NAOMI OMC/NCU Acceptance Tests at the University of Durham wht-naomi-44

ATC Document number AOW/GEN/RAH/15.0/06/00 OMC/NCU acceptance tests

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The ID numbers are those used in Dr. Andy Longmore's Microsoft Access database (see AJL file: integration_tests.mdb) which summarises the WPD requirements. Most of the acceptance tests listed in the database have been included in this document; some selection of tests has been performed. The pressures of the schedule may lead to significant reductions. In later versions of this document the author plans to attach priorities to the tests and indicate test sequences for more efficient operation, i.e. tests with similar configurations and requirements should be grouped together. Notes in this draft have partially addressed the need for grouping but a scheme that readily identifies similar tests is needed.

ID	Objective	Requirements	Description of Test	Date & Examiner	Pass/ Fail	Comments
15	Verify that the optics maintain the registration of the DM with the WFS lenslets independent of the guide star position.	?? OMC ?? WFS ?? NCU ?? Engineering level GUI	1. The integrated system is required for this test with the Nasmyth focal plane mask installed. 2. Select the WFS fiducial mask and position the relay-lens/CCD carriage for the pupil-viewing mode. 3. Move the WFS pickoff to the on-axis DL pinhole and verify the DM registration with the fiducial mask. If not aligned adjust the DM x-y stage accordingly. Move the WFS pickoff to at least 4 other field points and measure the DM/fiducial-mask registration. 4. 0.115 subaperture misregistration is predicted due to non telecentricity.			
19	The NCU should provide a WHT pupil simulator (for on-axis use only)	?? NCU ?? OMC ?? WFS ?? Engineering level GUI.	1. Measure the f/ratio of the NCU output beam with the pupil mask in place. 2. If brightness is sufficient, verify that the pupil mask is imaged at the DM and its size is correct (56 mm). 3. If brightness inadequate for visual observation at DM the pupil viewing mode of the WFS may be used as follows. 4. Flatten DM and set FSM to midrange. 5. Set WFS ADC to zero dispersion and select doublet. 6. Acquire on-axis point source by moving WFS pickoff and centre in WFS FOV. 7. Switch to WFS pupil viewing mode. Verify pupil is in focus and record image for analysis. Confirm that pupil size is acceptable.			Test may be limited by source brightness.

20	NCU provide capability to distortion map of AO optical train.	?? NCU ?? OMC ?? WFS ?? Engineering level GUI	Capability is demonstrated by performing test ID 22 in WFS acceptance tests.			
21	Average transmission from Nasmyth focus to WFS input must be >0.58 over 0.5 to 0.8 ?m (Mode 1).	?? NCU ?? OMC ?? Engineering level GUI. ?? ATC photometer (or equivalent, e.g. SBIG camera) ?? 0.5 -0.8?m filter	1. Flatten DM and set FSM to midrange. 2. With on-axis point source, pupil mask and spectral filter measure NCU output flux. 3. Measure flux passing through centre of dichroic at WFS input and calculate transmission.			
41	Average transmission from Nasmyth focus to WFS input must be >0.83 over 0.5 to 1.0 ?m (Mode 1).	?? NCU ?? OMC ?? Engineering level GUI. ?? ATC photometer (or equivalent, e.g. SBIG camera) ?? 0.5 –1.0?m filter (if ATC photometer not available)	1. Flatten DM and set FSM to midrange. 2. With on-axis point source, pupil mask and spectral filter measure NCU output flux. 3. Measure flux passing through edge of dichroic at WFS input by moving dichroic laterally. Calculate transmission.			
51	Show that loop closure can be maintained while dithering.	?? NCU ?? OMC ?? WFS ?? Engineering level GUI	1. Select NCU on-axis point source, i.e. no FP mask. 2. Flatten DM and set FSM to midrange. 3. Move WFS pickoff to acquire point source and centre in WFS FOV. 4. Close DM and FSM loops. 5. Setting the configuration to the dither mode, inject an increasing amplitude, low frequency tilt signal to the NCU tip/tilt mirror (maximum amplitude and frequency TBD). 6. Demonstrate that the system can maintain loop closure while dithering.			
55	On-axis common/science path wavefront error shall be <30 nm rms within a subaperture (note exceptions in WPD).	?? OMC ?? FISBA interferometer ?? Concave spherical mirror and x, y & z mount (for use as retroreflector)	1. Install dummy DM with pupil stop. 2. Mount FISBA on axis at the OMC input (Nasmyth focus). 3. Install and align concave sphere so that its centre of curvature is coincident with the focused FISBA light at the WFS focus. 4. Measure and record the wavefront. Analyse for compliance.			

