The Perfect Machine

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This issue of the Messenger marks the tenth anniversary of first light of the Very Large Telescope. It is an excellent occasion to look at the broader implications of the VLT's success and to consider the next steps.

Mission

ESO's mission is to enable scientific discoveries by constructing and operating powerful observational facilities that are beyond the capabilities of individual member states. This principle was understood right at the start in 1962, when Belgium, France, Germany, Sweden and the Netherlands created ESO (with Denmark joining in 1967) to build a large telescope in the South. The main motivation was the need to be able to compete scientifically with astronomers in California who had access to large private telescopes, most notably the 5-m Hale telescope on Mount Palomar, known as the 'Big Eye', and considered by many to be 'The Perfect Machine' of its time. In the United States of America, the same motivation had already led in 1957 to the creation of AURA, the Association of Universities for Research in Astronomy, which resulted in the Kitt Peak and Cerro Tololo Observatories, each including a 4-m telescope and supported by the National Science Foundation. In Europe the ESO mission resulted in the construction of the La Silla Observatory north of La Serena in Chile, operating a fleet of telescopes, with the 3.6-m as flagship.

The Very Large Telescope

By the early 1980's there were half-a-dozen observatories with 4-m-class telescopes available to astronomers worldwide, La Silla being one of them. Plans were being drawn-up to construct much more powerful telescopes with primary mirrors in the 8–10-m range. The Keck Foundation enabled the California Institute of Technology and the University of California to build twin 10-m telescopes on Mauna Kea, obtaining first light in the early nineties, providing, in particular, a ground-based spectroscopic complement to the Hubble Space Telescope. Italy and Switzerland had joined ESO in 1981, enabling the construction of the 3.5-m New Technology Telescope with pioneering advances in active optics, crucial for the next step: the construction of the Very Large Telescope, which received the green light from Council in 1987 and was built on Cerro Paranal in the Atacama desert between Antofagasta and Taltal in Northern Chile. The 8.1-m Gemini telescopes and the 8.3-m Subaru telescope were constructed on a similar time scale, while the Large Binocular Telescope and the Gran Telescopio Canarias are now starting operations.

The VLT was designed from the start as an integrated system of four 8.2-m telescopes, including the possibility to combine the light from individual telescopes for optical interferometry, enabling stupendous spatial resolution. First light on Antu occurred in May 1998, with Kueyen, Melipal and Yepun following soon after. Most of the VLT and VLTI instruments were built in close collaboration with institutes in the member states. The entire first-generation instrument suite was completed in 2007 with the commissioning of CRIRES. The Paranal arsenal includes turnkey adaptive optics systems and a rapid-response mode to react to fast transient events. Recently, the near-infrared imager HAWK-I was added as a 'generation-1.5' instrument.

The VLT and VLTI have contributed to all areas of astronomy, including the nature of dark matter and dark energy, the extreme physics of gamma-ray bursts and supernovae, the formation, structure and evolution of galaxies, the properties of super-massive black holes in galactic nuclei, in particular the one in the Galactic Centre, of star clusters and stellar populations, of the interstellar and intergalactic medium, the formation of stars and planets, the properties of exoplanets, and of Solar System objects. The output in terms of refereed research papers was 469 in 2007 alone, bringing the total since first light to over 2 200, with the annual rate still increasing.

The total number of observing proposals for ESO facilities has doubled in the past decade, and now approaches nearly a thousand each semester, 800 of which are for Paranal. The User Portal has about 4 000 registered users and the archive contains 74 TB of data and advanced data products.

Winning strategy

The VLT opened for business some five years after the Keck telescopes, but the decision to take the time to build a fully integrated system, consisting of four 8.2-m telescopes and providing a dozen foci for a carefully thought-out complement of instruments together with four 1.8-m Auxiliary Telescopes for the interferometer, was the right one. The combination of a long-term adequately-funded instrument and technology development plan, with an approach where most of the instruments were built in collaboration with institutions in the member states, with in-kind contributions in labour compensated by guaranteed observing time, has created the most advanced ground-based optical observatory in the world. The operations model distinguishes visitor and service mode, and provides world-leading observing efficiency on a site where nearly 90 % of the nights are clear. All of this was made possible by the motivation of ESO staff members to build, operate and support the best possible observatory. As a result, the VLT is arguably the natural successor of the 'Perfect Machine' on Mount Palomar. Our 2007 Visiting Committee, chaired by Professor Günther Hasinger, stated it thus: "ESO has become the premier observatory for optical-infrared astronomy on a worldwide basis."

