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CHANGE RECORD

Issue	Date	Section affected	Change Description
0.1	9/9/02		First issue of compliance matrix
0.2	2/10/02	all	Modified to final tests form. Added column for JAC witness, and final/sub-system test.
1.0	22/1/03	all	Added links to test references, or described these in greater detail in the text.
2.0	3/2/04		Updated following input from JAC and project team.
2.2	21/5/04	all	Final modifications and details added by project team.

APPLICABLE DOCUMENTS

Reference	Document Title	Document Number	Issue & Date
AD1	Functional Performance and Requirements Document	1.1 d 035 G	2.0
AD2	WFCAM electronics sub-system integration and test plan	6.2d009E	0.1 - 6/11/02
AD3	WFCAM opto-mechanics integration and test plan	6.2d008M	25/10/02
AD4	Integration and test plan for filter mechanism	6.2d005M	25/6/02
AD5	WFCAM vacuum vessel and cryogenics system I&T plan	6.2d006M	31/10/02
AD6	integration and test plan for focus mechanism	6.2d007M	24/10/02
AD7	WFCAM optics integration and test	6.2d010O	0.1 - 4/10/02
AD8	Integration and test plan for autoguider optics	6.2d011O	0.0 - 4/11/02
AD9	integration and test plan for autoguider box	6.2d012O	0.1 - 8/11/02
AD10	WFCAM infrared detector coplanarity alignment	3.2d005O	1.0 - 4/11/02
AD11	I&T plan for control and acquisition software and hardware	6.2d013S	0.2 - 8/11/02
AD12	Full system integration	6.2d015G	0.2 - 8/11/02

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1. INTRODUCTION

This document summarises the planned tests to ensure WFCAM compliance to the FPRD prior to delivery to the Joint Astronomy Centre, and during commissioning. The spirit of the test plan is to test as much as possible as early as possible to allow time to resolve problems. In many cases final compliance can only be confirmed on the telescope

It should be appreciated that this document covers FPRD compliance and testing only. Tests ensuring proper operation of sub-systems are detailed elsewhere (AD 2 to 11).

A test report will be produced for each test to document compliance.

2. EXPLANATIONS

2.1 FPRD

The requirements to be fulfilled are as specified in the FPRD.

2.2 COMPLIANCE CRITERIA

A compliance verified by analysis
D compliance verified or enforced by design
T compliance verified by relevant test or inspection
C compliance verified during commissioning

2.3 COMPLIANCE TESTS

These are tests which will be performed to show compliance. In some cases it will not be possible to prove compliance solely with tests in the lab, since the telescope/Mauna kea are required. In these cases a combination of lab tests and analysis will be used with final compliance demonstrated during commissioning.

Details of tests are either given in the table or referenced to other documents/sections.

2.4 SYSTEM OR SUB-ASSEMBLY LEVEL TESTS

This shows the level at which the acceptance test will be conducted. In general, those marked System (S) will be conducted after full integration of the cryostat. Those marked sub-assembly (SA) will be performed at sub-assembly or partial-integration level. This means they will be carried out well before final system integration and test.

2.5 JAC-WITNESSED ACCEPTANCE TESTS

Final tests to be witnessed by JAC personnel, prior to acceptance, are indicated.

3. TESTS

FPRD No	Relates to	Compliance criteria	ATC Test number	System level or sub-assembly test (S/SA)	JAC to witness
1.1	Imager only.	D	-	none	
1.2	4 Hawaii-2 PACE detectors	D	E-1	S	
1.3a	bright star limit	A & C	E-2	SA & S	
1.3b	IR controller crosstalk	T	E-3	SA	
1.3c	electronic system noise	T	E-4	SA & S	YES
1.3d	allowable readout modes	T	E-5	SA & S	YES
1.3e	detector safe against damage	D	E-6, E-10	none	
1.4a	Removed. Repeat of 1.3a.		-		
1.4b	telescope + wfcam background WFCAM throughput	D T & C	- O-2	None S	 YES
1.5a	pixel scale	T & C	O-3	S	
1.5b	microstepping range and accuracy (CCD pixel scale)	T & C	O-4	S	
1.5c	availability of microstep modes	D	-	none	
1.6a	tip-tilt secondary	D	-	none. JAC tests.	
1.6b	M2 control loop	C	-	SA. JAC tests.	
1.6c	tip-tilt system latency	T	-	SA. JAC tests.	
1.7a	Encircled energy requirement	T	O-5, O-9	S	YES

