EUROPEAN SOUTHERN OBSERVATORY

VERY LARGE TELESCOPE

Data Flow System Operations Model for VLT/VLTI Instrumentation

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Contents

1 Introduction

This document describes the Data Flow system operations model for VLT/VLTI instrumentation. It details the framework, responsibilities, dependencies and development breakdown within the Data Management Division and in relation with the VLT Division and Instrumentation Division, for the development and operation of the instrument dependent components of the Data Flow system. It analyzes in particular the process of production and operation of the pipelines, quality control, and instrument models, in order to guarantee the quantitative predictability and performance control of the instrumentation during the operations of the observatory.

The document has been written in collaboration with the members of the Data Flow Project Team and the Instrumentation Division.

1.1 Scope

The scheme is defined in a general manner and may need to be adapted to the context of each instrument project. For instance different development plans may be defined whether the instrument is developed internally at ESO or by a consortium, or depending on the instrument construction schedule. This document is part of the overall VLT Operations Model [4]. The policies presented in this document will be presented to the Operations Policy and Oversight Committee.

1.2 Applicable Documents

[1]	VLT On-line Data Flow Requirements	VLT-SPE-ESO-19000-0749
[2]	VLT On-line Data Flow Analysis Document	VLT-SPE-ESO-19000-0790
[3]	VLT On-line Data Flow Design Description	VLT-SPE-ESO-19000-0842
[4]	VLT Operations Model	VLT-PLA-ESO-19000-xxxx
[5]	ICD between the VCS and P2PP System	VLT-ICD-ESO-17240-19200
[6]	DFS Specifications for Pipeline and Quality Control	VLT-SPE-ESO-19600-1233
[7]	VLT Science Operations Plan	VLT-PLA-ESO-10000-0441

1.3 Reference Documents

[8]	VLT Software - Programming Standards	VLT-PRO-ESO-10000-0228
[9]	VLT Software - Graphical User Interface Manual	VLT-MAN-ESO-17210-0690
[10]	ESO Graphical User Interfaces Common Conventions	GEN-SPE-ESO-00000-0266
[11]	ESO DICB - Data Interface Control Document	GEN-SPE-ESO-00000-0794
[12]	VLT Software - VLT Instrumentation Software Specification	VLT-SPE-ESO-17212-0794
[13]	VLT Software - INS Common Software Specification	VLT-SPE-ESO-17240-0385
[14]	VLT DFS C++ Programming Standards	VLT-PRO-ESO-19000-1208

1.4 Abbreviations and Acronyms

ANSI	American National Standard Institute
ASCII	American Standard Code for Information Interchange

DAS	Data Analysis specialist
DICB	Data Interface Control Board
DFIR	Data Flow Instrument Responsible
DFO	Data Flow Operator
DFS	Data Flow system
DMD	Data Management Division
DPG	Data Pipeline Group
ESO	European Southern Observatory
ETC	Exposure Time Calculator
FITS	Flexible Image Transport system
FTE	Full-Time Equivalent
GUI	Graphical User Interface
I/O	Input-Output
ICR	Instrument Control Responsible
IR	Instrument Responsible
IS	Instrument Scientist
MIDAS	Munich Image Data Analysis System
NTT	New Technology Telescope
OB	Observation Block
OPC	Observing Programmes Committee
P2PP	Phase II Proposal Preparation
PAF	Parameter Format File
VCS	VLT Control Software
VLT	Very Large Telescope
VLTI	VLT Interferometer
VOM	VLT Operations Model
WWW	World-Wide Web

2 Overview

The document is fourfold and describes the DFS Operations Model for the VLT from the point of view of an instrument project. In Section 3 the main concepts of the Data Flow system are introduced and the instrument-dependent components of the system are identified. Baseline concepts for Pipeline and Quality Control are presented. The next Sections will detail the responsibilities and interfaces for the development and operation of the Data Flow products.

Section 4 details the role of the different groups involved in interfacing the Data Flow system to a particular instrument. The instrument project responsible in the Instrumentation Division has an important role as he requests and approves the Data Flow products. In the Data Management Division, the products are developed by the User Support Group and the Data Pipeline Group and after release are operated by the User Support Group and the Data Flow Operations Group.

