The VLT Data Quality Control System

P. BALLESTER, A. DISARÒ, D. DORIGO, A. MODIGLIANI, J.A. PIZARRO DE LA IGLESIA

Conducting service observing at large ground-based observatories profits from delivering standard data products to the users. The operational applications needed to quantitatively assess VLT calibration and science data are provided by the VLT Quality Control system (QC). In the Data Flow observation life-cycle diagram ([2], [3], [4], http://www.eso.org/projects/dfs), QC relates data pipeline processing and observation preparation. It allows the ESO Quality Control Scientists of the Data Flow Operations group to populate and maintain the pipeline calibration database, as well as to measure and verify the quality of observations. The QC system also provides models allowing users to predict instrument performance, and the Exposure Time Calculators are probably the QC applications most visible to the astronomical community.

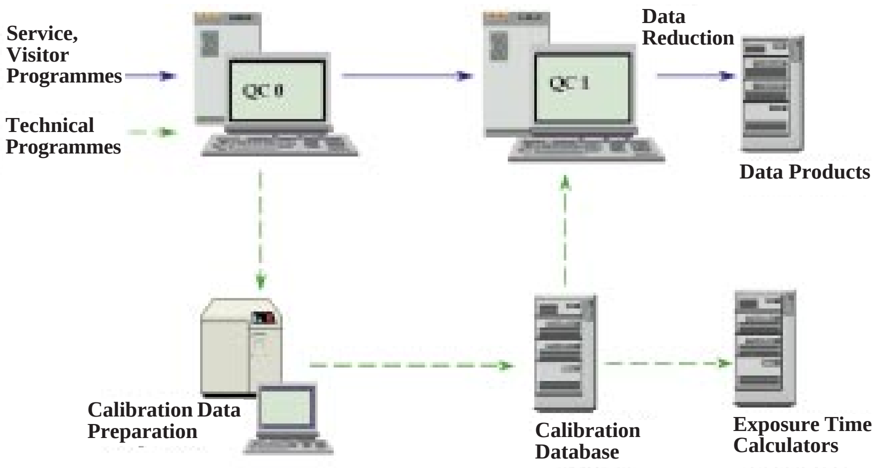

Figure 1: The VLT Data Quality Control system.

The Quality Control system is needed to cope with the large data volumes of the VLT, the geographical distribution of data handling, and the parallelism of observations executed on the different unit telescopes and instruments. Figure 1 shows how internal QC applications are used at the different stages of the observation life cycle. Technical programmes are executed and provide raw calibration data. These data are processed and prepared for use by the instrument pipelines. The McCreator application provides a unified interface to the instrument pipelines for the preparation of such reference calibration data. These data are then stored in the observatory archive using the Calibration Database Manager and distributed to the operational pipelines and Exposure Time Calculators. During the course of operations, a number of parameters are tracked by the QC processes and allow the operations teams to verify the observation conditions (QC level 0) and the performance measured on pipeline processed data (QC level 1).

1. Predicting and Controlling the Instrument Performance

The choice of exposure time for scientific programmes usually depends on the estimation of the signal-to-noise ratio necessary to reach a given measurement accuracy. This can be evaluated using the on-line Web Exposure Time

