The evolution of observing modes at ESO telescopes

S. Marteau*[a], O.Hainaut [a], G. Hau [a], S. Mieske [a], F. Patat [a], M. Rejkuba [a], I. Saviane [a], L. Tacconi-Garman [a]

[a]European Southern Observatory, Karl-Schwarzschild-Str. 2, 85748 Garching-bei-München, Germany

ABSTRACT

From the implementation of Service Mode at the NTT in 1997 to the recent "designated" Visitor Mode observations, we review how the palette of observing modes and the types of programs have evolved at ESO. In more detail, we present how the evolution of tools at the disposal of external astronomers and the Observatory staff has enabled ESO to implement new types of observations. We also take a look at the new challenges posed by upcoming instruments at the VLT and present the first steps towards enabling remote observing for ESO telescopes.

Keywords: observatory operations, observing modes, user-driven implementation

1. INTRODUCTION

Traditionally, astronomers travel to the telescopes for observing. With the start of space telescopes this obviously has changed, and soon the large ground-based observatories followed along, introducing the service-observing mode in addition to the visitor mode. Ever since ESO entered the VLT era in 1999, it has been possible for the astronomers to choose between these two modes based on the requirements of the observations to be performed. This duality was included early on in the genes of the VLT by the ESO Council through the overarching document that is the "VLT Science Operations Policy"[1], which explicitly states that the telescopes should be operated using these two observing modes. ESO was in this way building upon the experience of the space telescope and the in-house experiments carried out at the NTT – see section 3.1. But both modes were not set apart during the conception of the data flow surrounding the facility. On the contrary, service mode and visitor mode at ESO have always benefited from common services and tools, thus ensuring synergies between the two (as a simple example, an observing proposal can perfectly request both types of modes[1]). The fundamental concepts behind visitor and service mode have not radically changed since they were introduced. However, the emergence of new scientific rationales, observing strategies and an impetus to take advantage of improving IT technologies have spawned new variants of these observing modes over the past 20 years. In the following sections, we present how the evolution of tools available to astronomers and the Observatory staff has enabled ESO to implement new observation types. These new tools have also led to an improvement in efficiency.

2. VISITOR MODE

Often called classical observing, visitor mode has of course been the first to be offered at ESO facilities. Today the site of La Silla is operated entirely in this mode. That is not to say that visitor mode has not evolved through time.

2.1 Observing at the telescope

When granted observing time in visitor mode (VM), the observer is asked to travel to the observatory in Chile at a pre-defined date. With a substantial share of our astronomical community being based in Europe, this generally implies a 2-day journey to La Silla or Paranal, accounting for the stopover in Santiago. Visitors are asked to arrive on site one or two days before their scheduled telescope time slot, to allow for sufficient preparation time. The Visiting Astronomers Travel Office (VATravel for short) handles about 550 trips a year shared between both sites of the La Silla Paranal Observatory,

[1] Sometimes this is by construction: MOS programs scheduled in visitor mode have a small part of their allocated time dedicated to "pre-imaging". It is given a high priority in service mode so as to quickly provide the sufficient data to prepare the spectroscopic masks.

with an almost equal split, cf. figure 1. Note that this number includes the travellers with observing time granted on the national telescopes in La Silla (Swiss Euler telescope, Danish 1.5m…).

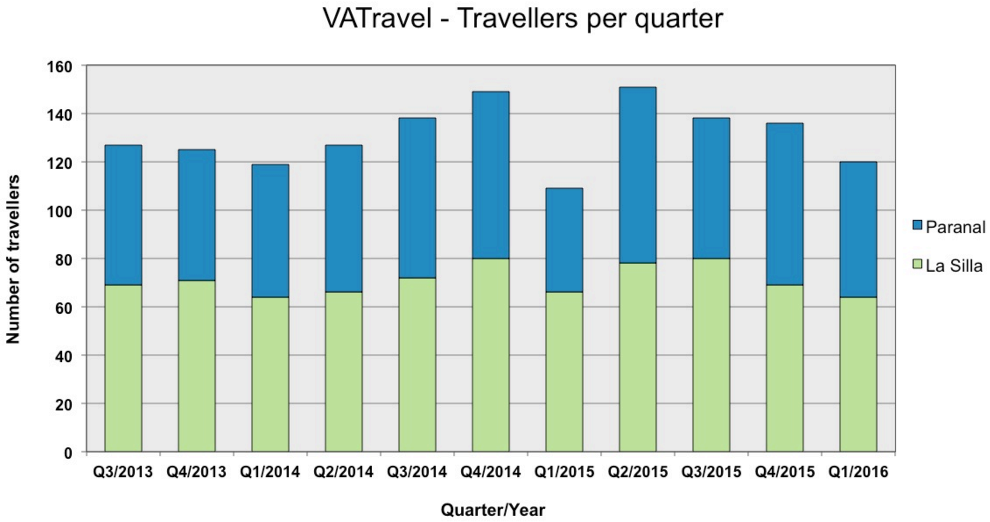

Figure 1: quarterly numbers of visiting astronomers to the ESO sites of Paranal and La Silla

One of the obvious advantages of taking part directly in the observations at the telescope is the ability to react in real-time to the acquired data, and be able to adjust one's observing strategy accordingly, while also benefiting from the advice of the instrument specialists on site. At the VLT we also reserve some of the more complex observing modes of our various instruments for VM observing runs, when carrying out the observations require on-the-spot decisions and adjustments from the observer in order to achieve the scientific goals at hand. For example, use of the sparse aperture mask of the NACO instrument is currently reserved to visitor mode. The flip side to this active participation of the astronomer and his ability to fine-tune the acquisition of the data is that it takes place at a time scheduled well in advance. Even at excellent sites such as Paranal and La Silla, the chances to lose some observing time to bad weather are never null. More often, the required seeing conditions may simply not be quite good enough on the prescribed night(s) to achieve the expected quality level on the final images. Nevertheless, visitor mode retains the favors of a sizeable fraction of the ESO users, as shown by the community poll issued for the ESO2020 workshop in early 2015[2]. When asked to prioritize the importance of different types of observing modes for their own research, almost 60% of the respondents ticked the box next to "classical observing", i.e. visitor mode at the La Silla Paranal Observatory. While initial plans made for the VLT relied on a 50/50 share between visitor and service mode[3], the demand for visitor mode has kept decreasing during the first periods of availability of the facility and has now stabilized in recent years around 30% of the total available time for the VLT and VLTI.