Section 5 describes the content of the documentation produced in parallel to the software and data products related to an instrument: User Requirements, Software Requirements, Detailed Design for phase II, data reduction and simulations, Calibration Plan, and User Manual. Some of these documents, like the Calibration Plan are living documents, regularly updated and made visible to the community, for instance on the Web.

Section 6 addresses software development issues such as development platform, contract policy, and maintenance. Development environment, coding standards, interface documents valid for the Data Flow project are listed in this Section.

Figure 1: Software Architecture of the Data Flow system

3 Data Flow Structure

The Data Flow system is composed of a number of subsystems and foundation layers (Fig. 1). The foundation layers are shared by the subsystems, which provide the functionalities necessary to handle the Observation Blocks and Reduction Blocks during their life-cycle. The subsystems include both generic facilities e.g. for proposal handling, pipeline processing, or archiving, and instrument dependent modules and description files (e.g. template GUIs, instrument description files, reduction recipes). More detailed definitions are given in the Data Flow design documents ([1],[2],[3]).

A set of classes is of major importance in the Data Flow system. It includes in particular Templates, Observation Blocks, Frames, Reduction Recipes, and Reduction Blocks. Templates define standard instrument operation modes and configurations. The set of parameters associated to a Template is called the Template Signature. Templates are called in sequence by an Observation Block, which also contains the Phase II information ([5]). The detector acquisition system produces FITS files which are manipulated in the DFS in the form of Frames. Rules are applied on the incoming frames in order to create Reduction Blocks, which contain the set of frames to be processed and a reference to the applicable Reduction Recipe. Reduction Recipes are the data analysis procedures executed to process the frames for the purpose of calibration, reduction, or quality control ([6]). These classes are part of the domain specific layer of the DFS (see Section 3.6).

3.1 Proposal and Observation Handling

The procedure for proposal preparation in the Data Flow system will differ from the current procedure in particular by the introduction of a Phase II proposal preparation. In Phase I, proposals are submitted electronically to ESO which forwards them to the Observing Program Committee (OPC).

After the OPC selection has taken place, Phase II preparation is mandatory for service observing mode and is based on Template forms which allow to program a finite set of standard instrument modes and configurations. Feasibility checks of the proposals will be performed by the User Support Group and will include instrument configuration control, exposure time control using the ETCs. The use of Templates and generic Templates will be mandatory in classical observing mode unless it does not allow to achieve the scientific aims of the observing program. Generic Templates will offer a wide variety of configurations and will therefore not be suited for pipeline processing.

Observation preparation tools will be available during Phase I and Phase II. There will be generic systems like finding chart generators or guide star selection systems, and instrument related tools like exposure time calculators. Access to these tools will be supported over the World Wide Web only since it allows users to access easily the latest versions of software while facilitating the distribution and maintenance for the observatory. During prototype development Phase II tools will be developed both with the VLT Panel Editor and Web based technologies.

For each exposure time calculator a database of instrument description files and characteristic data will be maintained by a Data Flow Instrument Responsible located in Garching. A generic framework for the development of the exposure time calculators is being developed in the DMD. The driving design goal of this framework is to minimize the effort to create exposure time calculators for new instruments, while providing a common framework for all ETCs developed for the DFS.

Target information is also provided in Phase II and the Template sequences are defined within Observation Blocks. At the end of Phase II, Observation Blocks parameters have been defined and are submitted to the Observation Block Repository. The interface between P2PP and the VCS is described in [5].

3.2 VLT Control system

The VCS is an autonomous already existing system. In order to integrate it into the DFS, interfaces have been defined and the VCS will accept Observation Blocks ([5]). The VLT Control System (VCS) will execute Observation Blocks and deliver Frames. The software for near real-time assessment of data from instruments (Quick-Look) is not part of the Data Flow system, but part of VCS ([13]).

3.3 Science Archive

The Archive system is involved at many stages in the Data Flow system. For the sake of clarity it is important to distinguish between:

- the **Science Archive** which is a subsystem of the Data Flow available to archive researchers and astronomers for catalog access and retrieval of scientific data as they become available after the end of the proprietary period, as well as retrieval of calibration, instrument data and logs as soon as they have been processed and verified by the Data Flow Operations.
- the **Database Services layer** of the Data Flow system which provide the storage facility necessary for the intermediate and process data needed for the operations of all Data Flow facilities.

