

WFC3 Science Calibration Plan

Part 6: Thermal-Vacuum #2 Test Procedures

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by

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PREAMBLE

The WFC3 Science Calibration Plan: Part 1 (ISR WFC3-2002-07) outlines a series of tests designed to calibrate the operational performance of Wide Field Camera 3 (WFC3). The measurements will be undertaken at Goddard Space Flight Center with WFC3 under both ambient and thermal-vacuum environmental conditions. This document presents the set of procedures for each test included in the SciCalPlan, together with basic procedures covering optical alignment, that will be used to calibrate WFC3 during the second system-level thermal-vacuum campaign (TV-2), which is to be conducted in the summer of 2007. Many of the tests used in the first system-level thermal-vacuum campaign (TV-1) in 2004 (ISR WFC3-2004-03) have been modified to accommodate current circumstances, as well as instrumental knowledge gained as a result of that previous testing.

Procedure	Test name	PI	SciCal ref.	Comments
UVAL1	UVIS focus sweep	Hartig		Alignment
IRAL1	IR focus sweep	Hartig		Alignment
UVIS01	Darkcount vs. T_{Det}	S. Baggett	3.1.2	Science calibration
UVIS02	CTE vs. T_{Det}	Robberto	3.1.3	Science calibration
UVIS03	Gain vs. T_{Det}	S. Baggett	3.1.4	Science calibration
UVIS04	Linearity: absolute calibration	S. Baggett	3.1.7A	Science calibration
UVIS05	Linearity: areal calibration	S. Baggett	3.1.7B	Science calibration
UVIS06	CTE: Charge Injection	Robberto	3.1.9	Science calibration
UVIS07	UVIS sub-array darkcount and readnoise	S. Baggett	3.1.11	Science calibration
UVIS08	UVIS shutter performance	Hilbert	3.2.1 3.2.2	Science calibration
UVIS09	UVIS FOV location & orientation	Hartig	3.3.1	Science calibration
UVIS10	UVIS Geometric distortion	Hartig	3.3.2	Science calibration
UVIS11	UVIS Encircled energy	Hartig	3.4.1	Science calibration
UVIS12	UVIS Image stability	Brown	3.4.3	Science calibration
UVIS13	UVIS PSF wings & halo	Hartig	3.4.4	Science calibration
UVIS14	UVIS throughput calibration: filters	Brown	3.5.1A	Science calibration
UVIS15	UVIS throughput calibration: system	Brown	3.5.1B	Science calibration
UVIS16	UVIS throughput calibration: detector-defined passbands	Brown	3.5.1C	Science calibration
UVIS17	UVIS throughput calibration: narrowband filters	Brown	3.5.1D	Science calibration
UVIS18	UV throughput stability	Brown	3.5.2	Science calibration
UVIS19	UVIS UV blocking	Brown	3.5.3	Science calibration
UVIS20	UVIS flat fields: photometric filters	Bushouse	3.6.1A	Science calibration
UVIS21	UVIS flat fields: spectroscopic filters	Bushouse	3.6.1B	Science calibration
UVIS22	UVIS Fringing	Hill	3.6.3	Science calibration
UVIS23	UVIS Internal calibration system	S. Baggett	3.6.4	Science calibration
UVIS24	UVIS Grism wavelength dispersion calibration	Bushouse	3.7.1	Science calibration
UVIS25	UVIS Ghosts	Brown	3.8.1	Science calibration
UVIS26	UVIS Gap behaviour	Brown	3.8.4	Science calibration
UVIS27	UVIS Light leaks	Hartig	3.8.5	Science calibration
UVIS28	UVIS System performance monitoring	Bushouse	3.9.2	Science calibration
UVIS29	Bias level as a function of T_{det}	S. Baggett	3.1.5	Science calibration
UVIS30	Readnoise as a function of gain	S. Baggett	3.1.6	Science calibration
UVIS31	Electronic Crosstalk	S. Baggett	N/A	Science calibration
UVIS32	Bias versus WFC3 voltage	S. Baggett	N/A	Science calibration
UVIS33	Filter wheel repeatability	Petro	N/A	Science calibration
UVIS34	Filter wedge	Kim	N/A	Science calibration
UVIS35	Subarray locations	Bushouse	N/A	Science calibration
IR01	Darkcount vs. T_{DET}	Robberto	3.1.2	Science calibration

IR02	Gain vs. T_{DET}	Robberto	3.1.4	Science calibration
IR03	IR Linearity: absolute calibration	Robberto	3.1.7A	Science calibration
IR04	IR Linearity: areal variations	Robberto	3.1.7B	Science calibration
IR05	IR sub-array darkcount and read noise	Robberto	3.1.11	Science calibration
IR06	IR FOV and orientation	Hartig	3.3.1	Science calibration
IR07	IR Geometric distortion	Hartig	3.3.2	Science calibration
IR08	IR Encircled energy	Hartig	3.4.1	Science calibration
IR09	IR Image stability	Brown	3.4.3	Science calibration
IR10	IR PSF wings & halo	Hartig	3.4.4	Science calibration
IR11	IR Throughput calibration: filters	Brown	3.5.1A	Science calibration
IR12	IR Throughput calibration: detector-defined passbands	Brown	3.5.1B	Science calibration
IR13	IR Flat fields: photometric filters	Bushouse	3.6.1A	Science calibration
IR14	IR Flat fields: spectroscopic elements	Bushouse	3.6.1B	Science calibration
IR15	IR internal calibration system	S. Baggett	3.6.4	Science calibration
IR16	IR Wavelength dispersion relation	Bushouse	3.7.2	Science calibration
IR17	IR Ghosts	Brown	3.8.1	Science calibration
IR18	IR Light leaks	Hartig	3.8.5	Science calibration
IR19	IR System performance monitoring	Bushouse	3.9.2	Science calibration
IR20	Bias as $f(\text{gain})$	Robberto		Science calibration
IR21	Readnoise as $f(\text{gain})$	Robberto		Science calibration
IR22	Subarray photometry	Robberto	N/A	Science calibration
IR23	Electronic Crosstalk	S. Baggett	N/A	Science calibration
IR24	Bias versus WFC3 voltage	Robberto	N/A	Science calibration
IR25	Subarray locations	Bushouse	N/A	Science calibration

1 Optical alignment

1.1 UVAL1: UVIS focus sweep

PROCEDURE#: UVAL1

TITLE: UVIS focus sweep.

TEST CATEGORY: Alignment.

DATE: 12/31/2002.

PURPOSE: This procedure is executed either manually with the optical bench in the Ball WFAS alignment station and the mini-stimulus, or is run as an SMS when the complete WFC3 is integrated with the OS/RIAF/SITS at GSFC. The purpose of the procedure is to determine the best focus position and focal plane tilt for the UVIS detector. The procedure uses the mini-stimulus or OS to provide an unresolved fiber point source located initially on axis (The center field point is the UF1 position. Note this position is adjusted with a 1mm offset on Chip 1 (A and B amps) to avoid the inter-chip crack between the two CCD chips). The focus drive of the corrector mechanism is then used to sweep the position of the UVM1 mirror over a specified range of motion of the corrector (for example, the range from -1.2mm to +1.2mm, in .4mm increments can be used). An overshoot of 100mm is needed to compensate for backlash whenever the direction of motion is changed. Before this is done, the inner (tip) and outer (tilt) cylinders of the corrector mechanism are adjusted to remove any residual coma and symmetrize the image. At each focus position, the Encircled Energy is measured and plotted. Hartig's IDL software is used to analyze the Encircled Energy data to fit a focus curve to determine the optimum on-axis focus position. Subsequently, the point source is moved over the FOV to other designated field positions. Sub-arrays centered on each field position are used to increase readout efficiency. The focus sweep is repeated at each field point. The data from all field points are then simultaneously fit with another of Hartig's IDL software packages to characterize the tilt and orientation of the focal plane. The analysis provides a best fit focal plane that is then used to determine the correct detector position and tilt. This analysis also calculates the detector shimming needed to place the UVIS detector focal plane at this best fit focal plane.

FREQUENCY: This procedure should be run each time a detector is installed into the bench, to either align the detector, or to verify it's alignment from previous work.

DETECTOR: UVIS Surrogate and Flight Build#1; Readout Amps dependent on sub arrays; F625W filter; 2x2 binned full frame image for initial survey; 200x200 sub arrays for each field point.

PREREQUISITES: The nominal, "best guess" focus position (from Code V predictions) must be determined before execution and image quality will need to be checked and adjusted first. If coma is severe, the Tip/Tilt procedure will be applied before the focus sweep is carried out.

HARDWARE REQUIREMENTS: The instrument must be installed in the WFAS at Ball or integrated in the OS/RIAF at GSFC. The UVIS surrogate detector requires the CEB test set to operate. Also, the mechanism test set is needed to operate the corrector mechanism, the CSM and the SOFA. At Ball, the mini-stimulus must be set up at pre-determined locations for best focus positions at various field points.

SOFTWARE REQUIREMENTS: ICAL Quick Look Data Acquisition, Display and Logging software. Hartig's IDL software is needed for data analysis.

COMMAND MODE: Manual/Real Time (at Ball) and SMS or CCL (at GSFC).

PROCEDURE/EXPOSURES: The UVIS corrector mechanism is swept from -1.2 mm (max) (-TBD steps) to +1.2 mm (max) (TBD steps) in increments of 0.4mm. At each focus position, two 0.5sec images are acquired consecutively for each field location using the F625W filter. For efficiency, the data are read out in sub-arrays of 200x200 pixels. Typical coordinates are given below. As a consistency check, the 0.0mm (Focus=0) acquisition is repeated at the end. The first and last focii are overshoot by 100 corrector steps to avoid backlash.

VARIANTS: none

IRHW01A: 9 point source fiber positions (with the OS, 5 with the mini-stimulus) x 2 exposures/fiber x 8 focii = 144 200x200 UVIS Sub-arrays.

TOTAL EXPOSURES: 144 200x200 UVIS sub-arrays.

TOTAL TIME: One execution of the focus sweep takes approximately 3 hrs. Mini-Stimulus set up requires about 1hr for each field position.

ANALYSIS: For each corrector position, sum and average the images of each pair and measure and remove the bias and background counts. Measure the encircled energy (EE) (note the maximum counts in the peak) and plot the EE as a function of focus. From the best fit, determine the optimal value for the focus for each location for the entire field.

FSW FIELD POINT LOCATIONS (center of 200x200 sub array coordinates):

- | | |
|--|----------------------------|
| (1) Field Center-(offset 1mm on chip1 (A, B) - UF1 | -200x200@2078,2260 |
| (2) Field Point 2(Near B Amp) | - UF6S - 200x200@0,3862 |
| (3) Field Point 3(Near D Amp) | - UF8S - 200x200@3674,3882 |
| (4) Field Point 4(Near C Amp) | - UF7S - 200x200@3369,99 |
| (5) Field Point 5(Near A Amp) | - UF9S - 200x200@274,414 |

1.5 IRAL1: IR Focus Sweep

PROCEDURE#: IRAL1

TITLE: IR focus sweep.

TEST CATEGORY: Alignment.

DATE: 12/31/2002.

PURPOSE: This procedure is executed manually with the optical bench in the Ball WFAS alignment station and the mini-stimulus, or is run as an SMS when the WFC3 is integrated with the OS/RIAF at GSFC. The purpose of the procedure is to determine the best focus position and orientation/tilt for the IR detector. The procedure uses the mini-stimulus or OS to provide an unresolved point source fiber located on axis (at the IRF1 position; no offsets are required). The focus drive of the corrector mechanism is then used to sweep the position of the IRM1 mirror over a specified range of motion (see note below). At each focus position, the Encircled Energy is measured and plotted to determine the optimum on-axis focus position. In addition, the point source will be moved to various field locations over the FOV to characterize the tilt and orientation of the focal plane/surface and the spatial dependence of the PSF. The data are then used to fit the optimal plane to the best focus positions for the individual field locations. These data are also analyzed to determine the amount of shimming needed to optimize the IR detector tilt.

(**Note:** If the IR surrogate detector (mux) is used, the combination of under sampling and poor sub-pixel responsivity will not provide a useful EE result. In this case, a phase retrieval technique can be employed that operates on out of focus images obtained with the source positioned well inside and outside of best focus. See George Hartig.)

FREQUENCY: This procedure should be run each time a detector is installed into the bench.

DETECTOR: IR Surrogate and Flight Build#1, Amps ABCD.

PREREQUISITES: The nominal, "best guess" focus position from Code V predictions must be determined before execution.

HARDWARE REQUIREMENTS: The instrument must be installed in the WFAS at Ball or integrated in the OS/RIAF at GSFC. The IR surrogate detector requires the DEB test set to operate. Also, the mechanism test set is needed to operate the corrector mechanism, the CSM and the FSM. At Ball, the mini-stimulus must be set up at pre-determined locations for best focus positions at various field points.

SOFTWARE REQUIREMENTS: Hartig's IDL for data analysis.

COMMAND MODE: Manual and SMS

PROCEDURE/EXPOSURES: The IR corrector mechanism is swept, for example, from -1.5 mm (Focus=-TBD steps) to 1.5 mm (Focus=TBD steps) in increments of 0.5mm (CorFocus=TBD steps). At each focus position, two 0.5sec (under DEB control) images are acquired consecutively with the F625W

filter (using the mini-stimulus with the IR Surrogate; TBD (e.g. F125W) with the IR FPA and the OS). As a consistency check, the 0.0mm (Focus=0) acquisition is repeated at the end. The first and last focii are overshot to avoid corrector backlash.

VARIANTS: none.

IRHW01A: Do 5 field locations x 2 exposures/fiber x 8 focii = 80 IR images. (Do 4 additional positions with the OS.)

TOTAL EXPOSURES: 80 IR images.

TOTAL TIME: One execution of the procedure at each field point takes approximately 3 hrs. Set up time for each field point using the mini-stimulus is approximately 1 hr. With the OS, the set up time is TBD.

ANALYSIS: For each corrector position, sum and average the encircled energy EE of each pair. Measure the maximum counts in the peak to assure adequate S/N (~30kDN), and avoid saturating the image. Plot the EE as a function of focus. Determine the optimal focus position from the best fit. Repeat for each location over the entire field, and fit the best plane to all field points to determine (or verify) the detector tilt. Measure and remove the reference pixel and background counts.

2 Science calibration procedures for UVIS channel

The scientific and technical justification for the overall test program encapsulated in these procedures is given in the Science Calibration Plan, Part 1; the Science Calibration Plan, Part 3, provides a summary of the main goals of the individual procedures. The exposure times listed are based on measurements of the intensities of the Optical Stimulus light sources, of the WFC3 throughput and the detector quantum efficiencies. They have been validated using either the CASTLE Exposure Time Calculator or results of previous WFC3 ground testing.

2.1 *UVIS01: Dark count rate and bias level*

CALIBRATION TEST#: 3.1.2, 3.1.5

TITLE: Dark count rate & bias level vs temperature

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: July 2003; validated Sept 2003; revised Nov 2006; revised May 2007

PURPOSE:

To verify that the dark count rates and readnoise levels of the UVIS CCD detectors are within the CEI specifications for detector temperatures spanning the range expected for on-orbit operations.

PRIORITY:

High for measurements at the nominal operating temperature; medium for other temperatures.

CEI SPECIFICATION(s):

4.6.4: Dark current $<20 \text{ e}^-/\text{pix}/\text{hr}$ at -83°C

4.7.1: Detector thermal control - nominal temperature -83 (goal -90)

setpoints -50 to -100°C to be provided

absolute temperature measurements accurate to $\pm 1^\circ\text{C}$ at TV/SMOV

4.6.14: Single row bias repeatable to 2 e^- RMS and bias level for entire array correctable to 1 e^- RMS.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting ($1.5 \text{ e}^-/\text{DN}$).

BACKGROUND:

The baseline characteristics of the Marconi flight CCD detectors have been measured by the GSFC Detector Characterisation Laboratory (DCL). Those measurements include a determination of the dark count rate of the flight-candidate CCDs over the full on-orbit operating temperature range. The current test procedure is designed to verify the performance of the flight detectors once integrated in the WFC3 system. These tests will be undertaken under both ambient and T/Vac conditions.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed, and the detector temperature should be controlled to an accuracy of 1°C .

SOFTWARE REQUIREMENTS:

Standard IRAF and/or IDL routines should be sufficient. Images will need to be displayed to look for anomalous features; Fourier analysis may be required to evaluate any structure evident in the frames. Standard statistic and image stacking tasks will be needed to generate required CDBS files.

