Five years of science operations of the VLT on Paranal

The operations statistics of the first five years of VLT science operations are presented and analysed. The difficulties and successes encountered in the organisation and execution of the science operations support tasks are reviewed. The lessons drawn from this experience are discussed.

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Dinner time. One of my table fellows raises his glass of wine: "Cheers!". This would not be a particularly remarkable scene, if we were not in the dining room of Paranal Observatory – a place where consumption of alcoholic drinks is, as a rule, not allowed. Someone else asks me if I know why the Director of the Observatory has made the exception tonight of offering each of the diners one (and only one!) glass of wine. It takes me one second to realise today's date: April 1, 2004. Five years ago, exactly, on the evening of April 1, 1999, at the very same time, instead of enjoying a good Chilean Cabernet Sauvignon with some hearty food, I was sitting at the console of UT1, together with a couple of other early Paranal Science Operations staff members, for the first ever night of actual science operations of the VLT. This was quite an exciting time – almost: fog and clouds all night actually prevented us from even opening the dome! Yet, the night of April 1–2, 1999 would forever be recorded as the first night of science operations of the VLT, and we just celebrated a few weeks ago the fifth anniversary of this achievement. Incidentally, it was not before the night of April 3–4, 1999, that the first general observer data of the VLT could eventually be obtained, since the UT1 dome also had to be kept closed on April 2–3, due to high winds! This anniversary represents a good opportunity to take a look back at what has happened in those five years and to reflect on what we have learned from it. And a lot has happened, indeed! Science operations started in April 1999 with the lone UT1: today all four Unit Telescopes collect scientific data on a nightly basis. The rather simple and conventional instruments FORS-1 and ISAAC, which were originally mounted on UT1, are still there at present, but they have been joined by five more instruments on the other three telescopes. While FORS-2 and UVES remain rather traditional in their functionalities and bear quite a number of similarities with instruments that existed at 4-m class observatories before the VLT era, the last three arrivals, FLAMES, NACO and VIMOS, break new ground in the areas of observational paradigm and efficiency. This is not over, actually: around the corner come MIDI (the first VLTI instrument to be used in full science operations), VISIR and SINFONI (both to be commissioned in 2004), and a little later, AMBER, CRIRES and OMEGACAM (the latter on the VST). The number of service mode runs scheduled for Period 63 (April 1-September 30, 1999) was 84; this number reached 300 in Period 72 (October 1-March 31, 2004). To support this fast growing operation, and in parallel with its development, a huge recruitment and training effort had to be made. During the Science Verification of UT1, in August 1998, the embryonic Paranal Science Operations (PSO) department was composed of Roberto Gilmozzi (who in 1999 moved on to become Director of the Paranal Observatory), myself, and two data handling administrators (José Parra and Blanca Camucet). Nowadays, it counts 56 members (including 13 ESO fellows "on loan" from ESO's Office for Science for their functional duties).

These are but a few numbers, to illustrate where science operation of the VLT on Paranal has come from and where it stands now. What has happened along the way can be better understood by taking a finer look at the operations statistics. From their analysis, complemented by a reflection on the difficulties and successes encountered in the organisation and execution of the science operations support tasks, lessons can be drawn. The results of this exercise are presented in the rest of this article.

What the numbers tell us...

A fundamental feature of the science operations of the VLT is the implementation of two modes of observation: service and visitor. In the traditional Visitor Mode (VM), successful proposers are allocated a number of nights on fixed dates, on which they travel to Paranal to carry out their observations. By contrast, observations for Service Mode (SM) are queued for execution by PSO staff

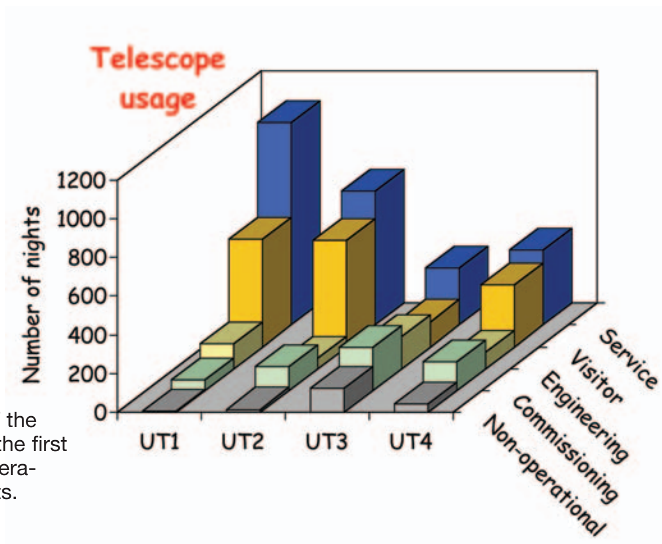

Figure 1: Distribution of the usage of each UT over the first five years of science operations of the VLT, in nights.

