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# HARPS

## Operation, Calibration & Maintenance Plan

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# Chapter 1

## Introduction

### 1.1 Scope

This document describes the operation and maintenance plane as well as the calibration scheme for HARPS. It is established accordingly to the baseline science program driving the construction and the trade-off design of HARPS: the planet search program. Other observing scheme like for example astero-seismology observations have also been taking into account when establishing this document. If conflicts between the base-line program and other possible use of the instrument was found, preferences has been given to the base-line program.

### 1.2 Acronyms

BOB	Broker for Observing Blocks
CCD	Charge-Coupled Device
CDB	Calibration DataBase
CFA	Cassegrain Fiber Adapter
CMTL	Corrective Maintenance Task List
DCS	Detector Control Software
DRS	Data Reduction Software
ESO	European Southern Observatory
ETC	Exposure time calculator
FF	Flat-field
FSDB	Functions Status DataBase
FSL	Instrument Functions List
ICS	Instrument Control Software
ID	Identification
IEDB	Instrument Environment DataBase
IEL	Instrument Environment List

IMS	Instrument Maintenance Scheduler
IPDB	Instrument Performance DataBase
IPL	Instrument Performance List
LED	Light-Emitting Diode
LN <sub>2</sub>	Liquid Nitrogen
ME	Maintenance Engineer
MLB	Maintenance Logbook
MS	Maintenance Software
MUI	Maintenance software User Interface
PMTL	Preventive Maintenance Task List
OA	Operation Astronomer
OB	Observing block
OG	Geneva Observatory
OS	Observing system
OT	Observing tool
OHP	Observatoire de Haute-Provence
OS	Observing Software
PAE	Preliminary Acceptance Europe
P2PP	Phase 2 proposal preparation
RV	Radial velocity
SAU	Statistics Analysis Unit
SIL	Spare Item List
S/N	Signal-to-noise ration
STS	Short Term scheduler
SW	Software
TBC	To Be Confirmed
TBD	To Be Defined
TCS	Telescope Control System
WP	Work Package

# Chapter 2

## Operations

### 2.1 Overview

#### 2.1.1 Generality

HARPS uses a single detector (made of two CCDs) and its optic combination is fixed. Moving parts in the CFA are used to obtain the different light injections into the fibers. The choice of *instrument configurations* is limited. Actually only one *instrument mode* is available. Operations described in this document includes observations for "classical" spectroscopy, high precision Doppler measurements by simultaneous wavelength reference with thorium spectrum, and observations with I<sub>2</sub> cell. An automatic data reduction system (DRS) is included with HARPS to reduce, shortly after the exposure, observations for "classical" spectroscopy observation and high precision Doppler measurements with simultaneous wavelength reference. For observation with the I<sub>2</sub> cell, only the reduced spectra will be provided. The analysis of the I<sub>2</sub> spectrum and the measurement of the radial velocity is left to the observer.

The main research program driving the HARPS design is the planetary search program. The repeatability of the observation tasks and the large amount of spectroscopic data to handle adds some extra constraints on the operations and the reduction software compared to other instruments. The base-line philosophy for the operation is established on the concept of minimum actions of the astronomer during the night. As a result, the observer should be more focused on the target selections and the supervision of the results. We do not discuss "service mode" observations. This facility is not available at the 3.6m tel.

#### 2.1.2 Instrument configurations

In the CFA, three different injections of light in each of the two fibers are possible :

- no light

- telescope light
- calibration lamp

In all cases the I<sub>2</sub> cell can be inserted into the input beam of the two fibers simultaneously.

We defined for this instrument three observing modes and three exposure types (science, calibration and maintenance)

### **2.1.3 Observing modes**

The following observing modes are available to the observer:

1. simultaneous wavelength reference (sim. wav. ref.)
2. spectroscopy
3. I<sub>2</sub> cell

Each of these modes are related to different kind of science programs and they need a different data reduction optimization. The operation and the calibration scheme is also different. It is more the reduction strategy and the observational concept rather than a real difference in instrument setup that makes each of these observation modes different. Provided that the adequate set of calibration exposures are made, observations combining the three modes are possible during a night.

### **2.1.4 Exposure types**

#### **2.1.4.1 Calibration exposures**

The calibration exposure sequence has to be conducted accordingly to the operation plan in order to provide calibration data for the automatic reduction. A calibration archive and a calibration data-base is maintained by the DRS.

The choice of calibration exposures available is described in Table2.1.

#### **2.1.4.2 Science exposures**

The choice of all science exposures available to the observer is described in Table2.2

#### **2.1.4.3 Maintenance exposures**

On regular basis maintenance exposures are carried out by ESO-staff. These exposures are used to check specific parts of the instrument performances. (See Chapter 4.)

exposure	fiber A	fiber B
description	fed by	fed by
dark and bias	no light	no light
wavelength calibr.	thorium	thorium
I <sub>2</sub> spectrum	tungsten+ I <sub>2</sub>	no light
location orders fiber A	tungsten	no light
location orders fiber B	no light	tungsten
flat-field	tungsten	tungsten

Table 2.1: Description of all calibration exposures available

exposure	fiber A	fiber B	Related Observing
description	fed by	fed by	Mode
accurate RV measurement	telescope light	thorium	sim wav. ref.
spectroscopy + I <sub>2</sub>	telescope light+I <sub>2</sub>	no light	I <sub>2</sub> cell
spectroscopy object only	telescope light	no light	spectroscopy
spectroscopy object and sky	telescope light	telescope light	spectroscopy with sky substr.