OS CONFIGURATION: N/A

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES: (contain biases and darks unless noted otherwise)

UV01S01A – nominal and off nominal temperature at nominal gain (1.5)

UV01S02A - high temperature (gain 1.5)

UV01S03A – data for reference files (gain 1.5)

UV01S04A – binned format (gain 1.5)

UV01S05 – two-amp read outs (gain 1.5)

UV01S06 – biases only (four amp read outs; gain 1.5)

UV01S11 – nominal and off-nominal temperature at gain=1

UV01S13 – data for dark & bias reference files (gain 1.0)

UV01S16 – biases only (gain 1.0)

DETAILED TEST PROGRAM:

A series of bias-level and dark frames will be taken with the detector temperature set to five values: T_{nom} , the nominal on-orbit operating temperature (-83°C); $T_{nom} \pm 3 \text{ K}$; $T_{nom} + 6 \text{ K}$; and $T_{nom} + 15 \text{ K}$. The off-nominal temperatures listed are only approximate; final values will be determined during the instrument testing. Data will also be taken at T_{nom} with 2×2 and 3×3 binning as well as 2-amp read outs (binned & unbinned) to verify performance under those configurations.

To maximize exposure-taking efficiency, SMS's with unbinned images are designed with 2 biases at the start, followed by dark/bias pairs. The first two biases fill the buffer and while they are read out, a dark exposure is occurring in parallel. Each dark is followed by a bias; each dark/bias pair fills the buffer again; the read out occurs in parallel to any subsequent dark. This technique of image pairing could be applied to other SMSs which contain long exposures, such as narrowband flatfields, to efficiently accumulate extra biases while minimizing overhead time. To acquire any additional biases needed to construct a UDF-like reference file, one SMS is dedicated to only biases. SMS script UV01S04A is written to make best use of the read out overhead times as well: a set of 8 biases (binned 2×2 ; 18 for 3×3 binning) are taken before every binned dark, as the bias read outs can occur during the dark exposure.

EXPOSURES:

SMS	exptime (sec.)	detector temperature	comment
UV01S01A	2x0	T_{nom}	2 biases
	1000, 0		dark + bias
	3000, 0		dark + bias
UV01S01A	2x0	$T_{nom} \pm 3, +6$	2 biases (same SMS as used for T_{nom})
	1000, 0		dark + bias
	3000, 0		dark + bias
UV01S02A	2x0	$T_{nom} + 15$	2 biases
	600, 0		dark + bias
	1000, 0		dark + bias
UV01S03A	2x0	T_{nom}	data for CDBS dark & bias files
	3x (3000, 0)		dark + bias
UV01S04A	2x(8x0, 1x1000)	T_{nom}	2×2 binning
	2x(18x0, 1x1000)		3×3 binning
UV01S05	4x(0,1000)	T_{nom}	one pair each for AC, AD, BC, BD read outs
	8x(0)		2×2 , 3×3 binned bias in each 2-amp read out

	2x(0)		SMS starts and ends with ABCD bias
UV01S06	10x0	T _{nom}	images for UDF-like superbias

FREQUENCY/No. of ITERATIONS:

To run during both ambient and T/Vac:

Three cycles of UV01S01A at nominal temperature

Two cycles of UV01S01A at each detector temperature setting (6 cycles total)

Two cycles of UV01S02A (high temp)

Two cycles of UV01S04A (binned images)

Three cycles of UV01S05 (2-amp read outs)

To run during T/Vac only:

Three cycles of UV01S03A (for reference files)

TBD cycles of UV01S06 (only biases) Note: about 300 full frame biases will be needed to generate a UDF-like superbias. As discussed in the Detailed Test Program section above, biases can be acquired most efficiently when interleaved, if possible, with long exposures being taken in other UVIS proposals. If the combined count of biases from such other proposals along with UV01S01/S03/S05 images yields less than the required 300 images, this bias-only SMS can be used to acquire the rest.

TOTAL ELAPSED TIME:

UV01S01A – 1.9 hours

UV01S02A – 1.3

UV01S03A – 3.6

UV01S04A – 3.9

UV01S05 – 3.3

UV01S06 – 1.3

UV01S11 – 1.9

UV01S13 – 3.6

UV01S16 – 1.3

VARIANTS:

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or small-scale structure. The background level on the overscan should be about 2500 DN, with the signal level in image area of darks being only a few DN, at most, higher.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis.

The analysis procedures will involve measurement of basic image statistics (dark levels and the distribution of noise on a pixel-by-pixel basis); generation of histograms; plotting results as function of time to search for any trends; and stacking images for the generation of a reference files. Dark frames from the system monitor (3.9.2) may also be included if taken under suitable conditions.

TEST RESULTS AND DATA PRODUCTS:

Darks:

- Tabulated dark rates vs temperature (for the instrument handbook):

- Hot pixel population characteristics (as a histogram for instrument handbook, lists for WWW).
- List of bad pixels for CDBS table (BPIXTAB).
- At nominal operating detector temperature only, T/V dark reference files are needed for CDBS, full-frame and binned modes. Assuming system readnoise of $4\text{ e}^-/\text{pix/read out}$, a full-frame CDBS file generated from the eleven unbinned 3000 s darks will have S/N of ~ 0.07 and ~ 4 per pixel for detectors with lowest and highest dark current, respectively.

Bias:

- Tabulated bias levels as function of temperature and as a function of gain. Summary of any bias frame trends at T with time.
- Average bias levels needed for CDBS CCD characteristics table (CCDTAB).
- Overscan areas defined for overscan region table (OSCNTAB).
- Initial TV superbias file needed for CDBS, in full-frame and binned modes. A UDF-like (unbinned) superbias will also be constructed from the accumulated biases taken via all UVIS proposals. Noise in the TV full-frame CDBS bias is expected to be on the order of 1 e^- , assuming no structure is present in the bias and that the system readnoise is $\sim 4\text{ e}^-$.

SMOV/ON-ORBIT FOLLOW-UP:

SMOV: a series of bias-level and dark exposures will be taken only at the operating temperature, unless circumstances dictate changes in T_{nom} .

On-orbit: bias and dark frames will be taken regularly at T_{nom} for a set exposure time to monitor performance and provide calibration files for the pipeline.

ADDITIONAL COMMENTS:

Data and analysis results obtained during previous WFC3 ambient and T/Vac science calibration campaigns should be available for comparison. Single amp read outs are obtained as part of the subarray test (3.1.11).

SMS HISTORY:

UV01S01: Ran in TV1.

UV01S01A: Optimized version for TV2.

UV01S02: Created for TV1, but never run.

UV01S02A: Optimized version for TV2.

UV01S03: Ran in TV1.

UV01S03A: Optimized version for TV2.

UV01S04: Ran in TV1.

UV01S04A: Optimized version for TV2.

UV01S05: Created for TV2.

UV01S06: Created for TV2.

UV01S11: Created for TV2.

UV01S13: Created for TV2.

UV01S16: Created for TV2.

2.2 UVIS02: Charge Transfer Efficiency

CALIBRATION TEST#: 3.1.2

TITLE: Charge Transfer Efficiency (CTE) characterization

CATEGORY: Science Calibration

P.I.: M. Robberto

IPT REVISION DATE: 4 June 2003, October 2006 (pre-TV2)

REVISION HISTORY

- 27 August 2003: changed point source pattern from 5x5 on subarray to the standard 16 points across the entire field of view; changed the 3x3 pattern to 4 points at the corners of each CCD (“2x4 pattern”); changed the 30,000e, 5x5 pattern to 30,000e, 2x4 pattern. (mr)
- October 2006: reduced the number of point sources to 10: 4 corners of each detector plus for middle points at the bottom (serial register side). Changed point sources to subarrays. UV02S04-S06 are now identical except for the illumination.
- February 2007: Howard B. found that EPER flats cannot be taken with external illumination. Illumination changed to internal CALSYS.

PURPOSE:

To verify that the charge transfer efficiency meets the CEI specifications for a range of detector temperatures

PRIORITY:

Medium priority for flat field EPER measurements;
Low priority for point source images.

CEI SPECIFICATION(s):

4.6.9: “CTE testing shall be performed both with radioactive (on the ground) and light sources. Performance requirements are specified in Table 4-9. The required charge losses are across 2048 under zero background conditions (i.e. independent of the number of sources on the detector). In addition, ground testing shall characterize the performance at 50 and 100 electrons per pixels signal level.”

Table 4.9

Signal level	At launch		After 5 years	
	Uncorrected loss	Correctable to	Uncorrected loss	Correctable to
300 e ⁻ /pixel	<3%	1%	<10%	2%
3,000 e ⁻ /pixel	<2%	<1%	<5%	1%
30,000 e ⁻ /pixel	<1%	<1%	<3%	<1%
1620 e ⁻ /pixel	.99999/pixel (5.9)		.99995/pixel (at 2.5 years)	

DETECTOR:

Flight build detector UVIS#2 at standard gain setting ($1.5 \text{ e}^-/\text{DN}$); standard read-out through all four amps ABCD simultaneously for full frame measurements. Subarray readout from selected amplifier for point source measurements.

BACKGROUND:

Charge transfer efficiency in CCD detectors degrades on orbit due to damage by energetic cosmic rays. These measurements are designed to ensure that the WFC3 flight detectors meet the performance specifications at launch. Baseline measurements have been made during testing at the GSFC DCL. The expectation is that CTE degradation will not be measurable at this stage during TV.

HARDWARE REQUIREMENTS:

The UVIS flight detector installed, detector temperature set to nominal and controlled to an accuracy of 1° C . CASTLE OS will provide point source images to be placed on pre-determined locations on the detector.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to determine the image profile across the trailing overscan region, and to measure the profile of point-source images.

OS CONFIGURATION:

Point source images will be taken using the UV fibers to feed to integrating sphere. The flux will be adjusted to the appropriate levels using neutral density filters at the monochromator source. Point source images will be taken with the HeNe laser and single-mode fiber.

SITS COMMAND MODE: SMS**SITS SMS/OS SCRIPT NAMES:**

UV02S01: EPER flat fields

UV02S04: Point sources: standard 10 point pattern, 300e illumination

UV02S05: Point sources: standard 10 point pattern, 3000e illumination

UV02S06: Point sources: standard 10 point pattern, 30000e illumination

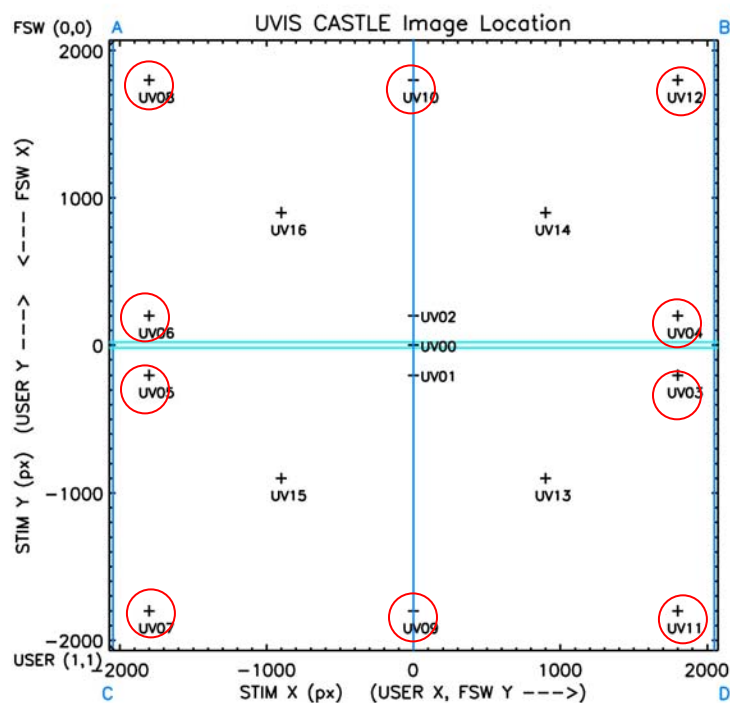
DETAILED TEST PROGRAM:

Flat field images will be taken using different filters with the detector operating at T_{nom} .

Exposures will be taken to reach flat field illumination with 5 different signal levels: 3000, 1000, 500, 250 and 100 e^- . The CTE of the detector is determined by measuring the profile into the trailing overscan region (EPER measurement technique); low CTE will result in significant residual charge and a less sharp profile. These data will provide measurement of both serial and parallel CTE. However, the expectation is that CTE should be sufficiently high that any effects are negligible.

In addition, point source images will be taken at three different signal levels ($\sim 300 \text{ e}^-$, 3000e and 30000e total) at the 10 standard positions on the WFC3 detectors marked in the figure with a red circle. The exposures are repeated 3 times alternating the amplifiers in order to sample any drift in the CASTLE illumination output.

Note: the exposure time has been estimated using CASTLE ETC V.1.5; the integration time has been found by dividing the target flux in ELECTRONS (e.g. 3000) by the amount of e/s/pix provided by the CASTLE ETC in the “EXP time to S/N” box (e.g 122.9 e/s/pix).



EXPOSURES:

Name	SMS	OS Configuration	Filter	Exp.time (secs)	Comments
UV02A	UV02S01	None – Internal	F280N	11	100 e ⁻
			F390M	25	250 e ⁻
			F390M	50	500 e ⁻
		None – Internal	F438W	8.5	1000 e ⁻
			F438W	25	3000 e ⁻
UV02S04	UV02S04	Tungsten/double-UVIS mode/200mic UV, ND4 attenuation	F606W	~27.9	10 point pattern 10 subarrays. 300 e ⁻ at peak
UV02S05	UV02S05	Tungsten/double-UVIS mode/200mic UV, ND1 attenuation	F606W	~20.9	10 point pattern 10 subarrays. 3000 e ⁻ at peak
UV02S06	UV02S06	Tungsten/double-UVIS mode/200mic UV, ND4 attenuation	F606W	~24	10 point pattern 10 subarrays. 30000 e ⁻ at peak

FREQUENCY/No. of ITERATIONS:

Two cycles of flat field measurements (UV02S01). One cycle each of point source measurements (UV02S04, UV02S05, UV02S06)

The full test will be undertaken during both the ambient and T/Vac science calibration campaigns.

TOTAL ELAPSED TIME:

UV02S01 – 1.7 hours

UV02S04 – 1.6

UV02S05 – 1.6

UV02S06 – 1.6

VARIANTS:

Serial and parallel CTE could be determined from point source images taken as part of the optical alignment procedure and as part of the geometric distortion calibration (UVIS10/3.3.2).

ANALYSIS:**TEST RESULTS AND DATA PRODUCTS:**

Measure (upper limit) of serial pre-launch serial and parallel CTE

SMOV/ON-ORBIT FOLLOW-UP:

CTE will be measured using both EPER techniques and flat field images, and from stellar profiles.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the ambient and T/Vac science calibration campaigns.

SMS HISTORY:

UV02S01: Prototype created for TV#1 but never run. Updated for TV#2.

UV02S04: Prototype created for TV#1 but never run. Updated for TV#2.

UV02S05: Prototype created for TV#1 but never run. Updated for TV#2.

UV02S06: Prototype created for TV#1 but never run. Updated for TV#2.

2.3 *UVIS03: Gain characteristics*

CALIBRATION TEST#: 3.1.4

TITLE: Gain as a function of detector temperature

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: Sept 2003; Apr 2004; Oct 2006

PURPOSE:

Measure the relative gain of the WFC3 UVIS flight detectors as a function of temperature, to provide background data should it be necessary to operate at different settings on-orbit.

PRIORITY:

High for measurements at T_{nom} .

Medium for measurements at off-nominal temperatures.

CEI SPECIFICATION(s):

4.6.7 - Minimum full well capacity of 50,000 e^- per pixel with goal of 85,000 e^- .

4.10.2.4 - Four selectable gains shall be available for the UVIS detectors (nominally 1, 1.5, 2, and 4 e^- /DN).

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e^- /DN); standard read-out through all four amps ABCD simultaneously.

BACKGROUND:

The baseline gain characteristics of the Marconi flight CCD detectors have been measured at the GSFC DCL. This test is designed to verify the gain settings with the flight detector integrated into the WFC3 system.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed, with the detector temperature controlled to an accuracy of 1° C. The CASTLE OS should be capable of providing flat field illumination, with the flux level monitored to an accuracy of better than 5%.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to measure image statistics, generate histograms, and ratio images as well as visually inspect images to look for any unexpected features or patterns.