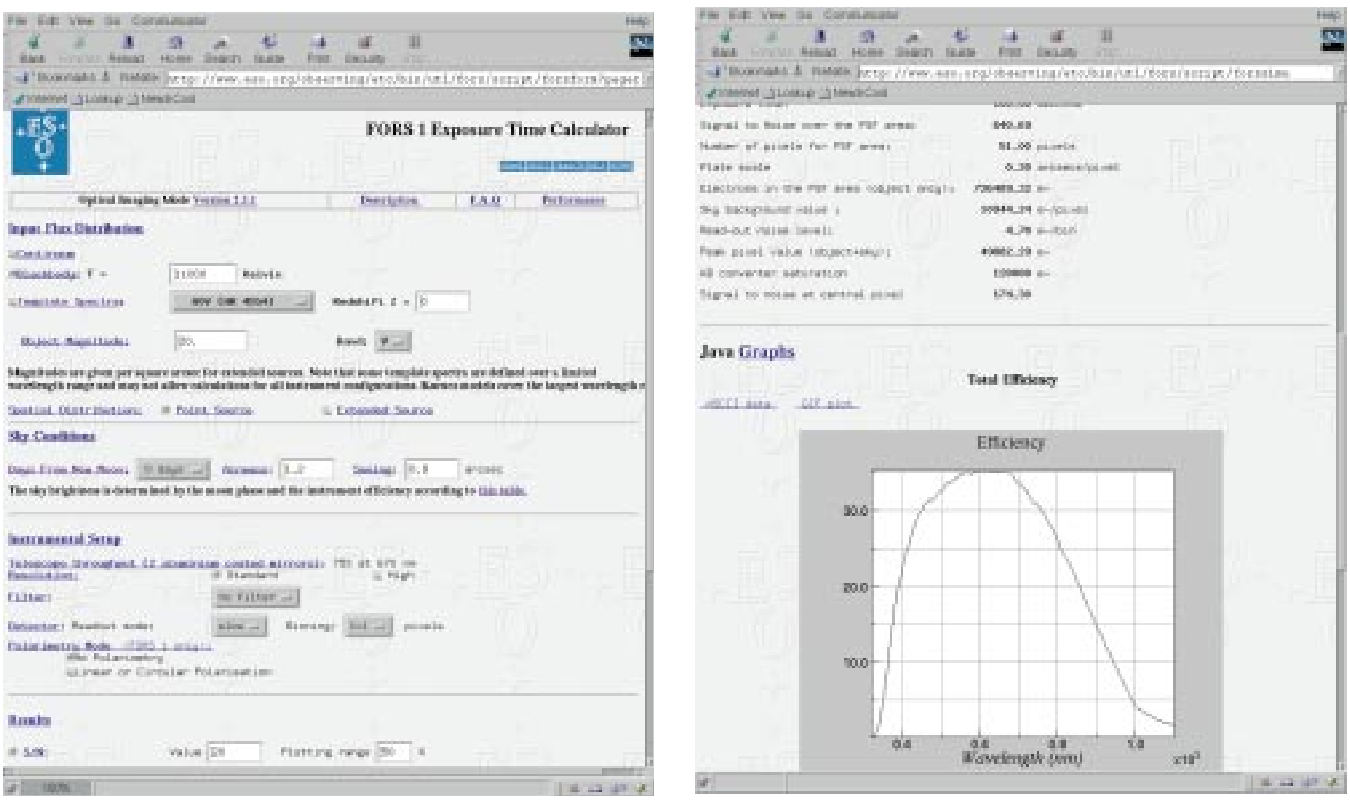

Figure 2: The FORS Exposure Time Calculator.

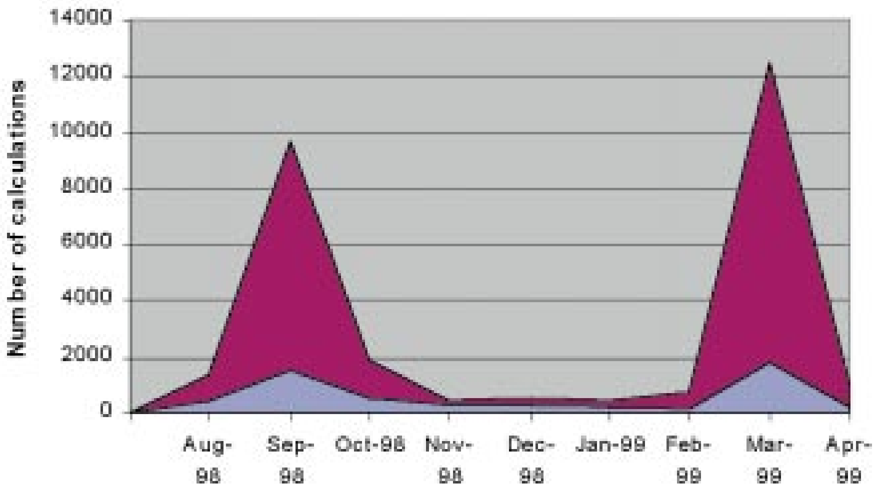

Figure 3: The ESO ETCs usage statistics over the first two VLT Call for Proposal periods.

