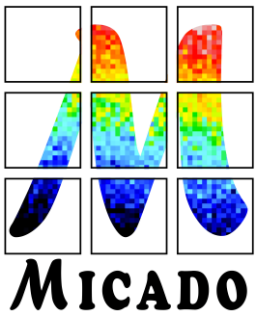

ELT - MICADO

Phase C

MICADO Data Flow Interface Control

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CHANGE RECORD

ISSUE	DATE	SECTION/PARAGRAPH AFFECTED	REASON/INITIATION DOCUMENTS/REMARKS
0.1	23/02/17	All	New document (first Draft)
0.2	27/02/17	All	Comments A*, NOVA, USM
0.3	30/05/18	All	Complete revision
0.4	11/09/18	All	GVK: complete update
0.5	17/09/18	All	GVK: iteration to highlight work for WWZ to achieve a version suitable for PDR internal submission.
0.5.1	19/09/18	2.3, 3.2, 4.1, 4.10, 5.1	Michael W.: Some ICS interface info added.
0.6	21/09/18	2.1, 3.2, 4	WWZ: AD/RD update & updates mainly related to PSF-R interfaces
0.6.1	21/09/2018	1,2 and fig. 3.1	GVK: minor textual updates. Significant update Fig3.1 to baseline for PSF-R interfaces.
0.6.5	24/09/18	All	WWZ
0.6.6	24/09/18	All	GVK: feedback for WWZ in green highlight. Update Fig3.1. Minor textual edits.
0.7	24/09/18	RD list, 5.1.2	GVK: added more detail on DPS-ICS implementation plan
1.0	27/09/18	All	GVK, WWZ
1.1	16/11/18	3,4,5 and fig. 3.1	WWZ: RIX revision for PDR
1.2	01/04/20	All	WWZ: revision after CM#15
1.3	21/09/20	All	WWZ: update for FDR readiness check

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1. Introduction

1.1. Objectives

The purpose of this Data Flow Interface Control Document (ICD) is to define the interfaces within the ESO DFS which involve the MICADO DPS which consists of:

- QC level 0 observatory pipeline [AD7];
- QC level 1 quality control pipeline [AD7];
- QC level 2 pipeline and science-grade desktop environment [AD7];
- DPS libraries within the ICS;
- PSF Reconstruction Service [RD13]
- Instrument Package [AD7]

The document defines the interfaces that exist during development and/or regular operation.

1.2. Background

MICADO is the Multi-AO Imaging Camera for Deep Observations. It will equip the ELT with a first light capability for diffraction-limited imaging at near-infrared wavelengths.

The ESO DFS was defined as a concept in 1995. Originally, it provides high-level software tools and utilities needed for the VLT Science Operations and service to the astronomical community. The document applies to the ELT first light instrument MICADO with [AD7] as the main applicable document.

1.3. Document Conventions

1.3.1. Document Status

This document is a preliminary Technical Sub System ICD generated to initiate and accompany the work in phase C (towards FDR). It might use terms like: goal, optimize, adequate, minimize, TBDs and TBCs. After the PDR the number of times that these terms are used shall be significantly reduced. After FDR, this document will become a Technical Sub System ICD. This will imply the exclusive use of terms like:

- The verbal form “shall” shall be used whenever a provision is a requirement.
- The verbal form “should” shall be used whenever a provision is a recommendation.
- The verbal form “may” shall be used whenever a provision is a permission.
- The verbal form “can” shall be used to indicate possibility or capability.

1.3.2. Requirement Convention

All requirements specified in this document shall be assigned a unique reference identifier for the sub-system.

The unique identifier for the sub-system is: DPS

2. References

2.1. Applicable Documents

The following Applicable Documents (AD) of the exact issue contain provisions (statements, instructions, recommendations or requirements) that are ruling over - and implicate provisions in the present document.

