
# VLT Data Flow Operations News

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*Welcome to the first article in a regular series about VLT Data Flow Operations (DFO). DFO encompasses a large range of VLT science operations related activities from proposal preparation support to service observing and archival research. Over the next several issues of The Messenger, the entire gamut of DFO activities will be discussed. Eventually, these articles will evolve into regular updates about DFO status during VLT science operations.*

## 1. Introduction

Potential VLT users have been thinking about the science questions they want to address with the VLT for years. With the advent of VLT science operations approximately 15 months away, many potential VLT users are now beginning to think more seriously about how they will answer those questions with the VLT. As part of that planning process, users need to have a clear understanding of how the VLT will be operated.

In this article, our current perspective on user interaction with the VLT is described. Our operations plan is evolving rapidly at this time and not all of the details have been finalised. Nevertheless, our hope is that users will find a presentation of the global concepts helpful. We start with a quick overview of the VLT Data Flow System (see also P. Quinn, *The Messenger* No. 84). The majority of this article describes how users will interact with the VLT Data Flow Operations (DFO) during key data flow phases.

## 2. The Data Flow System (DFS): An Overview

The Very Large Telescope has the potential for being the most scientifically significant ground-based observatory in the early part of the next century. It certainly represents the largest single investment in ground-based astronomy ever made by the European community. The success of this facility will be measured by its impact on our understanding of the Universe. The VLT will only live up to its potential if it can be operated in such a way that observing programmes are executed efficiently and in a timely manner. This operational goal is complementary to the scientific goal of most astronomers. In an increasingly competitive environment, all astronomers want their observations completed as rapidly as possible to insure that they stay at the cutting edge of their fields.

The Data Flow System (DFS) was designed with these operational and scientific goals in mind. At its most fundamental level, the DFS is a set of protocols and interfaces for linking together the VLT telescopes and instruments with simple observation description tools, online data processing functionality and automated data archiving. While sitting at the telescope, an astronomer will be able to use simple software tools to create observation descriptions (called Observation Blocks or OBs)[1] which can then be executed by the DFS. As part of its normal execution process, the DFS not only produces the specified raw data but can also automatically process those data as well as archive it for later use. Simply put, the basic DFS is a system for increasing the efficiency of any astronomer using the VLT facility.

However, even the most efficient system will not prevent on-site observers, restricted to a fixed number of nights, from losing precious "time on target" to system failures and unfavourable observing conditions. At traditionally operated observatories, significant fractions of observing runs can be lost to such problems. For the vast majority of astronomers, being physically at the telescope will not mitigate the impact of these effects – they must rely on the expertise of the technical staff and the vagaries of nature to minimise their downtime. Given the choice, all astronomers would prefer to have the "perfect" observing run – completely functional instrumentation and observing conditions matched to the observational goals of their primary scientific experiment. Furthermore, most scientific communities would like the most scientifically meritorious programmes to be completed first given the well-known scarcity of resources, rather than have data randomly distributed across a set of projects, as often happens now (although all of us would like to see our programme executed first!).

Service observing is an operational way of achieving these goals. By breaking down an observing programme into a series of OBs, a programme can be executed when the observing conditions are suitable and the instrumentation is available and completely functional, not just when the observer happens to be on-site. Furthermore, the OBs of most highly ranked programmes can be given preference on any suitable night, not just when the particular PI is on-site. The DFS provides the infrastructure for service observing by providing software tools to the astronomer to create OBs and to the Data Flow Operations (DFO) staff to schedule and execute those OBs.

Will all VLT programmes be queue scheduled? Can all VLT programmes be queue scheduled? The answer to these questions is clearly and emphatically "no". It will be simply impossible to provide calibration and queue operations support of all modes of all VLT instruments, especially in the early years of VLT science operations, and ESO will not try to do so. Nevertheless, we expect that the majority of VLT users will only use a select number of instrument modes. We are trying to anticipate what those modes are and develop calibration and queue operation plans accordingly. These plans will be modified as time goes on to conform to real VLT usage patterns.