Table 2.2: Description of the science exposures available

### 2.1.5 CCD setups

For all science exposures two different read-out speeds of the CCD will be available. A fast read-out speed with high gain for high signal-to-noise spectra and a slow read-out speed with low read-out noise for low and medium signal-to-noise ratio spectroscopy. Fixed CCD-window and read-out binning will be used for all exposures. Multiple CCD output readout (2 ports) will be considered to minimize dead-time between exposures. Decision to make available **both** single and multiple outputs will be made at PAE depending on its effect on the radial velocity precision and low signal-to-noise spectra. If no side-effect is detected, preference will be made to a single read-out scheme using two CCD outputs per CCD. See Table 2.3. At PAE the effects of read-out speed on RV precision achieved in sim. wav. ref. observing mode will be investigated. It may turn out that for this mode only the fast read-out speed will be made available.

For the calibration exposures decision to make available two set (one with fast read-out and the other with slow read-out) will be made depending on impact on the calibration quality. If no significant difference is measured, a single set of calibration done at fast read-out speed will be preferred.

## 2.2 Preparation of the observations

For phase 1 proposal preparation HARPS-ETC will be available to the observers.

	Setup binning gain (e <sup>-</sup> /ADU)		Read Out			
			port nbr/CCD	Speed (kps)	noise (e <sup>-</sup> )	time/2kx4k CCD (s)
#1	1x1	0.5	1	50	2.1	168
#2	1x1	0.5	2	50	2.1	84
#3	1x1	2.2	1	625	4.7	13.4
#4	1x1	2.2	2	625	4.7	6.7

Table 2.3: Description of the CCD setups available to the observer

Phase 2 should be completed before the beginning of the night and ideally before the day of the actual observing run. It produces OBs ready for the observation handling system. The observer is required to provide the following information to the P2PP system:

1. Coordinates of the target objects, equinox and proper motion
2. Object identifier

Added to these parameters the following parameters are optionals:

1. Spectral type (needed for optimal RV computation)
2. Radial velocity of the star (needed for optimal RV computation)
3. Guide star Coordinate, equinox and proper motion [default is "target object"]
4. Guiding scheme (on-axis with fiber viewer, off-axis with fiber viewer, or autoguider) [default is "on-axis"]

## 2.3 Observations

### 2.3.1 Generality

The observation sequence starts when the OB are send to the OS and it ends when the CCD frame is archived with its descriptors. Usually DRS start is triggered automatically at the end of the execution of the corresponding observation template. For some case where the same target is observed in a repeated sequence DRS start will be trigged right after the archiving. If DRS is busy by the reduction of an older observation, a waiting list scheme is used. At the end of all calibration exposures, DRS includes an automatic quality control. Visual interfaces display the stage of each exposure in the observation-reduction data pipeline, key messages and errors.

At the end, results possibly impacting on the observation sequence or any corrective action from

the observer is displayed:

1. Signal to noise achieved and comparison with ETC results (for science exp. only)
2. Instantaneous drift of the wavelength solution
3. Environment drift in the instrument ( $\Delta T$ ,  $\Delta P$ , mini-earthquake)

### **2.3.2 Calibration**

Before beginning science observations, a minimum set of calibration exposures have to be carried out, reduced and locally archived (see Calibration plan) The following sequence of actions defines a calibration exposure:

1. HARPS setup (CFA and calibration unit)
2. Shutter open
3. Shutter close
4. CCD reading
5. Frame archiving
6. Online-reduction startup (waiting scheme possible if many frame are needed)
7. Reduction completed and reduced data archived

For multiple exposures, when the same calibration exposure is repeated, item 1 is done once and then skipped in the iteration loop. The loop iterates from item 2 to 5. DRS items (6 and 7) are not tied to observation itself. DRS will run parallel to the observing software. All parameters of the calibration exposures are preset to the "nominal" value for best performance achievement. Exposure time for example is preset and the observer can not change it.

### **2.3.3 Science observation**

The following sequence of actions defines a science exposure :

1. Telescope setup
2. Field visualization and object centering
3. HARPS setup (CFA and calibration unit)
4. Guiding on

5. Shutter open
6. Shutter close
7. CCD reading
8. Frame archiving
9. Online-reduction startup (waiting scheme possible if many frame are needed)
10. Reduction completed and reduced data archived

For multiple exposures, when the same target is observed with the same instrument configuration and the same telescope setup, items 1 to 4 are done once then skipped in the iteration loop. The loop iterates from item 5 to 8. Similarly to the calibration exposure scheme DRS items (9 and 10) are not tied to observation.

