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Period 100: The Past, Present and Future of ESO Observing Programmes

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1 October 2017 marks the start of ESO Period 100. To celebrate this centenary we look back at the evolution of observing time proposals at ESO. This article examines the way that science is facilitated by ESO and how this has evolved as new technologies mature in order to take advantage of new ideas from astronomers and engineers from across the ESO Member States and beyond. We look at how the first ESO observing periods were defined and how different the calls for proposals and proposal reviews were at that time. We then detail how these processes changed as the VLT started, showing how Service Mode has fundamentally changed how astronomy is being done on the VLT. Finally we look to the future, describing forthcoming instruments and experiments on ESO telescopes and at other facilities hosted onsite. We conclude by describing some of the challenges faced by ESO and the user community and how procedures will need to evolve further to accommodate these.

Table 1

Specification of the periods for which observing time was allocated to Visiting Astronomers

Reference number	Period from noon	Period to noon	Notes
1	Nov. 1, 1968	May 1, 1969	only 1 m telescope
2	May 1, 1969	Sept. 1, 1969	only 1 m telescope
3	Sept. 1, 1969	March 2, 1970	1.52 m tel. and GPO added
4	March 2, 1970	Sept. 1, 1970	
5	Sept. 1, 1970	March 2, 1971	
6	March 2, 1971	July 1, 1971	
7	July 1, 1971	Oct. 1, 1971	
8	Oct. 1, 1971	Apr. 1, 1972	50 cm tel. added
9	Apr. 1, 1972	Oct. 1, 1972	
10	Oct. 1, 1972	Apr. 1, 1973	
11	Apr. 1, 1973	Oct. 1, 1973	

Figure 1. This table from the ESO Annual Report 1972 shows how the duration of the observing periods at ESO varied over the first 2–3 years until operations settled down in 1971. The numbering system of these observing periods was agreed with the OPC at the time.

In the beginning

ESO astronomers have regularly been invited to apply for observing time on ESO facilities since November 1968, which marks the start of Period 1. In the beginning the only telescope offered was the recently commissioned ESO 1-metre photometric telescope. The 1.52-metre spectrographic telescope and the Grand Prisme Objectif soon followed and they came into regular use from September 1969. Over the next two years ESO experimented with how often telescopes should be offered, trialling observing period lengths of between four and six months (see Figure 1), and finally settling on six-month periods running October–March and April–September; a definition that continues to this day. The numbering system for the first observing periods was retroactively assigned and published in the 1972 ESO Annual Report[1]. This includes a description of the importance of the October–March period which "includes the meteorologically most favourable months and also coincides with the Magellanic Clouds season". Standard application forms, in which astronomers could describe their observing plans in detail, were only introduced from Period 4, which began in March 1970.

The announcement inviting ESO observing proposals for Period 2 (March to September 1969) can be found in ESO Bulletin No. 4[2] and reveals some fascinating insights into what observing trips looked like for visiting astronomers at that time. From the beginning, ESO would cover costs for travel, lodging and food for qualifying visiting astronomers; this is much the same today. However, there are also some key differences: additional funds could be sourced to contribute towards the travel costs incurred by "accompanying wives ... only in case the observer will have to stay in Chile for periods of at least 6 months". It is clear from this announcement that the community was predominantly male and that observing stays of weeks to months were not unusual. The announcement was published in both English and French until Period 53 and proposals were accepted in both languages during this time.

Until 1971 the Scientific Programmes Committee (first chaired by Bengt Strömgren) oversaw both scientific policy at ESO and the review of the observing proposals submitted every period[3] (Madsen, 2012). In that year the responsibility for time allocation moved to the new Observing Programmes Committee (first chaired by Paul Ledoux). The initial panel constituted six senior scientists and was extended to eight in 1981. Over the next few years, the success of the Observatory meant the numbers of proposals submitted continued to increase and put the review process under correspondingly increasing pressure. In 1988, 350 proposals per period were received, necessitating the recruitment of extra "Members-at-Large" to balance the workload for all the reviewers.

