W unit laboratory acceptance test specifications

S. Esposito, A. Tozzi, A. Puglisi, E. Pinna
ABSTRACT

The document gives a description of tests to be successfully completed during the laboratory acceptance of the W unit. The required HW subsystems and SW to perform the considered tests are listed too. Specifications for successful test completion are given. The list of the test has been defined in the AO review held in Florence in February 2005. The present discussion is following what stated in the meeting and listed in the document LBT Adaptive Optics System AIT management plan [1]. A picture of the W unit inside the AGW frame during the AIP flexure test is reported below.
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Abbreviations, acronyms and symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tr>
<td>LBT</td>
<td>Large Binocular Telescope</td>
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<tr>
<td>MMT</td>
<td>6.5m MMT telescope</td>
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<tr>
<td>LUCIFER</td>
<td>LBT NIR spectroscopic Utility with Camera and Integral- Field Unit for Extragalactic Research</td>
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<td>AGW</td>
<td>Acquisition, Guiding and Wavefront sensing unit</td>
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<td>AO</td>
<td>Adaptive Optics</td>
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<td>W</td>
<td>On axis Wavefront sensing unit</td>
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<tr>
<td>LBT672a</td>
<td>First Adaptive secondary unit of LBT telescope</td>
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<tr>
<td>PSF</td>
<td>Point Spread Function</td>
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<td>ARNICA</td>
<td>ARcetri Near Infrared CAmera</td>
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<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
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<tr>
<td>TCS</td>
<td>Telescope Control System</td>
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<td>ROI</td>
<td>Region Of Interest</td>
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<td>FoV</td>
<td>Field of View</td>
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<td>RTR</td>
<td>Real Time Reconstructor</td>
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<td>RON</td>
<td>Read Out Noise</td>
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<td>DM</td>
<td>Deformable mirror</td>
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<td>SNR</td>
<td>Signal to Noise Ratio</td>
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<tr>
<td>WFS</td>
<td>WaveFront Sensor</td>
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<tr>
<td>SR</td>
<td>Strehl ratio</td>
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<tr>
<td>ADS</td>
<td>ADS International SRL</td>
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<tr>
<td>DL</td>
<td>Diffraction Limited</td>
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<tr>
<td>FWHM</td>
<td>Full Width at Half Max</td>
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<tr>
<td>AIP</td>
<td>Astrophysikalisches Institut Potsdam</td>
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<tr>
<td>BCU</td>
<td>Basic Computational Unit</td>
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<tr>
<td>HW</td>
<td>Hardware</td>
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<tr>
<td>SW</td>
<td>Software</td>
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<tr>
<td>ADC</td>
<td>Atmospheric Dispersion Corrector</td>
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The document is listing the main specifications of the W unit system and describing the measurements to be done at the W unit acceptance test in Arcetri. The acceptance test guidelines are reported in [1] while the W system is described in [2,3,4]. To help in locating the different parts mentione in the document some picture of the system are reported below. In particular figure 1 below reports the WFS opto-mechanical parts.

Figure 1 WFS board optomechanical drawing. Main components are labeled with capital letters.

The components listed in figure 1 are the following:

A. Atmospheric dispersion corrector (ADC)
B. Filter wheel #1
C. Fast tip-tilt mirror
D. Optical derotator
E. Refractive pyramid
F. Camera lens
G. WFS camera (CCD39)
H. H filter wheel #2
I. Acquisition camera (CCD47)
Figure 2 shows the three translation stages assembled and mounted in the AGW frame together with the electronic boxes.

Figure 3 shows the auxiliary unit bench and details of the internal reference source of the wavefront sensor.

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1 Requirement before unit testing

The following items are needed in order to perform a full functional test on the W unit.