The sequence of science exposures will be organized as parallel as possible during the night to minimize dead-times between exposures. Ideally the next exposure sequence should be started when the "shutter close" stage of the previous exposure is reached in order to be ready to open the shutter when the CCD is read. However in a fast read-out mode the read-out time is very small in particular if the two read-out ports of each CCD can be used. Therefore the current limitation of VLT software to a sequential execution of templates is acceptable.

The DRS will run parallel to the observation. A queuing strategy will be used to deal with possible delays in the reduction process compared to the observation data flow. In this cases, possible delays in the DRS will not impede the observation efficiency.

The field visualization is the only step of the sequence where we expect that an observer decision could be needed (field selection, identification of the target,...). For bright and isolated stars (most of the baseline targets) the sequence should not require an action of the observer. Given a pointing error (TBD), if the star is bright and single the selection and the centering is obvious.

### **2.3.3.1 Before starting an exposure**

For accurate radial velocity measurements the moon effect has to be taken into account. The projected distance on the sky between object and moon, the mean barycentric radial velocity of the sun light reflected by the moon at the time of the middle of the night has to be computed in order to check if the light pollution from the sun spectra do not offset the star velocity. For easy data



handling of large programs an ad-hoc tool may be available to the observer.

### 2.3.3.2 From telescope setup to target centering

Ideally, no action by the observer is required during these steps. The guiding is possible on the star itself or off-axis on an other field star visible on the fiber viewer or on the autoguider. Bright object target selection is obvious. In most cases it should be done automatically. For faint objects manual selection may be required. In any case the centering of the target object on the fiber will be done automatically. A fine centering scheme is finally used to fine-center the star on the fiber during the first seconds of the guiding procedure.

### 2.3.3.3 Shutter open-close

The exposure time is defined in the OBs. During the exposure, the exposure meter records the flux entering the spectrograph for mean time exposure definition and other statistics. Real time display of the cumulative flux and instantaneous flux must be visible to the observer. At any time the exposure may be *aborted* (stopped, file not saved), *ended* (stopped, file save) or *paused* (stopped with the option to continue). However it is worth to keep in mind that for a science exposure in a simultaneous wavelength reference mode, the decision to *end* or to *pause* an exposure may prevent the accurate computation of instrument drift. For calibration exposures, the only option to interrupt the exposure is to *abort* it.

### 2.3.3.4 CCD read-out and frame archiving

When the shutter closes the CCD is automatically read and the frame is archived with all its relevant descriptors (TBD for format and descriptor list).

## 2.4 Data reductions and archiving of results

For science exposures, DRS outcome will be flat-fielded and wavelength calibrated spectra and when possible and requested, barycentric (to solar system) radial velocity of the target. Calibration exposures will be used by the DRS to calibrate the instrument for best quality reduction of science exposures. DRS is designed to run automatically like a batch process on archived frame. All relevant parameters to the DRS (raw frame ID, reduction template) are passed to DRS system through the DFS.

Results of the DRS are stored in the fits keywords of reduced frames. Results will be written as well in ASCII files for easy data handling. Ad-hoc tools to display and analyze results will be provided

as well (see DRS Req).

## 2.5 Science templates

Science exposures are carried out with two templates: Acquisition template and Observation template. The acquisition template points the telescope and do the CFA setting (different for each science exposure type). The observation template takes care of the ADC, the spectrograph and CCD setup, the exposure itself and triggers the DRS. Only one observation template is used for science exposures with HARPS.

### 2.5.1 Acquisition templates

The first four templates presented hereafter are needed to allow proper science observations. The third and fourth are also used for technical exposures on the sky to characterize the optical efficiency of the spectrograph through the two fibers. The fifth and sixth acquisition templates are symmetrical with respect to the third and fourth, and are used only for technical purpose.

#### **Accurate RV measurement:**

Template name	HARPS_ech_acq_thosimult
Description	Points the telescope for target selection and setups the CFA in order to have target in fiber A and fiber B illuminated by thorium lamp for simultaneous referencing. Finally starts the guiding
Parameters	Object ID Coordinates of object Guiding mode Calibration lamp (THAR1 THAR2) Spectral type of object Estimated object radial velocity
Main DRS output	Wavelength calibrated spectrum and measurement of the RV of the target with best instrumental accuracy. There is a minimum exposure time constraint given by the minimum flux needed on thorium spectra for accurate simultaneous referencing.

**Spectroscopy + I<sub>2</sub>:**

Template name	HARPS_ech_acq_I2cell
Description	Points the telescope for target selection and setups the CFA in order to have target in fiber A and fiber B dark. I <sub>2</sub> cell is inserted in the input beam of the target to superimpose a I <sub>2</sub> line absorption forest to the target spectrum. Finally starts the guiding
Parameters	Object ID Spectral type of object Coordinates of object guiding mode
Main DRS output	Wavelength calibrated spectrum

**Spectroscopy for object only:**

Template name	HARPS_ech_acq_objA
Description	Points the telescope for target selection and setups the CFA in order to have target in fiber A and fiber B dark. Finally starts the guiding
Parameters	Object ID Spectral type of object Estimated object radial velocity (if "NONE" no radial velocity will be computed by DRS) Coordinates of object guiding mode
Main DRS output	Wavelength calibrated spectrum. See also maintenance template HARPS_ech_tec_effA