whenever the constraints set by the users are fulfilled. When SM was originally considered, it was realised that, in order to achieve the flexibility needed to take full advantage of this mode, it is necessary that a sufficient fraction of the available observing time be devoted to it. Yet, it was unclear whether it would be possible to reach a fraction of 50% of the time assigned to SM, which had been adopted as the target number, and this was a source of concern. Five years later, the challenge has been met beyond the most optimistic expectations, as illustrated in Figure 1. The ratio of the time actually used for SM observing to that devoted to VM, averaged over all four Unit Telescopes over the first five years of science operations, is close to 60/40. The concern nowadays is rather not to let this ratio be tipped even more towards SM, so as to maintain sufficient direct contact between the observatory and its users.

The total time available for execution of scientific observations, or science time, is the sum of the SM and VM nights. For UT1, between April 1, 1999 and April 1, 2004, 1604.5 nights have been dedicated to science, which represents more than 89% of the total number of 1796 nights corresponding to the five year interval from April 1, 1999 to April 1, 2004. The remaining 11% of the time were dedicated to planned technical interventions (labelled as engineering time in Figure 1) and to commissioning of new systems. Engineering time has primarily been spent on preventive maintenance activities, which are scheduled at regular intervals, and include mirror recoatings, which take place every 18 months. The ratio of science time to total time over the first four years of operations of UT2 is similar to UT1, 87%. By contrast, when UT3 and UT4 went into operations, they were equipped with a single instrument (FORS-1 and FORS-2, respectively), whose use made sense (almost) only in dark time periods. To this day, this is still the case for UT3, where the only instrument in operations is VIMOS. Therefore the fraction of the total time that could be devoted to the execution of scientific programmes was limited on these telescopes by the Moon phase, and hence is considerably lower than on UT1 and UT2. Paranal Observatory optimised the use of this time by concentrating on UT3 and UT4 commissioning and planned technical activities that could be carried out indifferently on any telescope. One can accordingly see in Figure 1 that the total numbers of commissioning and engineering nights on UT3 and UT4 are larger than on UT1 and UT2, although UT3 and UT4 have come into operations after UT1 and UT2. This left only a limited number of (bright time) nights when no useful technical or commissioning activities could be scheduled: these nights appear as non-operational time in the figure. The very small number of such nights that

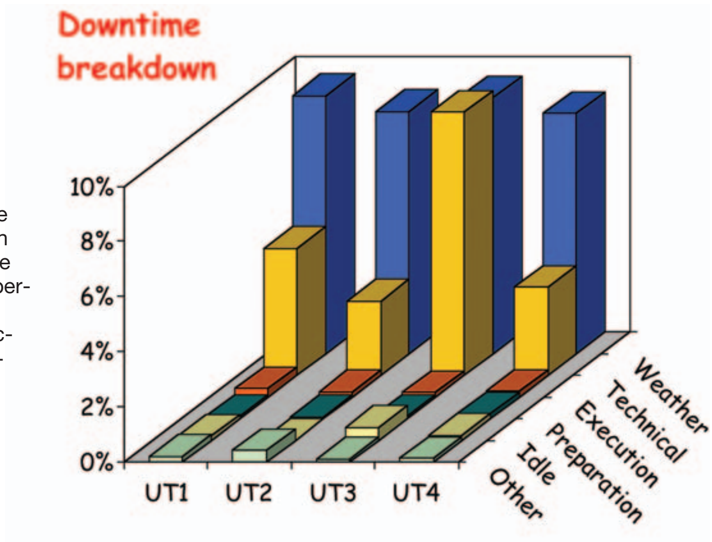

Figure 2: Downtime distribution for each UT over the first five years of science operations of the VLT, expressed as a fraction of the total science time.

also appear for UT1 and UT2 (less than 1% of the total number of nights since beginning of operations) mostly results from a higher than expected rate of completion of SM observations, a lower than planned need for time for maintenance activities, delays in the readiness of new instruments to be commissioned, and low demand of the astronomical commmunity for observations in specific right ascencion ranges. Such deficiencies in the scheduling process only appeared in the first periods of operations and they have since been corrected: there has been no non-operational time on either UT1 or UT2 since Period 68.

