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ESO's Extremely Large Telescope Dome and Main Structure Update

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In the ongoing saga of constructing an 80-metre-high dome and an expansive telescope structure for ESO's Extremely Large Telescope (ELT), the narrative unfolds as a testament to human resilience and determination. Originating from a contract signed in 2016, the Dome and Main Structure (DMS) project has survived financial restructuring, partner bankruptcy and global upheaval caused by the COVID-19 pandemic and market fluctuations that resulted in a complex contractual and commercial situation. The DMS project includes the construction of both the internal telescope structure that supports the telescope mirrors and the instruments, as well as the external dome that provides protection against the harsh conditions of the Atacama Desert. Following the design phase, the project started with the construction of the foundations and of the gigantic dome. In September 2023 a new chapter began, marked by the start of the construction of the telescope structure, a phase demanding an unprecedented level of precision and constant supervision by the ESO team on site. The design, born from a collaboration of many disciplines, is now consolidated and frozen, setting the stage for a race against time to achieve the highest possible level of quality demanded by the 'biggest eye on the sky'.

Dimensional marvels and technical precision

The monumental dome stands 80 metres high, with a commanding 92-metre diameter. It requires nearly 80 000 pieces of steel to come together with no fewer than 500 000 bolts. It sits on a concrete foundation of 21 000 tonnes, fully isolated from seismic accelerations.

The 6200 tonnes of the dome rotating mass will protect the 4600-tonne telescope structure with all its mirrors and instruments. Rotating such a complex structure without inducing any vibrations in the telescope has required many hours of design and analysis that have resulted in 36 driving trolleys, each the size of a small 27-tonne truck. The high level of protection of the telescope is ensured by the complex cladding structure representing 30 000 m^2 of material that shields the precious mirrors and instruments from light, dust, water and lightning. The design has required complex tests to validate the non-propagation of dust and resistance to lightning, and even required dropping big lumps of ice on the structure to demonstrate its resistance to falling icicles.

The telescope structure is an engineering marvel that required no fewer than four complex design reviews, generating thousands of questions and actions to be analysed before the construction drawings could finally go to production. Pointing the telescope towards the celestial heavens demands an unparalleled level of precision. The azimuth and altitude tracks, machined and aligned with micrometric accuracy, are now part of a race against time. The three azimuth tracks (the largest one having a diameter of 54 metres) that allow the telescope to rotate on its base are now fully installed. And the 27-metre-diameter curved altitude tracks that allow the telescope to move in the vertical direction require machining accuracies that have never been achieved before — and are still not fully demonstrated — to maintain a constant film of oil a few tens of microns thick that will allow the structure to point to the stars in a precise and smooth fashion.

ESO DMS team

Figure 1. Dome and Main Structure construction status (January 2024).

Manufacturing and shipping thousands of tons of precision material against a ticking clock

Putting together a large and complex dome and the most technically challenging telescope on the planet on top of a mountain in an unforgiving environment requires more than just steel, it requires a degree of preparation and logistics that is very uncommon in this kind of industrial project. The level of quality implemented by the contractor and by ESO in terms of inspection and tests is unprecedented; for hundreds of hours experts are present at the contractors' premises to inspect every weld and painted surface, and to test every mechanism before it is packed and shipped. At the time of writing, the complete dome structure has been manufactured and shipped to Chile and only eight beams out of 16 000 required some local welding, a testament to the high quality achieved during manufacturing. About 70% of the dome mechanisms (motors for the windscreen, lifts, cranes etc.) — largely off-the-shelf components — have been procured and are currently being shipped. More than 90% of the structure dome has now been completed (see Figure 1).

The telescope structure, manufacturing of which started in summer 2022, has now reached ~ 40% and is being shipped to the site for assembly in a just-in-time

mode. Pre-assembly in Europe is done in a systematic manner to ensure that no corrective actions will be required on site. The size of the elements is such that entire vessels have been used to transport the DMS components across the ocean, and unloading those vessels and bringing the material to the site on Armazones has sometimes required up to two months of trucking with police escorts.

A giant growing towards the sky

Having been closed for a year during the COVID-19 pandemic, the site reopened in June 2021 and construction restarted. For some reason, the clock is always ticking faster on a construction site. On average no fewer than 200 people are needed to assemble this giant on top of the Armazones mountain. The top platform itself, the Armazones Top Platform (ATP), where the ELT sits, is too small to host all; a basecamp – the Armazones Basecamp (ABC) – had to be built at the bottom of the mountain to accommodate all the workers with all the logistics and also the very important storage and pre-assembly areas that cover a total area of 65 000 m^2. The 70-tonne modules are brought from the ABC to the ATP, some 7.4 kilometres away, using Self Propelled Modular Transport systems, taking approximately two hours for each trip. Up to seven cranes, the biggest one with a capacity of 600 tonnes and with a boom reaching 120 metres in height that allows lifts of 90 metres, are being regularly used at the ATP and another three at the ABC. Having such a permanent ballet of cranes combined with working at height requires uninterrupted vigilance. With safety on top, quality, quality, and quality are the goals that drive all 16 ESO staff on site, along with the other 20 ESO DMS experts in Europe, who continuously follow the work of the contractors.

This massive industrial setup in the middle of the desert saw the first 2000 tonnes of the dome structure, between the 14-metre and 66-metre levels, erected in only four months. With the Main Structure erection started in December 2023 and the Azimuth Floor now fully installed, we are all looking forward to the end of 2024 when the dome will be fully closed and sealed, the Main Structure erected, and the gigantic air conditioning system (heating, ventilation and air conditioning) under commissioning.

Looking ahead another year, 2025 will see the installation of mechanisms and systems commissioning. In early 2026 the acceptance activities will start, lasting until July 2026, the date set for the Provisional Acceptance when the DMS will finally be fully handed over to the ELT programme by the contractor, ready to begin the assembly of the mirrors that will transform this monumental structure into a functioning telescope, the biggest eye on the sky that humanity has ever built.

ESO's Extremely Large Telescope (ELT) is quickly coming together before our eyes. In this webcam image over Cerro Armazones in Chile from 16 February 2024, the setting Sun illuminates the first pieces of cladding installed on the ELT dome. The hemispheric structure of the dome will be encased in thermally insulated aluminium cladding to protect the delicate mirrors from the harsh desert environment, enabling the world's biggest eye on the sky to capture the cosmos in never-before-seen detail for a long time to come.