AD Nr	Doc Nr	Doc Title	Issue	Date
[AD1]	ESO-253082	Common ICD between the E-ELT Nasmyth Instruments and the Rest of the E-ELT System	4.11	draft
[AD2]	ESO-262869	Interface Control Document Between the E-ELT SCPs and the SCP Clients	3.0	20.07.2017
[AD3]	GEN-SPE-ESO-1900-0794	Data Interface Control Document	5.0	8.7.2011
[AD4]	ESO-193058	Standard Coordinate Systems and Basic Conventions	6.0	03.12.2015
[AD5]	ESO-254547	Common Requirements for E-ELT Instruments	2.0	15.09.2015
[AD6]	ESO-244537	MICADO (E-ELT CAM) Technical Specification	1.0	16.09.2015
[AD7]	ESO-037611	Dataflow for ESO Observatories Deliverables Specification	4.0	02.03.2020
[AD8]	ESO-264642	E-ELT Instrument Control System Common Requirements	2.11	draft
[AD9]	ESO-044286	ESO Science Data Product Standard	5.0	11.01.2013
[AD10]	ELT-PLA-MCD-56301-0004	Operational Concept Description	2.0	11.09.2018
[AD11]	ELT-SPE-MCD-56302-0012	Observation Preparation Tool Specification	1.0	15.09.2018

2.2. Reference Documents

The following Reference Documents (RD) contains useful information relevant to the subject of the present document.

RD Nr	Doc Nr	Doc Title	Issue	Date
[RD1]	ESO-213265	Document Requirement Definition (DRD)	2.0	01.06.2016
[RD2]	ESO-231062	ESO PDM Document Types and Definitions	1.0	03.07.2014
[RD3]	ELT-SPE-MCD-56304-0007	MICADO MAORY SCAO RTC User Requirements	4.0	27.09.2018
[RD4]	ELT-TRE-MCD-56300-0011	MICADO System Design & Analysis	1.2	04.04.2019
[RD5]	ELT-PLA-MCD-56301-0002	Science Use Cases	1.0	21.06.2016
[RD6]	ELT-SPE_MCD-56305-0008	Data Reduction Library Specification	1.0	27.09.2018
[RD7]	ELT-SPE-MCD-56302-002	MICADO Instrument Software Functional Specification	1.0	15.09.2018
[RD8]	ELT-ICD-MCD-56306-0050	SimCADO: the Data Simulator for MICADO	1.0	27.09.2018
[RD9]	ESO-306455	ELT ICS Framework – Observation Coordination Framework Design	1.2	draft
[RD10]	ELT-TRE-MCD-56306-0055	MICADO PSF Reconstruction Calibration and Processing	1.0	27.09.2018
[RD11]	ELT-PLA-MCD-56305-0007	MICADO Calibration Plan	1.0	27.09.2018
[RD12]	VLT-MAN-ESO-17240-3968	Common Library For Image Processing - Software Specification	1.0	19.12.2006
[RD13]	ELT-TRE-MCD-56306-0051	PSF Reconstruction Specification	1.0	23.02.2017

2.3. Acronyms

This document employs several abbreviations and acronyms to refer concisely to an item, after it has been introduced. The following list is aimed to help the reader in recalling the extended meaning of each short expression:

AO	Adaptive optics
AOWFC	Adaptive optics wavefront-sensor camera
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange
CPL	Common Pipeline Library
DFS	Data flow system
DPS	Data processing subsystem
DRL	Data reduction library
DRS	Data reduction system
ELT	Extremely Large Telescope
ESO	European Southern Observatory
GUI	Graphical User Interface
FDR	Final design review
FITS	Flexible Image Transport System
FPA	Focal plane array
HDRL	High-level data reduction library
ICS	Instrument control system
ICD	Interface control document
IF	Interface
JPEG	Joint Photographic Experts Group
LTAO	Laser tomography adaptive optics
MAIT	Manufacture, Assembly, Integration, Test
MAORY	Multi-conjugate Adaptive Optics Relay
MEF	Multi-extension FITS
MCAO	Multi-conjugate adaptive optics
MICADO	Multi-adaptive optics Imaging Camera for Deep Observations
N/A	Not applicable
NCPA	Non common path aberration
NGS	Natural guide star
NOVA	Nederlandse Onderzoekschool voor Astronomie
OB	Observation block
ODP	Online Data Processing Component of the ICS framework
OS	Observer Support Software
OSS	Observing Support Software
PAF	Parameter File
P2	Phase 2 Proposal Preparation tool
PAE	Preliminary acceptance in Europe
PAO	Preliminary acceptance at the observatory
PDR	Preliminary design review
PSF	Point spread function
PSF-R	PSF reconstruction
PWV	Perceptible water vapour
QACITS	Quadrant analysis of coronagraphic images for tip-tilt sensing

RTC	Real time computer
SCAO	Single-conjugate adaptive optics
SDP	Science data product
SGS	Secondary guide star
SVN	Apache Subversion software
TBD	To Be Defined
TBW	To Be Written
TCCD	Technical CCD
TGS	Telescope guide star
USM	Universitätssternwarte München
VLT	Very Large Telescope
WFS	Wavefront sensor
WP	Work package

2.4. Definitions and assumptions

This chapter contains definitions and assumptions which shall be used for the sub-system Design and as the boundary conditions for the requirements defined in subsequent chapters.