Of course, some unforeseen events occasionally hamper observation, such as bad weather or equipment failure. The resulting downtime is summarised in Figure 2. Bad weather is the primary source of loss of observation time, with losses averaging 9% of the science time. Leaving out UT3, downtime due to technical failures is of the order of 3.5%. The technical downtime number for UT3 is significantly higher than for the other telesccopes, mostly due to the difficulties encountered with VIMOS in the first months of its operations (see D'Odorico et al. 2003) and to a failure of the coating plant during the last re-coating of the primary and tertiary mirrors of UT3. Over its first five years of operations, the fraction of the time during which UT1 was not available for scientific observations for technical reasons (either because of planned engineering and commissioning activities or because of troubleshooting of technical problems) was less than 15%; a similar number applies to the first four years of science operations of UT2. Accounting also for weather downtime, both UT1 and UT2 were actually used for observing 76% of the time since their operations started. Downtime due to do other reasons is much smaller, less than 1% of the science time for all telesccopes. It includes execution downtime (due to operator errors during the observations), preparation downtime (resulting from mistakes in the preparation of the observation blocks by the users), and idle time (lack of executable observation blocks in the SM queues, reflecting deficiencies in the processes of telescope time allocation and long-term scheduling).

Of all the VLT instruments, the one that so far has been most used is ISAAC, with a grand total of 1070 nights of usage over the first five years of VLT operations (see Figure 3). It is followed by UVES, which has just overtaken FORS-1 in spite of totalling one year less in operations. Not surprisingly, the four instruments that have been most used until now are those that have been in operations for the longest time, that is the four instruments that were originally mounted on UT1 and UT2: ISAAC, UVES and the two FORS instruments. For these instruments, the usage number includes, in addition to the science time, the technical time that was specifically devoted to the instrument (e.g. to characterise its performance, to test new observation templates, to check its functionality after a technical intervention, etc.). For FLAMES, NACO, and VIMOS, which were commissioned on telescopes already in operation, the commissioning time also contributes to the usage statistics. Commissioning nights (including Science Demonstration Time) represent the major fraction of the VLTI entry in Figure 3 (which refers only to nights when interferometry was carried out with the Unit Telescopes - the far more numerous nights of siderostat use do not appear). A small amount of science time also contributes to the VLTI usage number, corresponding to MIDI Guaranteed Time Observations. The meaning of "No operations" is the same as in Figure 1, while "No instrument" refers to technical or commissioning time dedicated to work on the telescope itself: establishment of pointing models, calibration of adaptive optics system, various performance tests (such as tracking accuracy, etc.) and, of course, mirror recoatings. Finally, a very small number of nights were dedicated to a guest instrument on UT2 (SPIFFI, commissioned and used for science observations) and to preparatory work for the Laser Guide Star Facility (LGSF) on UT4.

Of course, mere statistics of usage of telescope time only give an incomplete picture of the value of VLT operations for their ultimate goal, that is, to maximise the scientific return of the VLT. In order to complement this picture, the opinions of the users represent an important element. At the end of their observing runs, visiting astronomers are requested to complete a questionaire, in which they rate various aspects of the support given by the Observatory and are invited to write the comments that they judge relevant. Over the first five years of operations, 357 end-of-run reports have been received: about 50% of the users return such reports. Their feedback is summarised in Figure 4.

More than 75% of the users report that they have completed at least 75% of their planned programme. Also, with the exception of the computing facilities (to which I shall come back below) the various aspects of the support given by the observatory that are considered in the questionnaire are rated "good" or "excellent" by more than 75% of the users. The work of the support astronomers and of the telescope operators is particularly appreciated, with almost 97% of the top two qualifications. The only reason why the technical support does not receive the same positive appraisal is that a significant fraction of the users consider its evaluation as "not applicable" (N/A): they had no need for it because they encountered no technical problem. This, of course, can also be interpreted as a high level of satisfaction, so that if the "not applicable" answers are added to the "good" and "excellent" ones, the fraction of the visiting astronomers who judge the technical support better than just acceptable reaches almost 99%. It is particularly pleasing that the perceived quality of the support work of the Paranal staff is significantly better than that of the food and lodging at the guest house, which is always very popular with visiting astronomers! It will be a great challenge to keep the level of satisfaction at the same height in the coming years, but we definitely intend to try to do so!