Calculators (ETCs) provided for the VLT instruments, currently including FORS and ISAAC for the imaging and spectroscopy modes, as well as the NTT instruments SUSI, EMMI, SOFI, and the 2p2 Wide-Field Imager in La Silla. The Exposure Time Calculators have been offered for the VLT instruments since the first call for proposals for period 63 in August 1998. Figure 3 shows the usage statistics during the first two VLT periods. The blue curve represents internal use, and the red one the external usage, particularly important in the few weeks preceding the end of the proposal period, with a daily usage of about 1500 runs per day.

With the ETCs it is possible to compare the different options relevant to an observing programme, including instrument configuration, variable atmospheric conditions and observing parameters. Being maintained centrally on the ESO Web servers, the ETCs can always provide up-to-date information reflecting the known performance of the instrumentation. A single Web page (http://www.eso.org/observing/etc) gives access to all released ETCs. The tools are also a useful reference in the periods of instrument commissioning and in the first periods of service observing as they provide a reference for the expected performance of an instrument.

These programmes present an HTML/Java-based interface and consist of two pages. The observation parameters page includes the entry fields and choices for all parameters defining the observation: target information, expected atmospheric conditions, instrument configuration, observation parameters such as exposure time or signal-to-noise, and results selection. The target information section presents a choice of spectral flux distributions such as template spectra, blackbody, or single emission lines, magnitude scaling, and spatial distributions options like seeing-limited or extended sources. In the sky conditions section, the user can assign the expected moon phase, airmass, and seeing conditions as requested in the Phase II Proposal Preparation system [1]. Four classes of models are currently offered for optical or infrared, imaging or long-slit spectroscopy instruments. The target information and atmospheric conditions windows are identical for each class of instruments. The result page presents the a summary description of the observation, including number of counts for the object and the sky, signal-to-noise ratios, instrument efficiencies, PSF size, and the probability of realisation of the requested atmospheric conditions. Graphs are displayed within interactive Java applets for an easier manipulation. The graph results are also produced in different formats for further analysis and printing. Finally a summary of the input parameters is appended to the result page. Help files and documentation are provided on-line. A page of general information lists the latest updates and provides answers to Frequently Asked Questions. Detailed information concerning the spectral targets, atmospheric conditions, filter information, and usage of each section of the ETCs can be accessed by following the corresponding underlined links in the input and result forms.

2. Preparing Pipeline Calibration Frames with McCreator

The reduction pipelines associate reduction recipes and calibration data to the incoming observation data. While the reduction recipes usually remain stable over extended periods of time, the calibration data must be regularly updated to cope with always changing instrument and atmospheric properties. The nature and periodicity of the calibration exposures to be taken is defined in a calibration plan which for each mode of the instrument lists the observation blocks to be executed. Technical programmes are scheduled and produce on execution calibration data which are pre-processed by the pipeline and stored in a central repository. The pre-processed frames are then used to create reference calibration solutions. After certification the calibration solutions are copied to the Science Archive.

McCreator is a graphical interface application written in Tcl/Tk, which provides a front-end interface to pipeline and quality control modules such as the Data Organiser, Reduction Block Scheduler, and the Calibration Database. This tool is used internally by the Quality Control Scientists for the preparation of the pipeline calibration data. Calibration data can therefore be processed in a pipeline mode with an interface that allows the QC