- **Calibration Plan**: MICADO-specific description of what calibration data are required and what QC1 parameter will be derived [AD7]
- **Data Products**: FITS frames and/or tables produced by the DRS processing raw science and calibration data [AD7]
- **DRS**: describes the framework of pipelines used for the reduction of MICADO data
- **FITS Header**: standard FITS header contained in all FITS files [AD7]
- **Instrument Package**: is required for the definition of OBs. It contains all relevant information for Phase 1 proposal submission, Phase 2 proposal preparation and ETC. [AD7]
- **OB**: basic scheduling unit of ELT science operations. An OB contains the parameters necessary to configure the ELT – (MAORY) – MICADO system in order to execute a sequence of observations. [AD7]
- **PSF-R**: determining the Point Spread Function of an observation based on wavefront sensor data and AO telemetry.
- **QC parameters**: quality control parameters computed by the DRS used to assess the quality of the raw data. [AD7]
- **Raw data**: data produced by the execution of OBs. [AD7]
- **Recipe**: executable non-interactive program performing a sequence of individual data processing steps. [AD7]
- **Science Target Specification**: describes the specifications how to observe an astronomical object in order to achieve the science goals.

- **Science Use Cases**: describe the requirements of the science drivers for the main observing modes on basis of prototypical science cases [RD6].
- **SDP**: calibrated data product in physical units with instrument signatures removed, including error estimates fulfilling the requirements of [AD9]. SDPs are used to extract scientific conclusions [AD7]
- **Secondary guiding:** correction of guiding and centring errors which affect the precision of measurements. The deviation between actual and nominal positions of secondary guide stars shall be determined through centroiding after each exposure.

3. General Information

3.1. MICADO Overview

MICADO will be the first light imager at the ELT with the capability of diffraction limited imaging at near-infrared wavelengths. The key capabilities of MICADO are high sensitivity, high angular resolution, high-precision astrometry and wide wavelength coverage. The instrument will offer four observing modes:

- Standard imaging;
- Astrometric imaging;
- Slit spectroscopy;
- High-contrast imaging (coronagraphy).

MICADO is optimized to work with the laser guide star multi-conjugate adaptive optics system (MAORY). MICADO can also work with its internal SCAO module that uses a single natural guide star. The technical specifications of MICADO are given in [AD6] while the system overview is referred to [RD4]