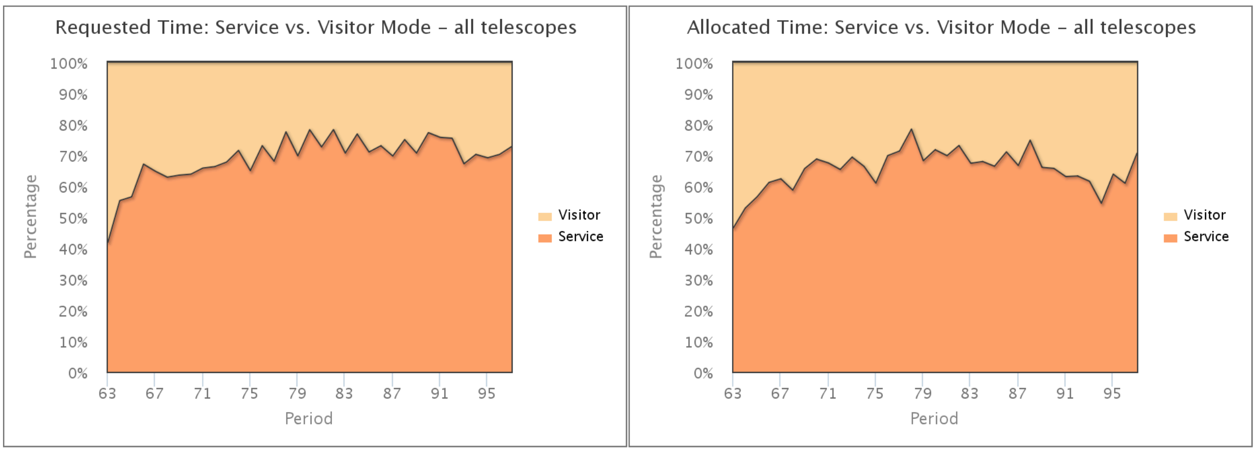

Figure 2: relative percentages of visitor and service mode in terms of the requested and allocated observing time at the VLT/VLTI. Period 63 corresponds to the first period of observation at the VLT (April 1999)

As shown on figure 2, the schedule reflects this share quite faithfully, with a small fraction of the time requested in service mode being eventually moved to visitor when observations are deemed to require more real-time interactions – see comments above. However, if one focuses solely on the 4 Unit Telescopes (dismissing the VLTI) and normal observing programs – no large programs, no guaranteed-time observations that are by definition executed in visitor mode – then the picture looks quite different (cf. figure 3). Indeed it shows that the demand for visitor mode has been steadily decreasing since the beginning of the VLT.

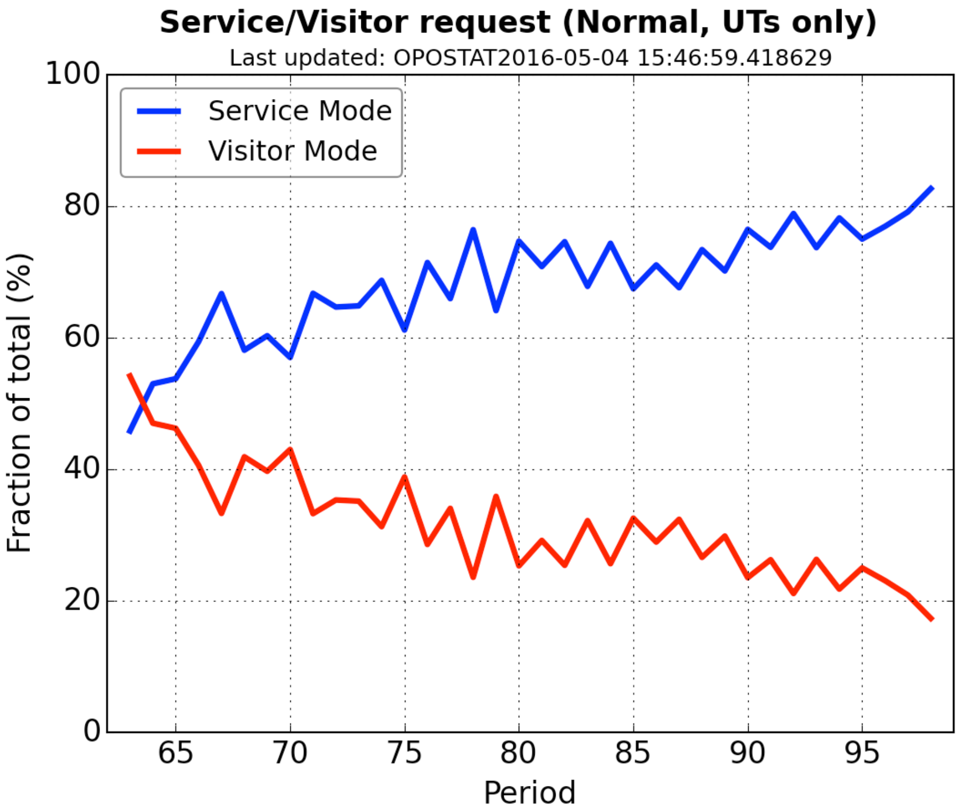

Figure 3: relative demands for service and visitor mode on the 4 VLT telescopes, for normal programs only. Period 63 marks the beginning of the VLT public time in April 99, while Period 97 started in April 2016.

Although being a less quantitative aspect, but nevertheless important, visitor mode offers the unique opportunity of a direct interaction between observatory staff and observers from the ESO community. The said astronomers can bring their own experience to the observing process, especially in case of very specialized data acquisition. This is certainly one of the reasons why so many astronomers voted for this observing mode in the aforementioned poll, and why ESO still keeps a good fraction of VLT time for visitor mode.