1.7b	MTF requirement	T	O-5, O-9	S	YES
1.7c	M2 position vectors	A	O-6	By design	
1.8a	point source stray light	T	O-7	S	YES
1.8b	diffuse straylight	D	-	None	
1.9a	4 detectors and spacing	T	M-1	SA	
1.9b	detector alignment	T	M-1	SA	
1.9c	detector coplanarity	T	M-1	SA	
1.10	photometric accuracy	T and A	M-2, E-7	SA	
1.11a.	astrometric accuracy	T and A	M-2	SA	
1.11b	Pointing model	A	-	none	
1.12	Filter specification and filter mechanisms	A T	M-3, O-1	SA SA and S	 YES
1.13	cold stop requirement	D	-	none.	
1.14	focus requirement	T	M-4, S-4, O-10	SA and S	YES
1.15	survey efficiency requirement	T, A	M-5	SA	
1.16a	semi-automatic operation	D	-	none	
1.16b	interface with WF astronomy	D	-	none	
1.16c	user-friendly interface	T	S-4	S	YES
1.16d	summit eng pipeline operation	D	-	None. CASU operation.	YES
1.16e	format of raw data	T	S-4	SA	
1.16f	speed of summit pipeline	T	-	none. CASU pipeline.	
1.16g	calibration procedures	D	-	none	
1.16h	observing pipeline hardware	T	S-4	S	
1.16i	calibration files available	-	-	none. CASU pipeline.	
1.16j	engineering mode required	D and T	S-2	SA and S	YES
1.16k	simple start-up/shut down procedures	T	S-4	S	YES
1.17a	automatic acquisition of guide star	D	-	None. JAC tests.	YES

1.17b	autoguider/science field flexure	D	-	None	
1.17c	observing preparation tools	D	S-3	SA	YES
1.17d	autoguider performance	T	E-8, O-8	S	YES
1.17e	microstepping capability	T	O-4	S	
1.17f	AG must be integrated into TCS	D	-	none. JAC responsibility.	
1.17g	UKIRT pointing to include flexure	-		None. Existing UKIRT pointing model will be used.	
1.17h	ability to read out full CCD frame	D	-	None. JAC tests.	
1.18a	mechanical stability	T and C	M-2	SA	
1.18b	focus stability	D	-	None	
1.18c	internal focus and M2 auto-updates	D	O-6	S	
1.18d	cryostat lift mass < 1250 kg	T	M-6	S	
1.18e	CoG requirement	D	M-7	S	
2.1	documentation requirement	D	A-1	S	YES
2.2a,b,c	spare parts	D	A-2	S	YES
2.3	WFCAM pre-installation	T	E-9	S	YES
2.4a	cryo/coolant spillage	D	-	none	
2.4b	closed cycle He refrigerator	D	-	none	
2.4c	refrigerator compatibility	D	-	none	
2.4d	Requirement removed.		-		
2.4e	maximum detector cooling rate not exceeded	T	E-10	S	
2.4f	pumping on telescope	D	-	none	
2.4g	cryostat cold time	T	M-8	SA	
2.5	instrument safety in power loss	T	E-6	SA	

2.6	window condensation	T	M-9	S	YES
2.7	installation and handling rigs	T	M-10	S	YES
2.8a	remote status monitoring	T	S-2	S	YES
2.8b	status monitoring from Hilo	D	-	none	
2.9a	data quality monitoring	-	-	none. CASU resposnibility.	
2.9b	warnings for data quality	-	-	none. CASU responsibility.	
2.10	safety	D	-	none	

4. COMPLIANCE TABLE

The current state of FPRD compliance is shown

FPRD no.	C - compliant NC - non compliant ( ) - expected but not proven	Note	Relates to
1.1	C		Imager only.
1.2	C		4 Hawaii-2 PACE detectors
1.3a	(C)		bright star limit
1.3b	NC		controller crosstalk
1.3c	(C)		electronic system noise
1.3d	(C)		allowable readout modes
1.3e	C		detector safe against damage
1.4a			Removed. Repeat of 1.3a.
1.4b	(C) NC	 Compensated somewhat by better-than-expected detector QE.	telescope + wfcam background WFCAM throughput
1.5a	(C)		pixel scale
1.5b	(C)		microstepping range and accuracy
1.5c	(C)		availability of microstep modes
1.6a	C		tip-tilt secondary
1.6b	C		M2 control loop
1.6c	(C)		tip-tilt system latency
1.7a	(C)		Encircled energy requirement
1.7b	(C)	Actually 0.3% NC at field	MTF requirement