By 1994, with over 500 proposals being submitted every semester, even this was not sufficient and it became necessary to significantly revise the procedure[3]. This led to the two-step process that continues to this day, whereby proposals are first reviewed by astronomers organised into panels with specific areas of scientific expertise, and then the Observing Programmes Committee (OPC) reviews the panel rankings across all scientific areas and issues final recommendations to the Director General. This model has largely been successful and has not substantially changed over more than 20 years, even though the numbers involved are very different. The first such review involved 34 panellists, of which 12 were OPC members (eight national representatives and four Members-at-Large). This was progressively increased to 48 (2000), 60 (2004) and 72 (2007). Since 2010 the

process has involved 79 astronomers per period, of which 17 are in the OPC-proper (including the OPC Chair).

Part of the challenge with organising peer reviews is to ensure that the pressure on reviewers is even across all scientific categories. The categories into which proposals were organised were initially defined as follows:
– Galaxies, Clusters of Galaxies and Cosmology
– Active Galactic Nuclei and Quasars
– Intergalactic and Interstellar Mediums
– High-mass and/or Hot Stars
– Low-mass and/or Cool Stars
– Solar System.

Four years later, some of these were updated and the list was as follows:
– Nearby Normal Galaxies and Stellar Systems
– Physics of AGNs, QSOs and Starburst Galaxies
– Interstellar Medium and Star formation
– High-mass and/or Hot Stars
– Low-mass and/or Cool Stars
– Solar System.

By June 2000, as the community started to avail itself of the new opportunities presented by access to the VLT, the OPC scientific categories were reassessed and four broad categories were defined, which remain substantially unchanged to the present day:
– Cosmology
– Galaxies and Galactic Nuclei
– ISM, Star Formation and Planetary Systems
– Stellar Evolution.

For reviews of the detailed procedures governing the review, selection and scheduling of observing time proposals at ESO the reader is referred to Breysacher & Waelkens (2001) and Patat & Hussain (2012).

From the La Silla boom to the VLT explosion

The proposal submission history at ESO during the last 40 years (1977–2017) is presented in Figure 2. This also shows the entry periods of the various Member countries and other significant events related to ESO telescopes and instrumentation. The pre-VLT era is characterised by steady growth, peaking in Period 54 (1995), when 556 proposals were submitted for the ten telescopes offered at La Silla. Immediately after, the New Technology Telescope (NTT), which had first been offered in 1990, was taken out of operation for the so-called "big-bang". During this phase, in which the NTT was used as a test bench for the hardware and software to be deployed at the Very Large Telescope, the number of proposals per semester stabilised at around 475. That was only a temporary pause, preceding the significant jump that was seen in Period 63 when Unit Telescope 1 (UT1, *Antu*), equipped with FORS1 (the FOcal Reducer/low dispersion Spectrograph 1) and ISAAC (the Infrared Spectrometer And Array Camera), was offered to the community for the first time. After that the number of submissions kept growing, peaking in Period 84 when, following the deployment of the first second-generation VLT instrument, X-shooter (a wideband ultraviolet-infrared spectrograph), ESO received almost 1100 proposals. Following this (still unchallenged) high point, the number of proposals has decreased to about 890, with another bump corresponding to the start of operations of other second-generation instruments (KMOS, SPHERE and MUSE).

Although it may be too early to draw firm conclusions, there are indications that the number of proposals is levelling out, at an average value slightly below 900 proposals per semester.

