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Expanding Horizons: Transforming Astronomy in the 2040s

Jarle Brinchmann[1]
Xavier Barcons[1]
Mariya Lyubenova[1]
Bruno Leibundgut[1]
Paul Callanan[2]
Sara Krauss[1]

[1] ESO
[2] School of Physics, University College Cork, Ireland

The Expanding Horizons process will help ESO define its next major undertaking after the Extremely Large Telescope. It is an open and inclusive process, in which the whole ESO community is invited to participate. The goal of Expanding Horizons is to trigger dialogue about the key scientific challenges that will face astronomy, and disruptive technologies required to address them, in the 2040s. This process is divided into four stages: (a) searching for transformational scientific questions, (b) the call for concepts for facilities to address these questions, (c) the assessment of the submitted proposals, and (d) a final decision by the ESO Council. Programmatic work will only start after this decision has been adopted, including study and early design phases and resourcing of the newly created Programme. The design, construction and operation of the new facility, or of the significantly upgraded existing facility, will be owned by ESO, either alone or in partnership with other organisations.

Introduction

ESO has a long tradition of building transformational facilities, dating back to the start of activity at La Silla more than 60 years ago. It has done this either alone or in partnership, harnessing the collective expertise of the astronomical community.

The Very Large Telescope (VLT) remains at the forefront of ground-based astronomy after more than 25 years of operation, and its interferometer, the VLTI, is a unique facility. The Atacama Large Millimeter/submillimeter Array (ALMA) is still the most powerful facility capable of studying the cold Universe after more than 10 years of operation. Looking to the near future, within a few years ESO's Extremely Large Telescope (ELT) will see first light, providing the next transformational step for astronomy.

Experience has shown that the time required to develop a new major facility is typically 15–20 years; it is clear therefore that the time is now ripe for planning the next major ESO facility to start exploring the sky in the 2040s. To this end, ESO has initiated the Expanding Horizons process[1], a consultation with the community to identify the most pressing scientific challenges that will face astronomy in the 2040s, and what will be needed to address them.

To help oversee the first stage of this process, ESO has appointed a Senior Science Committee[2] (SSC), a group of experts that will assist the Director General and ESO by assessing transformational scientific value of the proposed facilities, with the ultimate decision on the selected proposal to be made by the ESO Council.

Defining the scientific priorities

For ESO to embark on a new facility-type Programme, it is critical that the strongest science case is put forward. Only in such circumstances will the ESO Member States consider investing resources towards a new or upgraded facility, either out of the long-term ESO budgetary projections or from additional income. The first step in the process is therefore to establish the breakthrough science we can expect to tackle in the 2040s, beyond the reach of the existing or already planned facilities. There are several existing reviews of the astronomical landscape, such as the ASTRONET Science Vision and Infrastructure Roadmap[3], the US Decadal Survey 2020[4] and ESA's Voyage 2050[5], but the first two are primarily focused on science of relevance into the early 2030s and the last is focused on space missions. These are excellent references and help identify what science will be done with existing and upcoming facilities in the 2030s; see also the article on page 7 of this issue on the facilities ESO will be offering in the 2030s. However, these reviews are insufficient to define ground-based astronomy priorities for the 2040s. To determine these priorities, ESO has taken some important first steps, as described below.

In collaboration with the European Astronomical Society (EAS), ESO organised a symposium at the EAS Annual Meeting in Cork on 25 June 2025, a report of which can be found on page 51 of this issue of The Messenger. In this symposium the community presented some ideas for the main scientific questions that will need answering in the 2040s.

To complement this effort, the SSC also decided to ask the community to provide input through brief science White Papers, with a deadline of 15 December 2025[6]. This call is an open invitation to the astronomical community in ESO Member States to present the key scientific challenges which require a new facility or significantly enhanced capabilities of an existing one, beyond what is expected for the next decade.

Based on the input from the white papers, the SSC will organise one or more workshops in 2026 to further discuss the scientific priorities.

Whilst ESO is committed to developing or exploiting cutting edge technologies[7,8], this effort is focused on the facilities the observatory is currently operating. Hence, in parallel to identifying the key scientific goals of the 2040s, the SSC is also tasked to identify enabling, indeed disruptive, technologies that have the potential to significantly transform the way these key scientific challenges will be addressed. To stimulate discussion within the community a disruptive technology workshop will also be organised in 2026.