## 3. Interacting with the VLT DFS: A Few Critical Phases

It is important to have a sound guiding philosophy but the typical user is more interested in how they will use the VLT and what restrictions may be placed on that use. In what follows, a few critical phases of the interaction between the user and the VLT Obser-

[1] In the DFS model, Observation Blocks (OBs) describe how simple data sets are acquired and record the status of those data sets. OBs are simple – they consist of just one telescope pointing and the acquisition of a single data set. In short, OBs are the smallest items that can be scheduled and executed by the DFS.

vatory are discussed, illustrating the envisioned flexibility and efficiency of the DFS.

### *3.1 Proposal Creation and Review*

In many ways, VLT proposal creation and review will be similar to the equivalent process at any ESO telescope. Well in advance of the proposal deadline, a Call for Proposals will be issued. This Call for Proposals will describe what VLT instruments and instrument modes will be available and when they will be available. However, in addition, information about what instrument modes will be supported by service observing and an execution and calibration plan for each of these modes will also be provided. Proposers will also be told what the anticipated fractional split between service and visitor mode observing will be for the upcoming period.

As usual, VLT proposers will have to submit a scientific and technical justification for why they should be granted VLT time. As part of the technical justification, proposers will have to justify carefully the amount of time they need to complete their programmes. To assist them in this process, ESO will supply Exposure Time Calculators. These ETCs will allow users to estimate exposure times to an ESO guaranteed accuracy. At this time, our accuracy goal is 10%, i.e. the real delivered S/N should be within 10% of the estimated S/N for a given exposure time on a given instrument/telescope combination for the specified observing conditions. These ETCs will be constantly updated using information about the real instruments obtained by the DFO staff via a programme of regular instrument performance verification.[2]

Proposers will also be asked to specify and justify whether their programme should be executed in service or visitor mode. Since most users will be able to use the standard VLT observing sequences, most VLT science programmes will probably be able to be executed in service mode. Potential justifications for visitor mode (i.e. the PI goes to the telescope and executes the programme personally) include the need for higher-precision calibration, non-DFS supported instrument modes, or highly interactive real-time decisions about data acquisition.

After submission, all VLT proposals will be reviewed for scientific and technical feasibility. The scientific feasibility review will be done by the OPC, while the technical feasibility review will be done by DFO staff. Among the issues subject to technical review and approval will be the total amount of requested time, the requested instrument configuration and operation, and the request for visitor or service mode. These technical reviews will be passed on to the OPC. As usual, programmes which are found to be scientifically meritorious may still be rejected if they are found to be technically unfeasible.

### *3.2 Programme Scheduling*

After the review process is completed, OPC approved programmes will be assigned to service or visitor mode based on a combination of technical evaluation by the ESO staff and OPC recommendation. As with all time allocation decisions, the ESO Office of the Director General has the final responsibility for this assignment.

VLT programmes approved for visitor mode observing will be scheduled in the same manner as La Silla proposals. Visitor mode programmes will be assigned specific nights with specific instruments at specific telescopes. Users will be expected to be at the telescope to execute their programme.

VLT programmes approved for service observing, however, will be "scheduled" in a different manner. VLT queue programmes will be split into the three categories:

• **Category A: Programmes highly ranked by the OPC**. All possible effort will be made to execute all the OBs corresponding to these programmes in the requested observing period. Programmes will be placed in this group primarily because of their high OPC ranking but also to fill some undersubscribed set of observing conditions (e.g. poor seeing during bright-time).

• **Category B: Programmes well-ranked by the OPC**. Programmes in this category will only be executed if no Category A programme can be executed.

• **Category C: Programmes ranked at the cut-off line by the OPC**. These programmes will be executed only if no Category A or B programmes can be executed.

Matching requested observing conditions to expected observing conditions is a critical aspect of this grouping process. For example, it is impossible to observe only objects at a RA of 13 hours. It is also unlikely that VLT will produce 0.5″ images in the B-band every night. Thus, Category A must be populated with OBs that span all accessible target positions and all expected observing conditions more or less uniformly. Users should keep these constraints in mind when preparing their proposals. We will return to this topic in a future *Messenger* article.

### *3.3 Programme Preparation*

The DFS is intended to be the gateway to the VLT for all VLT investigators. Although there will be low-level interfaces to all VLT systems that will in principle be available to visitor mode investigators, OBs will be the primary agents for using the VLT facility. Thus, both visitor and service mode investigators will be required to create OBs before their programmes can be executed.