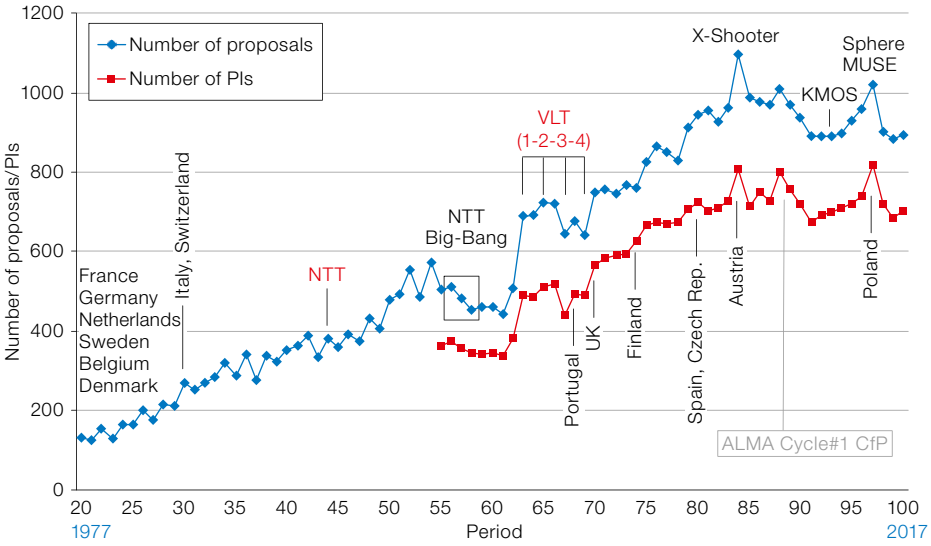


Figure 2. The "Breysacher" plot showing the evolution of the number of proposals submitted over time, for the last 40 years of ESO operations (1977–2017); this is named after Jacques Breysacher, who oversaw the proposal selection process at ESO between 1978 and 2003. The figure also shows the number of distinct Principal Investigators (PIs) from Period 55 (the period from which proposers data were digitally stored). The semesters during which new Member State countries joined are also indicated, as are significant events related to telescopes and instrumentation.

The ALMA Cycle #1 Call for Proposals opened on 31 May 2012 during ESO Period 89. This also corresponds to the time the first Public Spectroscopic Surveys started; both the ESO-Gaia survey and the Public ESO Spectroscopic Survey for Transient Objects (PESSTO) involve very large collaborative efforts. These factors probably contributed to the observed "plateau", although signs of flattening may already be visible as early as Period 85 (see Figure 2). This may indicate that the proposal submission capacity of the community has been reached.

It is interesting to note that a pause in the proposal growth is visible also in the phase immediately following the start of VLT operations (Periods 63 to 69) during which the average submission rate stabilised at around 700. The accession of the United Kingdom (Period 70) marked a new phase, characterised by other Member States joining and bringing new active users into the picture.

The shift from La Silla to Paranal

The trends in the number of proposals submitted over time to each site are shown in Figure 3, which illustrates the gradual shift from La Silla to Paranal from the start of VLT operations in Period 63. In this Period, only UT1 was offered on the VLT, and ESO received 400 proposals for La Silla and 237 for Paranal. This number quickly ramped up, with Paranal taking over from Period 70 and La Silla steadily decreasing with time. While La Silla receives fewer than 100 proposals per semester from Period 91 onwards, the overall demand for Paranal telescopes has remained roughly constant as at Period 82, with the two remarkable exceptions mentioned above. While there was some interest in joint La Silla-Paranal projects (about 40 proposals in Period 63), this has dropped with time to the relatively low level observed today (about 10 proposals per semester). The overall decrease that started in Period 85 can be explained as the combined decline in the number of submissions for La Silla and APEX (the Atacama Pathfinder EXperiment). For the La Silla telescopes, we note that there is a clear trend towards Large Programmes submitted by large teams. On the contrary, the request at the VLT is largely dominated by normal programmes (about 85 %), with a median time request of below 15 hours.

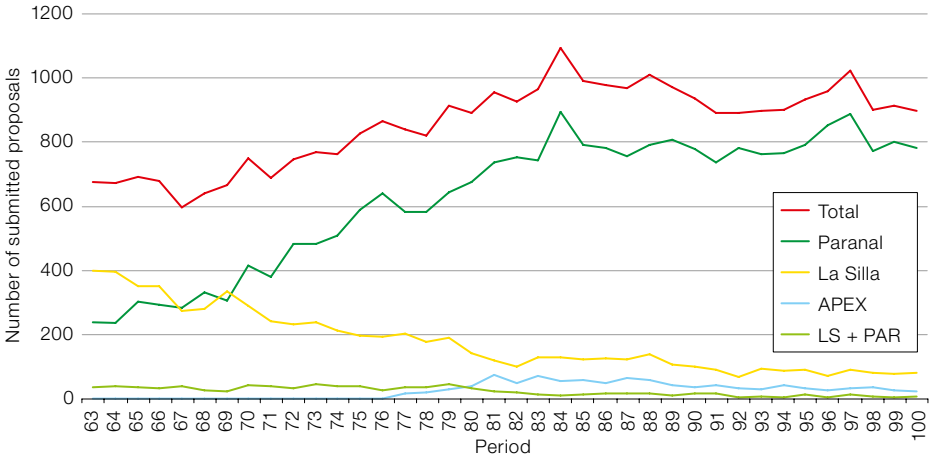


Figure 3. (Upper) Evolution in the number of proposals per site in the VLT era (starting from Period 63).