1. W control SW and engineering interface has to be installed and running on the control computer.
2. The W unit has to be mounted in the AGW frame. The main subsystems to be integrated are [2]:
   a. The three translation stages used for reference star acquisition together with their motors and encoders.
   b. The wavefront sensor board assembled with all the optomechanics has to be mounted on the focus stage.
   c. The three electronic boxes with their cabling have to be mounted and attached to the AGW chilling circuit. Electrical power has to be provided through the AGW socket.
   d. Auxiliary unit bench installed to the AGW structure
   e. Auxiliary units has to be installed on the AGW frame auxiliary unit bench
2. The external reference source for flexure tests of the wavefront sensor has to be installed. It will contain a pupil projection system.

2 Electronic boxes test

2.1 Box No. 1 & 2 functional tests

The successful power on and operation of all the control electronics inside the electronic boxes have to be checked. In order to do this low level SW has to be installed and running on the AO supervisor workstation. These commands will be available trough the engineering GUI. Control software has to provide feedback about the successful execution of issued commands (e.g. back-reading of encoder’s value). The list of the modules to be tested is given below:

1. System power on. The correct remote power on of the system has to be checked. The correct sequence of power on is the following:
   A. main 110V power is powered on by telescope control. This power on the network units, fiber to copper Ethernet converter, ethernet to RS232 converters, ethernet hub, remote unit power on rele.
   B. Remote unit power on rele is enabled. This rele is powering on the following devices: BCU39, BCU47 fast tip tilt mirror.
   C. System rele operation. Several subsystem power on is done using a solid state rele commanded by the BCU39 unit. This is the case for the following devices: WFS CCD, Technical CCD, ADC, Pupil Re-Rotator, X, Y and Z Bayside stages, Filter Wheel 1&2. The correct remote power on of all these devices have to be checked. Power on state will be checked via SW in all possible cases or by inspection if needed.
2. Filter Wheel #1 and #2 stepper motors. Correct filter selection after SW commands has to be tested. No beam vignetting shall be present.
3. Atmospheric Dispersion Corrector stepper motors. Motion of stepper motor has to be verified.
4. Pupil Re-Rotator stepper motor. Rotation of the pupil re-rotator optics group has to be verified.
5. Temperature probes operation. Measured temperature values from electronic boxes internal/external probes have to be acquired at 0.1 Hz rate. The calibration constant for all the PT1000 sensors will be measured. In particular a linear relationship between output voltage an current temperature will be determined for each PT1000 (two constants per sensor).
6. Fast Tip-Tilt mirror control electronic. The control electronic driving signals should be checked against parameter settings. Three sinusoidal signal of the given amplitude with a phase delay of 0, 120 and 240 degrees have to be measured. This measurement will be done measuring with an oscilloscope the three channels of analog input provided by the BCU47.
7. WFS CCD control electronic and CCD frame-grabber (BCU39). CCD control electronic power on and CCD parameter setting via RS232 has to be checked. Correct frame acquisition operation has to be checked. In particular frame acquisition operation has to be checked for CCD binning mode 1x1, 2x2, 3x3.

8. Technical channel CCD control electronic and CCD frame-grabber (BCU47). CCD control electronic power on and CCD parameter setting via RS232 has to be checked. Correct frame acquisition through BCU47 has to be checked. In particular frame acquisition operation has to be checked for CCD binning mode 1x1, 2x2 and 16x16.

9. BCU39 slope computation. Correct parameter settings like slopes null, dark frame, flat field and pixel position look up table have to be checked. Correct slopes computation has to be checked for all the WFS CCD binning modes.

10. Internal reference source. Correct power on of the light source for the wavefront sensor internal reference source has to be checked. Positioning of translation stage and rotatory stage have to be checked.

2.2 Box No. 3 functional test
This box contains the three drivers of the WFS translation stages. Correct power on of all the three stages has to be checked using SW. Correct signals for the limit switches has to be checked for all the three stages. Stages motion has to be verified.