2.2 Designated visitor mode

Yet there are cases when the granted observing time hardly justifies such a long trip to Chile. Indeed, the advantage of the collecting power offered by 8m-class telescopes such as the VLT sometimes imply that the time required to achieve the science goal at hand is inferior to one night of observation. In other cases, scheduling and logistical constraints of the observatory impose to split a given observing run into several, distinct nights that would in principle require several trips to Paranal during the same semester – this is particularly true for VLTI observations to be carried out using several baselines, whereas each said baseline is available only during a small fraction of time for each observing period of

6 months. In order to mitigate this issue it was thus decided to schedule such short runs in so-called "designated" visitor mode, aka dVM. This possibility has been officially advertised by ESO since Period 93 (April 2014) after being tested during the period prior to that. The decision to use dVM is left at ESO's discretion when elaborating the telescope schedule. It depends on the technical feasibility assessment of the observing runs and is limited to the ones shorter than one whole night of telescope time. When granted dVM time, the user is still allocated a fixed slot in the telescope calendar. The observations are thus subject to the same vagaries of weather and observing conditions, or technical issues as for regular VM. However, they are carried out by observatory staff while being in audio-video contact with the observer. Since the level of interaction with the observer is less than when s/he is on site with the ESO staff, more preparation is needed in advance of the observation, and the relevant material is then communicated directly to the astronomers on the mountain in order to try and resolve possible issues ahead of time. In a way, this preparation is more akin to what a service mode observer would need to do, albeit with a different timing. We will come back to this in section 4. Since it is offered dVM has been used for an average 16 nights per period.

3. SERVICE MODE

Service mode (SM) is of course a much more recent invention. Readers may also know it as "queue observing" or "flexible scheduling", and we will explain why just below. Before going into more details as to how SM has evolved at ESO over the years, let's see how it was born.

3.1 From early days to now

Back in 1997 when laying out the fundamental concepts behind the then-to-be operations of the VLT, service mode was seen as a way of scheduling different types of observational programs, as well as a means to try and match the expectations of the observing runs in terms of data quality to the weather conditions prevailing at any given time[4][5]. Indeed, any program requiring series of observations, sometimes spaced by weeks or months, are ill suited for VM. The same can be said of large/survey programs requiring a substantial amount of time to be allocated, sometimes over several observing periods. And of course, probably the best-known advantage of SM lies in the possibility of executing observations based on a set of pre-defined observing constraints set by the user, hence the term of flexible scheduling. Disadvantages are naturally linked to what VM does best and is lacking here: observations must be prepared in advance without the possibility of interacting while they are executed, and the user can feel detached from the said execution. Not being on site while the data is being collected inevitably leads to a need for the user to have a way of following up the progress of his/her observing run, as well as an easy means to collect the data for analysis. Numerous articles have been written that describe the advantages of SM and explain what is to be expected from the way that observations are scheduled, especially in terms of the completion of observing runs, and how one can maximize their chances for a successful SM run (e.g. Silva 2001[6]).

As part of the refurbishing of La Silla's NTT telescope and in preparation for the start of VLT operations[3], service mode observations were first offered at ESO during three observing periods (Periods 58 to 60) between February 1997 and March 1998. Initially available on a shared risk basis only, SM suffered from a rough start due to an initial lack of manpower and of proper tools, not to mention particularly adverse weather conditions (strong El Niño episode). Period 60 fortunately showed much more encouraging results through improved procedures and better software, not to mention a better staffed support team at the ESO headquarters in Garching[7]. The experiment in La Silla was stopped then but SM could be offered in Period 63 for the start of VLT operations.

The demand for this mode kept increasing since the first few periods of the VLT, and its appeal remained high when further telescopes and instrument got commissioned. Nowadays approximately 70% of the total available time at the VLT/I is scheduled in service mode (fig. 1). This is visibly higher than the initial plan to keep an equal share at the VLT between SM and VM, but because the time allocation matches the demand from the community this simply tends to show that service mode overall delivers what it is supposed to, and accommodates the types of observations that astronomers need to perform. The community poll we referred to in the previous section on visitor mode also shows that SM is in very high demand, both for existing but also future facilities such as the E-ELT. Because service mode tries to match the preset constraint for the observations to the prevailing conditions, it is anyway important to reserve a sufficient amount of time to this mode in order to statistically increase the probability of realization for the said constraints. A counter example on Paranal is the VLTI: interferometric observations require using different baselines for each program.

However each of the offered baseline can only be made available for a short amount of time during one observing period, because of practical and logistical reasons – even if considered "small" compared to the VLT main telescopes, moving the Auxiliary Telescopes from one configuration to another means a non-negligible overhead. For that reason the scheduling of VLTI programs has always favored a larger fraction of visitor mode observations, recently made more practical to carry out through designated visitor mode (as described in 2.2).

As we wrote above, service mode makes it possible to take advantage of the prevailing observing conditions, and this means being able to execute those programs that require the most stringent ones. The seeing and the sky transparency are two of the obvious, very variable constraints that one has to deal with. Figure 4 shows how good the observatory has been doing in terms of completing service mode runs which such demanding constraints on the observing conditions. Despite 0.4 arcsec of seeing being met around 7% of the time only at Paranal, it is quite remarkable that 2/3 of the high-priority (A-class) observing runs scheduled with such a constraint could indeed be completed. The completion fraction looks even better for the 0.6 arcsec mark, which is achieved about 35% of the time at the VLT. We refer the reader to Primas et al.[8] (2014) for a more in-depth analysis of these figures, along with many other insights about our service mode operations.

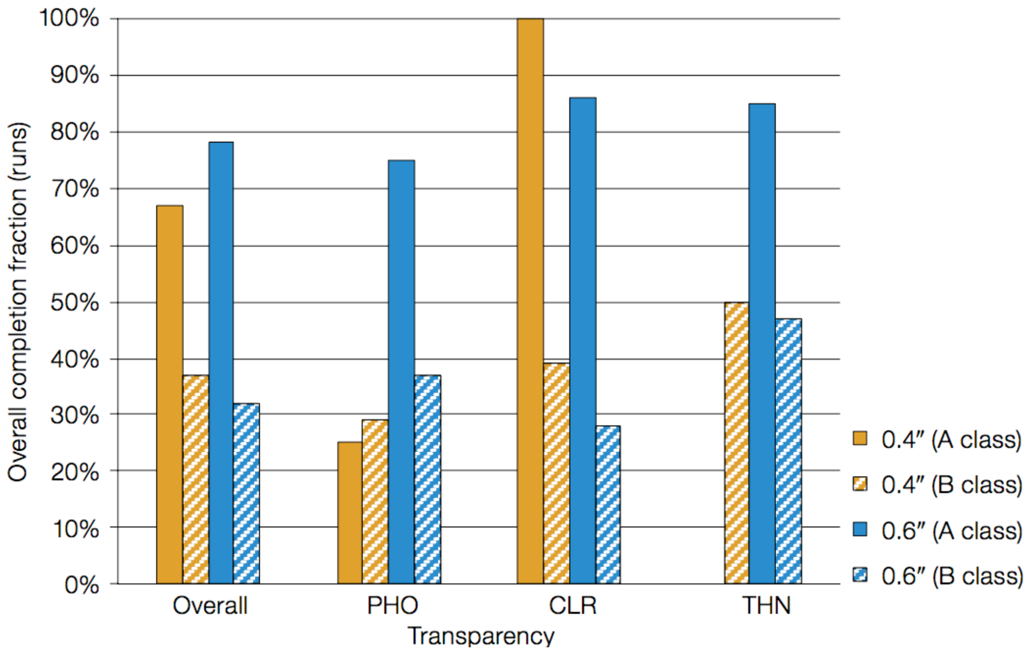

Figure 4: completion rates (by number of runs) are shown for the most demanding programs (in terms of seeing and transparency) scheduled at the VLT since Period 74 (October 2004). Photometric, clear and "thin clouds" bins for the sky transparency are depicted.