			5. Move the concave sphere to the science path and repeat the wavefront measurement. Analyse for compliance.			
56	Off-axis uncorrectable wavefront error over 1 arcmin field shall be <50 nm rms (note exceptions in WPD)	?? OMC ?? FISBA interferometer ?? Concave spherical mirror and x, y & z mount (for use as retroreflector)	1. Install dummy DM with pupil stop. 2. Mount FISBA at +0.5 arcmin off axis in x at OMC input (Nasmyth focus). 3. Install and align concave sphere so that its centre of curvature is coincident with the focused FISBA light at the WFS focus. 4. Measure and record the wavefront. Analyse for compliance. 5. Repeat steps 2-5 for –0.5 arcmin in x and ± 0.5 arcmin in y.			-0.5 arcmin in y may be omitted due to symmetry of the design.
57	The pupil wavefront error shall be <200 nm rms (goal < 170 nm) within 2 arcmin field. (Note exceptions in WPD).	?? OMC ?? FISBA interferometer ?? Concave spherical mirror and x, y & z mount (for use as retroreflector)	1. Follow same procedure as for ID 56 except that FISBA and sphere are located at ± 1 arcmin in x and y respectively. 2. Determine rms wavefront error over the pupil for each field position.			
58	The pupil wavefront error shall be <300 nm rms (goal < 265 nm) within 2.9 arcmin field. (Note exceptions in WPD).	?? OMC ?? FISBA interferometer ?? Concave spherical mirror and x, y & z mount (for use as retroreflector)	1. Follow same procedure as for ID 56 except that FISBA and sphere are located at ± 1.45 arcmin in x and y respectively. 2. Determine rms wavefront error over the pupil for each field position.			
60	Non-common path errors between science path and WFS shall be < 100 nm rms	?? OMC ?? WFS ?? FISBA interferometer ?? Concave spherical mirror and x, y & z mount (for use as retroreflector)	1. Calibrate wavefront quality of concave spherical mirror using the FISBA. Retain wavefront data for use in other tests that follow. 2. Set up the FISBA on axis at the input (Nasmyth focus) to the OMC. WFS should not be in position. 3. Flatten the DM or install the dummy DM. 4. Install and align the concave spherical mirror at the IR science port so that the IR science path can be measured in double pass with the FISBA. Measure and record the wavefront. 5. Move the concave sphere so that its centre of curvature lies at the WFS input focus. Measure and record the input wavefront to the WFS. Remove sphere.			

			6. Install the WFS and move its pickoff so that the FISBA light passes through to the optical science port (OSP). Reposition the sphere to allow a double-pass wavefront measurement to the OSP. Measure and record the wavefront. 7. Determine the non-common path errors from the measured wavefronts.			
77	Measures shall be taken to protect personnel from hazards.	?? OMC ?? NCU ?? Engineering level GUI	Verify compliance with documented safety audit. Procedure to be established when document is made available to Durham.			
78	Handling procedures and lifting aids should be provided for heavy items.	?? NCU ?? OMC ?? Lifting aids (e.g. handles)	Verify availability and function of lifting aids when demonstrating installation and alignment (or disassembly on completion of tests).			
94	SciOpReq Clauses 1 – 3 performance achievable for 1 hour integrations without recalibration	?? NCU ?? OMC ?? WFS ?? Engineering level GUI	Test operations to be defined later. Test is identical to WFS test ID 144 in AJL database.			
95	The uncorrectable tip/tilt induced jitter shall be < 30 nrad (0.006 arcsec) in WHT object space. Note the inclusion of the WFS in the specification.	?? WFS ?? NCU ?? OMC ?? Engineering level GUI ?? SBIG camera	1. Flatten DM and set FSM to midrange. 2. Install SBIG camera at the optical science port to view DL pinhole in FP mask. 3. Align WFS to suitable pinhole in FP mask without obscuring image of the SBIG camera. 4. Measure PSF width at science port with WFS power sources off. 5. Turn on WFS power sources. Close FSM loop. Measure PSF width again. Determine change in width. Note: This test is similar to the WFS test ID 146 which also lacks a satisfactory procedure.			Test requires further thought. Difficult to distinguish uncorrectabl e tilt from other sources of PSF degradation.
97	Cleaning procedures demonstrated on witness samples of all coatings.	?? Witness samples ?? Cleaning materials and procedures	1. If a suitable spectrophotometer is available the transmittance or reflectance of all witness samples should be measured before and after cleaning. 2. Perform cleaning in accordance with documentation. Verify that the cleaning does not leave residue or cause damage.			
100	Verify that the DM and its associated electronics on bench can be removed and	?? OMC ?? NCU ?? WFS	1. Flatten DM and set FSM to midrange. Select on-axis point source in NCU. 2. Select lenslet 1 and 4 x 4 pixel mode. Set ADC			