2.3 Thermal test
The thermal test of the electronic boxes considers the following two main points:

1. Thermal uniformity. Thermal uniformity of the external surfaces of the electronic boxes has to be checked. Specification on the external surfaces temperature difference with respect to the external environment temperature is +/-1 degree. The test will be done measuring the temperature differences on the external walls of the boxes after allowing for thermal settling time. The cold plates of the electronic boxes will receive water at a temperature two degree less than the environment temperature. Nominal water flow will be of 4.5 liter/min. Test will be done with all the control electronics powered on and working. The flow value will be adjusted in order to find the optimal value for the operating conditions.

2. Electronic boxes internal temperature. The internal temperature of the electronic boxes has to be measured during full operation and have to be 5 degrees less than the maximum working temperature of the various components. The limit temperature inside the electronic boxes is assumed to be 55deg. Temperature inside the boxes will be measured using the internal temperature sensors. External temperature will be measured using a set of external sensors.

3 WFS board internal reference source functional & performance test
An internal reference source is part of the W unit and is placed in the auxiliary units bench. This source allows the check of the optical alignment of the wavefront sensor board in terms of pupil positions and size. This reference source will be also available during telescope operation for on-line optical test. The source has to provide wavefront sensor illumination as an f/15 beam with an F/ accuracy of 0.15. This specification will be checked offline in the optical laboratory with an ad-hoc optical set-up. Illumination values on the CCD have to be measured as a function of the integration time. The beam splitter cube will be positioned using the translation and rotatory stages contained in the auxiliary unit bench. Command for all the above units will be done remotely from the AO supervisor GUI. The performance test of this unit require to light the reference source and position the beam splitter cube in order to create four pupil images on the wavefront sensor CCD. Nominal values for pupil images configuration have to be checked after fiber power on and positioning. The nominal position of the used motorized stages will be checked against the optimal position achieved during the reference source test.

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4 Pupil images optical configuration

The pupil images configuration provided by the sensor optical train on the WFS CCD has to be checked against the nominal values. The nominal arrangement of the pupil in the case of binning is listed below:

1. The pupil diameters have to be 30 pixel or 720 microns. The maximum difference on pupil diameters should be less then +/- 0.1 pixels.
2. The distances between adjacent pupils have to be 36 pixels. The pupil centers should be positioned on a square grid of side 36 pixels. The maximum error on the centers positioning should be less then +/- 0.1 pixel.

The pupil configuration will be tested as a function of the CCD binning. Nominal values will scale accordingly to the binning factor.

5 W unit hardware performance test

Some particular tests are done in order to check the correct optical performance of various subsystems of the W unit. These tests are listed below together with the required subsystem optical specifications.

5.1 Filter wheel # 1

The filter wheel operation has to checked for correct positioning of a requested filter. In particular no beam vignetting should be present.

The FW #1 acts in transmission for the WFS beam and in reflection for the acquisition beam. Requirements are first stated for the WFS beam and divided in PSF jitter and pupil displacement. The requirement for PSF jitter in the acquisition beam is stated as third.

1. The repetability of the the PSF displacement in the WFS f/45 focal plane when a given filter is selected should be less then 0.047 arcsec on sky (PI mirror offset of +/- 1/20 of range) corresponding to 28.2 micron linear displacement.
2. Pupil displacement due to filter tilt has to be less than of 1/10 of a WFS subaperture in the 30x30 configuration. This is achieved when condition 1 is fulfilled. The maximum pupil displacement will be the same of the PSF linear displacement so less than 28 microns. This number has to be compared with 1/300 of the pupil image diameter at the tip tilt mirror or 29 microns.
3. The maximum PSF displacement on the acquisition channel is given at point l. This is completely acceptable considering that the acquisition camera FoV is 7.4x7.4 arcsec.

It has to be noted that the error on PSF displacement for different filter will be corrected using a look up table giving a different reference point on the technical viewer for each filter of the FW#1.

Maximum time for a filter change will be measured and should be less then 10 seconds. Filter wheel stability against gravity should be checked.