The Science Archive is a service that will be provided and maintained from the central archive in Garching. The Paranal archive will store the observation acquired during the latest 6 months. The Garching archive will contain the complete history of observations.

3.4 Pipeline Processing

Pipeline processing will be available for a subset of the instrument modes described by standard Templates. Pipeline procedures will be subject to extensive testing and qualification procedures for robustness and speed. The header structure of the data will be used by the Data Organizer to classify and associate the incoming Frames, identify Reduction Recipes and create Reduction Blocks, as described in [6]. There will not be one but several pipelines located in Garching and Paranal and executing different kind of procedures. The locations indicated hereafter correspond to operations in classical and service observing modes.

- Calibration Pipeline (Garching)
  Will be used to process the data acquired during Technical Programs and prepare pre-calibrated solutions (aka Derived Data). Derived data may be prepared as well using calibration data generated during the observing runs. Derived data will be controlled by the DFIR before submission to the archive.
- Reduction Pipeline (Paranal)
  Quasi real-time calibration of scientific data obtained by supported templates. The pipeline operates mostly without supervision. Results are looked at by the Service Observer and/or the Observer Astronomer. The Reduction pipeline applies Reduction Rules which by default will select the derived data to be applied to the data. This guarantees robustness and stable performance of the pipeline. The possibility to produce on-the-fly derived data will be evaluated during the prototyping phase. The Reduction pipeline controls its own execution and reports are displayed at the telescope on a user interface and may be replicated on a central DFS message server.
- Quality Control Pipeline (Paranal)
  Quality assessment of the data involving instrument performance control (e.g calibration unit testing, exposure levels, flexures, read-out noise), and observational conditions assessment (e.g. sky background level, seeing). When calibration data are taken during an observing program, the quality control pipeline will verify the adequacy of the derived data for this configuration. Quality control involves on-line and off-line verifications, and the quality control pipeline implements the on-line part only (see Section 3.5). When calibration data are taken during an observing program, the quality control pipeline will verify the adequacy of the derived data for this configuration. If a problem appears, immediate notification will be given to the Service Observer and/or the Observer Astronomer, and the Quality Status of the observation will be marked. Quality control reports will be subsequently verified by the Data Flow Instrument Responsible. In the case scientific data appears corrupted or cannot be calibrated, the observation may be rescheduled.
- Observatory Pipeline (Garching)
  Calibration pipeline based on improved derived data and procedures (re-calibration, on-the-fly calibration, final archive preparation). Results of this pipeline are verified by the Data Flow Instrument Responsible. This pipeline can access all the data contained in the Science Archive.

Fig. 2 shows the most important instances of the pipeline involved in the DFS. For the sake of simplicity of the diagram, not all relationships have been shown, in particular between the reduction and quality control pipelines in Paranal.

A Data Organizer will classify the incoming Frames based on the FITS header to associate them to the relevant Derived data and generate Reduction Blocks ([6]). The relevant Derived Data are not hard-coded in the system but derived from the application of rules. This allows exported versions of the pipeline to process user data.

Figure 2: Pipeline and Quality Control processes

3.5 Quality Control

Quality Control provides the tools necessary for the calibration of the VLT instruments and the assessment of the data quality. For this purpose the system includes:

- the Calibration Plan maintained by the Instrument Scientist and describing the rules and recipes, calibration and physical data, as well as instrument descriptions, necessary for a given instrument.
- the Calibration Server, a local database structure storing all the above products. Applications allow to verify the data stored in the calibration server and submit them to the central archive.
- Instrument Models, ranging from ETCs to imaging simulations allowing to predict and control instrument performance.

The main activity of Quality Control is to monitor the performance of the pipeline and to assess the data quality. To this end the following systems are regularly monitored:

- Pipeline
  - Detector and calibration units
  - Observation conditions (e.g. sky background)
  - Instrument function testing: focus, instrument response
- Instrument
  - Specific testing: scattered light, non-linearities
  - Comparisons to instrument models
  - Certification of the master calibration data
- Observatory
  - Cross-correlations
  - Trend analysis

Number of the above tasks will be implemented in the Quality Control pipeline and be executed during observations. Another part will be available in the form of interactive procedures for use by the DFIR. If a problem is identified which relates to the instrument, the DFIR will make use of a central problem report system.

An aspect of the Quality Control will be the production and maintenance of instrument models for the purpose of exposure time calculation and control of the instrument efficiency.