**Spectroscopy object and sky:**

Template name	HARPS_ech_acq_objAB
Description	Points the telescope for target selection and setups the CFA in order to have target in fiber A and sky background emission feeding fiber B. Finally starts the guiding
Parameters	Object ID Spectral type of object Estimated object radial velocity (if "NONE" no radial velocity will be computed by DRS) Coordinates of object guiding mode
Main DRS output	Wavelength calibrated spectrum. See also maintenance template HARPS_ech_tec_effA

**Acquisition of object only in fiber B:**

Template name	HARPS_ech_acq_objB
Description	Points the telescope for target selection and setups the CFA in order to have target in fiber B and fiber A dark. Finally starts the guiding
Parameters	Object ID Coordinates of object guiding mode
Main DRS output	see maintenance template HARPS_ech_tec_effB

**Acquisition of object in fiber B with sky in fiber A:**

Template name	HARPS_ech_acq_objBA
Description	Points the telescope for target selection and setups the CFA in order to have target in fiber B and sky background emission feeding fiber A. Finally starts the guiding
Parameters	Object ID Coordinates of object guiding mode
Main DRS output	See maintenance template HARPS_ech_tec_effB

k.w.	description	example
OBJECT	Target ID	name of the target
OBJECT.SP	Target Spectral type	"Sun" is default
OBJECT.RV	Target estimated RV	"NONE" is the default
TEL.TARG.ALPHA	current RA of the target	
TEL.TARG.DELTA	current DEC of the target	
TEL.GUIDE.MODE	Guiding mode	on-axis, off-axis or guide probe
TEL.GS.ALPHA	current RA of the guide star	
TEL.GS.DELTA	current DEC of the guide star	

Table 2.4: HARPS Acquisition template keywords

## 2.5.2 Observation template

Template name	HARPS_ech_obs_all
Description	Sets the lamp attenuator accordingly to the exposure time, sets the ADC accordingly to the current position of the telescope, sets the CCD parameters, flush it and starts the exposure. At the end triggers the DRS ( triggering done after the frame archiving in case of repeated exposures)
Parameters	Exposure time Number of repeated exposures (ADC is set before each exposures using current poition of the telescope)



# Chapter 3

## Calibration Plan

The present calibration plan describes the set of calibration exposures available to fully characterize HARPS and to obtain best quality reduction of science exposures. The calibration exposures are automatically processed by the DRS right after their completion.

### 3.1 Minimum calibration set

The automatic DRS systems needs a minimum set of calibration frames to reduce any science observations. Before any science observation could be made the following sequence of calibration exposures has to be carried out (including correctly reduced and archived):

1. CCD Dark
2. Geometry of the orders of the fiber A
3. Geometry of the orders of the fiber B
4. Flat field sequence
5. Wavelength calibration with the thorium lamp

A calibration OB including this sequence will be executed before the beginning of each nights. Frequency may be modify when better knowledge on the day to day stability of the instrument will

be gathered.

## 3.2 Calibration templates

### 3.2.1 Detector Calibration Templates

#### 3.2.1.1 CCD Bias

Template name:	HARPS_ech_cal_bias
Description	Dark of zero second corresponding to a measure of the electronic Bias of the CCD. This exposure is not processed by the DRS.
Parameters	Number of repeated exposures CCD options
Frequency	TBD, Not needed for standard operations.
Trend analysis	This exposure provide to the observer a mean to do his own bias exposure. DRS does not compute any generic bias parameter parameters from this tempate excepted the one of this exposure. For all frames, Bias parameters will be computed by using a left and right overscan on each images. It allow to detect with more reliability any offset change occurring during the actual read-out of each image. It is worth mentioning that small variation of the Bias level has no effect on high-signal spectra.
Main DRS output	TBD



### 3.2.1.2 CCD Dark

Template name:	HARPS_ech_cal_dark
Description	On regular basic, the dark current of the CCD will be measured. A set of 1h exposures (number TBD) with shutter closed are measured and processed by the DRS.
Parameters	Exposure time (minimum duration will be needed to get processed by the DRS) CCD options
Frequency	TBD
Trend analysis	Dark is little sensitive to CCD temperature. Dark level in 1 hours is very low. Dark effect is order of magnitudes below systematic effects steaming from uncertainties in background correction for high S/N spectra.
Main DRS output	Mean dark level scaled to one hour. DRS is triggered at the end of the template

## 3.2.2 Order geometry and flat-field templates

### 3.2.2.1 Geometry of the orders of the fiber A

Template name:	HARPS_ech_cal_tunA
Description	The location of the order of the fiber A is made by illuminating the fiber A. The DRS find the order location compute their limits, their shape, the typical signal-to-noise and the background diffusion level through the image (scattered light) and finally it extracts the spectrum and it archives the results.
Parameters	CCD options
Frequency	Daily, before the beginning of the night
Trend analysis	The effect of drift during the night may affects the FF quality (see below)
Main DRS output	Calibration of the geometry and the profile (in Cross-dispersion direction) of the orders of spectrum A. DRS is triggered at the end of the template