3.2. ESO DFS for MICADO

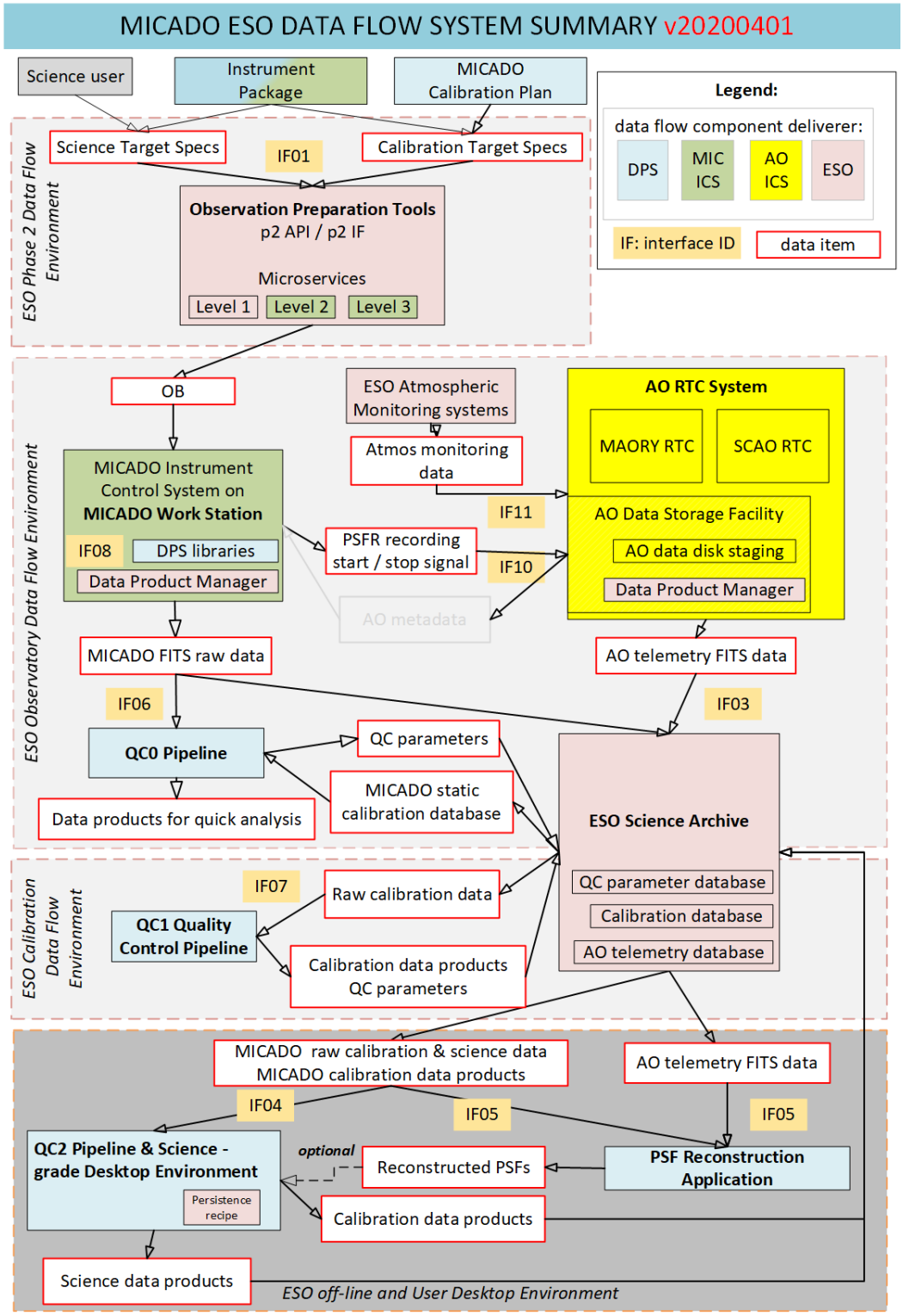

Figure 1. *Schematic overview of the MICADO DFS. System components (workstations, desktops, databases, processing pipelines, archives) are indicated by colour-filled rectangles. Data items (documents, files, raw and processed data, manual input …) are indicated by white-filled rectangles with red rims. Arrows indicate the flow direction of data items. The data flow passes through several environments indicated by white-filled dashed rectangles with coloured rims. The IFs described in section 4 are indicated.*

Figure 1 is a schematic overview of the MICADO DFS. It starts on top with components involved in observation preparation. It ends at the bottom with the pipelines that produce the data products that are input for scientific analysis and instrument health monitoring.

At the start, the Science Target and Calibration Target specifications are the manual input into the Observing Block Preparation Software which is part of the MICADO Instrument Package. The input specifies both the science objects and also the observations of them needed to meet the science case goals. The MICADO Calibration Plan [RD11] contains the observing specifications needed to prepare calibration observations and the definition of the QC parameters which are relevant for the DRS. MICADO observations have to be prepared in advance by means of ESO's generic web application p2. The latter consists of a browser-based client and microservices on three different levels [AD 7]:"

- Level 1: generic observation preparation microservices;
- Level 2: common instrument microservices for observation preparation;
- Level 3: dedicated instrument microservices for observation preparation.

The Observing Block Preparation Software turns these observing specifications into an OB that serves as input to ESO's observatory software environment. The MICADO ICS executes the instrument-relevant observing commands and creates the raw data acquired from the focal plane detector arrays. The Data Product Manager converts the raw data into FITS files which are stored into the ESO Science Archive.