Since Period 63 a lot of things have evolved with SM at the VLT, which we detail below. Today the service mode user can choose between 17 instruments to carry out his/her observations, and all of them benefit from the same end-to-end model. We could not have followed the evolution of the VLT and the other telescopes if our processes had not evolved accordingly. Note that after the initial test periods at the NTT, service mode did come back to La Silla, not only on that telescope but also at the 3.6m and the 2.2m (then on loan to ESO from the Max-Planck-Gesellschaft), albeit for a much smaller fraction of the available observing time – approximately 10%.

3.2 The time domain

As we mentioned, exploring the time domain is one of the main aspects that SM brings to the astronomers. Target-of-opportunity (ToO) programs were offered since day one of the VLT era (and before that in La Silla). While ToO programs are prepared along the same guidelines as all other SM observing runs, targets are chosen upon detection of the events and the astronomers then manually trigger observations by sending the relevant information to the observatory, for execution at the telescope. However, even the so-called "hard ToO" observations leave 48 hours to the ESO staff astronomers to carry out the trigger. There are events of such a transient nature that they require immediate follow-up. This is what the rapid-response mode (RRM) offers. Introduced in April 2004[9] at the beginning of Period 73, RRM allows users to send to the telescope the coordinates of the target to observe as well as the ID of the observation block (OB) to insert them into – of course the said observation block must be part of a program pre-identified as RRM for the trigger to work. The current observation is then interrupted automatically and the telescope moved to its new pointing. Only a few minutes elapse between sending the trigger and starting the integration. Robotic telescopes for follow-up of GRB events already existed in 2004, but the VLT was the first telescope of its class to implement RRM. The mode has been offered continuously since then and currently 5 instruments can be used for such observations: FORS2, UVES, X-SHOOTER, SINFONI, HAWK-I and MUSE.

Other observations that SM does facilitate are the long time series. Since 2013 users can submit proposals for monitoring programs, that need less than 100 hours of telescope time in total, but need to be scheduled across 2 to 4 consecutive observing periods. Only some of the instruments of the VLT do offer this type of program. At the time of writing 19 such monitoring programs have been successfully scheduled. As we explain in the next section, the execution of time-linked OBs has also been greatly improved by the implementation of "containers".

At the opposite end of the spectrum, let's not forget here that having service mode on an 8-metre class telescope is a way to enable very short observing runs, too. With such collecting power, you don't always need tons of telescope time to achieve one's scientific goals. What if you are just after one more data set to complete some existing observations? Or you would like to just try a new observing technique, as a proof of concept? Or try out some risky (meaning: with a priori low chance of success) observations, but with a potentially big, scientific payoff? All of this is possible and easy if service mode is enabled. The distribution of service mode runs vs. allocated time shown below (fig. 5) does indicate a bias towards short runs – admittedly, an observing proposal may be split into an arbitrary number of runs beyond the mandatory reasons to do it (e.g. one run per instrument), but we do tend to limit the absolute number of runs to a minimum in the schedule in order to eliminate unnecessary overheads during the preparation phase. The alternative DDT proposal channel (Director's Discretionary Time) allows for such short, spontaneous requests for telescope time all year long and aims at catering for such use cases.

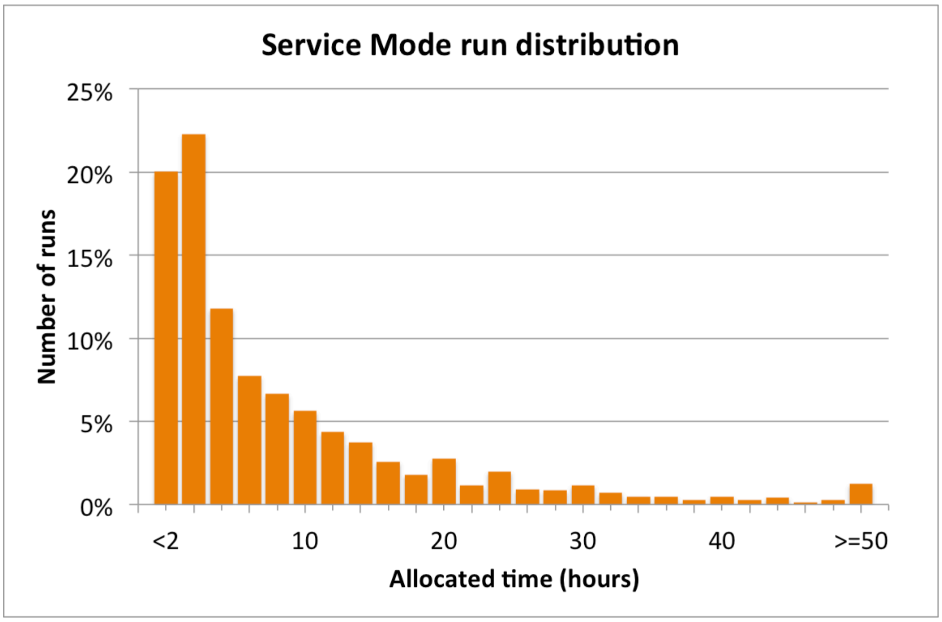

Figure 5: number of service mode runs as a function of the allocated time. Large programs have been excluded from this plot, and we considered service mode runs since Period 76. Pre-imaging runs for spectroscopic programs are included in the leftmost bins of the plot.

3.3 Tools to prepare and observe

Software is certainly an area where some major changes occurred over the years, on the users' side, as well as for the observatory. Let us first focus on P2PP (Phase 2 Proposal Preparation), which has always been the main interface for constructing observation blocks and submitting them to ESO. The tool evolved from a first version based on C++ and Tcl/Tk onto a Java desktop tool that is much more portable, while retaining the same features, but even if this has made the users' life easier this is not the most important evolution that happened.