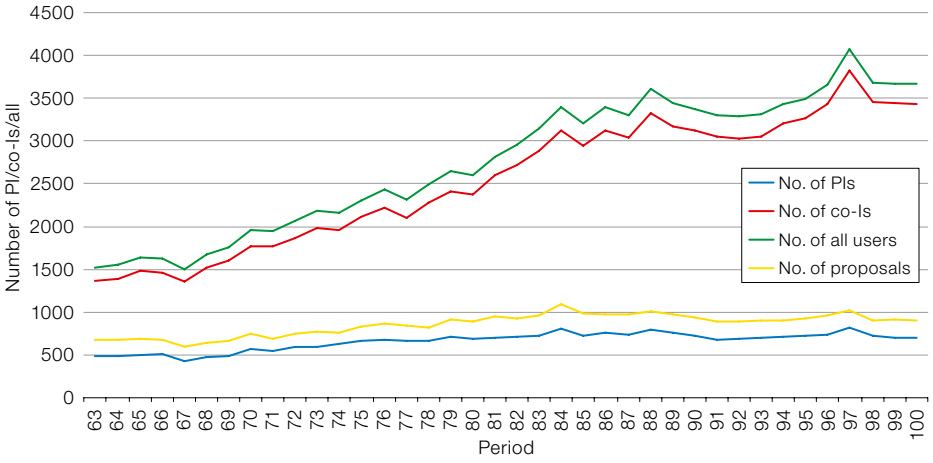


Figure 4. (Lower) Trends in the number of investigators over time in the VLT era. The figure shows the evolution of the number of distinct Principal Investigators, co-Investigators (co-Is), total users and proposals per semester.

The evolution of the user community and the shift in scientific interests

The evolution of the ESO user community is presented in Figure 4, where we have plotted various indicators for the VLT era. After the initial, comparatively flat part (from Periods 63 to 67), in which the total number of users (distinct scientists, both PIs and co-Is) was slightly above 1500, a steady rise commences. The number of scientists involved in ESO proposals has kept growing, exceeding 3500 proposers in Period 88, and reaching its maximum value (4078) in Period 97, to stabilise at about 3700 researchers in the last few semesters. The size of the active ESO community has more than doubled since the start of the VLT era.

Despite the significant growth in the number of proposals, the submission rate per PI (in terms of average number of proposals per semester) has remained practically constant at about 1.3 proposals per semester per PI. This is shown in Figure 5 and it is due to the combined evolution of the number of proposals and distinct PIs, which practically balance out; the observed increase is totally driven by the rise in the number of active PIs (and not by an enhanced submission rate per PI). A similar stability is observed for the average number of proposals per co-investigator; on average, each co-investigator is connected with about two proposals every semester.

On the other hand, the size of proposing teams has continued to get larger, with no signs of saturation across the whole VLT era (see Figure 5). While at the start of VLT operations the average team included two co-investigators, by P100 this number has almost doubled (to 3.8).

To illustrate the changes in the scientific interests in the community, we present in Figure 6 the fractions of the number of proposals for each of the four categories introduced in Period 66 (A: cosmology; B: galaxies and galactic nuclei; C: interstellar medium, star formation and planetary systems; D: stellar evolution). The most significant development is the pronounced growth of the C category, from about 21 % in Period 66 to the 36 % peak attained in Period 83. This trend is certainly related to the expansion of the exoplanet field sparked by the announcement of the first detection by Mayor & Queloz (1995), a discovery that led to the development of efficient planet-hunting instrumentation at ESO.

Another interesting aspect concerns the A and B categories. While these fields lost some interest since the start of VLT operations in favour of the more popular categories C and D, each regained at least part of it in the last five years. In addition, around Periods 80 to 83 there was an inversion in the trend; cosmology took over from galaxies and galactic nuclei studies. This, coupled with the increase in the overall number of proposals, motivated ESO to introduce an extra panel in the A category in Period 85 which, like B, traditionally had only two panels (in contrast to the C and D categories, which have four panels each). In P100, C and D categories include 61 % of the proposals, while A and B account for the remaining 39 %.