The MICADO DRS consists of two automated pipelines and one interactive pipeline that take as input the raw FITS data and delivers QC parameters, calibration data products and SDPs. Each pipeline serves a different QC level:

- QC level 0 pipeline: the observatory pipeline runs in quasi real-time without user interaction and processes in the incoming individual raw FITS data obtained from the Data Product Manager using a static calibration database. The pipeline executes event-driven data reduction recipes to generate QC parameters and data products optimized for quick analysis to assess if the science observations meet the specifications on observing conditions and raw data quality.
- QC level 1 pipeline: the quality control pipeline processes complete raw data sets from a full observing night in order to generate QC parameters and master calibration frames. The QC parameters characterize the observational performance of the instrument and are input for trend analysis. The calibration data serve the following purposes:
  - Remove instrument signatures from the science frames;
  - Convert science data into physical units;
  - Monitor the instrument performance.
- QC level 2 pipeline: the science-grade desktop environment is an off-line pipeline to generate SDPs using the best calibration data. The pipeline has the capability to combine (mosaic) data frames from different OBs. The pipeline recipes are callable from different front-ends as described in [AD7]:
  - Command-line esorex front-end;
  - Gasgano user-IF (TBD);
  - ESO Reflex workflow tool allowing an interactive data reduction flow.

The pipeline software is a deliverable to ESO. ESO maintains the software and facilitates that users can install the science-grade desktop environment on their local hardware. All pipelines will have most of their software recipes in common which are based on the CPL and HDRL functions.

The recipe cascades in the DRS for standard imaging, astrometric imaging and spectroscopy have as final output SDPs which are ready for scientific analysis. For the high-contrast imaging, which is mostly performed with pupil de-rotation, only basic processing steps of individual exposures will be performed to characterize / correct instrumental effects. This is because processing techniques develop rapidly, and the preferred method to derive SDPs depends strongly on the parameters of the target and individual goals of the observations. In general, no processing of the acquisition frames is foreseen in the DRS.

Furthermore, the DPS team shall provide a specific DPS library for the MICADO ICS to support its secondary guiding. The coding language and software development platform will follow the CPL/HDRL standards (TBD).

The PSF-R application delivers reconstructed point spread functions. The PSF is reconstructed from WFS and deformable mirror telemetry. In addition, dedicated calibration observations with the MICADO focal plane array are required. Its operational environment is self-contained. The coding language and software development platform will follow the CPL/HDRL standards (TBD).

[AD02] deals with the specification of requirements on the interfaces involving DPS components.

The amount of data produced by MICADO will depend on the observation and detector mode (see [AD10], [RD9]). An average value might be of the order 60 GB/hr, the maximum value will be smaller than1.5 TB/hr in all cases (TBC). This does not include PSF reconstruction data.

3.2.1. DFS Components

The system responsibilities for the various DFS components are identified in Fig. 1. These components constitute the MICADO DPS. The 4 responsible teams are:

- MICADO DFS: blue components;
- MICADO ICS; green components;
- MICADO/MAORY AO/PSF-R: yellow components;
- ESO: red components.

Observation Preparation Tools (p2). The output of p2 defines the observational specifications for data acquisition at the telescope. It allows to attach parameter files to an OB acquisition. The parameter files are in ASCII format containing keyword-value pairs which constrain target, observational and instrument-specific properties. It produces ESO-compliant PAF files that can be attached to OBs created by means of p2. The contents of the PAF file shall be reflected in the headers of the raw FITS frames of the corresponding observation.

MICADO ICS. The MICADO ICS contains the instrument control software, units, devices and local communication infrastructure which guarantee functional operation of the MICADO instrument for scientific and maintenance purposes. The ICS supports the following functionalities in the DFS framework:

- Handling of data frames from the MICADO FPA detectors;
- Handling of FITS header keywords;
- Data visualisation of incoming observational data.

The ESO Data Product Manager assembles the final raw FITS data products and submits them to the ESO Archive.

RTC System. The AO RTC is primarily concerned with the implementation of the main AO loops using the following sensors and actuators in real-time, as applicable:

- AO WFS of MICADO;
- AO WFS of MAORY;
- FPA detectors of MICADO;
- AO corrective optics of MICADO;
- AO corrective optics of MAORY;
- ELT M4;
- ELT M5.

The handling of the RTC WFS data is described in [RD13].

ESO Science Archive. The Data archive is the main storage area for the raw and processed data products. The data products are stored in FITS format. The ESO Data Product Manager interacts with the ESO Data Archive to deliver the incoming raw data products. The instrument data reduction pipelines will obtain the raw data products from the archive, in case of the Observatory Pipeline TBD.