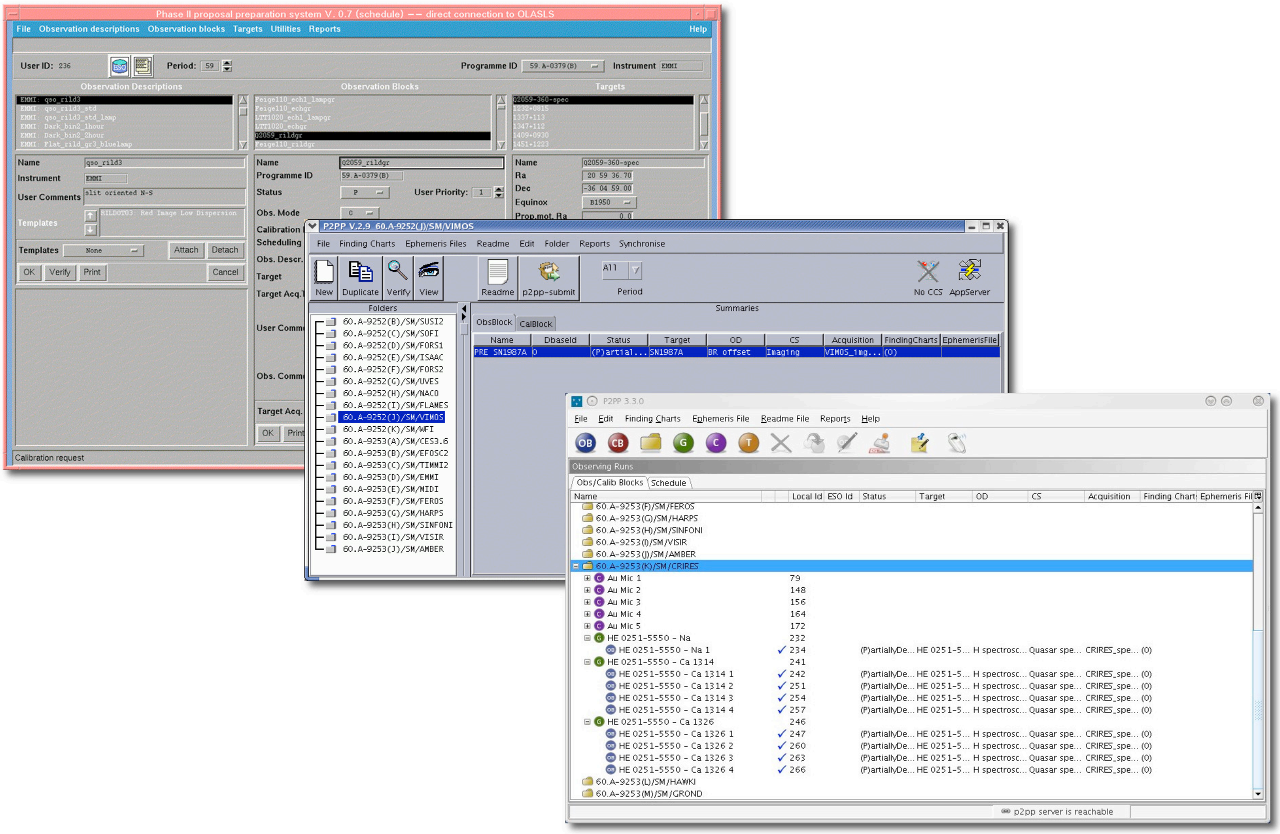

Figure 6: the three generations of the P2PP software. Version 1 (top-left) was based on C++ and a Tcl/Tk user interface. Version 2 (middle) became a Java desktop tool, while the most recent version 3 has introduced the possibility of using OB containers.

For example, when SM was first started the astronomers of the User Support Group in Garching had to validate all the submitted OBs manually. The process was not only tedious but also error prone, thus increasing the risk of passing on defective OBs to Science Operations, thereby leading to potential time loss at the telescope. The so-called External Validation Modules (EVM) were thus introduced so as to allow astronomers to verify their OBs before ingesting them into the central ESO database. Therefore erroneous OBs are simply prevented from entering the system. Validation rules exist for every VLT instrument and are generally updated every observing period if changes are warranted. The palette of the applied rules covers a wide variety of checks, going from simply preventing to mix observing templates from different, incompatible modes to advice on the observability of the target in sidereal time space. Paired with the EVM are the External Time Reporting Modules, or ETRM, that compute the foreseen execution time of OBs, including the telescope and instrumental overheads. This is of course extremely useful for SM users: firstly, individual OBs are best kept to a maximum duration of 1 hour to allow for a better implementation of flexible scheduling. Then, one obviously needs to limit the submission of OBs to the allocated time. Both conditions can easily be checked within P2PP by calling the ETRM code. Note that both functionalities are named "external" because the code is not included in P2PP itself, but rather downloaded from a central database depending on the observing runs associated to the user. This was not always the case as early versions of P2PP 2.x did include some hardcoded ETRM functionality, which imposed to release a new version of the tool every time the way to compute execution times needed to evolve. Both EVM and ETRM have become an integral part of the service mode experience and facilitate both the preparation work on the users' side as well as the Phase 2 review carried out by the User Support Department every period[10]. Another type of automation that came after the start of service mode at the VLT is how ancillary Phase 2 material such as finding charts and so-called README files are collected and dispatched to the observatory. At the start, users had to upload this essential information to a dedicated ftp server, where they were manually harvested, checked and then sent to Science Operations. Fortunately they were soon included into the overall flow and have been handled since then directly within P2PP.

Another important change happened in 2009 and was this time driven by the introduction of the new survey telescopes in Paranal (first VISTA, then later on the VST). The need to prepare and schedule large quantities – thousands! – of OBs for one single observing program required to once again challenge the existing concepts and invent new tools to make this possible. The Survey Area Definition Tool introduced for that purpose allows users to define sky areas that can then be imported into version 3 of P2PP so as to automatically generate all relevant OBs based on a single one (or several) that serves as template for the whole set[11]. The requirements specific to large surveys also made it necessary to find ways to connect several OBs together: several types of OB containers were introduced for that purpose[12][13]. "Groups" can hold OBs that are complementary in terms of the scientific goal to achieve (e.g. same target to observe through different filters), "concatenations" denote sets of OBs that must be executed back-to-back, while "time-links" allow to specify series of observations that must be executed at separate but relative times from each other. While indispensable for the scheduling of the public surveys on the survey telescopes, these new concepts are of course beneficial to regular SM programs as they allow users to encode their observing strategies into their submitted material, instead of relying only on some provided textual information ("README file") that could be overlooked by the staff at the telescope – remember that several hundreds of new SM observing runs are scheduled every period at the VLT. Users of the facility started using P2PP 3 and its new features in 2012 during Period 89 (UT2 only) and Period 90 (all telescopes).