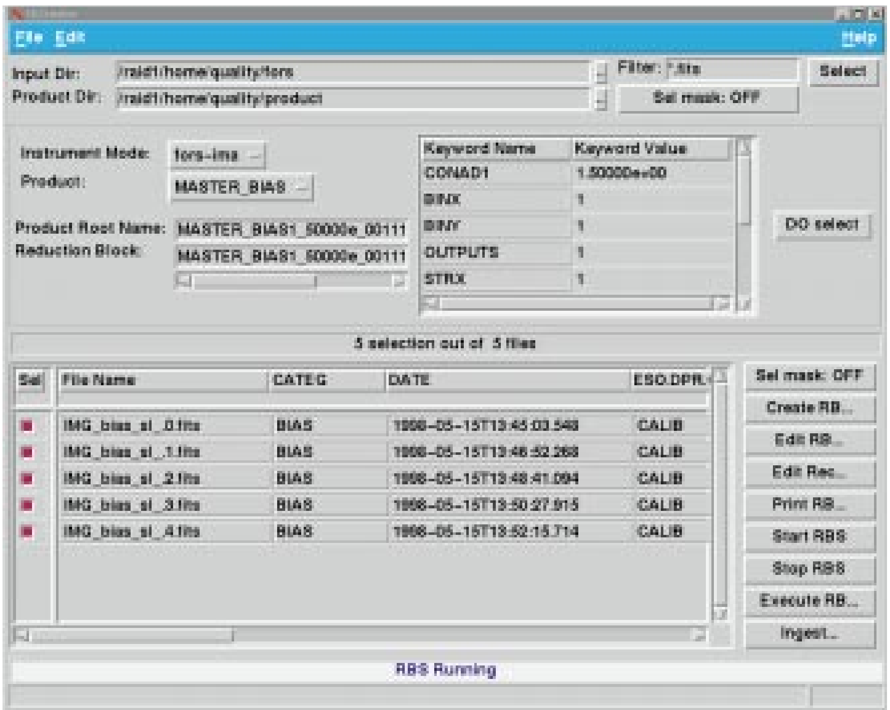

Figure 4: The McCreator main panel.