OS CONFIGURATION:

Flat field images will be taken with the monochromator in single mode, using the VISIR fibers to feed to integrating sphere. No neutral density filters are required.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

UV03S01 – unbinned readouts

UV03S02 – 2x2 binned readouts

UV03S03 – 3x3 binned readouts

DETAILED TEST PROGRAM:

UV03S01 - A pair of flat fields, bracketed by a pair of biases, will be taken through the F606W filter at each of the four available gain settings for the UVIS channel followed by a repeat set at gain=1 to verify that results are stable from the beginning to the end of the test. Exposure times are chosen to achieve ~40K e⁻ per pixel. The measurements will be taken at four detector temperatures: T_{nom}; T_{nom}+/- 3 K; and T_{nom} + 6 K, to match the detector temperatures from UVIS01 dark countrate measurements.

UV03S02/UV03S03 – These consist of the same image sequence as UV03S01 but images are taken in binned mode (2x2 and 3x3, respectively) and exptimes are set to achieve 40K e⁻ per binned pixel.

EXPOSURES:

OS Configuration	filter	gain	num exp	filetype
N/A	N/A	1.0	1	bias
QTH lamp/mirror/VISIR flat/ no ND filter	F606W	1.0	2	flat
N/A	N/A	1.0	1	bias
N/A	N/A	1.5	2	bias
QTH lamp/mirror/VISIR flat/ no ND filter	F606W	1.5	2	flat
N/A	N/A	1.5	1	bias
N/A	N/A	2.0	1	bias
QTH lamp/mirror/VISIR flat/ no ND filter	F606W	2.0	2	flat
N/A	N/A	2.0	1	bias
N/A	N/A	4.0	1	bias
QTH lamp/mirror/VISIR flat/ no ND filter	F606W	4.0	2	flat
N/A	N/A	4.0	1	bias
N/A	N/A	1.0	1	bias
QTH lamp/mirror/VISIR flat/ no ND filter	F606W	1.0	2	flat
N/A	N/A	1.0	1	bias

FREQUENCY/No. of ITERATIONS:

One cycle of UV03S01, UV03S02, UV03S03 at each temperature setting: T_{nom}, T_{nom}+/- 3 K, and T_{nom} + 6K; temperatures should match those taken for UV01S0* (dark countrates). The full test should be performed during both the ambient and T/Vac science calibration campaigns

TOTAL ELAPSED TIME:

UV03S01A – 2.9 hours

UV03S02 – 1.1

UV03S03 – 0.7

VARIANTS: none

QUICK-LOOK VERIFICATION:

Each exposure must be inspected visually – there should be no significant non-uniformities or structure. The signal level on the chip should be $\sim 40K\ e^-$ for flat fields. The raw background level on the overscan should be $\sim 2500\ DN$.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. The flat field images taken at each gain setting will be inspected visually for irregularities and anomalies, bias-subtracted and combined. The ratios between these frames will provide the relative gain settings.

TEST RESULTS AND DATA PRODUCTS:

Tabulated gain ratios vs temperature for WFC3 Instrument Handbook.

Gain values at nominal temperature for each amplifier are needed for the CCD characteristics reference CDBS table (CCDTAB). Those values will be derived using the ratios measured in this test in conjunction with absolute gain values derived from the Linearity test (UVIS04/3.1.7).

Placeholder or dummy bias CDBS reference files will be constructed for non-default gains (default gain may need to be changed to 2, particularly if CCD40/50, with readnoise $\sim 4.5e^-$, are flown).

SMOV/ON-ORBIT FOLLOW-UP:

SMOV and on-orbit: the relative gains should be verified at T_{nom} using either flat fields taken with the internal lamps or images of standard star fields..

ADDITIONAL COMMENTS:

Relevant images taken by the DCL during detector-level tests and analyses of these data should be available for comparison during the ambient and T/Vac science calibration campaigns. Temperatures for these procedures should match temperatures used in UV01S0* (dark countrates).

SMS HISTORY:

UV03S01: Ran in TV1.

UV03S01A: Optimized for TV2.

UV03S02: Created for TV2.

UV03S03: Created for TV2.

2.4 UVIS04: Detector linearity – absolute response

CALIBRATION TEST#: 3.1.7A

TITLE: Linearity of response of the WFC3 UVIS CCD detectors

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: July 2003; validated Sept 2003; revised May 2004; Nov 2006

PURPOSE:

Verify that the UVIS detectors meet the CEI specification for linear response, determine well depth at onset of non-linearity, and measure the response curve through saturation. This test uses a point source to determine absolute values on a quadrant-by-quadrant basis; areal variations in response are addressed in UVIS05.

PRIORITY: High

CEI SPECIFICATION(s):

4.6.8: Linear response to better than 5% (correctable to <0.3%) over the range 100 e⁻ to 50000 e⁻.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through each of amps A, B, C and D.

BACKGROUND:

The baseline characteristics of the Marconi flight CCD detectors have been measured by the GSFC DCL. The flight CCDs are expected to show linear response over most of the dynamic range. This test aims to verify the behavior of the detectors once they are integrated into the full WFC3 system. Detector linearity is expected to be wavelength independent, so measurements are made at only one wavelength.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed, and the detector temperature should be controlled to an accuracy of 1° C. The OS should be capable of monitoring the incident flux from the 200-micron point target to an accuracy of better than 1%, and should be capable of placing that source on fiducial locations on the UVIS CCD.

SOFTWARE REQUIREMENTS:

IRAF and/or IDL profile-fitting routines to determine image profiles and total fluxes, basic image processing tasks to measure the pixel to pixel linear response range as a function of input flux.

OS CONFIGURATION:

The 200-micron target will be used in conjunction with the monochromator, operating in double mode (13 nm bandwidth) at a wavelength of 555 nm. This narrowband setting is essential to ensure that the OS flux monitor measures all of the flux seen by the WFC3 detector. Neutral density filters will be used

to adjust the flux level to the appropriate levels, and the incident flux will be measured via flux cals using the OS flux monitor.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

UV04S01C UV04S02 UV04S03 UV04S04 - unbinned exposures (see table) for amps A,B,C,D
UV04S05 UV04S06 UV04S07 UV04S08 - 2x2 + 3x3 binned exposures for amps A,B,C,D

DETAILED TEST PROGRAM:

A series of point-source images are taken covering the full range of detector ADU levels. The target is centered on each quadrant of the UVIS CCD flight detector, with the appropriate amplifier used to read out the 400x400 sub-array that includes the target image (binned exposures are read out through all four amps, as binned subarrays are not an allowed mode). The exposure times listed in the table below are based upon exposure levels observed during TV1. Reference bias frames will be taken at the start and end of each set of image data. Flux cals are taken about every 5 exposures for images $<1000e^-$ and about every 6 exposures for those $>1000e^-$. As an additional check of the CASTLE fluxes, an extra exposure is added before changing ND filter. One proposal per quad is used for the unbinned data sets while quads in the binned proposals are covered in a staggered fashion to avoid any saturation effects (that is, S05 covers 2x2 and 3x3 binning with the target in quad A and B, respectively, S06 covers 2x2 and 3x3 binning with the target in quad B and C, respectively, etc).

EXPOSURES:

All exposures are taken with QTH lamp, double VIS, VISIR fiber, 13nm bandwidth at 555nm

CASTLE ND filter	filter	exptime (sec)	N _{exp}	comments
N/A	N/A	0	1	reference bias frame
ND4	F555W	2.8	10	$\sim 100 e^-$ fluxcal every 5 exps
ND4	F555W	30.6	10	$1000 e^-$ fluxcal every 5 exps
ND4	F555W	21.9	1	same exptime as next ND3 ($\sim 700 e^-$)
ND3	F555W	21.9	3	$10,000 e^-$, one fluxcal
ND3	F555W	44	1	$20,000e^-$
ND3	F555W	77	3	$35,000 e^-$, one fluxcal
ND3	F555W	12	1	same exptime as next ND2 ($\sim 5500e^-$)
ND2	F555W	12	3	$50,000 e^-$, one fluxcal
ND2	F555W	14.5	3	$60,000 e^-$
ND2	F555W	16.9	3	$70,000 e^-$, one fluxcal
ND2	F555W	19.3	3	$80,000 e^-$
ND2	F555W	20.5	3	$85,000 e^-$, one fluxcal
ND2	F555W	21.8	3	$90,000 e^-$
ND2	F555W	23.0	3	$95,000 e^-$, one fluxcal
N/A	N/A	0	1	reference bias

FREQUENCY/No. of ITERATIONS:

One cycle per proposal, UV04S01C and UV04S02 through UV04S08 during both the ambient and T/Vac science calibration campaigns

TOTAL ELAPSED TIME:

UV04S01C, UV04S02, UV04S03, UV04S04 – 2.2 hours each

UV04S05, UV04S06, UV04S07, UV04S08 – 5.2 hours each

VARIANTS:

If time permits, a subset of these tests could be run with alternate gain settings.

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure. The background level on the overscan should be ~2500 DN. For sub-array exposures that include a point source generated by the OS, the point source should lie well within the boundaries of the extracted sub-array.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. The data will be bias-subtracted using standard techniques, and standard software tools will be used to measure the total counts within each point-target image. Linearity is measured by comparing observed profile and total counts to predictions based on incident flux and exposure time.

TEST RESULTS AND DATA PRODUCTS:

Saturation thresholds are needed for CCD characteristics table in CDBS (CCDTAB) and instrument handbook. Gain values at nominal temperature for each amplifier needed for CCDTAB, to be derived by combining gain results from this test with gain ratios from gain vs temperature test (3.1.4). Data from UVIS04 could also be useful for encircled energy analyses.

SMOV/ON-ORBIT FOLLOW-UP:

SMOV & on-orbit: the linearity curve will be verified using observations of standard star fields.

ADDITIONAL COMMENTS:

Relevant images and data analysis results from previous ambient and T/Vac tests should be available for comparison to the new data.

SMS HISTORY:

UV04S01: Created for Ambient Cal #1 (June 2004). Amp A exposures

UV04S01A: Updated OS-Wait times for Ambient Cal #1.

UV04S01B: Updated for TV#1 (optimized exptimes and switch to F555W filter)

UV04S01C: Updated for TV#2 (optimized exptimes; changed subarray sizes)

UV04S02: Created for TV#1, but not run. Updated for TV#2. Amp B exposures.

UV04S03: Created for TV#1, but not run. Updated for TV#2. Amp C exposures.

UV04S04: Created for TV#1, but not run. Updated for TV#2. Amp D exposures.

UV04S05: Created for TV#2. Amps A/B binned.

UV04S06: Created for TV#2. Amps B/C binned.

UV04S07: Created for TV#2. Amps C/D binned.

UV04S08: Created for TV#2. Amps D/A binned.

2.5 UVIS05: Detector linearity – areal behavior

CALIBRATION TEST#: 3.1.7B

TITLE: Linearity of response of the WFC3 UVIS CCD detectors

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: Sept 2003; validated May 2004; revised Nov 2006; revised May 2007

PURPOSE:

Verify that the UVIS detectors meet the CEI specification for linear response, determine the well-depth at onset of non-linearity, and measure the response curve through saturation. Flat fields are used to test for variations in linearity as a function of location on the detector; the absolute response is measured in UVIS04.

PRIORITY: High

CEI SPECIFICATION(s):

4.6.8: Linear response to better than 5% (correctable to <0.3%) over the range 100 e⁻ to 50000 e⁻.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD.

BACKGROUND:

The baseline characteristics of the Marconi flight CCD detectors have been measured by the GSFC DCL. The flight CCDs are expected to show linear response over most of the dynamic range. This test aims to verify the behavior of the detectors once they are integrated into the full WFC3 system. Detector linearity is expected to be wavelength independent, so measurements are made at only one wavelength.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed, and the detector temperature should be controlled to an accuracy of 1° C. The OS should be capable of generating a flat field image covering the full UVIS CCD detectors, uniform to better than 1%.

SOFTWARE REQUIREMENTS:

IRAF and/or IDL profile-fitting routines to determine image statistics and basic image arithmetic to divide flat fields and measure the pixel to pixel linear response range. The absolute response will be calibrated with reference to data from UVIS04.

OS CONFIGURATION:

Flat field images will be taken with the CASTLE monochromator in mirror mode, using the VISIR fiber to feed to the integrating sphere.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

UV05S01B – linearity across FOV, unbinned read outs

UV05S02 – linearity across FOV, 2x2 and 3x3 binned read outs

UV05S03 – absolute gain only

DETAILED TEST PROGRAM:

A series of flat field images will be taken at 11 specific ADU levels, reading the full frame out each time. The OS is used in mirror mode which overfills the wavelength range defined by the F606W. However, this is not a problem for the current test as the intent is to measure the relative non-linearity as a function of position over the full UVIS CCDs. The absolute calibration of the linear response is determined from the point target images taken in UV04. Exposure times are chosen based upon exposure levels measured during the previous T/Vac; an additional exptime was added to extend the high end of the exposure range and fully cover the linearity turnover point in all amps. The low and mid-level flats are repeated at the end of the SMS to verify the CASTLE lamp stability. The following table lists exptimes for unbinned images; times for binned images are shortened to 1/4 and 1/9 of these values (2x2, 3x3 modes, respectively).

EXPOSURES:

OS configuration	filter	exptime (sec)	N _{exp}	comments
N/A	N/A	0	1	reference bias
Mirror mode, QTH, VISIR flat, ND 2	F606W	20	10	~100 e ⁻ median level
Mirror mode, QTH, VISIR flat, ND 1	F606W	20	10	1,000 e ⁻
Mirror mode, QTH, VISIR flat, no ND	F606W	20.4	3	10,000 e ⁻
	F606W	40	3	20,000 e ⁻
	F606W	100	3	50,000 e ⁻
	F606W	120	3	60,000 e ⁻
	F606W	130	3	65,000 e ⁻
	F606W	140	3	70,000 e ⁻
	F606W	150	3	75,000 e ⁻
	F606W	160	3	80,000 e ⁻
	F606W	170	3	85,000 e ⁻
	F606W	180	3	90,000 e ⁻
N/A	N/A	0	2	reference biases
Mirror mode, QTH, VISIR flat, no ND	F606W	20.4	1	10,000 e ⁻
Mirror mode, QTH, VISIR flat, ND 1	F606W	20	1	1,000 e ⁻
Mirror mode, QTH, VISIR flat, ND 2	F606W	20	1	100 e ⁻ median level

FREQUENCY/No. of ITERATIONS:

One cycle of each test is sufficient unless there is an indication the linearity is changing over time. The full test should be undertaken during both the ambient and T/Vac science calibration campaigns.

TOTAL ELAPSED TIME:

UV05S01B – 8.2 hours

UV05S02 – 4.6 hours

UV05S03 -

VARIANTS:

UV05S03 contains flatfield exposures at a subset of the UV05S01 signal levels, which can be used to derive the absolute gain of the detector (but not linearity).

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure. The signal level on the chip should be 10,000-30,000 counts for flat fields. The background level on the overscan should be ~2500 DN.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. Individual frames will be bias-subtracted using standard techniques, combined, and ratioed against each other. Visual inspection and standard software tools will be check for any irregularities as a function of position on each set of images.. Linearity is measured via standard $\log(\text{DN})$ vs $\log(\text{exptime})$, comparing observed profile and total counts to predictions based on incident flux and exposure time.

TEST RESULTS AND DATA PRODUCTS:

Saturation thresholds are needed for CCD characteristics table in CDBS (CCDTAB) and instrument handbook.

Gain values at nominal temperature for each amplifier needed for CCDTAB, to be derived by combining gain results from this test with gain ratios from gain vs temperature test (3.1.4).

SMOV/ON-ORBIT FOLLOW-UP:

SMOV & on-orbit: the linearity curve will be verified using observations of standard star fields.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained during the previous ambient and T/Vac science calibration campaigns should be available for comparison to the new results.

SMS HISTORY:

UV05S01: Used in ambient calibrations, June 2004.

UV05S01A: Optimized exptimes for TV#1.

UV05S01B: Added final set of low-level exposures and optimized exptimes for TV#2.

UV05S02: Created for TV#2 to get data for binned modes.

UV05S03: Created for TV#2 to get absolute gain only.

2.6 *UVIS06: CTE mitigation: charge injection*

CALIBRATION TEST#: 3.1.9

TITLE: CTE mitigation through charge injection

CATEGORY: Science Calibration

P.I.: M. Robberto

IPT REVISION DATE: 4 June 2003, Oct 2006

REVISION HISTORY:

- Discrete injection test is every 10th, 17th, and 25th row, 5 frames. (mr)
- Changed names of SMS's from UV02S02, UV02S03 to UV06S01, UV06S02 (mr, Oct. 2006)

PURPOSE:

To verify that the charge injection schemes implemented for CTE mitigation are operational.