The software at the Observatory was also updated accordingly to accommodate the changes of the central databases and take advantage of the new information present in the Phase 2 material for SM runs. In particular, the Observing Tool (OT) deployed at the telescope contained an improved short-term scheduler named ORANG (OB Ranking Engine). Reading the current observing conditions from the local site monitor, it takes into account a prioritized list of criteria to sort the OBs ready to be executed at any moment of the night: observability, seeing constraint, ranking of the proposal, current level of completion, timing constraints are some of the elements taken into account to select the OBs best suited for execution and thus simplify the work of the night astronomers and telescope operators throughout the night. Of course, by adding more and more ways to constrain one's observing strategy, you run the risk of losing the flexibility in scheduling that service mode is all about. For this reason, SM users are warned ahead of time about how the excess of constraints, e.g. as far as too strict timing requirements are concerned, can have a direct and meaningful impact on their chances to see their observations completed. Automatic checks done on incoming OBs will also impose some rules to make sure that flexibility is not hampered: the duration of individual OBs, but also of concatenations is limited by construction so as to keep some "atomicity" to the service mode scheduling queues. Such limitations can be overridden exceptionally but the users then do this at their won risk (observations of overlong OBs will not be repeated if the conditions worsen beyond the first hour).

One of the difficulties of Service Mode lies in the way of managing users' expectations. Because the observations are not carried out in their presence and can generally be executed over several months, astronomers legitimately request to be kept informed about the progress of their service mode runs, or lack thereof. Very early on, this aspect was considered at ESO while implementing SM. Since 2012, an improved night log tool has been installed at the VLT that automatically generates as a byproduct progress pages for all scheduled observing runs. Users can thus always know which OBs are executed[14].

This brings us to the final element in the logical chain of SM observations: retrieving the data. Ingesting data into ESO's science archive once required physically transporting hard drives from Chile to Garching. Because data had to be released using some kind of physical medium, accessing one's data acquired in Service Mode then meant waiting for the run to be completed or for the observing period to come to an end. If nothing else, this situation increased the delay between the start and the end of the whole process, namely between the submission of the proposal and the reception of the acquired data. Effectively this could go from an absolute minimum of 6 months to over a year. Justified by the increasingly large data output of newer instruments and improved by a new, high-speed data link installed in 2010, the data transfer between Paranal and the ESO headquarters is now performed as information is collected. The Science

Archive now routinely receives 90% of the raw data files less than 30 minutes after they have been acquired. They can then be downloaded using the dedicated form on the ESO web site. Consequently the physical data releases (formerly known as the "PI packs") have been discontinued. Following up the progress of SM runs is therefore much easier for PIs and their collaborators since data can be analyzed while the run is still ongoing. In some cases this offers the opportunity to correct remaining OBs if some adjustments (e.g. exposure times, offset patterns) are required.

3.4 Commonalities: the VLT data flow

As we have seen above, service and visitor mode are executed in different ways and are meant to address different observing requirements. Nevertheless, it is important to remember that their implementations at ESO within the VLT data flow take advantage of many common points. Indeed, most of the steps required to carry out either SM or VM are the same: proposal creation and submission are mode-independent; Phase 2 uses the same tools (P2PP or instrument-specific tools), and acquired data is always ingested into the main ESO archive. The data flow system around the VLT was designed through an object-oriented approach aiming to be fully independent of the chosen observing mode[15]. As much as possible, it has been built to detach the astronomers from the technicalities of the instrument at hand by building an interface that uses common concepts such as instrument templates and observation blocks.

Still on the topic of common services, all SM programs benefit from a common calibration plan executed on observatory time, and which output is recorded into the central science archive as well. As such, users are not required to provide their own calibration OBs, except if they are not covered by the general plan. Not only does it ensure that there is a coherent set of calibrations for all observations, but it is also a way to guarantee the possibility of "secondary science" through archive research.

4. FUTURE ENDEAVOURS

Both visitor and service mode may have come a long way, yet this is by no means the end of the path. New instruments are near our horizon that will once again challenge how we currently schedule and execute observing programs.

4.1 Observing strategies: new implementations

Let's take ESPRESSO (Echelle SPectrograph for Rocky Exoplanet and Stable Spectroscopic Observations) as our first example. Because the instrument will have to probe a large number of targets before focusing on the most promising hosts of potential exoplanets, it will be necessary for the observing teams to frequently adjust the OBs to execute at the telescope(s), leading to a sort of continuous Phase 2 process. Rather than using the established workflow channels, a new interface is currently being worked on that will allow the astronomers to ingest their OBs into the ESO central database using their own, dedicated tools such as EOPS (ESPRESSO Observation Preparation Software)[16]. The development of this API[2] makes it also possible to redevelop P2PP as a web application that should be offered to ESO users starting October 2016. This re-implementation of the tool will make it even more portable and simplify the I/O between the software and the database servers, thereby making future developments such as nested OB containers ("containers of containers") easier to carry out.