5.2 Filter wheel # 2

The FW #2 acts in transmission for the acquisition beam only. Requirements are stated for acquisition beam jittering. The PSF displacement in the WFS f/45 focal plane is measured in ZEMAX to be 0.31 µm/arcmin or 0.52 mas/arcmin. Assuming the same planarity error of FW#1 of 90 arcminutes the PSF jitter will be 0.047 arcsec. Large values could be easily managed using a stages positioning filter look up table.

Commento [SE3]: Misura da fare una volta allineata la board.
Commento [SE4]: Il size della pupilla e diverso da 30 pixel nella nuova versione della penna. Questo per avere la pupilla sul secondario. Aggiorna in base al nuovo valore del diaframma che pare essere (AT) 14.5.
Commento [SE5]: Questo requirement va modificato in quanto inutilmente stringente.
Commento [SE6]: Per poter effettuare questa misura occorre inserire alcuni filtri da 1 inch nella ruota #2.
The filter wheel operation has to check for correct positioning of a requested filter. In particular no beam vignetting should be present. Filter wheel stability against gravity should be checked. Maximum time for a filter change will be measured. The field displacement for reflective filters should be checked. The field jitter should be less than 0.1 mm.

5.3 Pupil Re-rotator

The pupil re-rotator stage is aimed to counter rotate the pupil images during AO operation keeping the correct registration between the actuator grid and the CCD pixel grid. The optical performance of the pupil re-rotator has four specifications:

1. PSF total displacement. This displacement has to be less then 0.25 of the WFS FoV. Assuming a working FoV of 2 arcsec we find 0.5 arcsec displacement as specification.

2. PSF displacement during integration. The target specification assumes that the PSF displacement has to be less then 5mas during an integration time or 9µm in the F/45 focal plane. This is corresponding to a SR reduction of 0.96. Assuming 10 minutes integration time and an average rotation speed of 15 degree/h the PSF displacement has to be less then 9µm over 2.5 degree of rotation of the pupil image.

3. Pupil image total center displacement. This displacement has to be less than +/- 2 pixel (half the stroke of the camera lens translation stage) over the 180 degree of pupil rotator rotation.

4. The pupil images center displacement during integration. This displacement have to be less then 1/10 pixel during 2.5 degree of counter rotation (10min of integration time). This condition has to be fulfilled over 180 degrees of rotation of the pupil rotator or 360 degree of rotation of the pupil image.

5. The accuracy of the rotation provided by the PRR has to be checked. This accuracy has to be good enough to provide a pupil edge displacement error less then 1/10 of a CCD pixel. This translates in a rotation error of approx. 7 mrad. This rotation accuracy measurement can be done using a custom pupil stop on the reference source HW. This pupil stop has a black finger that can be used to follow the rotation of the pupil image. To verify the correct rotation angle value we move the PRR simulating the field rotation during an observation and computing the angular motion of the pupil patch. This is done using as input data the wavefront sensor CCD frames.

The pupil center displacement can be checked removing the pyramid and measuring the pupil center displacement during the Pupil Re-Rotator motion using the pupil images acquired on the wavefront sensor CCD. Placing back the pyramid the measurement can be done simultaneously on the four pupil images. Specifications 2 and 4 should be checked in various positions of the pupil rotator.

5.4 Atmospheric Dispersion Corrector

Two requirements has to be fulfilled by the ADC:

1. Optical quality of the WFS PSF when no correction is applied by the ADC. The PSF optical quality is measured from PSF FWHM. We require that the PSF FWHM measured at F/45 WFS focal plane is matching the DL FWHM that is 36 µm at 0.8 µm wavelength.

2. The PSF baricenter displacement due to residual or uncorrected atmospheric differential refraction has to be less than 5mas in the shortest imaging band (30mas @ J band). This correspond to a SR loss of 0.96. ADC test have to check that the PSF induced displacement is below the 5mas level or less then 9 microns as linear displacement in the F/45 beam. The test will be done checking the wavelength dependent displacement at three different wavelengths sampling the wavefront sensors optical bandwidth (0.6-0.9) micron. For example using a HeNe laser (633 nm) we have to measure a PSF displacement on the F/45 technical viewer focal plane of 1.260 mm when the ADC is positioned for the maximum zenithal working angle (70 deg). To reach the considered accuracy in the PSF...
5.5 Fast Tip-Tilt mirror unit performance

The fast steering mirror used in the sensor will be tested at different tilt modulation amplitude and temporal frequencies. The specification of the requested maximum modulation amplitude as a function of temporal frequency is given in the plot below.