### 3.2.2.2 Geometry of the orders of the fiber B

Template name:	HARPS_ech_cal_tunB
Description	Similar to geometry of the order of the fiber A but with fiber B
Parameters	CCD options
Frequency	Right after the calibration of the geometry of the orders of the fiber A
Trend analysis	Similar to fiber A
Main DRS output	Calibration of the geometry and the profile (in Cross-dispersion direction) of the orders of spectrum B. DRS is triggered at the end of the template

### 3.2.2.3 Flat-field sequence

Template name:	HARPS_ech_cal_tunAB
Description	A set of tungsten exposures with the two fibers illuminated have to be carried out to estimate the flat-field spectrum and the blaze response of HARPS. The DRS computes and archives the mean flat-field spectrum and the mean blaze spectrum. Number of exposures will be defined at PAE in order to reach signal-to-noise ratio above 1000. This calibration is made of a sequence of identical CCD exposures.
Parameters	CCD options
Frequency	Daily after the geometry calibration
Trend analysis	A drift larger than 1/10 pixels with a average FF dispersion of 1% makes an systematic error less than 1/1000. The foreseen HARPS order stability is better than 1/50. The FF quality will not be limited by unmonitored order displacements.
Main DRS output	FF spectrum, blaze spectrum and background level. DRS is triggered at the end of the template (even if multiple exposures)

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Template name:	HARPS_ech_cal_tunUSER
Description	A tungsten exposure with the setting of the exposure time and the number of repeated exposition is available to the observer for his own reduction need. No calibration is carried out by DRS with this template
Parameters	Exposure time CCD options Number of exposures
Frequency	Never, it is not needed for standard operations.
Trend analysis	
Main DRS output	Extracted spectra. For multiple exposures the DRS is triggered after the frame archiving

### 3.2.3 Wavelength calibration templates

#### 3.2.3.1 Thorium lamp

---

Template name:	HARPS_ech_cal_thoAB
Description	The illumination of both fiber by thorium lamp defines the wavelength geometry of each fiber. The DRS will automatically compute the accurate wavelength geometry of the spectrum. At the end of the process the wavelength calibrated thorium spectrum is archived. The final solution provides information on image quality and resolution of the spectrograph as well.
Parameters	CCD options Calibration lamp (THAR1 THAR2) Number of exposures (for multiple exposures DRS triggering is done after the end of the calibration template)
Frequency	Each night, before the first science exposure and maybe more during the night (TBD)
Trend analysis	See DRS-REQ for full analysis on wavelength calibration
Main DRS output	Wavelength calibration, thorium spectrum and resolution check. DRS is triggered at the end of the template

### 3.2.4 Special calibration template

### 3.2.5 I<sub>2</sub> spectrum measurement

Template name:	HARPS_ech_cal_tunA_I2cell
Description	Available for I <sub>2</sub> observation mode. Fiber A is illuminated by the tungsten lamp and I <sub>2</sub> cell is inserted in the beam. No specific reduction is provided for this exposure excepted the extraction of the spectrum.
Parameters	Exposure time, CCD options Number of repeated exposures
Frequency	TBD
Trend analysis	-
Main DRS output	Wavelength calibrated I <sub>2</sub> spectrum. DRS is triggered after the frame archiving