[2] Application Programming Interface

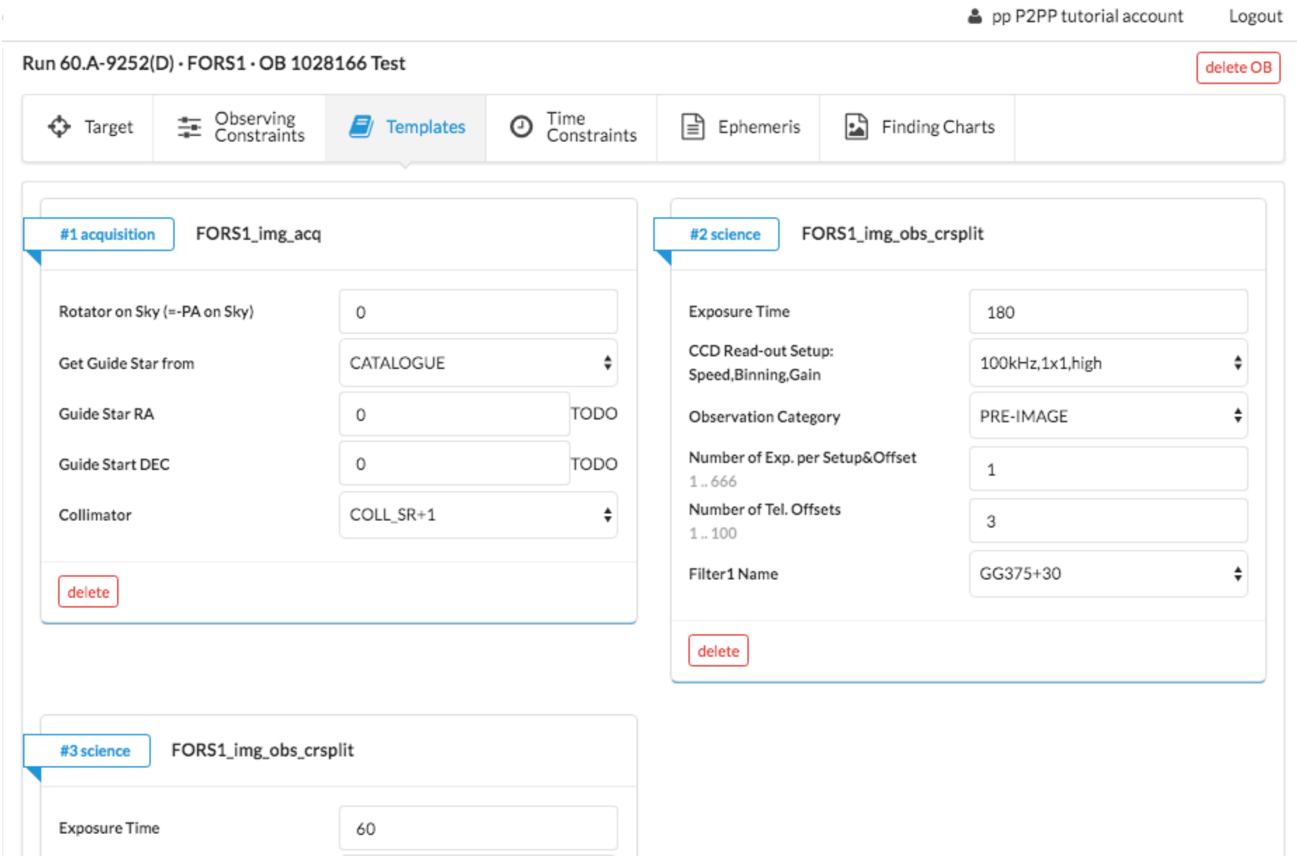

Figure 7: a sneak peek at the next-gen, web version of the Phase 2 preparation software. It is based on an interface that will also enable third-party software from instrument consortia to directly interact with the OB database.

The case of 4MOST (4-m Multi-Object Spectroscopic Telescope) raises difficulties of a different kind. Designed to provide the ESO community with a fibre-fed spectroscopic survey facility on the VISTA telescope, its high multiplex nature (minimum 1500 objects can be observed at the same time, with a goal of 2400) implies that one setup of the instrument will need to be used for multiple observing programs at the same time. The current concepts of observation preparation do not enable to carry it out under these new premises, since the "one OB – one program" paradigm does not apply any more. A potential solution would be to create an observing program encapsulating several, individual ones. They would need to be combined using dedicated preparation software that would create the "meta-OBs" and ensure we can keep track of the associations between targets and programs. Because the data would be collected at the same time and saved into the science archive, it would be ok for public surveys for which no clause of proprietary time applies. The question remains open as to how to handle use cases where data confidentiality is an issue.

4.2 Improvements for dVM

We mentioned "designated" visitor mode in section 2 as a convenient way for VM users to spare themselves the long overhead of the journey to Chile for short runs. However it must be also explained that it currently uses some ad hoc solutions that we are striving to improve. The dVM OBs must be prepared a few days ahead of the scheduled telescope slot, and the relevant Phase 2 material is then communicated to the observatory staff using a parallel channel – it is not ingested into the ESO database used for SM observations. We are currently working on making the EVM for all instruments "VM-proof" so that the relevant OBs can benefit from exactly the same infrastructure as SM observations. Users will thus be able to ingest their verified observation blocks at their convenience and they will be fetched directly by the observation software in Paranal. Naturally the EVM must take into account the specifics of visitor mode in terms of what is allowed or not. Generally speaking the VM observations are more relaxed in terms of instrumental modes and parameter values, but some other features such as OB containers only make sense in the context of flexible scheduling (i.e. service mode). As of Period 98 it will be possible for observers having telescope time in dVM to use the same channel as for SM, thus enhancing the user experience during preparation. As far as the execution phase is concerned, currently the interaction during the observation is a bit limited. Although being in audio-video contact with the staff observer (we are currently using Skype), this is obviously not offering the same user experience as what the physical presence at the telescope does. In particular, not being able to properly see the instrument console and have on-the-fly data access is a drawback compared to regular VM. We are thus investigating the possibility of offering remote access to the most important instrument displays, combined with a way to quickly access the acquired data through a kind of preferential data channel.

4.3 Remote observing

This possibility of eavesdropping on real-time observations is very close to what actual remote observing would be – the essential difference being that the instrument could also be controlled by the remote user. Such an observing mode has been offered in the past at ESO. First experiments of remote observing started in 1984 and it was routinely offered as of early 1989[17][18]. The system could be used either with the 1.4-m Coudé Auxiliary Telescope (CAT) or with the 2.2-m of the Max-Planck Gesellschaft, both in La Silla. The observations were performed remotely from a dedicated "Remote Control Room" located in the ESO premises in Garching (where some guest accommodation was also available at that time). A satellite link was used to ensure the communications between the equipment in Garching and the one located in La Silla. The last run to be executed remotely using this facility was completed on October 1st, 1998. In the meantime some experiment was also conducted in 1992 to establish a second-level remote observing station at the Observatory of Trieste[19]. This secondary station was successfully used to conduct observations with the SUSI and EMMI instruments on the NTT. High running costs of the dedicated satellite link as well as increasing data output from newer instruments incompatible with the provided bandwidth probably justified discontinuing the remote observing facility. But recently we have started once again taking advantage of a remote connection from Garching to Chile, this time to the VLT. The Garching headquarters host a remote access facility, which is used exclusively for internal, engineering purposes such as instrument troubleshooting or commissioning. It has proven to be a very useful tool helping teams collaborate very efficiently while sparing travel resources. The principle of the remote display could easily accommodate remote observing and we have started a feasibility study in that direction. If proven doable and provided that resources are available, one could then offer remote observing from the Garching headquarters. This would open the possibility to schedule VM runs shorter than 3 nights, which is currently not possible given the reduced operational budget that La Silla is running on in the frame of the "La Silla 2010+" plan[20]. At the time of writing all the logistical details as well as budget implications are still being worked on.