The move to Service Mode

One of the most important changes introduced by ESO in its operating model is the deployment of Service Mode. As stated in the VLT/VLTI Science Operations Policy[4], at least 50 % of the time at the VLT is reserved for this mode, while at least 40 % of the available time is reserved for Visitor Mode observations. The policy ensured some flexibility, stating that "these figures may be subject to periodic adjustments, depending on the experience gained at ESO and the evolution of the community demands".

The way the repartition of time evolved in practice is presented in Figure 7, which plots the fractions of requested time at the VLT only. As it turns out, the community quickly moved away from the 50/50 request seen in the first few semesters, gradually and steadily increasing the Service Mode fraction. After levelling out at around 70/30 between Periods 78 and 88, the Service Mode demand started growing again, to reach a peak in P100 (about 87 %). The reasons for the observed behaviour are probably manifold. The efficiency of the operational schema, its satisfactory science return and the increase in the number of short time requests (for which observing trips to Chilean sites are inefficient) have certainly contributed to the current status. ESO has not taken any action to counter this trend, which may lead to a loss of contact with the Observatory and the telescopes, with potentially negative effects on the next generation of astronomers.

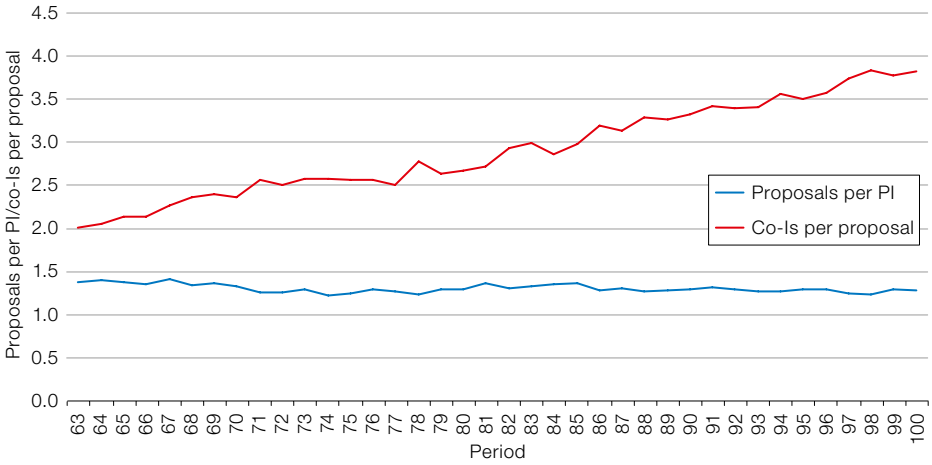


Figure 5. (Upper) Evolution of the average number of proposals per Principal Investigator and the average number of co-Investigators per proposal during the VLT era.