		edge in Y!	
1.8a	(C)		point source stray light
1.8b	(C)		diffuse straylight
1.9a	NC		4 detectors and spacing
1.9b	(C)		detector alignment
1.9c	(C)		detector coplanarity
1.10	(C)		photometric accuracy
1.11	(C)		astrometric accuracy
1.12	(C) (C)		Filter specification and filter mechanisms
1.13	C		cold stop requirement
1.14	(C)		focus requirement
1.15	(NC)	64% cf 65% requirement. Within uncertainties.	survey efficiency requirement
1.16a	(C)		semi-automatic operation
1.16b	C		interface with WF astronomy
1.16c	(C)		user-friendly interface
1.16d	(C)		summit pipeline operation
1.16e	(C)		format of raw data
1.16f	(C)		speed of summit pipeline
1.16g	(C)		calibration procedures
1.16h	(C)		observing pipeline hardware
1.16i	(C)		calibration files available
1.16j	(C)		engineering mode required
1.16k	(C)		simple start-up/shut down procedures
1.17a	(C)		automatic acquisition of guide star
1.17b	(C)		autoguider/science field flexure
1.17c	(C)		observing preparation tools

1.17d	(C)		autoguider performance
1.17e	(C)		microstepping capability
1.17f	(C)		AG must be integrated into TCS
1.17g	(C)		UKIRT pointing to include flexure
1.17h	C		ability to read out full CCD frame
1.18a	C		mechanical stability
1.18b	(C)		focus stability
1.18c	(C)		internal focus and M2 auto-updates
1.18d	(C)	Just under the limit.	cryostat lift mass < 1250 kg
1.18e	(C)		CoG requirement
2.1	(C)		documentation requirement
2.2a	(C)		long lead time spare parts
2.2b	(C)		spare parts for diagnosis
2.3	(C)		WFCAM pre-installation
2.4a	C		cryo/coolant spillage
2.4b	C		closed cycle He refrigerator
2.4c	C		refrigerator compatibility
2.4d			Requirement removed.
2.4e	C		maximum detector cooling rate not exceeded
2.4f	C		pumping on telescope
2.4g	(C)		cryostat cold time
2.5	C		instrument safety in power loss
2.6	(C)		window condensation
2.7	(C)		installation and handling rigs
2.8a	(C)		remote status monitoring

2.8b	(C)		status monitoring from Hilo
2.9a	(C)		data quality monitoring
2.9b	(C)		warnings for data quality
2.10	(C)		safety

5. TEST REPORTS

The following test reports will be provided.

test number	test type	Test description	JAC to witness	report	report status
A-1	All	Confirm completion of deliverable documentation	Yes	DL	
A-2	All	Confirm presence of spare parts.	Yes	DL	
E-1	electronics	Prepare summary of detector delivery and mounting position in focal plane.		KL	
E-2	electronics	Measure 1. detector full well. This is determined by a series of exposures up to saturation. 2. detector readout rate. The exact time between reads will be determined.		DJI	
E-3	electronics	Report on controller crosstalk measurements (that is, without detector)		KL	
E-4	electronics	Direct electronic tests of system noise as specified in Detector Tests document section 1.3. Also tests of stability of full system crosstalk over (i) hours and (ii) days	Yes	DJI, MMC	
E-5	electronics	Confirm operation of four detector readout modes by taking exposures • as dark frames • exposed to light	Yes	DJI, MMC	
E-6	electronics	Report on detector safety features incorporated in WFCAM.		KL	
E-7	electronics	Report on controller gain tests as a function of temperature		KL	
E-8	electronics	measure CCD noise performance and read rate simultaneous with IR detector operation.		DJI, KL	
E-9	electronics	Confirm ability to measure vacuum, temperatures, detector operation and CCD operation.	Yes	KL	
E-10	electronics	Confirm maximum detector cooling rate is never exceeded.		KL	