The test of the unit will be done when the unit is assembled on the WFS board. However a flipping mirror will be used to direct the beam on a CCD test camera having 652x494 pixels with 7.4 micron pixel size. Images taken from the test camera will be used to check the unit modulation amplitude. The unit modulation amplitude will be determined fitting a circle to the frames acquired by the test camera. The rotation accuracy will be measured looking at the residual displacement of the PSF along the estimated best circle. Tip tilt operating frequency has to be synchronized with the WFS CCD frame rate. Required accuracy is less than 0.2 %. An important feature of the unit is the maximum available stroke that could be used for fine centering of the PSF before loop closure. The maximum tip tilt amplitude will be tested with the same setup. The nominal maximum optical tilt amplitude and accuracy values are +/- 4 milliradians and 2 microradians respectively. These values translates in linear displacement at the test camera of +/- 1.2mm and 0.6 micron.

6 Translation Stages unit operation accuracy

As already mentioned the sensor board is positioned in the LBT f/15 telecentric FoV using three linear stages [3] [4]. Two of them (X and Y stages) translate the board parallel to the LBT focal plane and provide star centering. The third stage (Z stage) translates the board perpendicular to the LBT focal plane and provides star focusing. The three stages have to provide a homing command, a sensor positioning command and stage brake operation. The accuracy required to the stages positioning together with a stages test description is given below.

6.1 Stages positioning and focusing accuracy requirements

We assume to fine center the WFS on the reference source using the tip tilt mirror. Said that, the required accuracy of the stages positioning depends on how much of the tip tilt range we want to assume for this operation. We consider in the following that the tip tilt mirror optical stroke is +/- 4 mRad giving a maximum displacement of 1.2mm or 0.67 arcsec in the F/45 focal plane. This is corresponding to assume a safety margin of approx. 0.7 on the tip tilt full stroke measured to be +/- 6.1 mRad. We assume here as a tolerable loss about +/- 1/15 of the tip tilt mirror range or 0.067 arcsec. The linear error corresponding to 0.067 arcsec is +/- 40.2 microns (F/15 focal plane plate scale is 600 micron/arcsec). Summing in quadrature the errors of stages X and Y we find the single stage maximum error to be 40 / 2 =
28.3 microns or 0.047 arcsec. With this overall error the final PSF centering will be done using the fast steering mirror using a maximum amplitude less than +/- 1/10 of the overall mirror DC range. The focus stage accuracy is fixed to 0.1 mm that corresponds to 30nm defocus rms. Defocus adjustment below this level could be done iterating the stages positioning and the sensor defocus reading. The time required to complete a positioning command shall be less than 25s.

The following tests will be performed at different temperatures in the range +10,-20.

1. Single stage positioning command after homing and braking has to have a relative accuracy better then 28.3 µm.
2. Focusing command. The positioning error for the Z stage should be less than 0.1 mm corresponding to a defocus rms of 30nm. Positioning commands accuracy will be measured using external position sensor with 1 micron resolution.

6.2 Stages limit switches

The stages have software limit switches and internal mechanical limit switch. The following tests will be performed in the temperature range +10,-20.

1. The software limit switches will be tested to show that the sensor board is stopped by the control software if it is moving outside the W unit FoV.
2. The mechanical limit switches will be tested to show that the WFS board is stopped by them before any mechanical interference between the board and the AGW frame.