The more mitigated opinion of the users about the computing facilities on Paranal – "only" between 50 and 65% of "good" to "excellent" ratings appears to result from a rather complex conjunction of various factors. The on-line pipeline gets the highest number of N/A answers of all the items considered in the questionnaire. This generally arises when an on-line pipeline is not available (yet) for the instrument mode used by the visiting astronomer. However a fraction of visiting astronomers react to the lack of such a pipeline for a given observing mode by giving a rating of "poor". One should not be surprised that on-line pipeline reduction is not available for a significant fraction of VM runs: such pipelines are prioritarily developed for relatively standard observation modes, which are well suited to SM, while observations of a more experimental nature, which lend themselves poorly to automated data processing, tend also to require the presence of a visiting astronomer at the telescope. If one discards the N/A answers, one finds that "good" and "excellent" ratings account for 71% of the remaining answers. This represents a lower limit of the appreciation of the performance of the existing on-line pipelines, which brings them into the same ballpark as other items on which users are invited to give their opinion. On the other hand, for the offline workstation on which the users can process their data at the telescope as well as for the Linux PCs where they can prepare the observing run in the Paranal residence, a similar trend has surfaced in the past couple of years: namely, the number of N/A answers in the end-of-run reports is increasing. This reflects the fact that a growing number of users come to Paranal with their laptop computers, on which they carry out both observation block preparation and data reduction, not a deficiency of the service provided by the Observatory. Accordingly, it is justified to ignore the N/A answers to obtain the "true" image of the evaluation of the computing facilities put at the disposal of the visiting astronomers. This raises the fraction of "good" and "excellent" to, respectively, 74% and 67% for the offline workstations and the residence computers. For the latter, another factor has to be considered. Until the middle of Period 68, the visitors office was in the old camp, in a container, where the conditions were far from ideal for computers. Accordingly, it made little sense to invest in high-performance computing equipment, which would very quickly be damaged and rendered useless. In January 2002, the visitors offices were moved to their definitive location in the residence, and were equipped with state-of-the-art Linux PCs fully configured with all the major observation preparation and reduction tools. From that moment, the level of satisfaction expressed in the end-of-run reports increased considerably. Finally, a number of users appear to be disconcerted by the HP-UX operating system of the offline workstations of the control room, which was originally adopted for consistency with the computers that control the telescopes and instruments. However, few institutes in ESO member states use this operating system, and the improvement of performance of the ever more popular Linux machines in the past few years makes them an increasingly appealing alternative in the users' view. Use of this alternative for replacement of the current offline machines is under study.

The generally positive feedback of the visiting astronomers is mirrored by that of the SM users, which has been analysed in detail in a previous issue of *The Messenger* (Comerón et al. 2003).

...AND WHAT THEY DON'T

There is more to VLT science operations of the VLT on Paranal than just statistics. Efficient and smooth operations involve a wide range of aspects that cannot be reduced to dry numbers.

The popularity of SM observing with users, reflected by the fact that the number of SM nights exceeds by 50% that of VM nights, is a testimony to the success of SM operations. The latter, though, would not be achieved without a close-knit collaboration between PSO and the Garching based Users' Support Group (USG). I am pleased to stress here the excellent interaction that has been built between these two operations teams located 13,000 kilometers apart. One of its most concrete manifestations has been the implementation, since August 2002, of the so-called "Short-Medium Term Schedules" (SMTS). On a day-to-day basis, these (restricted access) Web pages provide the PSO astronomers with an up-to-date vision of the status of the SM queues, with