M-1	mechanical	Measure detector spacing, rotation and coplanarity with CP cryostat.		MMC	
M-2	mechanical	Cryostat flexure measurements. These have already been done. Results need to be brought together into a report.		DM	
M-3	mechanical	Filter Mechanism functional tests. These will be done as part of system software testing. Realistic observing scripts will cycle through the filters and focus and take exposures.	Yes	DM	
M-4	mechanical	Focus mechanism functional tests. These will be done as part of system software testing. Realistic observing scripts will cycle through the filters and focus and take exposures.	Yes	DM	
M-5	mechanical	measure filter deployment times. Will be tested in the lab.		DM	
M-6	mechanical	Measure WFCAM lift mass and total mass.		DM	
M-7	mechanical	Calculate CoG position, using measured WFCAM mass to +/- 100 mm.		DM	
M-8	mechanical	Confirm cryostat vacuum/temperature performance for 3 weeks.		DM	
M-9	mechanical	Confirm absence of window frosting in full system assembly with LN flow.	Yes	DM	
M-10	mechanical	Confirm completion of all assemblies related to handling and installation. These include spreader bar, top ring brackets, lifting pintels, top ring support feet, focus mechanism support feet, Michelle rig i/f bracket (shipped), focus mechanism guide pins, M2 target, M2 cover (shipped), M3 cover, detector G10 covers, window cover, field lens cover, M3 bezel guide pins, guide cone.	Yes	DM	
O-1	optics	Filter scans at ATC. All filters will be scanned and a report produced.		DMH	
O-2	optics	Measurement of system throughput to 10%. This will be done by using a calibrated blackbody, imaged through the telescope simulator. With a known detector gain calibration, the total counts detected can be used to calculate throughput.	Yes	DMH	

O-3	optics	Conduct optical test of IR pixel scale. Will be tested in the lab to 10% by 1. moving illuminated spot at focus of telescope simulator by a short distance. 2. measuring movement in the focal plane		DMH	
O-4	optics	Conduct optical test of CCD pixel scale. Identical to 1.5a.		DMH	
O-5	optics	Measure image quality with simulator. • encircled energy will be straighforwardly measured by imaging a point source on the IR detectors. • Image quality is specified as an MTF. We will recover MTF in two ways – using whichever gets the best results. (i) We will image a point source at different sub-pixel positions to obtain adequate sampling. The Fourier transform of this is the full camera system MTF. The optical system MTF will be obtained by dividing this by the MTF of a 0.4” top-hat function (pixel). (ii) We will use a curvature-sensing WFS algorithm developed for WFCAM to derive the optical system wavefront errors.	Yes	DMH	
O-6	optics	Provide initial list of M2 position vectors vs telescope attitude. We will provide M2 decentre, tilt and focus offsets from the nominal zenith position, as a function of telescope attitude.		DMH	
O-7	optics	Point source stray light. Images will be taken with a bright point source off and on. The difference image will be used to measure the scattered light pedestal in the focal plane (far from the point source). It will not be possible to measure straylight from a diffuse source in the lab.	Yes	DMH	
O-8	optics	Measure autoguider system throughput to 10%. This will be done as for the IR throughput – our blackbody source is calibrated from 300 nm to 2.5 microns.		DMH	
O-9	optics	Use optics modelling to show flexure results in acceptable images. This will take measured values of the flexure from lab tests and use these to predict the optical quality degradation.		DMH	

O-10	optics	Confirm that the filter focus offsets can be accomodated within the focus stage travel range. This will use the telescope simulator.		DMH	
S-1	software	Check WFCAM S/W against JAC Basic Software Requirements	Yes		
S-2	software	Engineering Mode, mechanisms and Monitoring Setup • WFCAM rack systems. One local Solaris system. Procedure • Start with EPICS & rack systems powered off • Power on systems • start engineering GUIs • perform series of mechanism tests • review results and monitors • power down systems	Yes	AV,AP,SM	
S-3	software	Observing Preparation Tools Setup • one local computer with suitable Java 2 environment • Examples of survey definitions Procedure • start SDT • Load survey details and generate MSBs • Load samples of MSBs into OT and check • Test observation definition and saving to disk using OT only.	Yes	MF, AV	
S-4	software	Full Up Systems test Setup • minimum two (preferably four) controllers • WFCAM computer systems • WFCAM rack systems • two cold eng detectors + two cold muxes • full ATC software system incl. Eng pipeline Procedure • Power on all systems	Yes	AV,AP	

		• Start EPICS with ENG screens running • start camera control, DHS etc. • Initialise systems and take a series of exposures in each of four modes (CDS,NDR,RRR,sub-array) • review output • check FITS headers vs agreed list • run Eng pipeline and review results • power down			