3.6 Domain Objects and Utilities

The Domain Objects and Utilities define classes specific to the Data Flow such as Observation Blocks, Reduction Blocks, Templates, and the lower level foundation classes including Frame and Signature. GUI development utility classes are also provided.

3.7 Database Services

The "on-line archive client" provides the database access service within the Data Flow system, which allows to dynamically request public files from the databases. Two storage facility will be directly accessible in Paranal, containing the last 3-5 nights and the last 6 months of observation.

4 Responsibilities for a VLT/VLTI Instrument

This Section summarizes responsibilities for the main deliverables provided by the parties involved in interfacing the Data Flow system to a given instrument. Context and deliverables are described in the next sections. The VLT control software is not considered in this Section and is described in the documents [12] and [13].

4.1 Construction period

During the phase of instrument design and until integration, a number of DFS products are defined and prepared, including Phase II and archiving tools, ETCs and data reduction software. Preliminary requirements are defined by the Instrument Responsible. As described in the VLT Science Operations Plan [7], instrument development projects are realised by mixed teams formed under the responsibility of department heads in the Instrumentation Division in Garching. For DFS products, an instrument control software specialist (VLT/INS) and a data analysis specialist (DMD) are member of the team.

4.1.1 Instrument Responsible

The instrument PI (or Work Package officer for ESO built instruments) has single point responsibility and authority for deliverables specified in the contract. In the case of externally developed instruments the Instrument Responsible in the Instrumentation Division is the only formal point of contact between ESO and the instrument consortium and is responsible for the proper execution of the contract and acceptance of the deliverables. In close consultation with him/her additional communication lines can be developed e.g. for technical and software aspects with no contractual impact. In the context of the DFS the Instrument Responsible will have the final responsibility for the performance of the different DFS products like Phase II, ETCs, and pipelines. He needs to be assisted in this by a number of persons.

The Instrument Responsible defines:

- which instrument templates and standard settings will be supported by the pipeline.
- data formats and data dictionary in conformity to DICB ([11]), integrating the information necessary for the Data Flow.
- maintenance procedures to produce and control the standard settings.
- engineering calibration procedures.
- calibration data needed.

He/she prepares the following documents:

- the general instrument software requirements including the Data Flow User Requirements document.
- the initial Calibration Plan and specifies quality criteria for the ETCs, Pipeline and Quality Control.
- the requirements for the maintenance and engineering software.

He/she validates and approves Phase II products, Calibration Plan, Reduction Recipes, Pipelines, archive procedures and GUIs

4.1.2 Instrument Control Responsible

The instrument control responsible prepares or supervises the preparation of the Phase II template GUIs, maintenance and engineering script. In general, s/he prepares the Sequencer, translating templates into observing software (OS) instructions, and performing a detailed validation of OBs during Phase II (see [5], [12], [13]). If this part of the realisation is contracted out, the instrument control responsible follows the consortium or sub-contractor for this aspect of the software development (see Section 4.1.4).

In addition, this person will prepare the documentation associated to Phase II, maintenance and engineering scripts. The instrument control responsible is answerable to the instrument responsible.

S/he implements:

- template signature and other Phase II files, as described in [5].
- instrument specifics into the scheduler.
- template GUIs
- maintenance scripts
- engineering scripts
- associated documentation and user guides

4.1.3 Data Analysis Specialist

The Data Analysis Specialist implements the Pipeline. Part of the realisation may be contracted out.

He/she writes the following documents:

- Data Reduction Detailed Design
- Data Reduction Documentation: maintenance guide, user guide, test procedures.

The data analysis specialist is answerable to the the instrument responsible. S/he implements and tests:

- instrument description files for the ETCs
- the different pipelines (calibration, reduction, quality control and observatory).
- final version of all reduction recipes, including the ones provided by consortia. For internal instruments, provides all reduction recipes.

- develops pipeline reduction recipes and algorithms, constructs the database and programs the reduction rules. Pipelines will be developed in a framework independent from any particular data reduction system (based in particular on Frame and Recipe Signature classes described in the Data Flow design document [3]). A clear separation between the DFS and the actual data reduction system will facilitate the migration to a new system. The implementation of the Recipes will be based on a data reduction system providing base functionalities (see Section 6.3).
- Test pipelines robustness and speed, develops imaging simulation. Imaging simulations and other physical models will be based on extensions of the framework developed for the creation of ETCs.