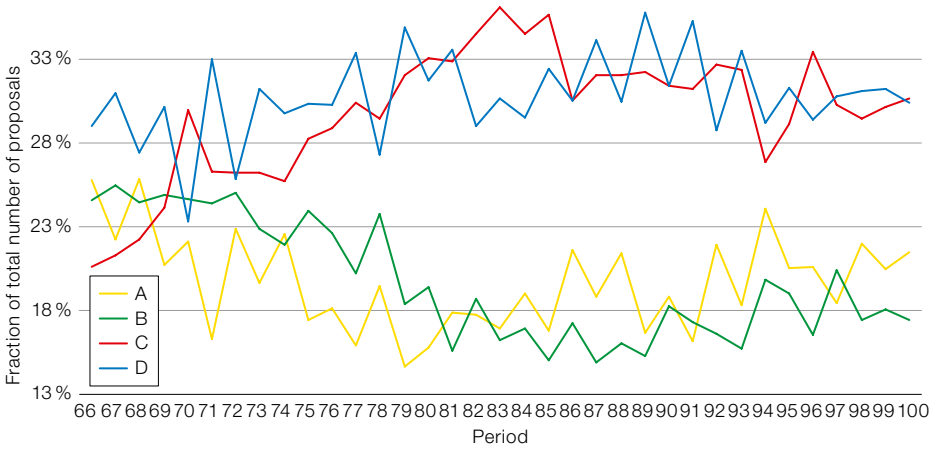
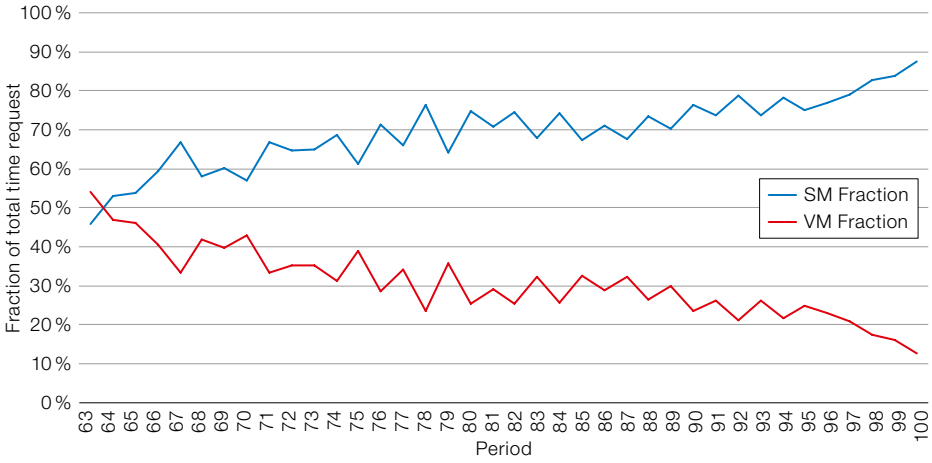


Figure 6. (Lower) Evolution of the number of proposals per scientific category since Period 66 (A: Cosmology, B: Galaxies, C: Star formation and planetary systems, D: Stellar evolution).



However, it is worth noting that the effectively allocated Service/Visitor Mode fraction is different, because the GTO as well as the Public Spectroscopic Surveys on

Figure 7. Service Mode (SM) *vs.* Visitor Mode (VM) time requests. This includes proposals for the VLT only. Large Programmes, Public Spectroscopic Surveys and Guaranteed Time Observations proposals are excluded.

the VLT are all scheduled in Visitor Mode, hence partially balancing the repartition, especially in the last five years. However, Figure 7 reveals a clear trend that requires consideration by both ESO and its user community.

Looking ahead

The history of ESO is marked by the constant development of new instrumentation and facilities, and an operating model that is capable of adapting to these changes. Likewise, the processes involved in the selection of the most promising observing programmes and the allocation of telescope time have to develop accordingly. Often this is accompanied by an evolution of the tools used at ESO. Figure 8 compares draft telescope schedules from Periods 22 (1978) and 100 (2017). Whilst in Period 22 this was done manually on paper, schedulers have used the TaToo time allocation tool since Period 73 (Alves, 2005).

Since there are virtually no pauses in the operation of ESO telescopes, new frameworks have to be tried at the same time as regular support to the ESO user community is provided, resulting in a number of additional challenges. This also means that the consequences of changes are seen immediately, and new ideas are constantly scrutinised and adapted in a feedback process between ESO and its user community. As the pace of technological progress and the ESO community both increase, so does the pressure on the different ESO systems, which grow in complexity to facilitate quick scientific exploitation.

In the very near future, the current framework will be challenged by ESPRESSO (the Echelle SPectrograph for Rocky Exoplanet and Stable Spectroscopic Observations) and 4MOST (the 4-metre Multi-Object Spectroscopic Telescope). As of 2018, ESPRESSO will be the first instrument to use the incoherent focus at the VLTI laboratory, employing either one or multiple UTs. When using multiple UTs it will be similar to the VLTI with the UTs as regards time allocation. However, in what is considered its basic operating mode, i.e. using a single UT, ESPRESSO allows the possibility of using any UT for the execution of a given Observing Block for the first time, hence adding extra complexity to the scheduling. Furthermore, when ESPRESSO is occupying a single UT, the VLTI coherent focus can still be used at the same time with either the Auxiliary Telescopes (ATs) or the other UTs.