5. CONCLUSIONS

Both service and visitor mode will likely continue to co-exist at ESO facilities in the foreseeable future. As we have seen above, these two ways of taking advantage of the telescope time remain complementary as they bring distinct advantages and different user experiences. Also, SM and VM now go well beyond the simple dichotomy of "to go or not to go" to the telescope: visitor mode observations can be experienced from a remote location, and service mode offers many variants through different types of proposals and the ability to encode diversified observing strategies using the most recent versions of the preparation tools. Information and astronomical data also flow more easily between the observer and the different teams supporting the observations either at the headquarters in Garching or in Chile. And yet we already know that further evolutions are inevitable. Instruments currently in their construction or design phase, such as ESPRESSO or 4MOST, will once again shuffle the cards and force us to re-invent part of the operations and observation system to address the new constraints that these facilities bring. Scientific optimization of observing strategy including on-the-fly adjustments to the planned observations, or the necessity to multiplex several observing programs into a single slot of observing time will challenge our current implementation of flexible scheduling and will require solutions that do not jeopardize the rest of the observations. Recent feedback from the community has indicated that both visitor and service observing modes are highly rated for current and future observing sites, but that there is also interest for further evolution.

REFERENCES

[1] ESO Council, “VLT/VLTI Science Operations Policy”, https://www.eso.org/sci/observing/policies/cou996-rev.pdf (2004)

[2] Primas, F., Ivison, R., Berger, J. P., Caselli, P., De Gregorio-Monsalvo, I., Herrero, A. A., ... and Spyromilio, J., “Shaping ESO2020+ Together: Feedback from the Community Poll”, The ESO Messenger, 161, 6-14 (2015).

[3] David R. Silva, Bruno Leibundgut, Peter J. Quinn, Jason Spyromilio and Massimo Tarenghi, "Data Flow System operations: from the NTT to the VLT", Proc. SPIE 3349, Observatory Operations to Optimize Scientific Return, 10 (1998).

[4] Silva, D., and Quinn, P., “VLT Data Flow operations news”, The Messenger 90, 12-14 (1997).

[5] Leibundgut, B., “Operational concept of large telescopes”, Optical Telescopes of Today and Tomorrow, 755-761 (1997).

[6] Silva, D., “Service Mode Scheduling: a primer for users”, The Messenger, 105, 18-24, (2001).

[7] Silva, D., “The NTT service observing programme: period 60. Summary and lessons learned”, The Messenger, 92, 20-25 (1998).

[8] Primas, F., Tacconi-Garman, L., Marteau, S., Mainieri, V., Rejkuba, M., Mysore, S., ... and Sterzik, M., “Fifteen Years of Service Mode Operations: Closing the Loop with the Community”, The Messenger, 158, 8-15 (2014).

[9] Paul M. Vreeswijk, Andreas Kaufer, Jason Spyromilio, Ricardo Schmutzer, Cédric Ledoux, Alain Smette and Annalisa De Cia, "The VLT rapid-response mode: implementation and scientific results", Proc. SPIE 7737, Observatory Operations: Strategies, Processes, and Systems III, 77370M (2010).

[10] S. Mysore, S. Marteau, A. Smette and P. Santos, “Instrument Packages: seamlessly presenting the instrument to the user”, Science Operations ESA/ESO Conference 2013, http://www.cosmos.esa.int/documents/946106/1007422/Poster-Mysore.pdf/0b1cf1d9-c4ee-4a4d-b6de-e8e1ff822886 (2013)

[11] Arnaboldi, M., Dietrich, J., Hatziminaoglou, E., Hummel, W., Hussain, G., Neeser, M., ... & Emerson, J., “Preparing for the ESO Public Surveys with VISTA and VST: New Tools for Phase 2 and a Workshop with the Survey PIs”, The Messenger 124, 42-45 (2008).

[12] Chavan, A. M., Comeron, F., Peron, M., Canavan, T., Dorigo, D., and Nunes, P., “From Handicraft to Industry: Supporting Surveys at ESO Telescopes”, Astronomical Data Analysis Software and Systems XV (Vol. 351), 116 (2006).

[13] T. Bierwirth, T. Szeifert, D. Dorigo, P. Nunes, M. Rejkuba, K. Baugh, M. Klein Gebbinck, A. Manning, D. Muravov and I. Vera, "New observing concepts for ESO survey telescopes", Proc. SPIE 7737, Observatory Operations: Strategies, Processes, and Systems III, 77370W (2010).

[14] D. Dorigo, B. Amarand, T. Bierwirth, Y. Jung, P. Santos, F. Sogni, and Vera I., "Evolution of the phase 2 preparation and observation tools at ESO", Proc. SPIE 8451, Software and Cyberinfrastructure for Astronomy II, 84511B (2012).

[15] Peron, M., and Grosbol, P., “Design of the VLT data flow model”, Optical Telescopes of Today and Tomorrow, 762-767 (1997).

[16] P. Di Marcantonio, V. D'Odorico, G. Cupani, Danuta Sosnowska, C. Lovis, S. Sousa, P. Figueira, J. I. González Hernández, G. Lo Curto, A. Modigliani, R. Cirami, D. Mégevand and S. Cristiani, "ESPRESSO data flow: from design to development ", Proc. SPIE 9149, Observatory Operations: Strategies, Processes, and Systems V, 91491Q (2014).

[17] Baade, D., “Visitor facilities and user support at ESO-Garching”, The Messenger 58, 14-18, (1989).

[18] Baade, D., “Three Years’ Experience with Routine Remote Observing at the European Southern Observatory”, Proceedings of a Workshop on Remote Observing, 131 (1993)

[19] Balestra, A., Santin, P., Sedmak, G., et al. “NTT remote observing from Italy”, The Messenger, vol. 69, 1-5 (1992).

[20] Saviane, I., Ihle, G., Sterzik, M., and Kaufer, A.,“La Silla 2010+”, The Messenger 136, 18-19 (2009).