# Chapter 4

## Maintenance plan

### 4.1 General description

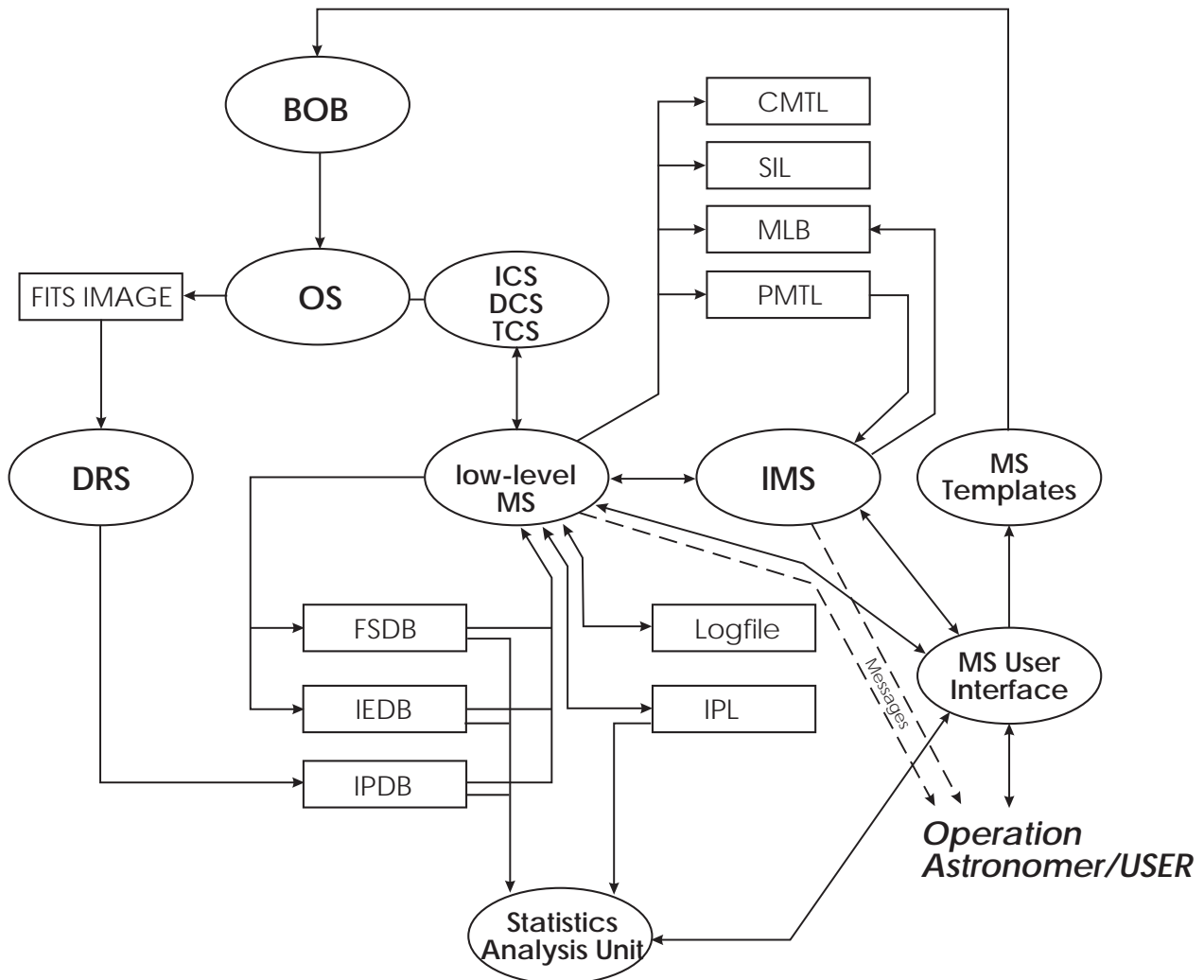
#### 4.1.1 Responsibility

HARPS maintenance is composed of two main activities: preventive maintenance and corrective maintenance. Both are formally under the responsibility of the ESO La Silla Operation Astronomer (OA) responsible for the HARPS operations (WP-7300, see HARPS Project Plan and Schedule 1.0). However, for specific tasks concerning the corrective maintenance of the spectrograph or critical items in general defined in the Corrective Maintenance Task List (CMTL) he will inform the Maintenance Engineer (ME) at OG (WP-7400) who will organize repair or modification of the concerned subsystem or component.

#### 4.1.2 Concept

The Operation Astronomer will manage the whole maintenance via the Maintenance Software User Interface (MUI). He will be able to execute maintenance templates for high-level maintenance, interact with the low-level Maintenance Software (MS) for accessing the different Instrument database and execute instrument check, but also to run statistics analysis tools for trend analysis and visualization of various instrument parameters. In his preventive maintenance task he will be helped by the Instrument Maintenance Scheduler (IMS) which will notify the Operation Astronomer whenever a task is imminent and execute this task automatically if possible. Finally, the low-level MS will provide to the Operation Astronomer and the Maintenance Engineer tools to edit different reference lists needed by the MS to compare the recorded parameters with their reference values or validity ranges. An overview of the Maintenance Software is given in Figure 4.1.

Figure 4.1: Overview of the maintenance software



#### 4.1.2.1 Units

- Maintenance software User Interface (MUI)
- low-level Maintenance Software (low-level MS)
- Statistics Analysis Unit (SAU)
- Instrument Maintenance Scheduler (IMS)

#### 4.1.2.2 Instrument data

- Functions Status DataBase (FSDB)
- Instrument Environment DataBase (IEDB)

- Instrument Performance DataBase (IPDB)
- Functions Status List (FSL)
- Instrument Environment List (IEL)
- Instrument Performance List (IPL)

#### **4.1.2.3 Maintenance data**

- Preventive Maintenance Task List (PMTL)
- Corrective Maintenance Task List (CMTL)
- Maintenance Logbook (MLB)
- Spare Item List (SIL)

### **4.1.3 Preventive maintenance activity**

#### **4.1.3.1 Preventive maintenance tasks**

For preventive maintenance the IMS accesses the Preventive Maintenance Task List (PMTL) wherein all preventive maintenance tasks, their periodicity and specific actions are listed. If the task can be performed automatically the IMS calls the corresponding function of the low-level MS. If not, the IMS informs the Operations Astronomer on imminent tasks, e.g. exchanges filters of the air conditioning or pump oil, check contaminations of the CCD, etc. In both cases, as soon as the maintenance task has been carried out, a logbook entry in the Maintenance Logbook is produced either by the low-level MS automatically, or by the Operation Astronomer manually via the MUI. The IMS checks periodically (ca. 1 hour) by comparison of the PMTL and the MLB whether the maintenance task has been performed and, if this not the case, it reiterates the maintenance task.