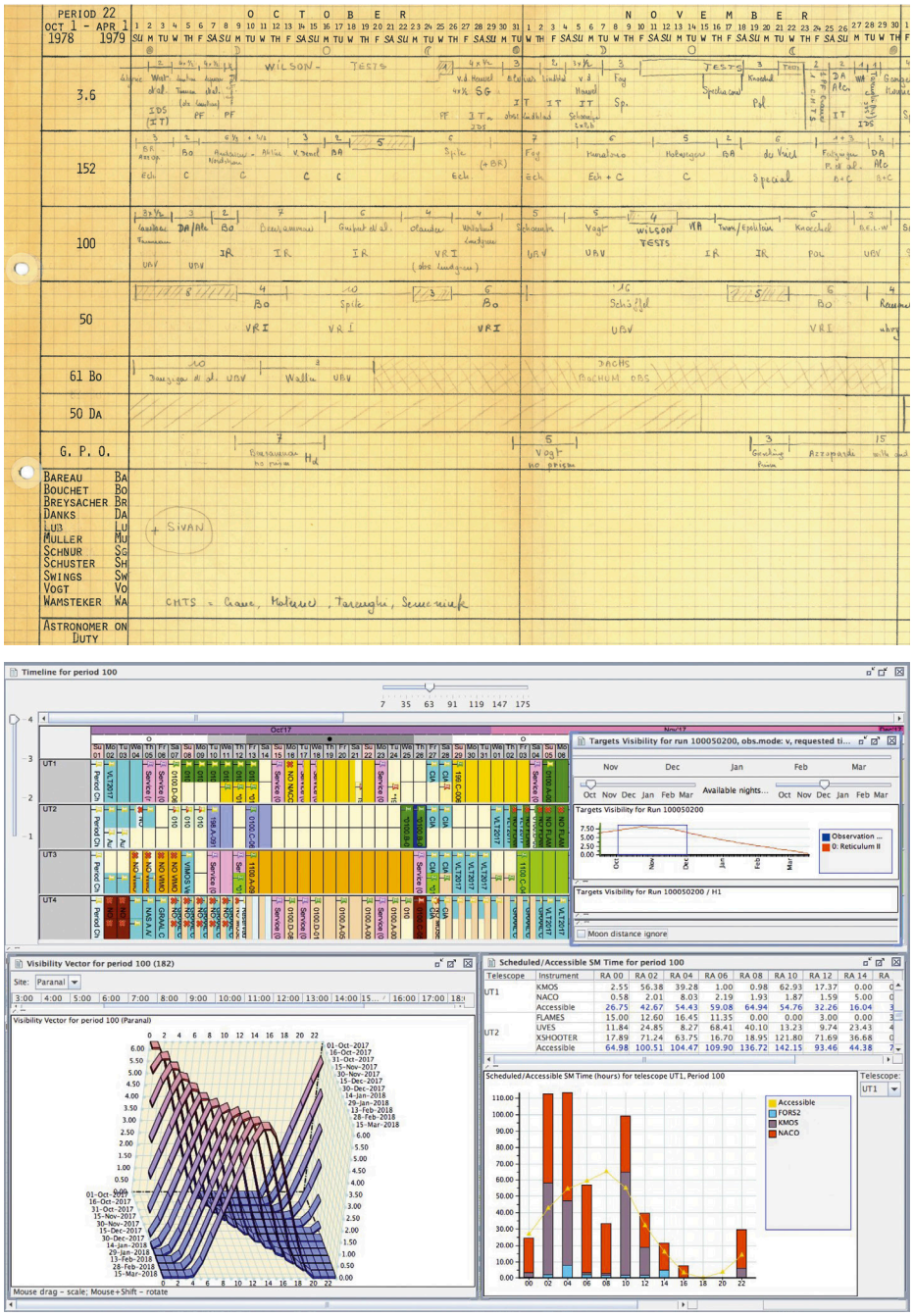


Figure 8. Draft telescope schedules in Periods 22 (top) and 100 (bottom). Until Period 73, scheduling the telescopes was done manually on paper.

4MOST (to be installed on the VISTA telescope in 2021, replacing the VISTA InfraRed CAMera, VIRCAM) will bring about an entirely new concept as regards surveys at ESO. Whilst the selection of the most compelling observing proposals will still be the responsibility of a committee of experts from the community, the

preparation and queuing of Observing Blocks will be a joint effort between ESO and the consortium building the instrument. Most of the time, the observations of targets from multiple surveys will be done in parallel within the same Observing Block. A tool developed by the consortium — the 4MOST Facility Simulator — will be used to assess the execution and completion of observations corresponding to both community and consortium surveys (Boller & Dwelly, 2012). The tool will also have a built-in exposure time calculator to estimate the execution time of observations of large sets of targets.

