year, 24 hours a day. A routine has been determined and is followed: At night, the four domes open up with two employees supervising the observations. The next morning, the data is evaluated at the control center located beneath the summit

“We don’t want to lose a single quantum of light”

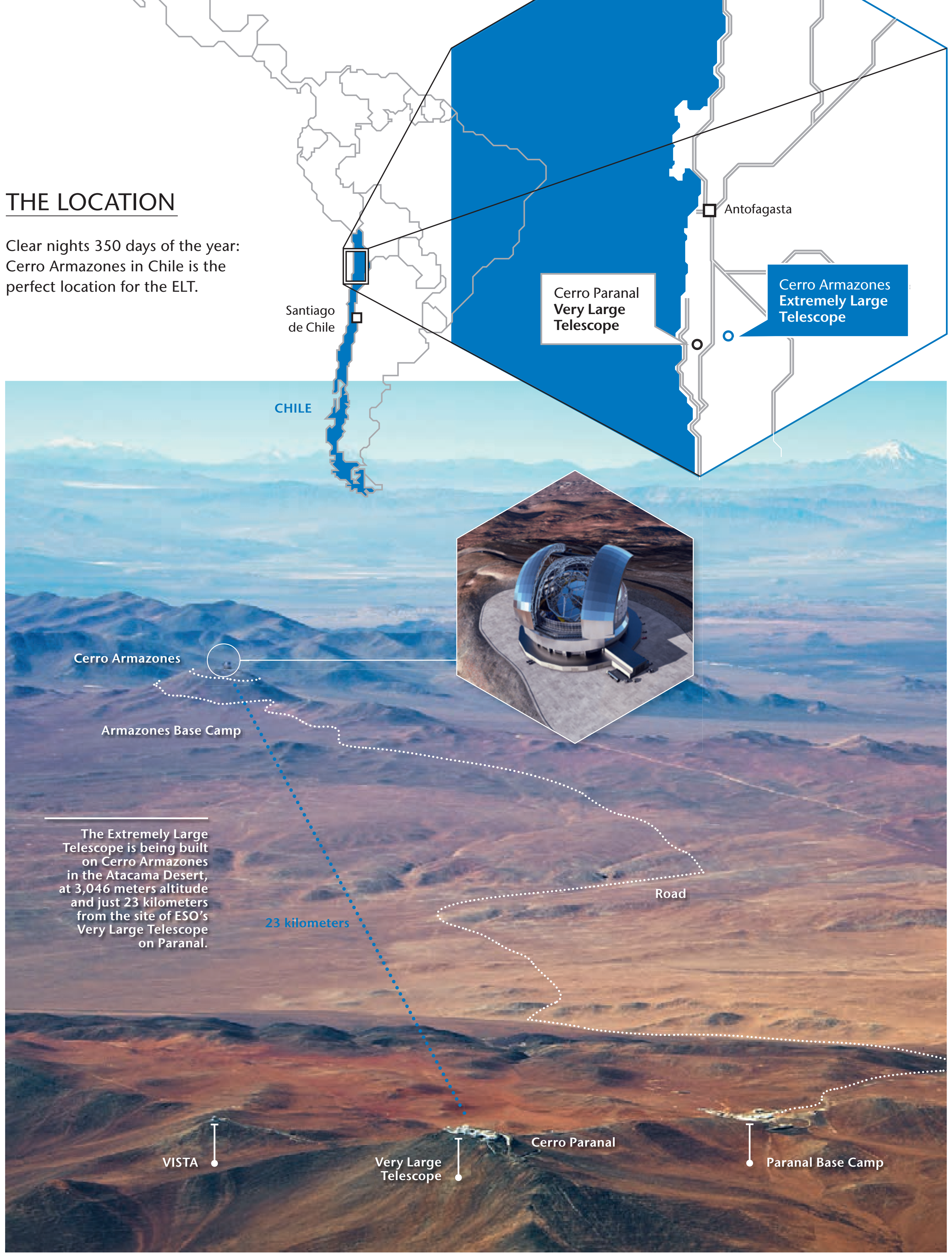
and almost simultaneously shared with the ESO headquarters in Garching. While the data analysis takes place, specialists are busy preparing the telescope for the next night’s shift. For safety and security reasons, nobody is allowed to work for more than two weeks at a time on the top of the mountain. The Cerro Paranal is an extreme environment to work in. The remoteness is a liability. It is dry as dust out here with air moisture ranging between only 5 to 10%. To survive, consuming liquids is crucial. Every day, tanker trucks filled with potable water leave the port city of Antofagasta some 120 kilometers away before the grueling climb up the mountain. Once the sun sets, the stars blossom. Their light has travelled billions of years before reaching the VLT and, by 2025, the ELT. Every photon counts. “We don’t want to lose a single one,” says Kissler-Patig, who has spent many nights gazing into the Chilean skies. This much he knows: you simply have to have the real experience; even if the simulation in the Supernova comes very close to replicating it. ■

? Did you know, that …

… in 2008, scenes from the “Quantum Solace” James Bond film starring Daniel Craig were filmed at “Paranal Residencia?” The subterranean hotel is an award-winning building with rooms for ESO visitors on the mountain Cerro Paranal.

THE LOCATION

Clear nights 350 days of the year: Cerro Armazones in Chile is the perfect location for the ELT.



Roberto Tamai,
ELT Program Manager
Extremely Large Telescope

“Nothing like this has been done before”

Tell us, what does your job as ELT Program Manager involve?

First of all, my job entails continuous concern about the team – I make sure that there are no weak points in the team. I bring in resources. I help people communicate among themselves and make sure they’re sharing the correct information to keep the project going. I try to anticipate problems. Broadly speaking, I plan – but on many different levels, from technical to financial to resources. Many people support me in this position – I receive a lot of help from my colleagues, the team, because it’s not just me building the ELT! This is fundamental: I’m just one of the pieces in the vast jigsaw puzzle of our team.

Progress with the ELT has advanced significantly. What has been happening recently?

In the last years we’ve translated the design and preparation work into requirements for procuring material. This has been, I believe, very successful work so far. We’ve started the construction; now we’re building. We’re working with industry and building with steel, with ZERODUR®, a material used for the mirror blanks. This is a huge recent step – everything is really coming together.

What is the biggest challenge we are facing when building the ELT?

Nothing like this has been done before. The ELT is the first of its kind. It’s a big machine with very, very stringent requirements in terms of positioning and tracking. We’re putting a giant 3,000-tonne piece of steel in a set position and need to move it with extreme precision. Yes, we have all the simulations and computational analyses to show that we can achieve it, but there’s a big step between simulations and reality. Taking this leap is one of the biggest challenges.

What excites you most about being involved in this project? What are you looking forward to?

We are constructing something that will expand humankind’s knowledge of the universe. This is absolutely fantastic; it’s an experience that is utterly unique.