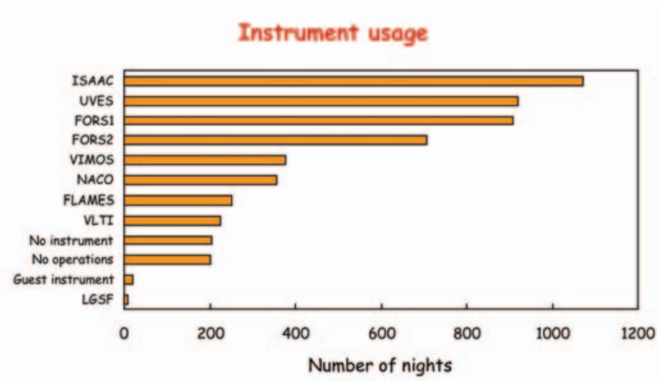

Figure 3: Usage of the various VLT instruments over the first five years of science operations of the VLT, in nights.

emphasis on the most critical aspects of the observations to be executed – stressing in particular the time-critical character of some of them. This tool, which has been developed as the result of a narrow interaction between USG and PSO, is instrumental for the optimisation of the real-time (or short-term) scheduling (STS) of SM observations. Proper handling of the latter, in turn, is the key to ensuring a high completion rate of the highest ranked runs. It can be noted that PSO night-time astronomers cannot rely on a computerised scheduling tool for STS decisions: in order for them to make such decisions "manually" in an adequate manner, it is essential that priorities are well defined and unambiguously communicated. What is also essential to ensure that high priority runs are completed is to avoid local oversubscriptions in the multi-dimensional parameter space (target location, sky transparency, seeing, lunar illumination) at the stage of creation of the SM queues. This has been described in detail in a previous *Messenger* article (Silva 2001). By contrast, the opposite effect, local undersubscription, may on occasion result in a lack of executable observation blocks in SM nights, leading to a telescope being left idle. It is now the reponsibility of the Visiting Astronomer Section (VISAS) to make sure that local over- and undersubscriptions are, as far as foreseeable, not built into the allocation of telescope time. Reaching this balance is not trivial, and some unfortunate experiences in the first few periods of science operations of the VLT taught us the hard way what had to be avoided. It must be put to the credit of USG (originally) and VISAS (more recently) that the number of deficiencies encountered in this area is now quite small.

Experience shows that the flexibility of observation scheduling in SM effectively allows the scientific return to be optimised and the technical downtime to be minimised, by switching during the night between the instruments mounted on the various foci of a given UT. The overheads involved in this operation prove to be small (of the order of a few minutes). By contrast, the benefits of a well-timed instrument switch for the scientific outcome of a night can be quite substantial. This is of course the case when one of the instruments undergoes a technical failure that requires time-consuming troubleshooting work. But more generally, instrument switches can also (and do regularly) happen to take the best advantage of the evolution of the observing conditions. This is especially beneficial for an instrument such as NACO, whose performance depends critically on environmental conditions (e.g. long correlation time of the turbulence) that are rather infrequently met and may be variable on short timescales. Such flexibility is quite demanding on the support staff, as it requires PSO astronomers to be cross-trained so as to be able to support the various instruments mounted on a given telescope. This challenging undertaking is well underway. But the understanding of flexible scheduling at Paranal Observatory goes beyond the alternation between instruments during a scheduled SM night. While some technical nights appear on fixed dates in the long-term schedule, in practice, planned night-time technical tests are to the extent possible executed during periods when the environmental conditions are not optimal for execution of SM observations and/or when the pressure in the SM queues is comparatively low. Also, on occasion, when delays in the arrival on Paranal of new instruments forced the observatory to cancel scheduled commissioning activities, the corresponding time was returned to science operations (primarily in SM). Several users benefitted from this as their programmes were belatedly allocated time that had been denied to them as part of the original time distribution. However this requires that the OPC ranking and comments are made in such a way as to allow additional runs, below the formal cutoff line, to be allocated time in the course of a period.