PRIORITY: Medium

CEI SPECIFICATION(s):

4.6.9: CTE testing shall be performed both with radioactive (on the ground) and light sources

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard readout through all four amps ABCD simultaneously.

BACKGROUND:

Charge transfer efficiency in CCD detectors degrades on orbit due to damage by energetic cosmic rays. The effects can be reduced by artificially 'filling in' electron traps produced by the CR's, either by illuminating the detector briefly before or after each exposure (pre- or post-flash), or by injecting ~10⁵ electrons into specific rows of the CCD. WFC3 has chosen to implement the latter procedure. The scheme has been characterized during detector testing by the DCL; the current measurements are merely to verify that this scheme operates in the integrated system.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed, and the detector temperature should be controlled to an accuracy of 1° C.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to permit visual inspection of the charge-injected images, and basic image statistics of the rows selected for charge injection.

OS CONFIGURATION:

N/A

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

UV06S01 (former UV02S02): Charge injection: full field

UV06S02 (former UV02S03): Charge injection: discrete rows

DETAILED TEST PROGRAM:

A set of three full-frame BIAS images will be taken in the full field charge-injection mode. In the discrete row injection, charge will be injected every 10th, 17th, and 25th row in the device, and 5 frames will be taken.

EXPOSURES:

Name	SMS	Exposure time (sec)	N _{Exp}	Comments
UV06A	UV06S01	0	3	Full field charge injection
UV06B	UV06S02	0	5	Discrete row charge injection, 10 rows
			5	Discrete row charge injection, 17 rows
			5	Discrete row charge injection, 25 rows

FREQUENCY/No. of ITERATIONS:

One set of measurements. The full test will be undertaken during both the ambient and T/Vac science calibration campaigns.

TOTAL ELAPSED TIME:

UV06S01 – 0.5 hours

UV06S02 – 2.0 hours

VARIANTS:

A more extensive series of measurements could be taken to measure repeatability, using the CASTLE OS to generate a point source image.

ANALYSIS:

Tasks in IRAF/IDL

TEST RESULTS AND DATA PRODUCTS:

Verification of charge injection mode operation for the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

These measurements will be repeated during SMOV to verify operational parameters.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the ambient and T/Vac science calibration campaigns.

SMS HISTORY:

UV06S01: Prototype created for TV#1, but never run. Updated for TV#2.

UV06S02: Prototype created for TV#1, but never run. Updated for TV#2.

2.7 UVIS07: Subarray dark count rates and bias

CALIBRATION TEST#: 3.1.11

TITLE: Dark count rate and read noise for UVIS subarrays

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: July 2003; validated Sept 2003; revised Nov 2006

PURPOSE:

Verify that the darkcount rates and readnoise levels of the UVIS CCD detectors operated in subarray mode are within the CEI specifications and are not significantly different from those of full-frame images, obtained at the nominal operating temperature.

PRIORITY: Medium

CEI SPECIFICATION(s):

4.6.4: Dark current $<20 \text{ e}^-/\text{pix}/\text{hr}$ at -83C

4.7.1: Detector thermal control - nominal temperature -83 (goal -90)

setpoints -50 to -100C to be provided

absolute temperature measurements accurate to $\pm 1\text{C}$ at TV/SMOV

4.6.14: Single row bias repeatable to 2 e^- RMS and bias level for entire array correctable to 1 e^- RMS.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting ($1.5 \text{ e}^-/\text{DN}$); standard read-out through amps A, B, C and D individually.

BACKGROUND:

The baseline characteristics of the Marconi CCD detectors have been measured by the GSFC DCL during detector-level testing (primarily the flight spare, CCD166). Those measurements include a determination of the bias level and dark count rate of the flight-candidate CCDs operated both in full-frame and in subarray mode. The expectation is that the noise characteristics of these devices should not change significantly between different readout modes. This test is designed to verify that expectation.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed, and the detector temperature should be controlled to an accuracy of 1°C . Sub-array operations should be implemented.

SOFTWARE REQUIREMENTS:

Standard IRAF and/or IDL routines should be sufficient. Display images to look for any patterns in the biases and darks; fourier analysis may be required to evaluate any structure evident in the data frames. Standard statistics tasks to evaluate bias and dark levels.

OS CONFIGURATION: N/A

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

Quad center subarrays: UV07S01 (amp A), UV07S02 (B), UV07S03 (C), UV07S04 (D)
UV07S05 – subarrays sampled along FOV edge

DETAILED TEST PROGRAM:

A series of bias-level and dark frames will be taken at the default gain setting with the detector temperature set to the nominal on-orbit operating value. Subarray images will be taken centered on each quadrant of the array, as well as a 2Kx4K image of the individual CCD, one SMS per quadrant. Subarray sizes are chosen to cover those most commonly used in TV exposures. An additional SMS is dedicated to sampling subarray sections along the edges of the WFC3 FOV: one image as far into each corner as possible and an image along the FOV edge partway between each pair of corners, including overscan areas when possible.

EXPOSURES:

name	format	exptime (sec)	comment
UV07S01-2-3-4	2Kx4K	0, 200	full CCD: bias + short dark
	1Kx1K	0, 200	start of subarrays at quad centers
	800x800	0, 200	
	400x400	0, 200	
	200x200	0, 200	
	64x64	0, 200	
UV07S05	800x800	0, 200	positions around FOV edge
	400,400	0	biases only
	64x64	0	biases only

FREQUENCY/No. of ITERATIONS:

Two iterations for each SMS, in both ambient and T/Vac science calibration campaigns.

TOTAL ELAPSED TIME:

UV07S01 – 0.7 hours

UV07S02 – 0.7

UV07S03 – 0.7

UV07S04 – 0.7

UV07S05 – 0.9

Total for 2 iterations each: 7.4 hours

VARIANTS:

None, assuming no problems are found in subarray biases.

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure. The bias level should be ~2500 DN with less than a few DN dark signal.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. More detailed analysis will involve measurement of basic image statistics (dark levels and the distribution of noise on a pixel-by-pixel basis); generation of histograms; plotting results as function of time to search for any trends; and stacking images for generation of pipeline reference files.

TEST RESULTS AND DATA PRODUCTS:

Tabulated bias and dark rates for subarrays, to compare to full-frame values.

Subarray bias and dark reference files for CDBS. If subarray bias and dark are similar to full-frame, can use the full-frame file to generate the needed subarray CDBS files; otherwise, the small number of frames taken in this test will be used to generate a placeholder until SMOV data is taken.

SMOV/ON-ORBIT FOLLOW-UP:

SMOV: images will be taken as a comparison to T/Vac dataset. If subarray biases and/or darks are significantly different from full-frame, sufficient subarray data will need to be taken to generate acceptable CDBS files.

On-orbit: calibration images will be taken to support use by calibration teams or GO programs.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

UV07S01: Created for TV#1, but never run. Updated for TV#2.

UV07S02: Created for TV#1, but never run. Updated for TV#2.

UV07S03: Created for TV#1, but never run. Updated for TV#2.

UV07S04: Created for TV#1, but never run. Updated for TV#2.

UV07S05: Created for TV#2 to more fully investigate bias level in subarrays.

2.8 UVIS08: Shutter performance

CALIBRATION TEST#: 3.2.1/3.2.2

TITLE: UVIS shutter performance

CATEGORY: Science Calibration

P.I.: B. Hilbert

REVISION DATE: 4 April 2006

PURPOSE:

.Measure the UVIS shutter's accuracy and shading effects from the shortest allowed exposure times (0.5 sec) to significantly longer exposures with external flat field exposures

PRIORITY: High

CEI SPECIFICATION(s):

4.5: UVIS Shutter performance

4.5.1: Exposure times should be supported from 0.7 seconds to 60 minutes

4.5.2: The shutter should be repeatable to better than 0.01 seconds.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously.

BACKGROUND:

The shutter consists of two blades (or sides). It rotates in one direction only, so consecutive exposures are alternately shaded by Side 1 and Side 2. There are two shutter properties that require calibration: (1) accuracy: Does the shutter remain open exactly for the commanded integration time? Are the deviations between the "effective" and commanded exposure times a function of the exposure time and shutter blade? What is the necessary correction in the count rates? (2) shading: does the finite time of passage of the shutter over the chip leave residual streaks or features on the image? At what exposure times does shading become important and to what level?

These two properties must be calibrated as a function of the shutter side (or blade) and of the commanded exposure time. Both are tested by comparing short (<1 sec) exposures with long exposure flat fields. Any deviations will be relatively more important and easily detectable at the shortest exposures. No differences are expected between the shutter blades.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed, and the detector temperature should be controlled to an accuracy of 1° C.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines are needed to find the ratio and perform basic statistics (counts, median, mean, sigma).

OS CONFIGURATION:

Diffuse illumination from a broadband source; mirror + Xe lamp is predicted to give a countrate of ~2023 photons/pixel/second with no ND filters. Since we will use 3x3 on-chip binning, source attenuation with well-calibrated neutral density filters will be required for all exposures.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

UV08S01B/UV08C01B

DETAILED TEST PROGRAM:

Shading effects will be identified by dividing a short-exposure flat field with a long-exposure flat field; shutter linearity and accuracy will be determined by comparing the relative flux levels for a series of flat fields spanning a range of exposure times and of a source of known intensity. Since the primary requirement is verifying overall accuracy, small-scale variations are not important and data will be taken using 3x3 on-chip binning. This demands source attenuation for all exposures. The 4 second-duration exposures are repeated with the higher ND required for the reference 30-second exposures. Use of the F438W filter should limit the fringing effects observed in this program during ambient and T/V 1 testing.

EXPOSURES:

Name	Filter	OS Configuration	Exp. time (s)	N_{exp}	Comments
UVIS08	F438W	Xe/mirror/IRIS/ND 0	0.5	32	~6070 cts/bin
	F438W		0.7	32	
	F438W		0.8	32	
	F438W		1.0	8	~12140 cts/bin
	F438W		1.2	8	
	F438W		1.4	8	
	F438W		2.0	8	
	F438W		4.0	16	~48500 cts/bin
	F438W	Xe/mirror/IRIS/ND 1	4.0	8	~4770 cts/bin
	F438W		30.0	8	~35800 cts/bin

FREQUENCY/No. of ITERATIONS:

One cycle.

Measurements made in both ambient and T/Vac science calibration campaigns.

TOTAL ELAPSED TIME:

UV08S01B – 2.3 hours

VARIANTS:

ANALYSIS:

Differential illumination due to shutter shading is minimal on the longest exposure images, which therefore provide a reference 'ground truth' for the shorter exposures. The latter frames will be ratioed against the 30-second exposures, if necessary, combining the separate images at the shortest exposure times to give sufficient signal-to-noise. Simple image statistics will be used to identify any significant shading as a function of exposure time, and to verify the linearity and accuracy of the shutter response times. These data should also prove useful for verifying CTE performance at a variety of flux levels. Randomizing the exposure times throughout the SMS will help to track any variability in lamp output. The 4.0 second exposures will be used to bootstrap between the clear and the ND filters.

TEST RESULTS AND DATA PRODUCTS:

WFC3 ISR 2004-14 gives results of from this SMS in TV-1 testing.

SMOV/ON-ORBIT FOLLOW-UP:

Shutter performance will be verified through observations of standard star fields, notably in 47 Tucanae.

ADDITIONAL COMMENTS:

SMS HISTORY:

UV08S01: Ran in Ambient Cal #1.

UV08S01A: Updated for and ran in TV#1.

UV08S01B: Optimized for TV#2.

2.9 UVIS09: FOV Location and orientation

CALIBRATION TEST#: 3.3.1

TITLE: UVIS field of view size, location and orientation

CATEGORY: Science Calibration

P.I.: M. Stiavelli/T. Brown

REVISION DATE: 4 June 2003; validated 9 Sept 2003

PURPOSE:

To verify the pixel size and to determine the size, location and orientation of the UVIS detectors with respect to the field of view of the WFC3 instrument. An OTA-like point-source image produced by the OS will be moved to known locations on the simulated HST focal plane, and measurement will be made of the position on the detector of the resulting image.

PRIORITY: Medium

CEI SPECIFICATION(s):

4.3.1.1: UVIS plate scale

4.3.1.2.1: UVIS unvignetted field of view

4.8.1: relative orientation of the UVIS and IR fields of view

DETECTOR:

Flight build detector UVIS# 1 at standard gain setting ($1.5 \text{ e}^-/\text{DN}$); standard read-out through all four amps ABCD simultaneously.

BACKGROUND:

A determination of the orientation of the UVIS detectors in the HST V2/V3 co-ordinate system is essential to permit reliable target acquisition on-orbit; confirmation of the unvignetted region within the full FOV of the detectors is essential for accurate photometry. Data obtained during the ground-based calibration campaign will provide initial estimates of both quantities; final calibration will be undertaken during SMOV, using observations of moderate-density star fields.

HARDWARE REQUIREMENTS:

see UVIS 11

SOFTWARE REQUIREMENTS:

Existing IDL (acs_gaussintfit, ms_center, wfc3_tv) or IRAF (display, imexam) tools can display images and measure the PSF centers.

OS CONFIGURATION:

see UVIS 11

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:**DETAILED TEST PROGRAM:**

see UVIS 11

EXPOSURES:

No specific images taken for this procedure. Data taken for procedure UVIS11/3.4.1 will be analysed to verify the detector orientation; data from procedure UVIS20/3.6.1A will allow determination of the area of the FOV subject to less than 5% vignetting.

FREQUENCY/No. of ITERATIONS: N/A**TOTAL ELAPSED TIME:**

see UVIS11

VARIANTS:**ANALYSIS:**

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. Simple PSF-fitting routines can be used to determine the centroids of the point-source images in detector co-ordinates; match against the known input positions permits determination of the detector orientation, platescale and field of view. Vignetting can be estimated through analysis of flat field images, searching for systematic deviations with radial distance from the optical axis (reduced flux with increasing radius).

TEST RESULTS AND DATA PRODUCTS:

Results for detector orientation, plate-scale and vignetting are used in the Instrument Handbook, The detector plate scale is required by the Exposure Time Calculator (ETC), in the SIAF file and other CDBS tables.

SMOV/ON-ORBIT FOLLOW-UP:

A final determination of the detector orientation and of the vignetting function will be made using observations of standard star fields (e.g. 47 Tucanae) obtained during SMOV and in subsequent on-orbit photometric calibration campaigns.

ADDITIONAL COMMENTS:

2.10 UVIS10: Geometric distortion

CALIBRATION TEST#: 3.3.2

TITLE: UVIS Geometric distortion

CATEGORY: Science Calibration

P.I.: M. Stiavelli/T. Brown

REVISION DATE: 4 June 2003; validated 9 Sept 2003

PURPOSE:

To verify the broad characteristics of the geometric distortion of the WFC3 UVIS channel over the field of view. An OTA-like point-source image produced by the OS will be moved to known locations on the simulated HST focal plane, and measurement will be made of the position on the detector of the resulting image.

PRIORITY: Medium

CEI SPECIFICATION(s):

4.3.1.1: UVIS plate scale

4.8.1: relative orientation of the UVIS and IR fields of view

DETECTOR:

Flight build detector UVIS# 1 at standard gain setting ($1.5 \text{ e}^-/\text{DN}$); standard read-out through all four amps ABCD simultaneously.

BACKGROUND:

The optical design of the UVIS channel results in appreciable geometric distortion in the image plane, resulting in a predicted change of $\pm 7\%$ in the pixel scale. These predictions can be tested to some extent during the ground calibration campaign, by determining the image centroids of point sources positioned at pre-determined locations. Since measurements are proposed at only a limited number of positions, the data will not allow derivation of the geometric distortion from first principles, but should be sufficient to verify the optical model.

HARDWARE REQUIREMENTS:

see UVIS 11

SOFTWARE REQUIREMENTS:

Existing IDL (acs_gaussintfit, ms_center, wfc3_tv) or IRAF (display, imexam) tools can display images and measure the PSF centers.

OS CONFIGURATION:

see UVIS 11

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

see UVIS11

DETAILED TEST PROGRAM:

see UVIS11

EXPOSURES:

No specific images taken for this procedure. Data taken for procedure UVIS11/3.4.1 will be analysed to provide the required parameters.

FREQUENCY/No. of ITERATIONS:

Execute once. Repeat if any changes are made to the instrument that would affect the FOV or location/alignment of the chips.