	re-installed safely in 1 hour or less.	?? Engineering level GUI	dispersion to zero. 3. Acquire and centre point source image in WFS by moving its pickoff. 4. In pupil viewing mode verify that DM segments are aligned to lenslets. If not adjust DM x-y position as required. 5. Turn off all power to system. 6. Remove and re-install DM and bench-mounted electronics, noting time required for complete operation.			
101	Verify that only further minor alignment is needed on re-installation of DM.	?? OMC ?? NCU ?? WFS ?? Engineering level GUI	This test is a continuation of the procedure for test ID 100. 1. Power up the system and check for the image of the point source and pupil alignment in the WFS. 2. If re-alignment is required, verify that it is minor, i.e. within limits of adjustments provided.			
103	Verify that there is at least ± 4mm of travel on the DM motorized stages.	?? OMC ?? Engineering level GUI. ?? Travelling microscope or equivalent	1. Set up travelling microscope to view a reference point on the DM, e.g. segment boundary. Take care not to touch the DM surface. 2. Command the DM x-y stage drive to each limit of travel and measure distance moved with the travelling microscope. Verify travel is acceptable.			
104	Verify that DM motorized stage motions are repeatable to < 0.2 mm.	?? OMC ?? Engineering level GUI. ?? Travelling microscope or equivalent	This test should be combined with test ID 103. 1. Set up travelling microscope to view a reference point on the DM, e.g. segment boundary. Take care not to touch the DM surface. 2. Command the x-y stage to drive set distances (TBD) repeatedly and measure position after each command with the travelling microscope. Verify that the repeatability is acceptable.			
110	Verify that the FSM is protected against being driven to limits of its safe operational range.	?? OMC ?? Engineering level GUI	Drive the FSM in incremental steps (TBD) towards its limits noting the point at which the offload to the TCS occurs. Verify that FSM does not exceed safe operating limits. Note: A means of independently monitoring the FSM surface tip/tilt is desirable for this test.			
111	Verify that FSM offsets are off-loadable to the TCS.	?? OMC ?? Engineering level GUI	This test should be combined with test ID 110.			
112	Verify that FSM frequency response is > 250 Hz (-3dB	?? OMC ?? Engineering level GUI	1. Set up collimator and position-sensing detector (PSD) to measure FSM surface tilt.			Repeat of tests

	point)	?? Collimator and position-sensing detector to measure FSM surface tilt.	2. Apply small amplitude (< 50?rad surface tilt) sinusoidal oscillation to FSM progressing from low to higher frequencies. Record FSM tip/tilt amplitude as measured with PSD. Exercise caution if resonance starts to occur. 3. Determine –3 dB frequency.			performed at the ATC. Test subject to equipment availability.
113	Verify that the FSM open-loop jitter is < 48 nrad (0.01 arcsec) rms in WHT object space for either axis.	?? OMC ?? SBIG camera ?? NCU ?? Engineering level GUI	1. Install and align the NCU and OMC. 2. Flatten the DM or install the dummy DM. 3. Install the SBIG camera at the OSP to view the NCU on-axis DL point source. 4. With the FSM power off, measure the point spread function (PSF) using the SBIG. 5. Measure the PSF again with the FSM power on in open loop. 6. Determine the increase (if any) in the PSF width in both axes with the power on and convert to angle in WHT object space using the plate scale.			
131	OMC and WFS must register repeatably to each other with < 50 ?m accuracy in all 3 axes.	?? OMC ?? NCU ?? WFS ?? Engineering level GUI.	This test is identical to WFS test ID 39 and it should not be repeated.			
147	NCU provides on-axis point source which is full-aperture diffraction limited (DL) at visible wavelengths.	?? NCU ?? SBIG camera	1. Set up the SBIG camera to view the NCU on-axis point source. 2. Record and analyse the PSF.			
150	Verify that the NCU point source radiant intensity conforms to OMC WPD Table 2.	?? OMC ?? NCU ?? WFS ?? Engineering level GUI.	1. Flatten DM and set FSM to midrange. 2. Select WFS lenslet 1, 4 x 4 pixel mode and ADC to zero dispersion. 3. Move WFS pickoff to acquire and centre NCU on-axis point source image in WFS field of view. 4. Determine photons received per subaparture in 5 msec integration time and convert to radiant intensity from source. 5. Extrapolate to infrared from these test results.			More detailed information to be provided.
153	Verify that the NCU point source tip/tilt injection amplitude is variable up to 2.6 arcsec	?? OMC ?? NCU ?? WFS ?? Engineering level GUI.	1. Select NCU on-axis point source, i.e. no FP mask. 2. Flatten DM and set FSM to midrange. 3. Select WFS doublet and set ADC dispersion to zero. 4. Move WFS pickoff to acquire point source and centre in WFS FOV.			