4.1.4 Instrument Consortium

Instrument consortia produce for externally developed instruments software components that will be assembled by the DMD to create the DFS tools for an instrument. For the Data Flow, this will involve:

- the ICR following Template GUI creations
- the DAS following reduction algorithms and ETCs

During this phase the consortia develop the contractually agreed upon suite of programs necessary for the engineering calibration of the instrument, the calibration and reduction of all types of data expected from the instrument, and the assessment of their technical quality. For in-house built instruments these tools will require DMD support and need to be available by the time of the laboratory integration and the subsequent tests when they have to be used the most.

When data reduction software will be developed by a consortium, the implementation in the DFS will be realized by the DPG. The consortium will provide basic calibration components in the most system independent, reusable way (see Section 6.4).

The instrument consortium provides the following initial information:

- initial instrument characteristic data and ETC.
- reduction Recipes for all modes of the instrument:
  - observing procedure
  - mathematical description
  - code implementation
  - validation sets, including test images and expected results.
- calibration data

4.1.5 Data Flow Instrument Responsible

The Data Flow Instrument Responsible is responsible for Phase I/II and data calibration procedures for an instrument. He updates the Phase II definition files, ETC database, derived data for the pipeline, and checks the results from Quality Control, taking if necessary the adequate actions to guarantee a stable performance of the DFS tools. During the instrument construction phase, the DFIR writes the following documents:

- Data Flow User Manual, describing Phase II, ETC, and Pipeline operations.
- initial version of WWW pages for this instrument.

He/she prepares:

- the calibration database for the instrument.

4.1.6 Data Flow Products Summary

The following tables summarize the software and data products necessary to build the Data Flow system for each instrument. It is assumed that the Data Flow system infrastructure software exists (generic Phase II software, pipeline, instrument models) and is identical for all VLT instruments. The responsibilities, associated documentation and development plan will be detailed in the next Sections. It must be noted that although the persons involved may belong to different divisions, they work in this context in a single work package under the responsibility of the Instrument Responsible. The tables list the person producing the different components of the instrument specific parts of the Data Flow. The responsibility for these products is, for the documents with the author and approvers of the document, for the software products with the developer and its group leader. All data products are under the responsibility of the instrument scientist.

Documents

Number	Product Name	Dependencies	Produced by	Remarks
1	User Requirements		IR	
2	Software Requirements	1	IR	
3	Calibration Plan	1	IR	
4	Data Reduction Det. Des.	2	DAS	
5	Data Flow User Manual	7,8,9,11,12	DFIR	For pipeline modes

Software Products

Number	Product Name	Dependencies	Produced by	Remarks
6	Reduction Algorithms	4	DAS	For all modes
7	Reduction Recipes	4	DAS	For pipeline modes
8	P2PP files and GUIs	15	ICR	
9	Exposure Time Calculator	2	DAS	
10	Imaging Simulation	2	DAS	Optional
11	Maintenance Procedures	3	ICR	
12	Engineering Procedures	3	ICR	

Data Products

Number	Product Name	Dependencies	Produced by	Remarks
13	Header Data Dictionary		IR	
14	Instrument Sample Data		IR	
15	Template and P2PP files	4	ICR	
16	Recipes Validation Set	5	IR	
17	ETC validation set	2	IR	
18	Physical data	3	IR	
19	Instrument model	2	DAS	
20	Calibration Data	3	DFIR	For pipeline modes
21	Classification Rules	3	DAS	
22	Reduction Rules	3	DAS	
23	Quality Control Rules	3	DAS	
24	Calibration Rules	3	DAS	
25	Reduction Recipes	3	DAS	
26	Technical Programs	3	IR	
27	Scheduling Parameters	3	IR	

4.2 Instrument installation and commissioning period

During this period of typically 2-3 weeks, the PI is primarily responsible for demonstrating to the Instrument Responsible that the instrument performance at the telescope conforms to its specification. During the commissioning phase the final versions of these programs will be formally delivered to and accepted by the Instrument Responsible.

The DFS products will be interfaced with the instrument during this period, or during the following performance evaluation period. For the necessary knowhow transfer it appears indispensable that the DFIR be at Paranal during this period.