Additional community workshops will also be held later in the proposal evaluation process to transparently share the most promising ideas that have emerged.

Proposing a new facility

The nature of this new facility is *a priori* not strongly constrained — the defining criteria are that it be scientifically transformative in the 2040s, and ground-based. It can for instance be a telescope, multiple telescopes, a significant upgrade of an existing facility that is (co-)owned by ESO, or an ambitious new instrument. In the case of a new facility, its location is also completely open for discussion.

ESO will issue a Call for Proposal Concepts for the new facility in Q3 of 2026, in response to which consortia should submit a Letter of Intent by 1 December 2026. The deadline for receipt of the full proposal is expected to be 1 June 2027.

The evaluation process

The evaluation of the submitted proposal concepts will consider at least four distinct areas: scientific drive, organisational impact, sustainability and risk to ESO.

The strength of the scientific case presented in the proposal will be the most important criterion of the evaluation. The SSC, in liaison with ESO's Directorate for Science, will assess the scientific excellence of the proposals and provide advice on this to ESO's executive and to the ESO Council. ESO will also assess, in collaboration with the SSC, the potential scientific synergies that a facility might present.

One broad concern for ESO is the impact of the proposed new facility on the organisation. This concerns, *inter alia*, the financial and operational impact, as well as whether ESO will need to grow substantially or to significantly alter the mix of expertise within the organisation. We expect that in some cases there will be proposals involving partnerships with international partners — and the impact and relevance of these will also be assessed. Associated with that, the degree to which the proposed facility puts the operation of other ESO facilities at risk will also have to be assessed.

ESO will also create cost estimates for the construction of the various proposed facilities and assess their sustainability, both environmental and social, as well as financial. This assessment will be carried out as uniformly as possible across proposals.

After the evaluations have concluded in the first two quarters of 2028, the Director General will decide on a recommendation for a proposal for a future facility, following discussions with the Directors Team and informed by the input from the SSC and the evaluation. The recommendation will be presented to ESO's Finance Committee, the Science and Technology Committee and finally to the ESO Council, with a decision planned for December 2028.

This would then signal the start of the next ESO Programme. ESO anticipates a slow ramp-up initially, until the main effort on the ELT decreases significantly. Current projections indicate that significant effort on the new Programme will only start to happen by the mid-2030s, with 'first light' in the 2040s.

Keeping ESO's community up to date

As Expanding Horizons is an open and inclusive process that aims to involve all of its community, ESO is executing a dedicated communication campaign to provide up-to-date information and to foster engagement. The main place where information is published is the Expanding Horizons website[1]. Whenever new important information on the calls or upcoming workshops becomes available, this is further disseminated via the ESO Science Newsletter as well as ESO's LinkedIn profile. Additionally, ESO is pleased to attend community meetings, give presentations about the Expanding Horizons process and answer any questions arising. Questions and requests for presentations can be submitted via the Contact form on the website.

ESO's next transformational facility is still a way off, but the journey and the results will be worth it. ESO has shown through its six-decade-long journey that it can deliver on such complex challenges, one time after another (first La Silla, then the VLT and VLTI, then ALMA and soon the ELT). The next step on this successful path starts with the Expanding Horizons process.

Links

[1] Expanding Horizons website: https://next.eso.org/
[2] Members of the Senior Science Committee: https://next.eso.org/ssc/
[3] ASTRONET Science Vision and Infrastructure Roadmap: https://www.astronet-eu.org/?page_id=521
[4] US Decadal Survey of Astronomy and Astrophysics 2020: https://www.nationalacademies.org/our-work/decadal-survey-on-astronomy-and-astrophysics-2020-astro2020
[5] ESA's Voyage 2050: https://www.cosmos.esa.int/web/voyage-2050
[6] Call for White Papers: https://next.eso.org/call-for-white-papers/
[7] ESO technology development webpage: https://www.eso.org/sci/future/techdev.html
[8] ESO's ALMA development studies group webpage: https://www.eso.org/sci/facilities/alma/development-studies.html