6.3 Source acquisition WFS FoV

The nominal FoV is specified as a rectangular region of sides [3.2, 2.3 arcmin]. The LBT optical axis is not centered in the FoV. The optical axis displacement is [0.55, 0.15 arcmin]. A sketch of the W unit FoV is reported in fig.2.

Figure 1. FoV of W unit in arcminutes. Linear dimension of this FoV at the f/15 focal plane are 115x83 mm.

The acquisition FoV will have sides larger then the nominal values of 3.0 and 2.0 arcmin. In particular the Y negative side of FoV should be reduced no more than 2arcsec corresponding to approx. 1mm. The achievable FoV will be measured doing a bi-dimensional scan of the stages travel range to check against mechanical interference between AGW frame and the WFS unit. The center position of the FoV has to be measured with respect to the fixed structure to verify the FoV placing.

7 Stages unit flexures

This test will use an external reference source fixed on the AGW structure to measure the effect of relative displacement and tilt between AGW structure and WFS board. This displacements and tilt will be mainly due to the stages flexures. In particular the displacement of sensor PSF and pupil images will be measured as a function of the rotation angle of the

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AGW frame on the stand available in Arcetri. The specifications on the W unit flexure are given in terms of PSF and pupil displacements during operation. They are stated as:

1. PSF total displacement. The displacement due to flexures should be the same in the WFS focal plane and in the acquisition focal plane. Holding this no differential error is due to this flexure. A total displacement has to be a fraction of the acquisition camera FoV to ensure that the PSF is found in all system orientations. A displacement diameter of 2 arcsec is still a completely tolerable displacement with respect to the acquisition camera FoV of 7.4x7.4 arcsec.

2. PSF displacement during integration. The target specification assumes that the PSF displacement has to be less than 5 mas during an integration time of 9µm in the F/45 focal plane. This is corresponding to a SR reduction of 0.96. Assuming 10 minutes integration time and an average rotation speed of 15 degree/h the PSF displacement has to be less than 9µm over 2.5 degree of rotation of the pupil image.

3. Pupil image total center displacement. This displacement has to be less than +/- 2 pixel (half the stroke of the camera lens translation stage) over the 180 degree of pupil rotator rotation.

4. The pupil images center displacement during integration. This displacement has to be less than 1/10 pixel during 2.5 degree of counter rotation (10min of integration time). This condition has to be fulfilled over 180 degrees of rotation of the pupil rotator or 360 degree of rotation of the pupil image.

It has to be considered that the stated requirements do not take into account that PSF shift can be partially compensated using stages translation. This is possible because PSF displacement was found sinusoidal and repeatable in a previous flexure test at AIP Potsdam. Results for PSF and pupil displacements after mentioned test are shown in fig.1

Figure 2 PSF displacement for various positions in the f/15 focal plane. The W unit was attached to the AIP telescope simulator. The W unit rotation axis is perpendicular to the optical axis and almost (6deg offset) parallel to the wavefront sensor board plane. Displacements are measured using the technical CCD of the wavefront sensor board.

Look up table to achieve sensor board counter displacement for telescope operation can be built so reducing the PSF displacement rate. LUCIFER internal tip-tilt detector will provide further reduction of PSF displacement.

8 Wavefront Sensor CCD performance test

The main quantities that have to be measured on the WFS camera (CCD39, 80x80 pixel) are the read out noise, the dark current rate, the maximum frame rate and chip cosmetic defects. The first three quantities will be measured as a function of the pixel read out rate. The maximum frame rate will depend on the binning used in the CCD operation and
will be measured as a function of the binning too. The Read Out Noise (RON) specifications are reported in table 1. As a goal the measured RON values should be equal to those that were measured in the lab for the CCD39 unit installed in the W unit #1. As a baseline the RON values are taken as from error budget computation as those values that decrease the SR of less then 10% of the original value achieved with the RON goal value. The excel file used to compute the baseline values is attached as annex to the present document.

<table>
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<th>Baseline RON [e-]</th>
<th>Goal RON [e-]</th>
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The CCD dark current rate will be measured at different pixel rate and exposure time. The achieved values have to be compared with a nominal value of 600 e-/pixel/s given by EEV for the CCD39 chip.