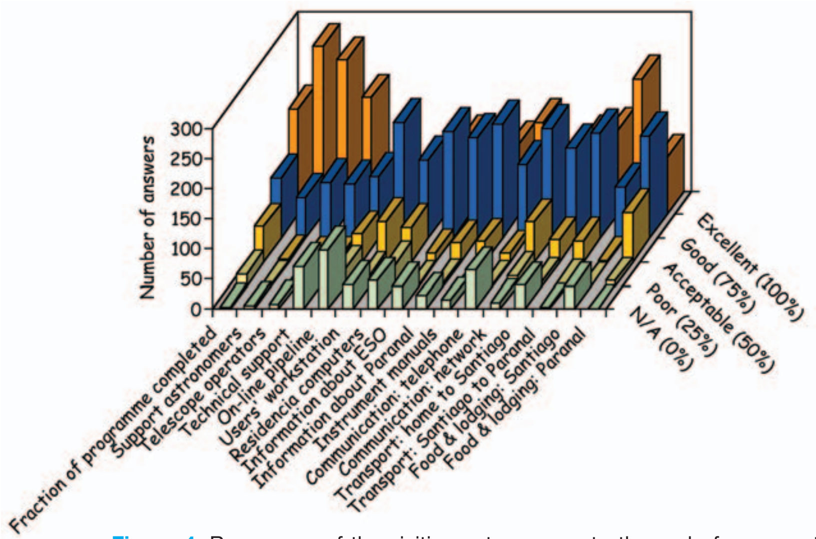

Figure 4: Responses of the visiting astronomers to the end-of-run questionnaire about the evaluation of the support provided for their observing run (qualitative marks) and the completed fraction of their intended programme (percentages in parentheses, applying only to first abscissa bin).

A couple of additional points about the VLT SM operations experience are worth noting. On the one hand, we have found that a clear definition of the respective priorities of the various Target of Opportunity (ToO) programmes approved by the OPC for execution on the same UT is needed. Even though the probability that conflicting triggers for execution of two different ToO observations with the same telescope at the same time can *a priori* seem negligibly small, in practice this has happened several times during the first five years of operations of the VLT! One can easily understand why the resolution of such cases in real time, when a delayed decision may result in missing the observation of a unique event of transitory nature, is far from ideal. On the other hand, we have learned (sometimes the hard way...) that allowing exceptions to the SM rules and handling observation blocks in a non-standard manner often turns out to be very time-consuming and error prone. This may (and does on occasion) ultimately prove counterproductive. Therefore requests from users to deviate from the established procedures cannot always be granted. This is not done lightly, but only after careful assessment of the balance between the gain that the considered exception can bring (to the single run of interest) and its possible negative impact (not only on this very run, but also overall, on all SM runs).

One feature of the organisation of the science operations support that is probably unique to the VLT is that, for each UT, a Paranal staff astronomer is present all night long to help the visiting astronomer throughout the whole run. This appears to be greatly appreciated by the users. The benefits of this operations scheme are especially significant for short VM runs, which makes it particularly appropriate to the current Paranal situation, where the average VM run length over the last 5 years has been below 2 days. Users have been encouraged, or even urged, by ESO to consider longer runs, without success. Short runs not only represent an additional burden for support astronomers, in particular by increasing the number of introductions to be given and by resulting in the simultaneous presence of more visiting astronomers on Paranal, all of whom have to be attended. They also put a significant stress on the logistic aspects, in particular the accommodation. Indeed room demand almost permanently exceeds the Paranal residence capacity, due in great part to the succession of visits of teams integrating and commissioning systems still to be put into operations. To make matters worse, both from the support and from the logistics points of view, runs consisting of half nights (or other fractions of nights) are becoming increasingly frequent. Nights shared between two (or more!) VM runs, or between a VM run and a SM part, are no longer exceptions. Besides the already mentioned crowding inconveniences, another consequence that should be pointed out is the increase of complexity and the accompanying decrease of flexibility of the SM STS process when only fractions of nights are available for SM operations. Finally, while shortage of accommodation is one of the reasons why it is not always possible to authorise the presence of two visiting astronomers for a single run, it is also worth noting that, with the highly automated VLT observation process and the support of a dedicated Paranal astronomer all night long, the presence of two observers during a VM run is effective only in a limited fraction of cases. For the same reasons, the value of a VLT run for the training of young astronomers in observations is often quite limited.