An Engineering Version of the data reduction software must be available during commissioning of the instrument. It allows to check baseline performance and verify the optical configurations. It may be more interactive and not so fast as the procedures prepared for the pipeline. The engineering version will not be distributed to users outside the observatory.

4.3 Performance Evaluation

This period occurs within the space of a few months during which the initial commissioning results are analysed and any necessary corrective action taken. It is expected that the Instrument Scientist (who may be but is not necessarily the Instrument Responsible) and the Paranal operations and support staff will gain hands on experience with the instrument during this phase. Limited service observing may be possible if the instrument performance is satisfactory.

During the performance evaluation or running-in period, also the pipeline software (assembled from the stand-alone modules provided by the consortia) and associated template operation procedures will be commissioned.

4.4 Provisional Acceptance

It will take place after a second commissioning period during which all aspects of the instrument performance will be verified under joint responsibility of the PI and Instrument Responsible.

4.5 Running-in period

It is the least-defined phase. Responsibility for the instrument performance will be transferred to the Instrument Scientist and Garching/Paranal mixed support team. Operations responsibility will be transferred to the Operations Team. After certification of the pipeline by the Instrument Scientist, the responsibility for the operations of the pipeline will remain with the DFIR under scientific supervision of the Instrument Scientist.

4.6 Routine Operations

It will be the responsibility of the Operations Team comprising, Paranal and DMD staff. INS will be responsible for instrument performance and upgrades through the Instrument Scientist and mixed support teams. During this phase the DFIR ensures that the pipeline is operating correctly. S/he performs further regular quality checks and trend analysis as stipulated in the Calibration Plan and related documents and specified by the Instrument Scientist. In case of any suspected anomalies, the DFIR brings them to the attention of the Instrument Scientist, who, after consultation with other members of the Mixed Team in charge, decides about the remedial actions to be taken. The Instrument Scientist will be responsible for the quality of the input to the pipeline, the DFIR for its output.

The operations model in this phase involves a number of actors. The persons or groups directly in contact with DFS product users include the User Support Group and the DFIR. They will share a number of responsibilities.

The Operations Model identifies 10 roles:

- Instrument Support
- User Support
- Observing Programmes Committee
- Schedule Coordinator
- Paranal Observation Preparation
- Paranal Observing
- Paranal Maintenance
- Data Quality Control
- Archive

We will detail in this document the roles more specifically related to instrument specific activities. After commissioning the Instrument Scientist becomes responsible for the routine operations of the instrument. Routine operations are performed by a Mixed Team which includes members for the Data Flow Operations.

4.6.1 Instrument Scientist

Within the INS, the Instrument Scientist is the central source of knowledge concerning the instrument. In case of any suspected anomalies, the DFIR brings them to the attention of the IS, who after consultation with other members of the Mixed team in charge, decides about the remedial actions to be taken. The Instrument Scientist will be responsible for the quality of the input into the pipeline, the Data Flow Responsible for its output.

In addition, the Instrument Scientist is interacting with the User Support group and provides scientific/technical advice to the astronomical community on the optimal exploitation of the instrument.

- Updates the Calibration Plan.
- Updates the Operating Manuals

4.6.2 User Support

Within User Support, a person assists users with Phase II, ETC tools, archive research. This person must have astronomical knowledge as well as a close integration in the Mixed Team in order to be informed about the latest developments regarding an instrument.

Note: This responsibility could possibly be merged with the one of the DFIR described below.

4.6.3 Paranal Observing

Telescope, instrument and data flow operators are involved in this role:

- Executes Observation Blocks (Instrument Operator)
- Supports classical/service observing modes (instrument operator and DFO)
- Uses results from the pipelines (DFO)
- Certifies data products (DFO)
- Monitors archiving (DFO)

The Data Flow operator initializes the pipeline and interprets the results during the night. As described in Section 3.4, both a reduction pipeline and a short-term quality control pipeline are running during the night.

Note: the number of FTEs required for the Paranal Observing will be evaluated at the NTT.

4.6.4 Paranal Instrument Maintenance

- Performs the maintenance procedure to verify the standard configurations
- Performs engineering calibrations

Maintenance software for the verification of the instrument functions is required by the Operations Team. Engineering calibrations of instrument servos and telescope, standard configurations of the instrument will be supervised by the Instrument Scientist.