AO telemetry data disk staging. The AO data storage facility is the main storage area for the incoming MAORY MCAO and MICADO SCAO RTC AO telemetry data which are used in the PSF-R Application (TBC). The expected high data rates justify a dedicated storage facility where the data are stored for TBD period of time for the off-line use by science users. The AO telemetry data flow is constrained by specific input from the associated OB (e.g. time stamp of start/end of integration).

QC Level 0 Pipeline. The observatory pipeline processes incoming MICADO FITS raw data from the ICS event-driven using standard calibration solutions. The set of frames produced by a template is the biggest unit of raw data which can be processed together. The pipeline supports all 4 observing modes of MICADO and delivers the followings data products:

- QC0 parameters as defined in [RD11];
- Specific data products optimized for quick analysis to assess if the science observations meet the specifications on observing conditions and raw data quality (TBD).

QC Level 1 Pipeline. The quality control pipeline processes MICADO raw calibration data on basis of the specifications of the Calibration Plan [RD11] obtained from the ESO Science Archive. The pipeline delivers the following data products:

- QC1 parameters as defined in [RD11];
- Master calibration data products.

QC Level 2 Pipeline. The off-line pipeline processes MICADO raw data from the ESO Science Archive. The science-grade desktop environment allows the user to access the data reduction workflow through various front-ends. The pipeline delivers the following data products:

- Master Calibration data products;
- SDPs.

The three above mentioned pipeline frameworks are based upon CPL and HDRL which are used for the development of pipeline recipes. The pipeline recipes are for a large part identical in all 3 environments. The main differences come from how they are operated, e.g. QC Level 0 and 1 pipelines have to run fully automatic while the QC Level 2 (science-grade desktop environment) in the case of the Reflex workflow provides interactive flexibility adding also additional

functionality with non-standard recipes. The detailed description of the DRS pipelines is given in [AD7].

PSF-R Application. The off-line pipeline processes FITS data from the AO RTC system (MAORY MCAO or MICADO SCAO unit and related ancillary data) which contain the information relevant for

- PSF reconstruction
- NCPA correction

A detailed description is given in [RD13]. The pipeline delivers reconstructed PSFs in FITS format.

Instrument Package. The key elements are the templates which are used to create OBs. The Instrument Package shall conform to the p2 IF of the OB Preparation Software and has the following deliverables [AD7]:

- Template Signature File for each template;
- Instrument Summary File;
- Definition of the functionality of each template.

MICADO Static Calibration Database. The database contains default input parameters and standard calibrations solutions required to run the QC Level 0 observatory pipeline automatically. The input data shall allow a robust and reliable performance of the pipeline. The database shall be updated from the ESO Science Archive in regular intervals (TBD).

Calibration Database in the ESO Science Archive. The database contains the all necessary data to calibrate the MICADO raw science data. They are identified in the ESO Science Archive by appropriate FITS keywords (TBD). The Calibration Database consists of

- Master calibration data products from QC Level 1 pipeline;
- QC parameters derived by QC level 0 and 1 pipelines;
- Calibration data delivered by ESO: detector persistence maps
- TBD

4. Interfaces in regular operations

This section describes the DFS-specific interfaces which are relevant for the regular operations of the MICADO instrument (observations and maintenance). The interface AO RTC system to the AO Data Storage Facility (ex IF02) is internal to the AO RTC system and fully described by the RTC team.

4.1. IF01: Calibration Plan / Instrument Package / Science Target Specification → OB Preparation Software / Observation Preparation Tools

The Calibration Plan [RD11] specifies the tasks for the regular calibration data acquisition (calibration OBs) which are handled by the ICS and processed by the QC pipelines. The Science Target Specification (in case of simulations Science Use Cases) contain all necessary parameter for the definition of OBs. The Instrument Package contains the templates to be used for creating OBs for all supported instrument observing modes. These data will be used for the preparation of OBs. Any MICADO-specific source code shall be checked in the ESO SVN repository [AD7].

This IF is internal to ICS and fully described in [AD11].

4.2. IF03: AO Data Storage Facility → ESO Science Archive

This IF satisfies the requirements for the AO data transfer from the AO data storage facility (disk staging) to the ESO Science Archive.