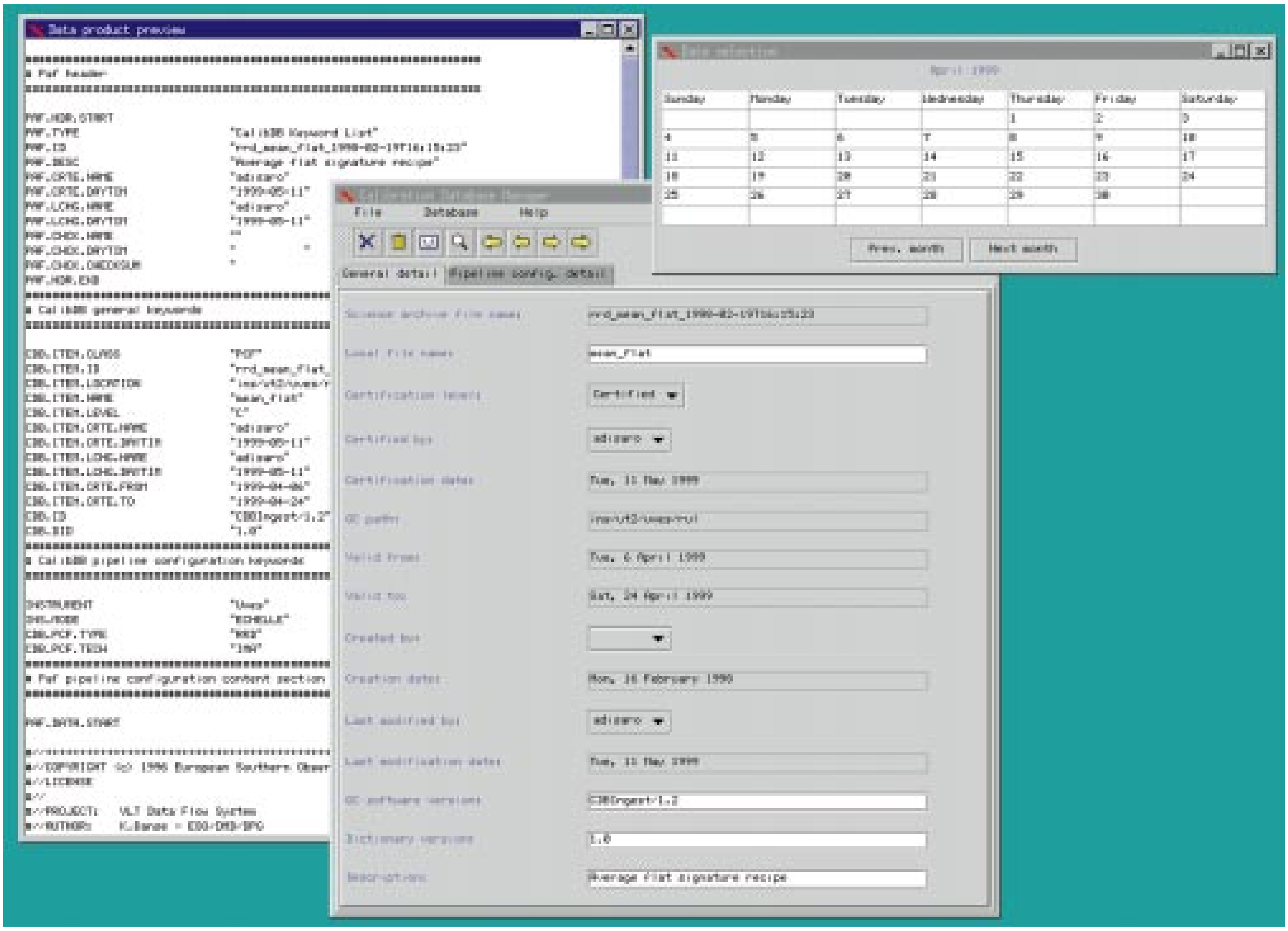

Figure 5: The Calibration Database Manager.

Scientist to adjust all steps of preparation of the reference calibration data.

3. The Calibration Database Manager

The Calibration Database includes a collection of observation data and reduction procedures representing as completely as possible the observing modes and configurations of the different VLT instruments. The Calibration Database Manager standard application for browsing, editing, populating and aligning the local calibration database contents. This application written in Java is the interface between the pipeline local calibration database and the ESO archive system. It allows the ESO Quality Control Scientists to request and submit files to the archive, and to structure calibration information to the formats supported by the pipeline and needed for long-term archival and trend analysis.

4. Assessing Observation Data

In the Data Flow System, Observation Blocks are queued for service observing and organised in a schedule managed on a long-, medium-, and short-term basis. The Short Term Scheduler is a decision support system which assists the operations manager in producing the observing time–line for one or a few nights. The main purpose of the scheduler is to maximise the utilisation of telescope time respecting a number of heterogeneous, user-defined constraints: target viewing, lunar illumination, weather and absolute and relative timing. The Science Archive stores all raw frames produced by the instruments, as well as reference calibration data, and log files including maintenance and ambient conditions logs. The Science Archive is available to archive researchers and astronomers for catalogue access and retrieval of scientific data as they become available after the end of the proprietary period

The verification of QC parameters allows us to assess observation data by comparing values measured on the raw or reduced data to target values specified by service observing users or by the observatory. Two levels of control are foreseen, called QC0 and QC1, differing by the need for calibration data. The level 0 of control is to verify that the user requested parameters, evaluated by the scheduler to trigger an observation, have been all respected during the observation. The parameters presently supported by the QC0 application in place for UT1 include airmass, moon distance, fractional lunar illumination, and seeing, and correspond to the observation constraints available in the Phase II Preparation System. This post-observation verification is performed independently and will catch variations of the meteorological conditions that might have occurred after the schedule evaluation. QC0 involves only access to the raw frames or the FITS header. It can therefore be applied to all frames produced by the instrument. The level 1 of control is the verification of the data by measuring parameters on reduced frames. It involves the association of calibration data and pipeline processing. Depending on the parameter controlled the processing is performed directly at the instrument pipeline after the observation or prior to the release of the user data package.

References

[1] D. Silva and P. J. Quinn, "VLT Data Flow operations news," The Messenger 90, 1997.

[2] P. Grosbøl and M. Peron, "The VLT Data Flow concept," in Astron. Data Anal. Soft. Syst. VI, G. Hunt and H. Payne, eds., vol. 125 of ASP Conf. Series, 1997.

[3] P. J. Quinn, 1996, "The Data Flow System," The Messenger 84, 30.

[4] P. Ballester, M.R. Rosa, P. Grosbøl, 1998, "Data Quality Control and Instrument Modeling", SPIE Proceedings 3349, "Observatory Operations To Optimize Scientific Return", Kona, Hawaii, 20–21 March 1998.

pballest@eso.org