Measurements will be made during both ambient and T/Vac science calibration campaigns.

TOTAL ELAPSED TIME:

see UVIS11

VARIANTS:

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis.

Simple PSF-fitting routines can be used to determine the centroids of the point-source images in detector co-ordinates; match against the known input positions permits determination of the detector orientation, platescale and field of view.

TEST RESULTS AND DATA PRODUCTS:

Results on the geometric distortion will be presented in the Instrument Handbook.

SMOV/ON-ORBIT FOLLOW-UP:

A final determination of the geometric distortion will be made using observations of standard star fields (e.g. 47 Tucanae, NGC 1850) obtained during SMOV.

ADDITIONAL COMMENTS:

2.11 UVIS11: Encircled energy

CALIBRATION TEST#: 3.4.1

TITLE: UVIS encircled energy

CATEGORY: Science Calibration, technical performance

P.I.: G. Hartig

REVISION DATE: 16 July 2003; validated 9 Sept 2003

PURPOSE:

To determine the radial profile of a point source as a function of position on the detector and as a function of wavelength. This will be achieved after the focus and tip/tilt values of the UVIS M1 mirror has been optimized from the detector alignment procedure. Focus will be checked and the inner and outer corrector cylinder positions will be adjusted to optimize the coma correction. Sixteen images will be taken, in a well-spaced grid centered on the nominal aperture, at each of four wavelengths.

PRIORITY: High

CEI SPECIFICATION(s):

4.3.2.1: UVIS channel point source profile (see table)

Specification	Center of FOV	Corner of FOV
core @633nm in 0.25 arcsec diameter	>75% goal: >80%	>75% goal: >80%
core @250nm in 0.25 arcsec diameter	>75% goal: >80%	>75% goal: >80%
wing @633nm in 0.5 arcsec radius	>=88%	>=88%
wing @633nm in 1.0 arcsec radius	>=91%	>=91%
wing @633nm in 2.0 arcsec radius	>=92%	>=92%
wing @633nm in 3.0 arcsec radius	>=93%	>=93%
wing @250nm in 0.5 arcsec radius	>=93%	>=93%
wing @250nm in 1.0 arcsec radius	>=94%	>=94%
wing @250nm in 2.0 arcsec radius	>=95%	>=95%
wing @250nm in 3.0 arcsec radius	>=95%	>=95%

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously. Subarray readout through individual amplifiers.

BACKGROUND:

The encircled energy distribution of a point source provides a key test of the optical quality of the WFC3 UVIS camera. This calibration item will be performed in early measurements at GSFC, using the flight detector. This procedure assumes that the UVIS detector has been previously aligned at its optimal

focus, tilt and orientation. UVIS images will be acquired through the F225W, F336W, F606W and F814W filters to test for chromatic effects. An initial estimate of the relation between input fiber position (on the OS) and spot location on the detector is required.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed and aligned in WFC3. The OS should be capable of placing a fiber-fed point source at the desired field location, with an accuracy of 0.1 arcseconds (2.5 pixels). The fibers should be chosen to give an unresolved point-source image on the detector.

SOFTWARE REQUIREMENTS:

Special IDL EE tools previously developed and successfully used for earlier HST instruments. The relatively large central obscuration (0.46) reduces the expected EE in the core significantly; the expected OTA+WFC3 EE will be estimated from PSF modeling.

OS CONFIGURATION:

Xenon lamp and 5 μ fiber for F225W and F336W, with monochromator set at 250nm and 350nm, respectively, with ~2% passband. HeNe laser, single-mode fiber for F606W and single-mode fiber with 810nm laser diode for F814W.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

uv11s01a, uv11s02a, uv11s03a, uv11s04a

DETAILED TEST PROGRAM:

After a few manually-commanded trial images to set the CASTLE illumination level to achieve the correct exposure (~30k DN in peak px), an SMS will be used to acquire a pair of 200x200 px subarray images at the each of 16 field positions. Separate SMSs will be used for each wavelength/CASTLE set-up. Subarray bias frames will be acquired before each image pair.

EXPOSURES:

The 16 UVIS field point IDs and locations, given in px from nominal field center in User Axis1 (X) and Axis2 (Y), and 200x200 px subarray corners (in FSW coordinates) and readout amplifiers are indicated in the table below:

FPID	dX (px)	dY (px)	Amp	XCOR	YCOR
UV01	0	-200	D	2130	1972
UV02	0	200	A	1770	1972
UV03	1800	-200	D	2130	3772
UV04	1800	200	B	1770	3772
UV05	-1800	-200	C	2130	172
UV06	-1800	200	A	1770	172
UV07	-1800	-1800	C	3730	172
UV08	-1800	1800	A	170	172
UV09	0	-1800	D	3730	1972
UV10	0	1800	A	170	1972
UV11	1800	-1800	D	3730	3772
UV12	1800	1800	B	170	3772

UV13	900	-900	D	2830	2872
UV14	900	900	B	1070	2872
UV15	-900	-900	C	2830	1072
UV16	-900	900	A	1070	1072

The CASTLE source and fiber/aperture for each wavelength, and the WFC3 UVIS filter and initial exposure time estimates are shown below:

Wavelength	Source	Fiber/aper	Filter	Expo (s)
250 nm	Xe	5 μ	F225W	20
350 nm	Xe	5 μ	F336W	10
633 nm	HeNe	SMF	F606W	1
810 nm	LD810	SMF	F814W	1

FREQUENCY/No. of ITERATIONS:

Execute once. Repeat if any changes are made to the instrument that would affect the optical alignment and/or image quality.

Measurements to be made during both the ambient and T/Vac calibration campaigns.

TOTAL ELAPSED TIME:

UV11S01A – 3.3 hours

UV11S02A – 2.5

UV11S03A – 2.3

UV11S04A – 2.2

VARIANTS:

None

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure in the background.

The bias level on the chip should be ~2500 DN with essentially no additional background signal; the point source should lie well within the boundaries of the extracted sub-array.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis.

Determine the centroid and measure the radial intensity profile and encircled energy at specified radii for the point source on each image. The measured positions and positional offsets between the images can also be combined with model predictions, to verify the plate scale, geometric distortion and orientation of the WFC3 UVIS camera and detectors. These data constitute the requirements for test UVIS09,10 (FOV, orientation, and geometric distortion check).

TEST RESULTS AND DATA PRODUCTS:

The encircled energy distribution is included in the WFC3 instrument handbook and used by the ETC.

SMOV/ON-ORBIT FOLLOW-UP:

Observations of standard stars and standard star fields will provide encircled energy/PSF measurements for both SMOV and on-orbit calibration.

ADDITIONAL COMMENTS:

SMS HISTORY:

UV11S01: Ran in Ambient Cal #1.

UV11S01A: Optimized for TV#1. Reuse for TV#2.

UV11S02: Ran in Ambient Cal #1.

UV11S02A: Optimized for TV#1. Reuse for TV#2.

UV11S03: Ran in Ambient Cal #1.

UV11S03A: Optimized for TV#1. Reuse for TV#2.

UV11S04: Ran in Ambient Cal #1.

UV11S04A: Optimized for TV#1. Reuse for TV#2.

2.12 UVIS12: Image stability

CALIBRATION TEST#: 3.4.3

TITLE: UVIS and IR image stability

CATEGORY: Science Calibration, technical performance

P.I.: T. Brown

REVISION DATE: 28 February 2006

PURPOSE:

To verify the optical stability of WFC3 in a changing thermal environment is within the CEI specifications. A series of short exposures of a point source will be obtained over a period of at least 200 minutes, during which time the thermal environment will be varied.

PRIORITY: High

CEI SPECIFICATION(s):

4.3.2.5.1: Image drift shall be less than 10 mas over 2 orbits.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); 400x400 subarray used for imaging.
Flight build detector IR#1 at standard gain setting (2.5e⁻/DN); 512x512 subarray used for imaging.

BACKGROUND:

WFC3 will be subjected to a range of thermal environments on-orbit, with significant variation possible during the course of moderate to long exposures. This test aims to verify the stability of the optical system using a series of point-source images.

HARDWARE REQUIREMENTS:

The UVIS and IR flight detectors should be installed in WFC3 and capable of producing subarray images. The instrument temperature needs to be changed during the drift monitoring.

SOFTWARE REQUIREMENTS:

Existing IDL (acs_gaussintfit, ms_center, wfc3_tv) or IRAF (display, imexam) tools can display images and measure the PSF centers.

OS CONFIGURATION:

The Tungsten lamp with the mirror and 10 micron fiber will be used to provide a point source image at the specific location on the UVIS and IR detectors.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES: UV12S03, UV12C03

DETAILED TEST PROGRAM:

A point source generated by the Tungsten lamp will be placed at the “AF” field point, which can be monitored independently by the CASTLE team using their quad cell. A continuous series of sub-array images will be taken with both the IR and UVIS channels, alternating between a series of 10 UVIS images and a series of 3 IR images, repeated 10 times. The individual exposures will be spaced at approximately 2 minute intervals (determined by the readout and dump time), over a period of 4.1 hours.

EXPOSURES:

Filter	Exposure time	OS Configuration	No. of exposures
F814W	10 seconds	Tu lamp, point-source at AF field point	101
F128N	8 seconds	same	31

FREQUENCY/No. of ITERATIONS:

Execute at hot temperature, cold temperature, during transition from cold to hot, and during transition from hot to cold. Measurements will be obtained during both the ambient and T/Vac science calibration campaigns (but IR data will be unavailable during ambient).

TOTAL ELAPSED TIME:

UV12S03 – 4.7 hours

VARIANTS:

Scripts are also available with longer durations on the UVIS and IR series (i.e., less rapid switching between channels) and also with the CSM partially inserted into the beam (thus providing a measure of the stability isolated to components downstream of the pickoff mirror). Use UV12S01C for one long run of UVIS and then one long run of IR exposures. Use UVIS12S04 for the CSM shadow test.

ANALYSIS:

Simple centroid routines can be used to determine the positions of the point-source images in detector co-ordinates. A script for automatic analysis has been written.

TEST RESULTS AND DATA PRODUCTS:

Results for image stability are reported in the Instrument Handbook.

SMOV/ON-ORBIT FOLLOW-UP:

Repeated observations of moderate-density star fields will verify performance during SMOV. No further on-orbit calibration activities are currently planned.

ADDITIONAL COMMENTS:

SMS HISTORY:

UV12S01: Created for and ran in TV#1.

UV12S01A: Use IR subarray to reduce exposure time. Used in TV#1.

UV12S01B: Do only one set of IR and UVIS exposures. Used in TV#1.

UV12S01C: One set of UVIS then IR. Used in TV#1.

UV12S02: Short version for testing of procedure. Used in Ambient Cal#1.

UV12S03: Switch more rapidly between UVIS and IR channels. Used in TV#1. Reuse for TV#2.

UV12S04: CSM shadow version of test. Used in TV#1.

UV12S05: UVIS only version of test for use in ambient testing.

2.13 UVIS13: PSF Wings and halo

CALIBRATION TEST#: 3.4.4

TITLE: Wings and halo of the UVIS PSF

CATEGORY: Science Calibration

P.I.: G. Hartig

REVISION DATE: 16 July 2003; validated 9 Sept 2003

PURPOSE:

To determine the radial profile of a saturated point source as a function of wavelength. Deep images will be taken with a point source near field center, together with bias frames, at each of four wavelengths.

PRIORITY: High

CEI SPECIFICATION(s):

4.3.2.1: UVIS channel point spread function (see table for UVIS11)

DETECTOR:

Flight build detector UVIS# 1 at standard gain setting ($1.5 \text{ e}^-/\text{DN}$); standard read-out through all four amps ABCD simultaneously.

BACKGROUND:

Extremely bright stellar images produce extended halos. This calibration item will be performed in early measurements at GSFC, using the flight UVIS detector. UVIS images will be acquired through the F225W, F336W, F606W and F814W filters to test for chromatic effects. Deep, core-saturated images will be obtained at a single field point, near field center.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed and aligned in WFC3. The OS should be capable of placing a fiber-fed point source at the desired field location.

SOFTWARE REQUIREMENTS:

Special IDL EE tools previously developed and successfully used for earlier HST instruments. This measurement provides a check for gross scattering or ghosting effects, but will not correctly predict the on-orbit PSF wing profiles, which are expected to be dominated on-orbit by OTA mid-frequency error and in these measurements by scatter in the stimulus optics.

OS CONFIGURATION:

Xenon lamp and 5 μ fiber for F225W and F336W, with monochromator set at 250nm and 350nm, respectively, with ~2% passband. HeNe laser, single-mode fiber for F606W and single-mode fiber with 810nm laser diode for F814W.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

Included in uv11s01, uv11s02, uv11s03 and uv11s04

DETAILED TEST PROGRAM:

A set of 13 exposures will be taken with each filter in the following order: two over-exposed images at about 10 times full well in the core, one dark frame, two over-exposed images at about 100 times full well, and a series of 8 darks. The dark images serve both to flush the detector and to check for residual images, the final series measuring the decay rate of any persistence. A separate field point, one in each quadrant, is used for each wavelength to better sample the field for ghosts, scatter, etc. and to check for cross-talk from all 4 amps. Full-frame images will be obtained to search for ghosts, scatter and cross-talk, with exception of the final dark series, which are 200x200 subarrays. These frames are a logical extension of the point source images obtained for UVIS-11, and will be obtained with the same set of SMSs developed for that program.

EXPOSURES:

FP ID	filter	iter	obstype	image size	exp (s)	comment
UV13	F225W	2	pt src	full	200	~10x full well
UV13		1	dark	full	200	get bkgd, check persistence
UV13	F225W	2	pt src	full	1000	~50x full well
UV13		8	dark	subarray	200	measure persistence decay
UV14	F336W	2	pt src	full	100	~10x full well
UV14		1	dark	full	100	get bkgd, check persistence
UV14	F336W	2	pt src	full	500	~100x full well
UV14		8	dark	subarray	100	measure persistence decay
UV15	F606W	2	pt src	full	10	~10x full well
UV15		1	dark	full	100	get bkgd, check persistence
UV15	F606W	2	pt src	full	100	~100x full well
UV15		8	dark	subarray	100	measure persistence decay
UV16	F814W	2	pt src	full	10	~10x full well
UV16		1	dark	full	100	get bkgd, check persistence
UV16	F814W	2	pt src	full	100	~100x full well
UV16		8	dark	subarray	100	measure persistence decay

FREQUENCY/No. of ITERATIONS:

Execute once with the UVIS flight detector. Repeat if any changes are made to the instrument that would affect the optical alignment/image quality,

TOTAL ELAPSED TIME:

Included in UVIS11 estimate.

VARIANTS:

At low priority, repeat at other field points (e.g., near corners)

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure.

The raw background level on the chip should be ~2500 counts (bias level); the point source should lie well within the boundaries of the extracted sub-array.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. Determine the radial profile for each point source image; inspect dark frames for residual images; inspect full field for evidence of ghosts, scatter, or cross-talk.

TEST RESULTS AND DATA PRODUCTS:

SMOV/ON-ORBIT FOLLOW-UP:

No specific follow-up observations are scheduled. Incidental observations of bright stars obtained during other SMOV activities will provide on-orbit verification of the PSF profile at large radii.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

2.14 UVIS14: Throughput, broad and mediumband filters

CALIBRATION TEST#: 3.5.1A

TITLE: Throughout of the UVIS broad- and medium-band filters

CATEGORY: Science Calibration

P.I.: T. Brown

REVISION DATE: 28 February 2006

PURPOSE:

To determine the absolute throughput of the broad- and medium band filters available in the WFC3/UVIS channel.

PRIORITY: High

CEI SPECIFICATION(s):

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument. Filter limiting magnitudes as follows:

Band	Filter	Limiting magnitude (1000 seconds exposure)
U	F336W	25.5
B	F439W	26.4
V	F555W	27.1
R	F675W	26.3
I	F814W	26.1

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); sub-array read-out through amp C.

BACKGROUND:

WFC3 is designed to have high throughput over the full wavelength range covered by the UVIS channel. Images will be acquired using all the broad-band and medium-band UVIS filters. The fiber spot will be centered on the nominal aperture, and the input flux measured to an accuracy of better than 5%. An initial estimate of the relation between input fiber position (on the OS) and spot location on the detector is required.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3. The OS should be capable of placing a fiber-fed point-source at the desired field location, and of monitoring the incident flux to an accuracy of better than 5%.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to view the images and measure positions and profiles for extended sources.