IF architecture:
to be decided by FDR

IF data:
AO telemetry data from MAORY MCAO or MICADO SCAO systems and WFS data with associated ancillary meteorological data in FITS table format (TBD). The details will be specified by FDR.

IF custodians:
- DPS: lead WP PSF-R
- ESO: Science Archive Group (TBD)

4.3. IF04: ESO Science Archive → Science-grade Desktop Environment

This IF describes the off-line access to the raw MICADO FPA FITS science data and associated calibration data stored in the ESO Science Archive.
.
IF architecture:
manual FITS file exchange

IF data:
MICADO FPA FITS raw data as delivered by the ESO Data Product Manager and (optionally) reconstructed PSF FITS images from the PSF-R application.

IF custodians:
- ESO: Pipeline Systems
- DPS: lead WP DPS

4.4. IF05: ESO Science Archive → PSF-R Application

This IF describes the access to the AO RTC data and related ancillary meteorological data (TBD) for the PSF-R application. The AO telemetry data are stored in the ESO Science Archive. The data volume is limited to the start/end time stamps of the executed OBs which are associated with the AO telemetry data.

IF architecture:
to be decided by FDR (see section 6.1 in [RD10])

IF data:
AO telemetry data from MAORY MCAO or MICADO SCAO systems as delivered by the ESO Data Product Manager (FITS table format) and WFS data with associated ancillary meteorological data (TBD). The details will be specified by FDR.

IF custodians:
- ESO: Science Archive Group
- DPS: lead WP PSF-R

4.5. IF06: ICS (ESO Data Product Manager) → QC Level 0 Pipeline

This IF is internal to ESO and hence fully defined by ESO.

4.6. IF07: ESO Science Archive → QC Level 1 Pipeline

This IF is internal to ESO and hence fully defined by ESO.

4.7. IF08: DPS Libraries → ICS

The MICADO ICS shall enable the data processing tasks on the instrument workstation by means of a dedicated CPL/HDRL based functions and recipes in the framework of a DPS library. The source code shall be checked in the ESO SVN repository [AD7]. The DPS library will support the following data processing tasks:

- Secondary guiding in standard and astrometric imaging: The deviation between actual and nominal positions of secondary guide stars shall be determined through centroiding after each exposure. Reduced images of the respective SGS shall be provided for quick-look display.
    - Input from ICS to DPS library:
        - N = 9 raw detector readouts, probably no full FITS frames but only binary data in shared memory.
        - Telescope pointing in RA/Dec (mean coordinates) + derotator offset angle.
        - Nominal mean coordinates (RA, Dec) of M >= 3 SGSs (might be located on any of the detectors, number and position might also vary between the exposures).
    - Output from DPS library to ICS:
        - Actual mean coordinates (RA, Dec) corresponding to the detector positions where the SGS nominally should be. As an alternative, these corrections are an output from the DPS library (TBD)
        - Reduced images of windows around the SGS for quick-look display.
- Adjustment of positions in coronagraphic imaging mode: The required correction of the coronagraphic mask position shall be determined in order to keep it centred on the central star after each exposure
    - through direct flux measurement (with focal plane or pupil plane mask) or
    - by means of the QACITS algorithm (with focal plane mask only).

  - Input from ICS to DPS library:
    - Raw (central) detector readout of central detector, probably no full FITS frame but only binary data in shared memory (specifications which detector rows TBD)
    - Derotator offset angle.
    - Nominal mean coordinates (RA, Dec) of central star.
  - Output from DPS library to ICS:
    - Actual mean coordinates (RA, Dec) of the detector centre if the central star is assumed to be on its nominal position including a correction value for the instrument rotation
    - Reduced image for quick-look display.

- Adjustment of positions during spectroscopy in SCAO mode: The difference between the images of 2 reference lamps on the TCCD of the metrology system (TBD) shall be evaluated in order to keep the target centred in the slit during an observation after each exposure.
  - Input from ICS to DPS library:
    - Raw detector readout of the technical detector that belongs to the metrology system, probably no full FITS frame but only binary data in shared memory.
    - Nominal positions of metrology system's light sources on detector.
  - Output from DPS library to ICS:
    - Actual positions of the metrology system's light sources. How a deviation between the light sources on the TCCD translates into a correction which can be handled by the AO system is TBD.
    - Reduced image for quick-look display (TBC, probably not necessary).