			5. Set NCU tip/tilt mirror to 2.6 arcsec amplitude at < 10Hz and determine amplitude seen by WFS.			
154	Verify that the NCU point source tip/tilt injection frequency is controllable from 0.1 to 150 Hz.	?? OMC ?? NCU ?? WFS ?? Engineering level GUI.	Depending on maximum frame rate achieved with WFS, this test may be carried out as a continuation of ID 153. Spot motion will be poorly sampled at 150 Hz. Alternative approach is to use NCU He-Ne laser and a position-sensing detector (as used at the ATC).			
157	NCU point source spectral distribution shall correspond to G0 to K0 spectral type.	?? NCU ?? ATC photometer or equivalent calibrated detector. ?? Spectral filters (ideally 0.1 ?m bandwidth over 0.5 to 1.0 ?m)	Measure the spectrum of the direct output of the NCU using the photometer and filters.			Test subject to availability of suitable filters and detector.
165	Verify that the extended source radiance conforms to Table 3 of OMC WPD.	?? NCU ?? Engineering level GUI ?? ATC photometer	Note that the solid angle of the extended source must be determined (or assumed from the optical design). The photometer measures irradiance and the solid angle is needed to determine radiance, i.e. W/cm^2/ster. As the ATC photometer only operates over 0.5 to 1.0 ?m one may have to use an IR camera to complete the measurement.			Test subject to equipment availability.
167	Verify that NCU extended source uniformity is < 0.5 % over 10 mm diameter.	?? NCU ?? Engineering level GUI ?? ATC photometer with 1mm dia mask. ?? x-y stage with >10 mm travel for photometer head	1. Install mask on photometer head and mount assembly at NCU output. 2. Set up NCU to provide extended source. 3. Measure uniformity of illumination across at least two diameters moving in ≤ 1 mm increments.			Difficult to make reliable measuremen-ts to 0.5 %.
168	Verify that a NCU He-Ne laser source is available for on-axis alignment.	?? NCU ?? OMC ?? Engineering level GUI	1. Install He-Ne laser in NCU 2. Turn on the laser and verify that beam properly illuminates the DM.			
186	Provision must be made to calibrate non-common path errors between science path and the WFS.	?? NCU ?? OMC ?? WFS ?? Engineering level GUI ?? SBIG camera	Procedure to be added later to cover methods developed by Durham.			
199	Verify fit and function of spare components, if any.	?? Spare components	Any components to be identified by the ATC.			

200	Verify the mechanical fit of the OMC/NCU components in their shipping containers.	?? OMC ?? NCU ?? Shipping containers	Pack and inspect.			
202	Measure the open-loop transfer function of the NCU tip/tilt mirror.	?? OMC ?? NCU ?? SBIG camera ?? Engineering level GUI.	This test should be performed after ID 154, i.e. independent verification of the frequency range is required. The approach assumes that a sufficiently sensitive, high bandwidth position-sensing detector is not available. 1. Flatten DM and set the FSM to midrange. Set up the SBIG on axis at the science port. 2. Turn on the on-axis point source with the tip/tilt mirror stationary. Record the image and determine the PSF width (baseline). 3. Turn on the tip/tilt mirror (amplitude TBD) at 1 Hz. 4. Integrate with SBIG for > 30 sec. Determine width of blurred PSF and subtract baseline width to arrive at measured amplitude of oscillation. 5. Repeat at 10 Hz intervals to 150 Hz. Shorter integration times may be used at the higher frequencies. 6. Derive transfer function from ratio of commanded motion to measured motion as a function of mirror frequency.			Test approach is subject to review. Phase information is not obtained.