OS CONFIGURATION:

200-micron point target generated by fiber bundle linked to monochromator, operating in double mode, with bandwidth of 10 nm for the Xe lamp and 12 nm for the Tu lamp. The light source (Xe/Tu) and type of monochromator (UVIS/VIS/IR) will be set to match the appropriate wavelength range of the individual filters. A CASTLE flux calibration will be obtained with each WFC3 exposure.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

uv14s02a/uv14c02a, uv14s03/uv14c03

DETAILED TEST PROGRAM:

800-square sub-array images will be taken of the extended image produced by the 200-micron point target, centered on a defined aperture. Bias frames should be taken at the start and conclusion of the full sequence of exposures in a given script. The test is broken into two parts, each with their own SMS and OS scripts: the bandpasses tested in previous thermal-vacuum tests are in uv14s02a, while those added to test the full set of broad and medium filters are in uv14s03. The OS is in double monochromator mode, with the wavelength tuned to match the central wavelength of the filter being tested. This ensures that WFC3 ‘sees’ the same flux as the OS flux monitor (photodiode) – other OS configurations overfill some of the filter bandpasses. The exposure times are derived from previous test experience and are set to give S/N>100. At each wavelength, a pair of exposures is taken, with and without the filter, so that the filter transmission can be isolated from the rest of the system throughput. The entire test should be repeated at least twice during the thermal vacuum campaign to monitor throughput stability. The images will be centered on point UV15.

EXPOSURES:

Filter	OS wavelength	OS setup (lamp/monochromator/fiber/ND/bandpass/ordersort)	Exp. time (secs)
F218W	218 nm	Xe/doubleUV/200UV/none/10/none	7
CLEAR	same	same	2
F225W	225	same	3
CLEAR	same	same	1
F275W	275	Xe/doubleUVIS/200UV/ND1/10/none	3
CLEAR	same	same	1
F300X	300	same	1
CLEAR	same	Xe/doubleUVIS/200UV/ND2/10/none	5
F336W	336	Xe/doubleVIS/200UV/ND2/10/none	2
CLEAR	same	same	2
F390W	390	Xe/doubleVIS/200UV/ND2/10/LP340	1
CLEAR	same	same	1
F438W	438	same	1
Clear	same	same	1
F475X	475	Xe/doubleVIS/200UV/ND3/10/LP340	5
CLEAR	same	same	5
F475W	same	same	5
CLEAR	same	same	5
F555W	555	Xe/doubleVIS/200UV/ND2/10/LP340	1
CLEAR	same	same	1
F606W	606	same	1

CLEAR	same	same	1
F625W	625	same	1.5
CLEAR	same	same	1
F775W	775	Xe/doubleIR/200VISIR/ND2/10/LP700	1
CLEAR	same	same	1
F814W	814	Tu/doubleIR/200VISIR/ND2/12/LP700	5
CLEAR	same	same	5
-----	-----	-----	-----
F390M	390	Xe/doubleVIS/200UV/ND2/10/LP340	1
CLEAR	same	same	1
F410M	410	same	1
CLEAR	same	same	1
F467M	467	Xe/doubleVIS/200UV/ND3/10/LP340	5
CLEAR	same	same	5
F547M	547	Xe/doubleVIS/200UV/ND2/10/LP340	1
CLEAR	same	same	1
F621M	621	Xe/doubleVIS/200UV/ND2/10/LP700	1.5
CLEAR	same	same	1
F689M	689	same	1.5
CLEAR	same	same	1
F763M	763	Xe/doubleIR/200VISIR/ND2/10/LP700	1
CLEAR	same	same	1
F845M	845	Tu/doubleIR/200VISIR/ND2/12/LP700	5
CLEAR	Same	same	5
F850LP	880	same	2
CLEAR	same	same	2
F600LP	642	Xe/doubleVIS/200UV/ND2/10/LP700	1.5
CLEAR	same	same	1
F350LP	555	Xe/doubleVIS/200UV/ND2/10/LP340	1
CLEAR	same	same	1
F200LP	300	Xe/DoubleUVIS/200UV/ND2/10/none	5
CLEAR	same	same	5

FREQUENCY/No. of ITERATIONS:

Measurements will be made during both the ambient and T/Vac campaigns.

The scripts specify only one integration per filter. Each SMS will be run on at least two occasions, including measurements well separated in time to measure throughput stability.

TOTAL ELAPSED TIME:

UV14S02A – 2.9 hours

UV14S03 – 2.9 hours

VARIANTS:

A second set of measurements may be made with the target centered on the second CCD detector.

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure. The total flux in the spot should be significantly greater than 10,000 (giving $S/N > 100$) without saturating. Outside of the spot, the images should look like a normal dark frame.

ANALYSIS:

Perform aperture photometry on the image of the 200 micron spot using standard IDL routines.

TEST RESULTS AND DATA PRODUCTS:

Filter throughput needs to be verified for the Instrument Handbook.

The results will also be used by the WFC3 ETC.

SMOV/ON-ORBIT FOLLOW-UP:

Observations of standard stars during SMOV and in on-orbit calibration programs will verify and monitor the throughput for each filter.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

UV14S01: Created for TV#1, but never used.

UV14S02: Downsized version of UV14S01 for use in abbreviated TV#1.

UV14S02A: Optimized version used during TV#1. Reuse for TV#2.

UV14S03: Created for TV#2. Includes medium-band and LP filters.

2.15 UVIS15: System throughput

CALIBRATION TEST#: 3.5.1B

TITLE: Throughput of the WFC3 UVIS camera

CATEGORY: Science Calibration

P.I.: T. Brown

REVISION DATE: 25 Sep 2006

PURPOSE:

To determine the throughput of the UVIS camera, a series of frames will be taken of a flux-calibrated point source with the CLEAR filter position in the SOFA.

PRIORITY: High

CEI SPECIFICATION(s):

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument.

4.4.2.1: UVIS channel optics throughput shall exceed tabulated values:

Wavelength (microns)	Throughput
0.18	0.40
0.2	0.59
0.25	0.59
0.3	0.61
0.35	0.60
0.4	0.60
0.45	0.62
0.5	0.62
0.55	0.62
0.6	0.62
0.7	0.60
0.8	0.52
0.9	0.59
1.0	0.72

DETECTOR:

Flight build detector UVIS# 1 at standard gain setting (1.5 e⁻/DN); 800x800 sub-array read-out through amp A (chip 1 test) and amp C (chip 2 test), aligned to the UV16 and UV15 field positions, respectively.

BACKGROUND:

The UVIS SOFA includes a CLEAR (no filter) position. This allows measurement of the throughput as a function of wavelength of the full WFC3 UVIS camera. These measurements can only be obtained during ground calibration. Images will be acquired at 34 wavelengths between 200 and 1000 nm with

the CLEAR position set in the SOFA. The fiber spot will be placed at field positions UV15 and UV16, and the OS will provide absolute flux measurements accurate to better than 5%. An initial estimate of the relation between input fiber position (on the OS) and spot location on the detector is required.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3. The OS should be capable of placing a fiber-fed point-source at the desired field location, and should provide a measurement of the absolute flux accurate to better than 5%.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to view the images and measure positions and profiles for extended sources.

OS CONFIGURATION:

Extended source generated by 200 micron fiber, linked to the OS monochromator, operating in double mode with bandwidth of 5 nm (for 200 through 600 nm samples) and 10 nm (for 650 through 1000 nm samples). Total counts in the extended source should significantly exceed 10,000, in order to ensure S/N>100.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

uv15s01d, uv15s02b, uv15s03, uv15s04

DETAILED TEST PROGRAM:

A single 800x800 sub-array image will be taken at each wavelength setting. A bias frames should be taken at the start of the full sequence of exposures. The double monochromator will be used with the 200-micron target in the OS, tuned to the appropriate wavelength values. The exposure times are those used in previous thermal vacuum tests. The images will be centered on field points UV15 and UV16.

EXPOSURES:

OS wavelength (nm)	OS setup (lamp/monochromator/fiber/ND/bandpass/ordersort)	Exp. time (secs)
200	Xe/doubleUV/200UV/none/5/none	100
205	same	30
210	same	10
215	same	5
220	Xe/doubleUV/200UV/ND1/5/none	40
225	same	20
230	same	10
235	same	7
240	same	5
245	same	4
250	same	3
255	same	2
260	Xe/doubleUVIS/200UV/ND1/5/none	2
270	same	1
280	same	1

290	Xe/doubleUVIS/200UV/ND2/5/none	10
300	same	5
320	same	3
340	Xe/doubleVIS/200UV/ND2/5/none	1
360	Xe/doubleVIS/200UV/ND3/5/none	10
380	Xe/doubleVIS/200UV/ND3/5/LP340	8
400	same	8
450	same	5
500	same	8
550	same	8
600	same	10
650	Xe/doubleVIS/200UV/ND3/10/LP700	10
700	same	20
750	Xe/doubleIR/200VISR/ND3/10/LP700	10
800	same	5
850	Tu/doubleIR/200VISR/ND2/10/LP700	3
900	Tu/doubleIR/200VISR/ND3/10/LP700	10
950	same	10
1000	same	10

FREQUENCY/No. of ITERATIONS:

Measurements will be made during both the ambient and T/Vac campaigns.

TOTAL ELAPSED TIME:

UV15S01, UV15S02, UV15S03, UV15S04 – 4.7 hours each

VARIANTS:

This program can be repeated for one or more apertures centered on different locations on CCD1 and CCD2 of the UVIS detector system. The standard tests on chips 1 and 2 are currently UV15S01D and UV15S02B. Because the CASTLE is prone to failure at some point during the run, we tend to get fewer measurements at long wavelengths, so variations of these tests with the wavelength order reversed are available as UV15S03 and UV15S04.

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure. The extended source should have significantly more than 10,000 counts in it (in order to achieve $S/N > 100$) and the rest of the image should look like a nominal dark frame.

ANALYSIS:

Perform aperture photometry on the image of the 200 micron spot using standard IDL routines.

TEST RESULTS AND DATA PRODUCTS:

System throughput needs to be verified for the Instrument Handbook.

The results will also be used by the WFC3 ETC.

SMOV/ON-ORBIT FOLLOW-UP:

None

ADDITIONAL COMMENTS:

SMS HISTORY:

UV15S01: Ran in Ambient Cal #1.

UV15S01A: Modified version used in Ambient Cal #1.

UV15S01B: Optimized for TV#1. Ran in TV#1.

UV15S01C: Corrections for further use in TV#1.

UV15S01D: Corrections for further use in TV#1. Reuse for TV#2.

UV15S02: Ran in Ambient Cal #1.

UV15S02A: Optimized for TV#1. Ran in TV#1.

UV15S02B: Corrections for TV#1. Reuse for TV#2.

UV15S03: Created for TV#2. Reverse wavelength order of UV15S01.

UV15S04: Created for TV#2. Reverse wavelength order of UV15S02.

2.16 UVIS16: Throughput – detector-defined passbands

CALIBRATION TEST#: 3.5.1C

TITLE: Throughput of the WFC3 UVIS detector-defined passbands

CATEGORY: Science Calibration

P.I.: T. Brown

REVISION DATE: 3 March 2006

PURPOSE:

To determine the throughput as a function of wavelength at the long wavelength limit of the F850LP, where the cutoff is set by the detector, rather than by the filter.

PRIORITY: High

CEI SPECIFICATION(s):

4.4.3: Spectral range stability

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously; subarray read-out through individual amplifiers.

BACKGROUND:

Matching the predicted sensitivity of WFC3 against standard photometric systems requires accurate knowledge of photometric passbands. Most of the UVIS passbands are filter-defined, but F850LP is a long-pass filter, where the detector response defines the long-wavelength cutoff. The current test will empirically test the effective response function. 200-micron fiber images and flat-field images will be acquired at 19 wavelengths between 860 and 1100 nm with the F850LP filter.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3. The OS should be capable of monitoring the incident flux provided to an accuracy of better than 5% and tuning the monochromator to the required central wavelength and bandwidth with an accuracy of 0.1 nm.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to view the images and measure positions and profiles for extended sources.

OS CONFIGURATION:

Extended source generated by 200 micron fiber, linked to the OS monochromator, operating in double mode with bandwidth of 12 nm. Total counts in the extended source should significantly exceed 10,000, in order to ensure S/N>100. To measure the cutoff across the entire field, the measurements made with the 200 micron fiber on each chip will be repeated with a flatfield source. S/N per pixel will be

considerably lower (by a factor of ~5 at the shortest wavelengths), but regions of the detector can be coadded to given S/N>100.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

uv16s01a, uv16s02a, uv16s03

DETAILED TEST PROGRAM:

The 200-micron point target, fed by the OS monochromator in double mode, will be used to measure the absolute throughput as a function of wavelength. The target will be placed at positions UV15 and UV16, thus sampling both chip 2 and chip 1. Sub-array images will be taken over the wavelength range from 850 to 1100 nm. The same series wavelengths will then be sampled with the flatfield target on the optical stimulus, to look for variations in cutoff across the entire detector.

EXPOSURES for 200 micron target:

OS wavelength (nm)	OS setup (lamp/monochromator/fiber/ND/bandpass/ordersort)	Exp. time (secs)
850	Tu/doubleIR/200VISR/ND3/12/LP700	10
860	Tu/doubleIR/200VISR/ND4/12/LP700	same
870	same	same
...
1100	same	same

EXPOSURES for flatfield target:

OS wavelength (nm)	OS setup (lamp/monochromator/fiber/ND/bandpass/ordersort)	Exp. time (secs)
850	Tu/doubleIR/200VISR/noND/12/LP700	100
860	same	same
870	same	same
...
1100	same	same

FREQUENCY/No. of ITERATIONS:

Measurements will be made during both the ambient and T/Vac campaigns.

TOTAL ELAPSED TIME:

UV16S01A – 2.8 hours

UV16S02A – 2.8

UV16S03 – 1.8

VARIANTS:

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure. There should be a few thousand counts per pixel in the images of the 200 micron fiber at the shortest wavelengths, and then it should approach the background level by 1100 nm. If not, the test should be modified for subsequent runs continuing to longer wavelengths. In the flatfield images, there should be at least several hundred counts per pixel in the images at the shortest wavelengths, again approaching the background level by 1100 nm.

ANALYSIS:

Perform aperture photometry on the image of the 200 micron spot using standard IDL routines. Inspect flatfield images for significant variations in detector cutoff with position using standard IDL and IRAF routines.

TEST RESULTS AND DATA PRODUCTS:

The test results will be reported in the Instrument Handbook.

SMOV/ON-ORBIT FOLLOW-UP:

No direct follow-up observations. The on-orbit photometric performance will be determined through observations of isolated bright photometric standards and photometric sequences in star clusters.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

UV16S01: Ran in Ambient Cal #1. Not run in TV#1.

UV16S01A: Increased red wavelength limit to 1100nm for TV#2.

UV16S02: Ran in Ambient Cal #1. Not run in TV#1.

UV16S02A: Increased red wavelength limit to 1100nm for TV#2.

UV16S03: Created for TV#2.

2.17 UVIS17: Throughput – narrowband filters

CALIBRATION TEST#: 3.5.1D

TITLE: Throughput of the WFC3 UVIS narrowband filters

CATEGORY: Science Calibration

P.I.: T. Brown

REVISION DATE: 3 March 2006

PURPOSE:

To verify the wavelength dependence of the transmission function of the narrowband filters, a set of extended-source images (200 micron target) will be taken with the double monochromator set to a 10 nm bandwidth centered in the bandpass.

PRIORITY: Medium

CEI SPECIFICATION(s):

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument.

4.4.3: Spectral range stability - throughput stable to better than 5% per month (goal <1%) for wavelengths between 200 and 300 nm; <3% per month (<1% goal) for wavelengths between 300 and 400 nm.

4.4.5.1: WFC3 shall contain at least 48 selectable spectral defining elements

4.4.5.4: Once properly mounted, no spectral element shall relatively displace the image by more than 0.5 pixels or degrade image quality by more than 0.02 waves at 633 nm.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously; sub-array read-out through individual amplifiers.

BACKGROUND:

The input flux should be measured to an accuracy of <5 percent and the central wavelength of the monochromator passband should be tuneable to an accuracy of 0.1 nm.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3. The OS should be capable of monitoring the incident flux to an accuracy of <5%.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to view the images and measure positions and profiles for extended sources.