The stunning scientific success of the VLT attracted new member states to ESO. In the past decade Portugal joined (after a ten-year associate status), followed by the United Kingdom, Finland, Spain and the Czech Republic. At the time of writing it looks likely that Austria will join later this year (see text of Press Release on page 5). These countries are drawn to ESO because of the unique observing opportunities and by the possibility to be involved in a coherent long-term programme involving the design, construction and operation of future world-class ground-based facilities for astronomy. As their annual contribution and entrance

Photo: H. H. Heyer, ESO

The VLT as it is today with four Unit Telescopes and four Auxiliary Telescopes.

fee is added to ESO's income, the accession of new member states also enables new projects.

The next steps

The VLT will continue to increase in power over the next decade. X-Shooter will come on line this year, with KMOS, SPHERE and MUSE to follow, together with multiple laser guide stars, an adaptive secondary mirror on Yepun, and one or more third-generation instruments, including an ultra-stable high-resolution spectrograph at the combined focus (as foreseen in the original VLT design). The VLTI will be equipped with the second-generation instruments GRAVITY and MATISSE, to be followed by VSI, the latter perhaps with two additional Auxiliary Telescopes, if external funding can be found.

VISTA and the VST are expected to start regular operations next year with a five-year programme of coherent public surveys led by international teams. These surveys are performed together with data centres in the member states, coordinated by ESO. This collaboration builds a European survey capability which will deliver eminent science, provides crucial ground-based data in support of future space missions, and prepares the way for the next step in surveys.

The Atacama Large Millimeter/submillimeter Array is being constructed at 5 050-m altitude on Chajnantor east of San Pedro de Atacama in northern Chile. ALMA evolved from separate regional plans to a global partnership between Europe, North America (USA and Canada) and East Asia (Japan and Taiwan), with ESO representing Europe. Participation in ALMA expands ESO's activities into a wavelength regime often associated with radio astronomy. The first step has already been taken: ESO operates APEX, a single-dish 12-m antenna for submillimetre astronomy located on Chajnantor, in a partnership with Sweden and the Max-Planck-Gesellschaft.

ALMA construction is well underway. ESO has delivered key components, including the Technical Building for the Observing Support Facility at 2 950 m, and two antenna transporters (see the article on page 23). Institutes in the member states are providing the Band 7 and Band 9 high-frequency receivers and front-end integration for the 66 ALMA antennas. The 25 12-m antennas to be delivered by European industry are behind schedule, with the first one arriving in Chile in the first half of 2009, where Japan and North America already have four antennas each at the OSF being readied for acceptance. The hope is that the schedule slip can be recovered through a speedy delivery of the later antennas. The creation of the ALMA European Regional Centre, with nodes in many of the member states, will help prepare the European astronomical community for leadership in ALMA science exploitation, building on expertise with existing sub-millimetre telescopes, including APEX, and on science to be done with the 3.5-m Herschel Space Observatory, which ESA expects to launch in 2009.

The next world-class ground-based facility is the European Extremely Large Telescope for the visible/infrared wavelength regime. ESO is undertaking the design study, in close collaboration with industry and institutes in the member states. The baseline design consists of a 42-m segmented primary mirror, an innovative five-mirror design, and adaptive optics built into the telescope. The study draws on the entire expertise built up in ESO and the member states over the past decades, including lessons learned from ALMA construction. The aim is to be ready for a construction start in 2010, so that there is an opportunity for overlap with the James Webb Space Telescope, which is the next NASA/ESA/CSA flagship facility.

This combined programme is ambitious, but achievable by building on the 'VLT model' in which high-quality staff carries out a coherent programme in close collaboration with scientists and institutions in the member states, with long-term planning enabled by the security of an intergovernmental treaty.