4.6.5 Data Flow Instrument Responsible

The operational phase of the work of the DFIR starts in this period, namely the DFIR performs the activity listed under Quality Control in the VOM:

- Checks the Data Flow quality reports.
- Verifies and updates calibration database and Reduction Recipes
- Runs the Observatory Pipeline
- Performs trend analysis for DFS products
- maintains all DFS user documentation.
- Verifies and updates the ETC and other simulations.
- Follows pipeline and instrument performance in relation with Paranal Data Flow Operations and Maintenance groups. In case of problems, raises a flag to a central problem reporting system, if necessary will contact the Instrument Scientist.

4.6.6 Archive Group

User packages are prepared as described in the VOM in relation with the User Support Group.

4.7 Upgrade phases

During this phase, the Instrument Scientist monitors the adequacy of the DFS tools and initiates upgrades. The development cycle described above is reproduced for each upgrade.

5 Documentation

This Section describes the different documents needed to define the Data Flow system for a generic instrument.

5.1 Data Flow User Requirements

This document describes the general requirements concerning the complete Data Flow system for an instrument. It provides an instrument description information and sets the requirements for Phase I, Phase II, and additional tools like exposure time calculators, pipeline calibration and quality control. This document is prepared by the Instrument Scientist, jointly approved and released by the DMD and the IR. It details the following:

- **Instrument Description**

  This section of the document describes the instrument observing modes and resulting data formats. Typical data rates for these observing modes are indicated. All observing modes and typical targets (astronomical and calibration) are identified to define Templates (instrument operation mode) and Observation Blocks.

- **Standard Settings and Templates**

  The Templates, calibration Observation Blocks, and instrument standard settings to be processed in pipeline mode are listed. Maintenance procedures necessary to reproduce the standard settings are identified. Target acquisition templates are defined,

- **FITS Header**

  FITS keywords and structure of the data is defined for each instrument in conformity with DICB. In particular the information needed for pipeline reduction and quality control is listed in this section.

- **User Requirements**

  User requirements concerning Phase II preparation, ETC, general reduction recipes and pipeline reduction recipes are defined in this section including expected accuracies, execution time, and indication of the modeling and calibration methods.

- **User Requirements**

- **Engineering calibrations**

  Engineering calibrations (like wavelength vs. encoder position, etc..) and maintenance procedures required to guarantee the stability of the standard settings, in particular the ones supported by the pipeline, are defined with the required accuracies.

At this phase a plan concerning the cost of the project for this particular instrument is produced.

5.2 Data Flow Software Requirements

The document is prepared by the Data Flow Instrument Responsible, jointly approved and released by the Data Management Division and the IR. This document details the requirements and describes accurately the Template parameter set, template GUIs, model of exposure time calculator, pipelines.

- **Template files**

  Templates and calibration Observation Blocks are listed with their parameters. Preliminary versions of the Phase II Template PAF files are produced.

- **Exposure Time Calculators**

  The required ETC models are described (modes, sources, observation conditions, GUIs). This section will drive the generation of ETC PAF files.

- **Data Reduction Requirements**

  Procedures are listed for all observation modes of the instrument. The Templates and calibration Observation Blocks to be processed by the pipeline are identified. Needs for Reduction Recipes for the purpose of calibration, reduction, quality control, and observatory pipelines are identified.

  The data reduction requirements are defined by the Data Flow Instrument Responsible, initially in collaboration with the instrument development team. It will identify:

  - for all instrument modes, the detailed reduction recipes requirements.
  - the subset of the observing modes and instrument configurations that will be supported by the pipeline. For these modes, the following additional requirements will be defined:
    - Standard settings (or Templates).
    - Technical programs and data verification
    - Calibration data
    - Pipeline procedures allowing unsupervised calibration.
    - Quality control procedures (Instrument performance control, data control).
    - Simulations for pipeline testing.

The project manpower estimates are updated at this phase.

5.3 Data Reduction Detailed Design

For a subset of each Template, a Reduction Recipe will be defined (calibration, reduction, quality control). The following description will be given:

- **General Description**
  - Context of utilisation (type of object)
  - pre- and post- observation calibration data
  - Resulting data format (image structure, header)

  - Expected pre-processing, post-processing
  - Supports pipeline calibration (unsupervised)
  - Requires user interaction

- **Mathematical Description**
  - Mathematical justification
  - Articles, Publication
  - Error propagation
  - Random, systematic error estimation
  - Domain, limits of validity

- **Code Description and Implementation**
  - C-like syntax:
    * Basic mathematical functions and operations
    * Reference to a publicly available algorithm (e.g. Lapack)
    * Control structures (tests, branches)
  - Flow-charts

  The implementation of the code is also provided (see Section 6.2).