OS CONFIGURATION:

The 200-micron point target, generated by fiber-bundle linked to the monochromator, operating in double mode with a bandwidth of 10 nm, will be used for these measurements. The optics (monochromator/fibers) will be chosen to match the relevant wavelength setting.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

uv17s02, uv17s03

DETAILED TEST PROGRAM:

Images taken with the 200-micron target, linked to the double monochromator, will be used to measure the absolute throughput at the central wavelength of each narrowband filter. Data will be taken in 800x800 sub-arrays centered on the target position. One SMS is dedicated to the full aperture filters, which will be imaged at the UV15 field point (the same used for medium and broad-band filter throughputs). The second SMS is dedicated to the quad filters, which will be imaged at a field point centered in that particular quadrant (UV13, UV14, UV15, or UV16). The 10 nm bandpass ensures a reliable flux calibration for the CASTLE. The bandpass will often exceed the width of the narrow band filter, but this will still yield a measurement of the total throughput through the filter, and provide the best calibration of the system throughput (minus the filter) at the wavelength of each narrow-band filter.

EXPOSURES:

Filter	OS wavelength	OS setup (lamp/monochromator/fiber/ND/bandpass/ordersort)	Exp. time (secs)
F280N	218 nm	Xe/doubleUVIS/200UV/ND1/10/none	7
CLEAR	same	Same	1
F343N	343 nm	Xe/doubleVIS/200UV/ND2/10/none	2
CLEAR	same	Same	1
F373N	373 nm	Same	2
CLEAR	same	Same	1
F395N	395	Xe/doubleVIS/200UV/ND2/10/LP340	1
CLEAR	same	Same	1
F469N	469	Xe/doubleVIS/200UV/ND3/10/LP340	10
CLEAR	same	Same	3
F487N	487	Same	10
CLEAR	same	Same	4
F502N	502	Xe/doubleVIS/200UV/ND2/10/LP340	2
Clear	same	Same	1
F631N	630	Xe/doubleVIS/200UV/ND2/10/LP700	3
CLEAR	same	same	1
F645N	645	same	2
CLEAR	same	same	2
F656N	656	same	10
CLEAR	same	same	2
F657N	657	same	2
CLEAR	same	same	2
F658N	658.5	same	10
CLEAR	same	same	2
F665N	665	same	2
CLEAR	same	same	2
F673N	676	Xe/doubleVIS/200VISIR/ND2/10/LP700	2
CLEAR	same	same	2

F680N	688	same	2
CLEAR	same	same	2
F953N	953	Tu/doubleIR/200VISIR/ND2/10/LP700	2
CLEAR	same	same	1
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F437N	437	Xe/doubleVIS/200UV/ND2/10/LP340 [UV16]	3
CLEAR	same	same	1
F232N	233	Xe/doubleUV/200UV/ND1/10/open [UV15]	180
CLEAR	same	same	6
F243N	242	same [UV13]	60
CLEAR	same	same	3
F378N	379	Xe/doubleVIS/200UV/ND2/10/LP340 [UV14]	1
CLEAR	same	same	1
F387N	387	same [UV16]	3
CLEAR	same	same	1
F422M	422	same [UV15]	1
CLEAR	same	same	1
F436N	436.5	same [UV13]	2
CLEAR	same	same	1
F492N	493	same [UV14]	1
CLEAR	same	same	1
F508N	509	same [UV16]	1
CLEAR	same	same	1
F575N	575.5	same [UV15]	5
CLEAR	same	same	1
F672N	671.5	Xe/doubleVIS/200UV/ND2/10/LP700 [UV13]	10
CLEAR	same	same	2
F674N	673	same [UV14]	15
CLEAR	same	same	2
F889N	889	Tu/doubleIR/200VISIR/ND2/10/LP700 [UV16]	2
CLEAR	same	same	1
F906N	906	same [UV15]	2
CLEAR	same	same	1
F924N	924	same [UV14]	2
CLEAR	same	same	1
F937N	937	same [UV14]	2
CLEAR	same	same	1
F619N	620	Xe/doubleVIS/200UV/ND2/10/LP700 [UV16]	2
CLEAR	same	same	1
F634N	635	same [UV15]	3
CLEAR	same	same	1
F727N	727.5	same [UV13]	7
CLEAR	same	same	3
F750N	750	Xe/doubleIR/200VISIR/ND2/10/LP700	5
CLEAR	same	same	2

FREQUENCY/No. of ITERATIONS:

One set of measurements only.

Measurements will be made during both the ambient and T/Vac campaigns.

TOTAL ELAPSED TIME:

UV17S02 – 3.9 hours

UV17S03 – 4.9

VARIANTS:

None

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure. The total flux in the spot should be significantly greater than 10,000 (giving S/N>100) without saturating. Outside of the spot, the images should look like a normal dark frame.

ANALYSIS:

Perform aperture photometry on the image of the 200 micron spot using standard IDL routines.

TEST RESULTS AND DATA PRODUCTS:

Filter throughput needs to be verified for the Instrument Handbook.

The results will also be used by the WFC3 ETC.

SMOV/ON-ORBIT FOLLOW-UP:

No follow-up observations.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

UV17S01: Created for TV#1, but never used. Retired for TV#2.

UV17S02: Created for TV#1, but never used. Updated for TV#2.

UV17S03: Created for TV#1, but never used. Updated for TV#2.

2.18 UVIS18: Throughput stability in the UV

CALIBRATION TEST#: 3.5.2

TITLE: Throughput stability at UV wavelengths

CATEGORY: Science Calibration

P.I.: T. Brown

REVISION DATE: 28 July 2003; validated 9 Sept 2003

PURPOSE:

To verify that the throughput at UV wavelengths is not affected by contamination by outgassing during the ambient and T/V calibration campaigns.

PRIORITY: High

CEI SPECIFICATION(s):

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument.

4.4.3: Spectral range stability - throughput stable to better than 5% per month (goal <1%) for wavelengths between 200 and 300 nm; <3% per month (<1% goal) for wavelengths between 300 and 400 nm.

DETECTOR:

Flight build detector UVIS# 1 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously; subarray read-out through individual amplifiers.

BACKGROUND:

This calibration item will be performed in early measurements at GSFC, using flight build detector UVIS#2. Point-target (200-micron fibre bundle) images will be obtained in two UVIS filters, the F225W and the F218W. The input flux should be measured to an accuracy of better than 5 percent and the exposure times set to achieve reasonable S/N.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3. The OS should be capable of placing a fibre-fed point-source at the desired field location, measuring the incident flux to an accuracy of <5%, and tuning the central wavelength to an accuracy of 0.1 nm.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines are needed to ratio frames and perform basic statistics (counts, median, mean, sigma). Aperture photometry routines in *apphot* will be adequate for measuring the total counts in the image and hence determining the throughput.

OS CONFIGURATION:

200-micron point target generated by fibre linked to monochromator, operating in double mode with a bandwidth of 13 nm. Broadband flat fields, generated by single mode monochromator and integrating sphere, will also be employed.

SITS COMMAND MODE: SMS**SITS SMS/OS SCRIPT NAMES:**

Absorbed into UVIS monitor program, UVIS28.

DETAILED TEST PROGRAM:

see UVIS28

EXPOSURES:

see UVIS28

FREQUENCY/No. of ITERATIONS:

Measurements will be made during both the ambient and T/Vac campaigns.

Repeat at least 5 times during the T/Vac campaign and as often as possible during ambient calibration.

TOTAL ELAPSED TIME:

N/A

VARIANTS:

Additional UV filters could be sampled in this test.

QUICK-LOOK VERIFICATION:**ANALYSIS:**

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis.

Simple image arithmetic, coupled with measurements of the input flux, will give the relative throughput on a pixel-by-pixel basis as a function of wavelength. Determine the throughput by measuring the total counts in the point source image, either using profile fitting or aperture photometry techniques. The image profile will also provide information on variations in the PSF as a function of wavelength.

TEST RESULTS AND DATA PRODUCTS:

Test results on stability in response at UV wavelengths will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

The on-orbit photometric performance will be determined through observations of standard stars, both isolated bright standards and star clusters.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

2.19 UVIS19: Red-light blocking in UV filters

CALIBRATION TEST#: 3.5.3

TITLE: Red leak blocking in UVIS UV filters

CATEGORY: Science Calibration

P.I.: T. Brown

REVISION DATE: 14 March 2006

PURPOSE:

To determine the extent of stray light due to red leaks in the UV filters. All of the ultraviolet-centered UVIS filters are expected to exhibit low, but significant, transmission at selected wavelengths longward of the nominal red cutoff. This effect should be calibrated, since background (sky) radiation on-orbit increases with increasing wavelength.

PRIORITY: Medium

CEI SPECIFICATION(s):

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument.

4.4.3: Spectral range stability - throughput stable to better than 5% per month (goal <1%) for wavelengths between 200 and 300 nm; <3% per month (<1% goal) for wavelengths between 300 and 400 nm.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously; subarray read-out through individual amplifiers.

BACKGROUND:

This calibration item was partially explored as part of the first ambient tests of the UVIS channel.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3. The OS should be capable of producing a flat field uniform to better than 2% and of monitoring the incident flux to an accuracy of 5%, and of tuning the central wavelength of the monochromator passband to an accuracy of 10 nm.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines are needed to ratio frames and perform basic statistics (counts, median, mean, sigma).

OS CONFIGURATION:

200-micron point target illumination generated by the monochromator, operating in single mode, with a bandwidth of 125 nm. The OS should be capable of placing a fiber-fed point-source at the desired field location, and should provide a measurement of the absolute flux accurate to better than 5%. For the pinhole check, the flatfield source on the CASTLE will be used.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

uv19s01, uv19s02

DETAILED TEST PROGRAM:

All of the ultraviolet-centered UVIS filters are expected to exhibit red leaks – i.e. low, but significant, transmission at selected wavelengths longward of the nominal red cutoff. The original test envisaged taking flat-field images in the eight UV filters, with the monochromator on the OS tuned to match the wavelength of the expected principal red leaks. In this form, however, the test would require substantial integration times, given the flatfield fluxes produced by the OS and the relatively low levels expected for any red leaks. The revised test, outlined here, uses the 200-micron pinhole target with the 125 nm-bandwidth single monochromator. A series of long exposures will be taken with the spot imaged at the nominal position for throughput checks (UV15 for all but the quad filter FQ243N; see UV14 and UV17), and with the central wavelength stepped from 450 to 900 nm in 150 nm steps. As a check for filter pinholes, a single full-frame exposure will be taken of each filter, with the OS set to a central wavelength of 600 nm.

For the images of the 200-micron spot, the goal is to have ~1000 counts/pix/exposure, which will yield a S/N ratio exceeding 100 for the entire spot; this is a count level ~10x lower than that achieved in the throughput measurements, but more than sufficient for characterizing the red leak. The one exception will be the 900 nm measurement of the F336W filter; the component testing implies excellent red blocking here, so for this measurement the goal is only 10 counts/pix/exposure.

For the flatfield images, the goal is to have ~1 count/pix/exposure for most of the filters; pinholes can be easily found by binning regions of the detector (and in fact these exposures will be taken with 2x2 binning on the chip). For the F336W and F343N filters, the blocking is again too good to obtain this many counts in a reasonable exposure time, so the goal will be ~0.1 count/pix/exposure; pinholes will still produce brighter illumination patterns that should be obvious.

Instead of scanning through all the wavelengths for each filter in turn (as originally written), this revision of the test will rotate through all of the filters for each wavelength in turn. This will save considerable time because the lengthy CASTLE flux cal need only be done on the first exposure at that wavelength.

UV19S01 does the 200 micron spot imaging, while UV19S02 does the flat field imaging.

EXPOSURES:

Filter	Wavelength (nm)	OS Configuration (lamp/mono/fiber/ND/bandpass)	Exp. time (sec)	Comments
F218W	450	Xe/singleUVIS/200UV/noND/125nm	1	800x800, UV15
F225W	same	same	2	same
F232N	same	same	1	same
F243N	same	same	1	800x800, UV13

F275W	same	same	1	800x800, UV15
F280N	same	same	1	same
F336W	same	same	140	same
F343N	same	same	240	same
F218W	600	same	20	800x800, UV15
F225W	same	same	3	same
F232N	same	same	2	same
F243N	same	same	3	800x800, UV13
F275W	same	same	5	800x800, UV15
F280N	same	same	2	same
F336W	same	same	210	same
F343N	same	same	290	same
F218W	750	Xe/singleIR/200VISIR/noND/125nm	40	800x800, UV15
F225W	same	same	8	same
F232N	same	same	3	same
F243N	same	same	4	800x800, UV13
F275W	same	same	12	800x800, UV15
F280N	same	same	5	same
F336W	same	same	40	same
F343N	same	same	660	same
F218W	900	same	2	800x800, UV15
F225W	same	same	1	same
F232N	same	same	1	same
F243N	same	same	1	800x800, UV13
F275W	same	same	1	800x800, UV15
F280N	same	same	1	same
F336W	same	same	370	same (10x fewer e ⁻)
F343N	same	same	5	same
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F218W	600	Xe/singleUVIS/UVflat/noND/125nm	650	full frame 2x2
F225W	same	same	90	same
F232N	same	same	50	full frame w/quad
F243N	same	same	90	full frame w/quad
F275W	same	same	150	full frame 2x2
F280N	same	same	50	same
F336W	same	same	800	same (10x fewer e ⁻)
F343N	same	same	1000	same (10x fewer e ⁻)

FREQUENCY/No. of ITERATIONS:

One iteration of each SMS.

Measurements will be made during both the ambient and T/Vac campaigns.

TOTAL ELAPSED TIME:

UV19S01 – 2.2 hours

UV19S02 – 1.2

VARIANTS:

Finer sampling in wavelength may be undertaken over wavelength settings where significant red leak is detected.

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure (except for the quad filter images, F232N and F243N). The pixels in the 200 micron spot should generally have about 1000 counts in them, while the pixels in the flat field images should have about 1 count in them (exceptions noted above), without saturating. Outside of the 200 micron spot, the images should look like a normal dark frame.

ANALYSIS:

Perform aperture photometry on the image of the 200 micron spot using standard IDL routines. Standard image display tools to look for substructure in the flat field images.

TEST RESULTS AND DATA PRODUCTS:

Filter red leaks should be given in the Instrument Handbook. The results will also be used by the WFC3 ETC.

SMOV/ON-ORBIT FOLLOW-UP:

No direct follow-up. Photometric color terms (including potential red leaks) can be derived through imaging of standard stars with extreme colors.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

UV19S01: Created for TV#1, but never used. Rewritten for TV#2.

UV19S02: Created for TV#1, but never used. Rewritten for TV#2.

2.20 UVIS20: Flat fields – photometric filters

CALIBRATION TEST#: 3.6.1A

TITLE: Flat field response for UVIS photometric filters

CATEGORY: Science Calibration

P.I.: H. Bushouse

REVISION DATE: 28 July 2003; validated 9 Sept 2003; revised 9 Mar 2007 for TV#2

PURPOSE:

To obtain reference flat fields for initial on-orbit calibration, and to identify cosmetic defects in either filters or CCD detectors. These data will be used to generate reference images for the WFC3 pipeline.

PRIORITY: High

CEI SPECIFICATION(s):

4.6.10: Pixel-to-pixel QE stability (1-sigma)/hour shall be better than 0.2%.

4.6.11.1: CCD Detector Uniformity. The CCD detector shall be correctable to a uniform gain per pixel to <2% at all wavelengths and <1% between 450 and 800 nm. No more than 5% of all pixels shall have response outwith +/-10% of the mean response.

4.6.11.2: CCD Detector Low Spatial Frequency Flat Field Structure. Large scale flat field uniformities shall not exceed 3% peak to peak including the WFC3 optical system. Existing large-scale uniformities shall be correctable to <2%.

4.6.11.3: CCD Detector Non-functional Pixels. No more than 1% of pixels may be non-functional.

4.6.11.4: CCD Detector Flat Field Stability. The difference between two flat fields taken 60 days apart using the same instrumental configuration shall not exceed 1% rms. No more than 5% of the field of view shall exceed 5% variation.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously.

BACKGROUND:

Calibrating the response of the UVIS CCD's as a function of position is vital to establishing WFC3 as a photometric instrument. Flat fields – images taken while the detector is illuminated uniformly – allow calibration of the differential spatial response. This calibration item will be performed in early measurements at GSFC, using flight build detector UVIS#2. Flat-field images will be obtained in all of the UVIS filters, with the intensity level/exposure time adjusted to give a reasonable signal-to-noise.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed in WFC3. The OS should be capable of illuminating the full WFC3 UVIS detector with a uniformity of better than 1%. The OS specifications require a uniformity of <3%, but the OS Acceptance Test Report indicates that the OS meets the higher specification.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines will be used to ratio frames and perform basic statistics (counts, median, mean, sigma) and, if necessary, undertake Fourier analysis of the images.