ESO continues to attract and train high-quality staff both in Chile and in Garching. In the past eight months I spent a fair

amount of time at our sites in Chile, and after each visit I came away impressed by the dedication and motivation of our personnel in all areas of expertise. The same is true for our staff members in Garching, who provide general user support, develop critical software, coordinate the construction of new instrumentation, and follow developments in technology (both of which include in-house activities). The astronomers have a fraction of their time available for personal research, as this is crucial for ESO's ability to deliver the best observing facilities for the member states.

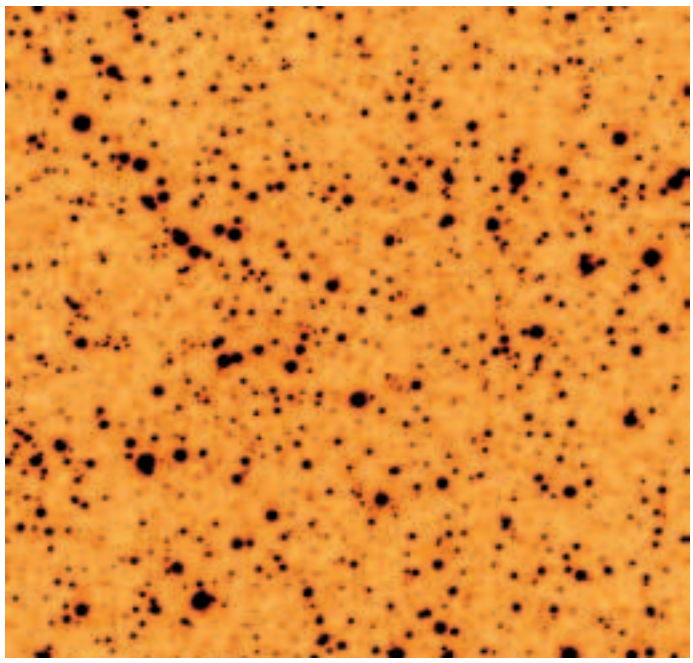
ESO's Fellowship programme deserves special mention. It also has grown over the past decade. A remarkable statistic is that 92 % of all former ESO Fellows are still active in astronomy, many in institutions in the member states. This strengthens the partnership between ESO and the member states in a natural way, contributing to the long-term success of the entire programme.

When the VLT turns 15 in five years time, the medium-sized telescopes on La Silla will be focused on unique long-term science, the VLT and VLTI will be nearing their full potential, and ALMA will be operational. If all goes well, the Extremely Large Telescope will be in construction, and ESO and the member states will already be planning for another world-class ground-based facility. This entire prospect is very exciting and I look forward to being a part of this.

10th Anniversary of First Light of the VLT

On 16 May 1998, 'First Light', in the sense of imaging with active optics and telescope tracking, was obtained with the VLT Test Camera for Unit Telescope 1. The First Light image, which originally appeared in The Messenger, No. 92 is reproduced here and shows a 10-min *R*-band image of the globular cluster Omega Centauri. The image was actually obtained before the mirror was coated but has measured image quality (Full Width at Half Maximum) of 0.43 arcsec. The accompanying photograph taken during that period shows the three key staff – Massimo Tarenghi, then director of the Paranal Observatory, Roberto Gilmozzi and Jason Spyromilio – in the VLT control room. All three are still with ESO: Massimo has been ALMA Director, Roberto succeeded Massimo as director of the Paranal Observatory and was himself succeeded by Jason. Both are now working on ESO's next large telescope project – the European Extremely Large Telescope (E-ELT). The understated sense of jubilation at the meeting of performance criteria is well caught in the quotation from the article "The First Steps of UT1" by Tarenghi, Gray, Spyromilio and Gilmozzi, which appeared in The Messenger No. 93, printed here.

To mark this anniversary a poster has been produced by the ESO Public Affairs Department (PAD) group and is enclosed with this issue.



VLT UT1 First Light image of Omega Centauri.

Massimo Tarenghi, Roberto Gilmozzi and Jason Spyromilio in the VLT control room in May 1998.