Investigators allocated service-mode time will be given instructions for preparing OBs at their home institutions. These instructions will include detailed programme preparation instructions and a deadline for when their OBs need to be submitted to ESO. Most service-mode investigators will create their OBs at their home institutions but support for OB creation at ESO will be supplied if requested. As part of OB creation, users will specify what observing conditions are acceptable, what instrument configuration is required, what their targets are, and what exposure times are required. Again, the instrument ETCs will be provided to allow users to specify exposure times.

For some kinds of observing programmes (e.g. multi-object spectroscopy), some sort of preparatory observations may be required to successfully execute the main programme.

Visitor-mode investigators will be required to perform the same programme preparation. These observers could elect to create their OBs on-site minutes before they wish to execute their observations. However, they will be encouraged to create their OBs well before arriving at the telescope. Early OB creation will allow classical investigators to take advantage of the OB verification tools under development by ESO. The DFO staff will provide assistance with OB verification if requested.

### *3.4 Programme Execution*

Visitor-mode investigators will of course be on-site to execute their own programmes. Thus, their programmes will lose time and efficiency to the usual vagaries of random observing conditions and facility downtime. Visiting astronomers will also have to absorb the not insignificant overhead of travelling to Paranal from Europe to observe. Since they will be using OBs, visiting astronomers will have the entire DFS infrastructure available to them, including on-line data processing if they wish to use it. But since the fundamental data product remains the unprocessed, raw data, visiting astronomers can choose to ignore the product of the on-line processing system. Their data will be automatically archived for later analysis and re-use after the 12 month proprietary period mandated by the ESO Council.

Service-mode investigators will have a much different experience. Service mode OBs will not normally be executed in some pre-defined order on some predefined date. The order in which individual OBs are executed will be determined

[2]ETCs for the NTT instruments SUSI, EMMI and SOFI are available. The current version of these ETCs are available on the ESO Web site at http://www.eso.org/dmd/data-proc/quality/simulators.html.

dynamically by a merit function whose form is still under development. High weight will be given to OPC ranking. Other parameters will include allowable zenith distance range (airmass), allowable sky background and/or lunar phase, seeing requirements, sky transparency, calibration requirements, etc.

During service observing operations, the DFO staff will endeavour to execute OBs only under the observing conditions specified by the service mode investigator. However, it may be necessary occasionally to execute some OBs under non-optimal conditions. If the data produced under these conditions clearly do not satisfy user specifications, these OBs will be repeated as time and conditions allow. In more marginal situations, ESO will work with service-mode investigators to determine whether or not the data are acceptable and whether or not these observations should be repeated.

Once a service-mode programme is initiated, achieved data quality will be monitored and compared to specified data quality. In most cases, it is expected that under nominal conditions, no PI interaction will be required. However, achieved data quality can be different from specified data quality by more than the nominal 10% accuracy for three main reasons:

- the VLT facility malfunctioned in some manner
- the given OB was executed under conditions worse than specified
- some user assumption used to compute the required exposure time was wrong

In the first two cases, OBs will usually be re-executed in a manner which is transparent to the service-mode investigator after the malfunction has been fixed or suitable conditions arise again. In the last case, an observing programme will be halted and a DFO astronomer will work with the service mode investigator to devise an alternative observing plan, if such an alternative plan is possible. During early VLT operations, ESO will be very conservative about what constitutes acceptable data and work with PIs as much as feasible.

## 4. A Final Note: Archive Investigators

All VLT data will eventually be accessible to the ESO community via a science archive system currently under development by the DMD Science Archive Group. The ESO Council has established a proprietary period of 12 months during which these data will only be available to the investigators associated with the original OPC approved programme. After that point, VLT data will be available for re-use. Policies for the use of the archive are still under development. Nevertheless, it is envisioned that DFO astronomers will support users of the science archive, particularly in issues of how to efficiently search for and extract data and how to reprocess it as necessary.

*Next issue: a discussion of the NTT Service Observing Programme, a DFO prototype.*

*The VLT mechanical structure during the tests at the Ansaldo factory in Milan, Italy.*