Furthermore, 4MOST will provide ample opportunity for spectroscopic follow-up of transient objects discovered with the Large Synoptic Survey Telescope (LSST), which will also be located in Chile, its first light expected in 2020. Given that the LSST will discover thousands of new transient sources (for example, supernovae and QSOs) every night, studies of such phenomena will push strongly for more dynamical scheduling.

After the installation of the HARPS (High Accuracy Radial velocity Planetary Searcher) instrument on the ESO 3.6-metre telescope in La Silla, this site has become a key player in research on extrasolar planetary systems. The unique capabilities of HARPS in studying the radial motion of extrasolar planets will be complemented in the near-infrared with the commissioning of the NIRPS (Near-InfraRed Planet Searcher) instrument, expected in 2019 (Bouchy et al., p. 21). The ESO 3.6-metre telescope becomes therefore an “extrasolar planet telescope”, i.e., a telescope dedicated to tackling a particular set of science questions, with a significant impact on a specific yet substantial fraction of the community — a potentially interesting prospect for other ESO telescopes.
A number of small telescopes hosted at La Silla are addressing similar questions using a wide variety of approaches: for example, TRAPPIST (TRAnsiting Planets and PlanetesImals Small Telescope; first light in 2010); and two projects that have first light in 2017, the MASCARA (Multisite All Sky CAmeRA) station, and the ExTrA project (Exoplanets in Transits and their Atmospheres). Similarly, Paranal has been hosting the NGTS (Next-Generation Transit Survey) since 2015, which is also dedicated to extrasolar planets.

Planning for the Extremely Large Telescope

After first light in 2024, the Extremely Large Telescope (ELT) will become part of the suite of facilities offered to the ESO community. The ELT will enable discoveries of a transformational nature. It will be one unique telescope serving a large community with a diverse range of science cases. Depending on the operational model adopted for the VLT during the ELT era, this may have an impact and cause the review and scheduling process to develop further. This is a good time to re-examine the framework within which observing programmes are selected and allocated time, in consultation with the community. The exercise should not only consider the ELT but also the VLT, which will take on additional roles to support ELT discoveries. ESO is working to ensure that members of the user community can realise their ambitions to carry out the planned experiments and make the exciting discoveries that are foreseen with the ELT, while leaving enough space to facilitate unpredictable discoveries and address long-standing questions. This amounts to a significant challenge. The goal is a *modus operandi* that benefits the community as a whole. In this context, it is worth noting that the expected ELT discoveries in respect of fundamental physics will expand the expertise required to evaluate proposals, which is already very broad.

Despite the significant growth of the user community, which makes ESO one of the largest astronomical facilities in the world, the way that telescope time applications are reviewed has remained substantially the same since 1993. Barring the necessary increase in the number of reviewers, the procedure has changed in the details, but not in its substance. The current review load (about 70 proposals per panel member, and up to 100 for OPC-proper members) has reached critical levels once again, requiring a re-evaluation of the procedures and an examination of the effectiveness of peer review. This has been the subject of study by the ESO OPC Working Group (Brinks, Leibundgut & Mathys, 2012) and the Time Allocation Working Group (Patat et al., in preparation), which was convened as a spin-off of the ESO2020 exercise (Primas et al., 2015). A clear outcome from these studies is that it is generally agreed that peer review still remains the most satisfactory way of selecting time applications. How this is organised and carried out remains a matter of ongoing discussion that continues to take place between ESO and the community. This will necessarily touch upon a number of aspects, including the way time will be allocated at the ELT.

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Links

[1] ESO Annual Report 1972: https://www.eso.org/public/archives/annualreports/pdf/ar_1972.pdf
[2] ESO Bulletin No. 4: www.eso.org/public/archives/bulletins/pdf/bulletin_0004.pdf
[3] ESO Annual Report 1993: https://www.eso.org/public/archives/annualreports/pdf/ar_1993.pdf
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