#### **4.1.3.2 Monitoring of the instrument parameters**

Monitoring of the instrument status and environmental conditions are performed by different functions of the low-level MS. Environmental conditions are recorded continuously or whenever available, even if the instrument is in stand-by mode. The results are stored in the Instrument Environment Database which will be accessible at any time. Also, before the beginning of every night, at the instrument start up, the low-level MS performs a self check of all instrument functions. The results of this self-check are stored in the Functions Status Database. These two permanent databases will allow the Operation Astronomer and the Maintenance Engineer to check at any moment the instrument status and to perform trend analysis or systematics studies of the impact of some param-

eters on the instrument performance over any time scale.

As part of the instrument self check, the low-level MS will verify whether the instrument parameters lie within the nominal range of values and functions have the correct status. To do so, the most recent entries in the IEDB and FSDB are compared with the Instrument Environment List and Function Status List, respectively. In case of failure of the instrument or if a parameter is out of range the Operation Astronomer as well as the Maintenance Engineer will receive automatically and by email a notification which includes detailed description of the encountered errors. The observer will receive an error message on whether the astronomical observation can be continued without any risk, is recommended but verification of the data is needed, is not recommended because of possible decrease of instrument performance, or is impossible. In addition a contact person will be indicated and an action recommend. *Note:* The instrument parameters check can also be run by the Operation Astronomer or the Maintenance Engineer at OG via the MUI at any time.

#### 4.1.3.3 High-level maintenance tasks

High-level MS will complete the preventive maintenance activity. High-level maintenance is performed fully by dedicated *maintenance templates* which will be executed according to the PMTL or during dedicated test phases. Through these maintenance templates the instrument performances will be monitored at any time scale. Examples of maintenance executed by ordinary calibration templates and recorded every night by the standard DRS are: optical efficiency and spectral resolution at different wavelengths, position of some echelle orders on the CCD, diffused background, etc. Every week also a LED-Flat Field template will be executed which will trigger a specific analysis SW. The corresponding values will be stored in the Instrument Performance Database and a MLB entry produced by the DRS. Again the low-level maintenance SW will be able to compare the IPDB with the corresponding Instrument Performance List and notify the User and the Operation Astronomer and Maintenance Engineer in case of problems. The specific function of the low-level MS is executed automatically, but can also be started by the OA or ME via the MUI.

#### 4.1.4 Corrective maintenance activity

Whenever an error or failure has been identified the Operation Astronomer will initiate corrective maintenance. If the reason of the problem is not clear he shall contact the Maintenance Engineer. Once the problem has been fixed the Operation Astronomer will identify by means of the CMTL the responsible person and organize with him repair or modification of the defective subsystem or component rapidly. As soon as the repair has been executed the Operation astronomer will add via the MUI a new entry to the MLB and update the Spare Item List. He will immediately proceed with procurement of spares, and as soon as they are received, update the SIL.



Table 4.1: Preliminary Preventive Maintenance Task List

Code	Item	Task name	Actor	Periodicity	Resulting action
TBD	LN <sub>2</sub> -vessel	check level	low-level MS	1 hour	exchange
TBD	detector dewar	check pressure	low-level MS	1 hour	re-pump
TBD	vacuum vessel	check pressure	low-level MS	1 hour	re-pump
TBD	air conditioning	replace filters	OA	365 days	
TBD	thorium lamp	check operation time	low-level MS	TBD days	replace
TBD	tungsten lamp	check operation time	low-level MS	TBD days	replace
TBD	fiber head	check fiber head cleanness	OA	TBD days	cleaning
TBD	instrument	test and check instru- ment functions	low-level MS	1 day	notify problem
TBD	instrument	measure and check in- strument performance	Calibration templates, DRS	1 day	notify problems
TBD	optical fibers	visual inspection	OA	7 days	notify problems
TBD	CCD detector	contamination check	HARPS_ech_tec_led	7 days	notify problems

## 4.2 Maintenance tasks

### 4.2.1 Preliminary Preventive Maintenance Task List

The PMTL will contain an entry for every preventive maintenance task, indicating the component, the action to be performed, the responsible person, and the periodicity. For automatic operation the list may contain also a function to be passed to a module and the name of the module. The IMS will in that case check whether the maintenance task has to be done and pass the command to the corresponding module for execution.

The PMTL will evolve with time and become as complete as possible. Passive columns which do not interact with IMS might be added via the user interface at a later stage. Ideally, the PMTL will contain a link to a web page or a manual describing the actions to be performed. A preliminary PMTL is shown in Table 4.1.

### 4.2.2 Preliminary Corrective Maintenance Task List

The CMTL will indicate for each component which may fail a responsible person, the foreseen action and an estimated duration of the repair. The CMTL will evolve with time and become as complete as possible. Passive columns which do not interact with IMS might be added via the user interface at a later stage. Ideally, the CMTL will contain a link to a web page or a manual describing the actions to be performed. A preliminary CMTL is shown in Table 4.2.