The staffing challenge

Beyond the numbers and the procedures, the successes and the difficulties, science operation of the VLT on Paranal is the work of a group of people. This group did not exist on April 1, 1998. Six years later, it counts 56 members. Taking into account staff turnover (some of the group members went to continue their career elsewhere, either inside or outside ESO), an average of more than twelve members of the PSO department were recruited each year for the last six years! All of them had to be integrated in the group, and to be trained: this represents a huge effort. That this could be achieved in such a way that, in spite of some deficiencies, science operations of the VLT have overall been successful, is a testimony probably more to the enthusiasm, motivation, dedication and competence of the people who joined the group than to particularly brilliant planning or organisation of the growth of the department. Planning, as a matter of fact, was made close to impossible by the difficulties met in the recruitment process, at least for the staff astronomers. Indeed after the first few staff astronomers had been hired, the response to subsequent vacancy notices was very low. Candidates were few and their qualification and experience level was often significantly below what had so far come to be expected for ESO staff astronomers. It just appeared that the limits of the market had been reached, that the large number of positions that had been opened in a very short time had absorbed all the astronomers in the community who fulfilled the requirements and were willing to work as operations support astronomers in a forefront but remote observatory. The shortage of candidates applying for positions of operations support staff astronomers on Paranal persists to this date (admittedly somewhat less extreme than a couple of years ago). While it is tempting to conclude that it would have been desirable to start recruiting PSO astronomers longer before the start of science operations, the persistent shortage of applicants for these positions leads one to question whether it would have been reasonably possible to start early enough to avoid the problem completely. As a consequence of the recruitment delays resulting from the shortage of suitable candidates, the PSO department was understaffed for four years. In order to reach a viable minimum staffing level, the recruitment requirements had to be lowered. The high level of enthusiasm and motivation of the more junior staff recruited under these conditions could not completely compensate for their lack of experience. Accordingly, a considerable training effort was required. This added to the demands put on the insufficient number of experienced PSO astronomers, some of whom started to show signs of wear. The combination of the predominence of junior astronomical staff in the department, with the excessive workload already assigned to its most experienced members, impedes the implementation of an intermediate managerial structure between the head of the department and the bulk of its members. Nevertheless, the recruitment difficulties that have been faced have also had some positive consequences. Most prominently, it gave the ESO Chile postdoctoral fellows the chance to grow into full operations support astronomers. This is beneficial both for the fellows, opening for them a career opportunity at the observatory earlier than would normally have been expected in the past, and for the observatory, since the training effort required to bring former fellows to the level of staff astronomers is considerably less than for external recruitees at the same stage of their career. It must be stressed however that, to be appointed as staff astronomers, ESO fellows have to go through the same open recruitment process as all other applicants, and they have to convince the selection board at that stage that they are effectively the best candidates for the considered positions. Note also that the use of ESO fellowships to develop operations support astronomer qualifications in young people is critical for the VLTI, since the very small community of astronomers with experience of optical interferometry does not represent a sufficient recruitment pool.

Fellows who move up to staff astronomer positions will eventually acquire sufficient experience to take up more senior responsibilities in the PSO department. However, for the time being, the additional experience that would be most valuable can only come out of the community. I can but encourage and urge our relatively senior readers to give more consideration to job opportunities that open on Paranal. In particular, one option that seems to have received little attention so far, is that of a limited-term contract as part of which an astronomer from some institution in Europe is either seconded to ESO or granted an extended leave of absence, so as to come and work in the PSO department for a few years, before going back to his/her original place. The continued success of the science operations of the VLT depends on the support of the community. In return astronomers who come to Paranal for a few years get a unique opportunity to further develop their expertise and experience, which upon their return to their original institution they can share with the astronomical community of their country. And the experience of working at Paranal Observatory, to keep the results of the operations at the same level as, or better than, described in this article, is without any doubt an exciting and very challenging one!

Acknowledgments

The support of the science operations of the VLT is a team work, and none of the achievements reported in this article could have been made without the participation of many people. First and above all, I wish to express my gratitude to all the past and present members of the PSO department, who night after night, and day after day, have worked and are working relentlessly to ensure the success of VLT science operations. Unfortunately they are too numerous for their names to be all listed here. The role of the Garching based Users' Support and Data Flow Operations groups in ensuring front and back end contacts with the SM users, in delivering timely and accurate information to PSO, and in monitoring the health of the instruments and checking the quality of the data that were obtained is essential to the success of the operations. I want particularly to thank their present and past leaders, F. Comerón, D. Silva, and B. Leibundgut, for the fruitful interactions that we have have had along the years towards building a close and reliable collaboration between these groups and PSO. Finally, I am deeply indebted to the Director of Paranal Observatory, Roberto Gilmozzi, for giving me the chance to run the science operations of what is, in my opinion, the world's foremost and best ground-based optical astronomical observatory.

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