IF architecture:
A deployment diagram will be provided once the full documentation on ODP will be available (TBD). The full specification will be provided at FDR.

IF data:
The full specification will be provided at FDR.

IF custodians:
- DPS: Lead WP DPS
- ICS: lead WP ICS

4.8. IF10: ICS → AO RTC System

The definition of the start and stop trigger mechanisms, which will limit the data volume of the AO telemetry data stored into the ESO Science Archive is TBD.

IF architecture:
The full specification will be provided at FDR.

IF data:
The full specification will be provided at FDR.

4.9. IF11: ESO → AO RTC System

The ancillary data for the PSF-R Application provided by the ESO Atmospheric Monitoring systems are still TBD and further information on data access is required from ESO.

IF architecture:
The full specification will be provided at FDR.

IF data:
The full specification will be provided at FDR.

5. Development interfaces

This section describes the interfaces specifically required for the MICADO MAIT phase.

5.1. DPS – ICS team

5.1.1. Instrument Package

The Instrument Package is a joint deliverable by the ICS WP and DPS WP. The Instrument Package consists of:

Science Target Specification. The science target specification provides to the ICS all relevant parameters to define a template-based OB which is to be created by p2. The deliverables to the ICS are:

- List of science templates.

Calibration Plan. The Calibration Plan [RD11] provides to the ICS all relevant parameters to define a template-based OB which is to be created by p2. The deliverables to the ICS are:

- List of calibration templates.

Instrument Package parameters. As described in section 3.2.1

DPS team tasks:

- List of needed templates & OBs to execute the tasks defined by the Calibration Plan and Science Target Specification (Science Use Cases).
- Provide template and OB parameters that are defined in Calibration Plan and Science Target Specification (Science Use Cases).

ICS team tasks: create the Instrument Package which consists of

- Instrument Summary File
- Template Signature File
- Templates

- Acquisition templates
- Calibration templates
- Science templates
- Maintenance templates

The full specification will be provided at FDR.

IF architecture:
ESO SVN repository (TBD)

IF custodians:
- DPS team: lead WP DPS
- ICS team: lead WP ICS

5.1.2. DPS libraries → ICS

The software libraries which are necessary for secondary guiding in the imaging modes will be supplied by the DRS on basis of CPL and HDRL-based recipes (possibly using CLIP). They share common data reduction recipes with other DRS pipelines. The tools will be part of the ICS.

I**CS team tasks:**
- Specification of the required functions with input and output parameters.
- Provision of test environment which ensures that the library can be linked to the ICS code and that all procedures can be called successfully

The DPS-ICS library contains functions which perform a single step. These functions are internals of the library and invisible to the ICS. The DPS-ICS library will include „API procedures" (e.g., "Do image analysis for coronagraphy") which can be called by the ICS (with all necessary parameters). These procedures are then responsible for calling the internal functions in the right order. The specification of the API procedures is done by the ICS and DPS teams together. The ICS code will link to this library and call the API procedures when needed. In conclusion, the executables will be created inside the ICS.

We have the following requirements for ESO regarding the implementation:

- ODP system as for the VLT instruments for the DPS-ICS library (TBC).
- The ESO ICS-framework and the ESO data reduction environment always use an identical CPL version.
- There is a straightforward procedure to synchronize the ICS and DRS code repositories.

With this in place the baseline plan for the implementation of the DPS-ICS library is to use CLIP ([RD12]). Then all DPS-ICS library functions and procedures will be implemented based on CLIP & CPL (i.e., in C & C++). The full specification will be provided at FDR.

5.2. DPS – RTC team

5.2.1. IF09: AO telemetry data storage → PSF-R Application

This IF describes a second option (c.f. IF05) to access AO RTC data and related ancillary meteorological data (TBD) for the PSF-R application. This option stores the AO telemetry data in a MICADO internal storage facility (disk staging) for a TBD period of time. The data volume is limited to the start/end time stamps of the executed OBs which are associated with the AO telemetry data. This option will be used during the MAIT phase.

IF architecture:
to be decided by FDR (see section 6.1 in [RD10])

IF data:
AO telemetry data from MAORY MCAO or MICADO SCAO systems as delivered by the ESO Data Product Manager (FITS table format) and WFS data with associated ancillary meteorological data (TBD). The details will be specified by FDR.

IF custodians:

- ICS: lead WP ICS
- DPS: Lead WP PSF-R

End of document