- **Validation Sets**
  - FITS images and tables
  - Input data and parameters
  - Intermediate results
  - Final results

- **Annex**
  - Articles, publications
  - Working group reports

5.4 Calibration Plan

This document is prepared by the IR, approved and released by the Instrumentation Division and updated by the IS. To a greater extent than the previous documents, the Calibration Plan will be regularly revised in the post-commissioning period. The Calibration Plan will be distributed to the ESO users community (e.g. published on the WWW). It contains the following information:

- **Technical Programs**

  Actual Technical Programs (calibration Observation Blocks) are listed for the acquisition of the calibration data. The programs detail the targets to be acquired, time intervals for the execution of the technical programs, and indicates the calibration functions which are evaluated and the recipes involved.

- **Calibration Database**

  The Calibration Database contains the Derived Data necessary for execution of the Pipeline. The master of the database is located in Garching, where it is prepared and updated by the Data Flow Instrument Responsible under supervision of the Instrument Scientist. The database is replicated in Paranal to run in Pipeline mode. It contains the following data.

  - Calibration Frames
  - Derived data and associated accuracies
  - Physical data
  - Instrument configuration and components data
  - Rules and recipes

  Physical data are shared between instrument scientists. Each needs to make sure the calibration database required for the instrument(s) he is in charge are present.

- **Pipeline Description**

  Every reduction step in the pipeline is described. A validation set for the pipeline and expected accuracies for each step of the calibration will be defined.

- **Instrument Models Reference Data**

  Validation sets for ETC and other models will be described as well as expected accuracies.

5.5 Data Flow User Manual

This document describes the operations of the Phase II tools, ETC, pipeline, quality control, and other Data Flow tools particular to an instrument. This document is written by the DFIR.

6 Software Development

This Section describes the development plan for software realisation, in particular for the development of Reduction Recipes and Pipeline software.

6.1 VLT instrumentation plan

UT1 and UT2 will receive instruments developed both by ESO and consortia. On the present schedule until beginning 2000, two instruments are being developed by consortia (CONICA, FORS I + II). UVES and ISAAC/SOFI will be realised by ESO. The development effort concerning reduction software for the already planned future (until 2000) will be about 50% for internal development and 50% in the consortia. Later will come a series of externally developed instruments (FUEGOS, VIRMOS, VISIR).

Astronomical institutes may be contracted for the development of the software for external instruments. Reduction Recipes will developed by the consortia in relation with the Instrument Responsible and the Data Analysis Specialist.

6.2 Software development plan

A template software development plan is given in Figure 3, detailing the dependencies between the different Data flow products. Depending on the instrument the software production typically spans over a one to two years period. This template schedule covers the preparation of Data Flow products during the pre-commissioning phase.

6.3 Instrument calibration packages

The interface between the Data Flow system and the reduction environment will be based on the Reduction Recipe class, a medium- to high-level description of a reduction procedure to which a Signature is attached. The aim of Reduction Recipes can be for instance to perform a flat-field correction, extract a spectrum, determine a magnitude correction, or estimate a magnitude. Lower level operations like fitting a polynomial, subtracting images, a.s.o. are assumed to be provided by the underlying data analysis system. At the level of the Data Flow system it is expected that this description of the operations to be performed on the data will remain stable over long period of time, whereas the actual implementation may vary.

6.4 Development environments

Coding standards for DFS software products are described in [14]. Software developed for the DFS shall be compatible with the VLT control software. User interfaces will be developed following the look and feel defined in the ESO GUI Common Conventions [10].

The implementation of the Recipes will be based either on

a) code written in Fortran, C or C++ accessing data via the Midas Environment, or

b) code written in Fortran, C or C++ accessing data via the Data Flow classes like Frames, Tables once they become available, or

Figure 3: Data Flow products network chart.

c) a combination of a) or b) with existing scripts/procedures of a data reduction system which is supported by the pipeline

Data reduction systems supported by the pipeline are specified explicitly in [6].

end of document