9 Acquisition camera performance test

The main quantities to be measured on the acquisition camera CCD (CCD57 1024x1024 pixel) are the read out noise, the dark current rate, the maximum frame rate and chip cosmetic defects. The first three quantities will be measured as a function of the pixel read out rate. The maximum frame rate will depend on the binning used in the CCD operation and will be measured as a function of the binning too. Measured RON goal values should be equal to those reported in the following table. Baselines values are identified as those values giving a SNR=50 on the acquired PSF in an exposure of 1s and 1 arcsec of seeing value at WFS wavelength (0.7 µm). This SNR correspond to a centroiding error of 1/50 arcsec or 20 mas. The reference source is assumed to be of magnitude 17.5 and CCD is binned 16x16. This magnitude value provides some margin with respect to the planned faintest working magnitude of 16.5.

<table>
<thead>
<tr>
<th>Pixel rate [kPixel/sec]</th>
<th>Baseline RON [e-]</th>
<th>Read Out Noise [e-]</th>
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<td>2500</td>
<td>6.5</td>
<td>8.5</td>
</tr>
<tr>
<td>890</td>
<td>6.5</td>
<td>8.5</td>
</tr>
</tbody>
</table>

10 Reference star acquisition sequence

The stages positioning commands will be used to perform an automated reference star acquisition sequence. To perform this test an external/auxiliary reference source will be placed in the f/15 focal plane located in front of the WFS board. The procedure for automatic reference star acquisition follows the steps listed below.

1. The reference source is placed off axis and reference lamp is [80].
2. The supervisor SW send the macro command to acquire the star providing the coordinates defining the reference source position.
3. The stages are positioned accordingly using the positioning command.
4. The technical viewer is used to find the star photometric center. The star position is compared with the star nominal position needed for sensing operation. This position will be determined during acceptance test by using the internal reference source.
5. A position command is applied to correct differences of positioning larger than 0.067 arcsecond or linear displacements larger then 40.2 microns. The residual error after two positioning commands (step 6 and 8) will be measured using the technical viewer. Iterations are stopped when residual tilt is less then 0.067 arcsec.
6. Brake commands are applied to stop the stages in the acquired positions.

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7. An image is taken with the sensor to evaluate the residual tilt. This residual tilt will be corrected internally to the wavefront sensor board using the fast tip tilt mirror unit. Successful execution of this step requires to measure the tip tilt signal with the wavefront sensor.

The specification for the automatic reference star acquisition procedure outlined above is that the star is centered in the WFS HO FoV with a residual error of 40.2 or 0.067 arcsec (see section 6).

11 Acceptance test schedule and test plan

The following list is giving the sequence and estimated time needed for the different measures to be performed during the acceptance test. The considered measurements have been described in the above sections. Data reduction is assumed to be done in parallel by the various group of people involved in a given measurement.

1. Electronic boxes 1&2&3 functional test, 1h, section 2.1.
2. Thermal test for boxes 1,2&3, 1day,1night., section 2.2 (daytime work is done in parallel with other measurement)
3. WFS board internal reference source, 1h, section 3.
4. Pupil images optical configuration, 2h, section 4.
5. Filter wheels #1, 1h, section 5.1
6. Filter wheels #2, 1h, section 5.2
7. Pupil rerotator, 2h, section 5.3.
8. Fast tip-tilt mirror performance, 1h, section 5.5.
9. Translation stages test positioning performance, 2h, section 6
10. Translation stages flexures, 2h, section 6
11. WFS CCD performance test, 2h, section 8.
13. Translation stages reference star acquisition test. 2h, section 10.
14. 14 Cold test 8h.

The total estimated time for the acceptance test is 18 not including the cold test. assuming an overhead of 30% we find 24 hour or something like 3 days for the measurement to be completed. The cold test will require an additional day so that the full acceptance should last 4 days.
12 References