Table 4.2: Preliminary Corrective Maintenance Task List

Code	Item	Error	Actor	Action	Duration
TBD	electronic board (any, TBD)	failure	TBD	replace	2 hours
TBD	electro-mechanical function (any, TBD)	failure	replace	TBD	TBD
TBD	thorium lamp	failure	OA	replace	2 hours
TBD	tungsten lamp	failure	OA	replace	2 hours
TBD	HCFA optics	misaligned	Optical engineer ESO	realign	2 days
TBD	optical fibers	broken	Optical engineer OHP	replace and realign	2 days
TBD	image scrambler optics	misaligned	Optical engineer OHP	realign	2 days
TBD	spectrograph optics	misaligned	Optical engineer OHP	realign	3 days
TBD	vacuum vessel temperature control	failure	ME	TBD	TBD
TBD	vacuum vessel pump	failure	TBD	replace	5 hours
TBD	vacuum vessel	leak	TBD	TBD	TBD
TBD	CCD vacuum pump	failure	TBD	replace	TBD
TBD	CCD dewar	leak	TBD	TBD	TBD
TBD	vacuum valve	failure/leak	TBD	replace	5 hours
TBD	CCD	failure	TBD	TBD	TBD
TBD	CCD temperature control	failure	OA/ME	replace	2 hours
TBD	exposure meter	failure	TBD	replace	TBD
TBD	air conditioning	failure	TBD	repair	TBD

### 4.3 Maintenance templates

<b>Template name</b>	HARPS_ech_tec_dark
Description	Performs a DARK exposure of the CCD. If the exposure time 0 [s] the frame will be considered as BIAS exposure
Parameters	Exposure time, read-out speed, # of read-out ports, gain
Main DRS output	Map of hot pixels and columns Dark Current on CCD Bias Dark counts on exposure meter

<b>Template name</b>	HARPS_ech_tec_led
Description	Performs a flat field exposure of the CCD by means of a LED
Parameters	Exposure time, read-out speed, # of read-out ports, gain
Main DRS output	Contamination level of the CCD Estimation of the gain Estimation of the linearity Map of bad pixels and columns

**Template name** HARPS\_ech\_tec\_tunA  
**Description** Performs an order-localization and *spectral*-flat field exposure with fiber A  
**Parameters** Exposure time, read-out speed, # of read-out ports, gain, position of the neutral-density filter  
**Main DRS output** Localization of the orders of fiber A  
Shape and position of the orders of fiber A  
Intensity of tungsten lamp

**Template name** HARPS\_ech\_tec\_tunB  
**Description** Performs an order-localization and *spectral*-flat field exposure with fiber B  
**Parameters** Exposure time, read-out speed, # of read-out ports, gain, position of the neutral-density filter  
**Main DRS output** Localization of the orders of fiber B  
Shape and position of the orders of fiber B  
Intensity of tungsten lamp

**Template name** HARPS\_ech\_tec\_tunAB  
**Description** Performs an order-localization and *spectral*-flat field exposure on both fibers A and B  
**Parameters** Exposure time, read-out speed, # of read-out ports, gain, position of the neutral-density filter  
**Main DRS output** Localization of the orders of fibers A and B  
Shape and position of the orders of fibers A and B  
Intensity of tungsten lamp

**Template name** HARPS\_ech\_tec\_thoA  
**Description** Performs a wavelength-calibration exposure on fiber A  
**Parameters** Exposure time, read-out speed, # of read-out ports, gain, position of the neutral-density filter  
**Main DRS output** Geometry of the wavelength solution  
“zero point” of the wavelength solution  
Spectral resolution of the spectrograph  
Intensity of thorium lamp  
ThAr flux on exposure meter A

**Template name** HARPS\_ech\_tec\_thoB  
**Description** Performs a wavelength-calibration exposure on fiber B  
**Parameters** Exposure time, read-out speed, # of read-out ports, gain, position of the neutral-density filter  
**Main DRS output** Geometry of the wavelength solution  
 “zero point” of the wavelength solution  
 Spectral resolution of the spectrograph  
 Intensity of thorium lamp  
 ThAr flux on exposure meter B

**Template name** HARPS\_ech\_tec\_thoAB  
**Description** Performs a wavelength-calibration exposure on both fiber A and B  
**Parameters** Exposure time, read-out speed, # of read-out ports, gain, position of the neutral-density filter  
**Main DRS output** Geometry of the wavelength solution  
 “zero point” of the wavelength solution  
 Spectral resolution of the spectrograph  
 Intensity of thorium lamp  
 ThAr flux on exposure meters A and B

**Template name** HARPS\_ech\_tec\_effA  
**Description** Performs an exposure on a photometric standard star with fiber A, while fiber B is dark or sky. This template uses an acquisition template to acquire the standard star, which also defines the illumination of the fiber B (HARPS\_ech\_acq\_objA or HARPS\_ech\_acq\_objAB).  
**Parameters** Exposure time, read-out speed, # of read-out ports, gain, position of the neutral-density filter  
**Main DRS output** Optical efficiency of the instrument on path A  
 Exposure meter response through fiber A

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<b>Template name</b>	HARPS_ech_tec_effB
Description	Performs an exposure on a photometric standard star with fiber B, while fiber A is dark or sky. This template uses an acquisition template to acquire the standard star, which also defines the illumination of the fiber A (HARPS_ech_acq_objB or HARPS_ech_acq_objBA).
Parameters	Exposure time, read-out speed, # of read-out ports, gain, position of the neutral-density filter
Main DRS output	Optical efficiency of the instrument on path B Exposure meter response through fiber B