OS CONFIGURATION:

Diffuse, flat-field illumination generated by the monochromator, operated either in white light (mirror) mode or with the single monochromator tuned to specific filter central wavelengths. The bare Deuterium lamp, mounted directly on the OS integrating sphere, will be used in ambient test environments for filters with central wavelengths below 300 nm. The Xenon lamp, together with either the UVIS or VIS monochromator optics, will be used for wavelengths less than 600-700 nm, including wavelengths <300 nm when in a thermal-vacuum environment. The QTH lamp, together with the IR monochromator, will be used at longer wavelengths.

SITS COMMAND MODE: SMS**SITS SMS/OS SCRIPT NAMES:**

uv20s01, uv20s02, uv20s03, uv20s04, uv20s05, uv20s06, uv20s07, uv20s08, uv20s09, uv20s10

DETAILED TEST PROGRAM:

Flat field images will be taken with every UVIS photometric filter. Two exposures will be taken for most filters during each science calibration campaign, with the individual exposures divided into two segments to provide a measure of the long-term stability. Comparison between images taken during ambient and T/Vac calibration can also be used to verify that the instrument meets CEI spec. 4.6.11.4. One SMS (uv20s10) will be used to obtain very high S/N flats in one filter, repeated over the course of a couple hours, in order to verify CEI spec 4.6.10.

Most exposure times are set to give ~40,000 e⁻ per exposure/iteration, resulting in S/N=200; exceptions are noted in the comments column of the table below. Quad filters having similar central wavelengths are exposed together, where feasible and where throughput and exposure levels will allow. The estimated exposure times are based on the CASTLE ETC. We adopt a maximum of 60 minutes for individual exposures. Multiple exposures are used for filters that require longer than 60 minutes to reach 40,000 e⁻/pix. No OS neutral density filters are used.

EXPOSURES:

SMS	Filter	OS Configuration	Central Wavelength	Exposure time (secs)	Comments
UV20S01	F218W	D2 bare/UV Flat	N/A	1075	40k e
	F225W		N/A	319	40k e
	F275W		N/A	236	40k e
	F280N		N/A	2 x 2310	40k e total
UV20S02	F218W	Xe/Mirror/UV Flat	N/A	2 x 2720	5k e total
	F225W		N/A	1301	10k e
	F275W		N/A	384	20k e
	F280N		N/A	2315	10k e
UV20S03	FQ232N FQ243N FQ437N FQ378N	D2 bare/UV Flat	N/A	1446	5k e 8k e 19k e 76k e

UV20S04	F336W	Xe/SingleUVIS/UV Flat	340 nm	108	40k e
	F343N		340 nm	194	40k e
	F373N		370 nm	850	40k e
	F390W		390 nm	33	40k e
	F390M		390 nm	163	40k e
	F395N		390 nm	362	40k e
	F410M		410 nm	136	40k e
	F438W		440 nm	40	40k e
	F475W		470 nm	19	40k e
	F467M		470 nm	82	40k e
	F469N		470 nm	392	40k e
	F487N		490 nm	372	40k e
	F502N		500 nm	372	40k e
	F547M		550 nm	39	40k e
	F555W		560 nm	24	40k e
UV20S05	FQ437N FQ378N FQ243N FQ232N	Xe/SingleUVIS/UV Flat	410 nm	685	25k e 66k e 0 0
	FQ387N FQ492N FQ422M FQ436N		440 nm	319	10k e 64k e 42k e 16k e
	FQ508N FQ575N FQ672N FQ674N		540 nm	200	40k e 5k e 0 0
	FQ508N FQ575N FQ672N FQ674N		625 nm	2675	0 68k e 49k e 40k e
	FQ619N FQ634N FQ727N FQ750N		630 nm	529	43k e 40k e 0 0
UV20S06	F300X	Xe/SingleUVIS/UV Flat	310 nm	310	40k e
	F200LP	QTH/Mirror/UV Flat	N/A	27	40k e
	F350LP	QTH/Mirror/UV Flat	N/A	25	40k e
	F475X	QTH/Mirror/UV Flat	N/A	74	40k e
	F600LP	QTH/Mirror/VISIR Flat	N/A	21	40k e
	F850LP	QTH/Mirror/VISIR Flat	N/A	40	40k e
UV20S07	F336W	Xe/Mirror/UV Flat	N/A	9 x 70	
	F555W	Xe/Mirror/UV Flat	N/A	9 x 7	
	F814W	QTH/Mirror/VISIR Flat	N/A	9 x 50	

UV20S08	F631N	Xe/SingleUVIS/UV Flat	630 nm	569	40k e
	F645N	Xe/SingleUVIS/UV Flat	640 nm	434	40k e
	F656N	Xe/SingleUVIS/UV Flat	660 nm	2210	40k e
	F657N	Xe/SingleUVIS/UV Flat	660 nm	326	40k e
	F658N	Xe/SingleUVIS/UV Flat	660 nm	1408	40k e
	F665N	Xe/SingleUVIS/UV Flat	670 nm	317	40k e
	F673N	Xe/SingleUVIS/UV Flat	670 nm	368	40k e
	F606W	QTH/SingleUVIS/UV Flat	610 nm	173	40k e
	F625W	QTH/SingleUVIS/UV Flat	620 nm	262	40k e
	F621M	QTH/SingleUVIS/UV Flat	620 nm	372	40k e
	F680N	QTH/SingleUVIS/UV Flat	690 nm	747	40k e
	F689M	QTH/SingleUVIS/UV Flat	690 nm	413	40k e
	F763M	QTH/SingleIR/VISIR Flat	760 nm	404	40k e
	F775W	QTH/SingleIR/VISIR Flat	780 nm	280	40k e
	F814W	QTH/SingleIR/VISIR Flat	820 nm	192	40k e
	F845M	QTH/SingleIR/VISIR Flat	850 nm	223	40k e
	F953N	QTH/SingleIR/VISIR Flat	950 nm	710	40k e
UV20S09	FQ889N	QTH/SingleIR/VISIR Flat	910 nm	1196	40k e
	FQ937N				63k e
	FQ906N				55k e
	FQ924N				59k e
	FQ727N	QTH/SingleIR/VISIR Flat	740 nm	2024	49k e
	FQ750N				40k e
	FQ619N				58k e
	FQ634N				63k e
UV20S10	F606W	Xe/Mirror/UV Flat	N/A	4 x 8	280k e total

FREQUENCY/No. of ITERATIONS:

Measurements will be made during both the ambient and T/Vac campaigns. Each SMS will be executed a minimum of 2 times, in order to reach a combined exposure level of ~80,000 e/pix (S/N=283; noise=0.35%) and to check for temporal changes. UV20S10 needs to be executed only once.

TOTAL ELAPSED TIME:

UV20S01 – 2.5 hrs (ambient only)

UV20S02 – 3.0 hrs

UV20S03 – 2.0 hrs (ambient only)

UV20S04 – 2.8 hrs

UV20S05 – 2.8 hrs

UV20S06 – 1.2 hrs

UV20S07 – 4.9 hrs (T/V#1 only)

UV20S08 – 4.7 hrs

UV20S09 – 1.4 hrs

UV20S10 – 2.6 hrs

VARIANTS:

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure. The background level on the chip should be a ~2500 DN for bias frames and 7000-40,000 DN (10,000-60,000 e) for flat fields. The background level on the overscan should be ~2500 DN.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. Fourier analysis will be used to search for correlated image structure and differencing will be used to identify filter-specific defects. Reference flat fields will be generated by combining individual images using appropriate filters. The goal is to provide <1% accuracy flat fields in all filters.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook. Flat fields are required for each filter for CDBS. Binned versions will be constructed from the full resolution data.

SMOV/ON-ORBIT FOLLOW-UP:

Flat fields with the internal calibration lamps will be taken during SMOV and in subsequent on-orbit calibration campaigns (see UVIS23). Sky flats will be constructed from deep imaging data for visual, red and far-red wavelength filters. The ground calibration images, however, may be the only flat fields available for some narrowband and UV filters.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

UV20S01: Created for use in ambient testing, using bare D2 lamp on OS integrating sphere.

UV20S02: TV#2 version of UV20S01, using OS Xe lamp.

UV20S03: Created for use in ambient testing, using bare D2 lamp on OS integrating sphere.

UV20S04: Created for TV#2.

UV20S05: Created for TV#2.

UV20S06: Created for TV#2.

UV20S07: Used in TV#1 to obtain F336W, F555W, F814W flats. These filters are now included in other TV#2 SMS's and therefore this SMS is not needed for TV#2.

UV20S08: Created for TV#2.

UV20S09: Created for TV#2.

UV20S10: Created for TV#2.

2.21 UVIS21: Grism flat fields

CALIBRATION TEST#: 3.6.1B

TITLE: UVIS flat fields: spectroscopic filters

CATEGORY: Science Calibration

P.I.: H. Bushouse

REVISION DATE: 28 July 2003; validated 9 Sept 2003; revised 9 Mar 2007 for TV#2

PURPOSE:

To obtain a series of narrowband flats spanning the wavelength range covered by the UV G280 grism for the purpose of calibrating the wavelength dependence of the detector response and to obtain sensitivity values for the system response with the grism.

PRIORITY: High

CEI SPECIFICATION(s):

4.4.1 Wavelength Range

4.4.1.1 UVIS Channel: 200-1000nm; priority on 200-400nm

4.6.11.1: CCD Detector Uniformity. The CCD detector shall be correctable to a uniform gain per pixel to <2% at all wavelengths and <1% between 450 and 800 nm. No more than 5% of all pixels shall have response outwith +/-10% of the mean response.

4.6.11.2: CCD Detector Low Spatial Frequency Flat Field Structure. Large scale flat field uniformities shall not exceed 3% peak to peak including the WFC3 optical system. Existing large-scale uniformities shall be correctable to <2%.

4.6.11.4: CCD Detector Flat Field Stability. The difference between two flat fields taken 60 days apart using the same instrumental configuration shall not exceed 1% rms. No more than 5% of the field of view shall exceed 5% variation.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously; subarray read-out through individual amplifiers.

BACKGROUND:

The WFC3 UVIS-channel SOFA includes a grism, providing low-dispersion (R~200) spectra covering UV wavelengths (180 to 500 nm). The grism is the refurbished spare from the WF/PC-1 instrument. Since grism spectra are slitless, accurate flux calibration requires knowledge of the pixel-by-pixel wavelength response of the detector. That response is determined by combining flux-calibrated images taken with the extended 200-micron target with narrowband (10 nm) flat fields. The latter measure the spatial response of the detector, with the zeropoint set by the 200-micron target images. This calibration activity will be undertaken during both the ambient and T/Vac science calibration campaigns.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed in WFC3. The OS should be capable of monitoring to an accuracy of 2% the incident flux in flat-field light sources, and of tuning the central wavelength of the monochromator passband to an accuracy of 0.1 nm. The OS should be capable of placing the 200 micron target at a defined aperture on the WFC3 UVIS detector. An auxiliary monochromator should be mounted directly on the OS integrating sphere during the ambient testing phase to provide higher flux levels shortward of 250 nm.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines are needed to ratio frames and perform basic statistics (counts, median, mean, sigma) and undertake Fourier analysis of the images. Standard routines for measuring the total flux within an image and determining centroids.

OS CONFIGURATION:

Diffuse, flat-field illumination generated by the monochromator, operating in double mode, with a bandwidth of 10 nm. Extended target images provided by the 200 micron fiber bundle, linked to the double-mode monochromator set to a bandwidth of 10 nm.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

uv21s01, uv21s02, uv21s03

DETAILED TEST PROGRAM:

A series of narrowband (10 nm) flat-field full-frame images will be taken at 10 nm intervals spanning the wavelength range 200-530 nm. These will be combined with 512-square sub-array images taken of the 200 micron point target, having similar spectral resolution and covering the same wavelength range as the flat-field exposures. The extended target data will provide absolute calibration. All data will be taken with the G280 optical element in place in the SOFA.

The integration times given below are based on the CASTLE ETC for the standard setup (fiber fed illumination of the integrating sphere). A custom-built UV monochromator, mounted directly on the integrating sphere, will be used under ambient conditions, resulting in significantly shorter integration times. Separate ambient and thermal-vacuum versions of the flat-field procedure will be used; the latter using the CASTLE Xe lamp instead of the D2 monochromator on the integrating sphere (which can only be used in ambient conditions).

EXPOSURES: UV21S01 (for use in ambient only)

Wavelength	OS configuration	Integration time	Comment
200 nm	D2 Mono/Dbl UVIS/UV Flat/no ND	3600 sec	S/N=30
210		1243	S/N=30
220		704	S/N=30
230		493	S/N=30
240		411	S/N=30
250		415	S/N=30
260	Xe/Dbl UVIS/UV Flat/no ND/10 nm	473	S/N=30
270		291	S/N=30
280		185	S/N=30
290		117	S/N=30
300		83	S/N=30

310	Xe/Dbl VIS/UV Flat/no ND/10 nm	68	S/N=30
320		53	S/N=30
330		45	S/N=30
340		42	S/N=30
350		39	S/N=30
360		37	S/N=30
370		35	S/N=30
380		38	S/N=30
390		36	S/N=30
400		33	S/N=30
410		34	S/N=30
420		40	S/N=30
430		42	S/N=30
440		51	S/N=30
450		56	S/N=30
460		61	S/N=30
470		65	S/N=30
480		96	S/N=30
490		137	S/N=30
500		190	S/N=30
510		236	S/N=30
520		322	S/N=30
530		391	S/N=30

UV21S02 (for use in ambient and thermal-vacuum)

Wavelength	OS configuration	Integration time	Comment
200	Xe/Dbl UV/200um UV fiber/ND0/10 nm	6 sec	S/N=100
210	Xe/Dbl UV/200um UV fiber/ND1/10 nm	11	
220	Xe/Dbl UV/200um UV fiber/ND1/10 nm	2	
230	Xe/Dbl UV/200um UV fiber/ND2/10 nm	22	
240	Xe/Dbl UV/200um UV fiber/ND2/10 nm	9	
250	Xe/Dbl UV/200um UV fiber/ND2/10 nm	5.5	
260	Xe/Dbl UV/200um UV fiber/ND2/10 nm	3	
270	Xe/Dbl UV/200um UV fiber/ND2/10 nm	2	
280	Xe/Dbl UV/200um UV fiber/ND3/10 nm	15	
290	Xe/Dbl UV/200um UV fiber/ND3/10 nm	9	
300	Xe/Dbl UVIS/200um UV fiber/ND3/10 nm	3	
310	Xe/Dbl UVIS/200um UV fiber/ND3/10 nm	2.3	
320	Xe/Dbl UVIS/200um UV fiber/ND3/10 nm	2	
330	Xe/Dbl UVIS/200um UV fiber/ND4/10 nm	27	
340	Xe/Dbl UVIS/200um UV fiber/ND4/10 nm	23	
350	Xe/Dbl UVIS/200um UV fiber/ND4/10 nm	22	
360	Xe/Dbl UVIS/200um UV fiber/ND4/10 nm	24	
370	Xe/Dbl UVIS/200um UV fiber/ND4/10 nm	26	
380	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	13	
390	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	12	
400	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	12	

410	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	12	
420	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	13	
430	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	16	
440	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	18	
450	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	20	
460	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	23	
470	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	25	
480	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	37	
490	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	48	
500	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	68	
510	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	86	
520	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	109	
530	Xe/Dbl VIS/200um VISIR fiber/ND4/10 nm	137	

UV21S03 (for use in thermal-vacuum)

Wavelength	OS configuration	Integration time	Comment
230	Xe/Dbl UV/UV Flat/no ND/ 10 nm	3203 sec	S/N=30
240		1432	S/N=30
250		858	S/N=30
260	Xe/Dbl UVIS/UV Flat/no ND/10 nm	473	S/N=30
270		291	S/N=30
280		185	S/N=30
290		117	S/N=30
300		83	S/N=30
310	Xe/Dbl VIS/UV Flat/no ND/10 nm	68	S/N=30
320		53	S/N=30
330		45	S/N=30
340		42	S/N=30
350		39	S/N=30
360		37	S/N=30
370		35	S/N=30
380		38	S/N=30
390		36	S/N=30
400		33	S/N=30
410		34	S/N=30
420		40	S/N=30
430		42	S/N=30
440		51	S/N=30
450		56	S/N=30
460		61	S/N=30
470		65	S/N=30
480		96	S/N=30
490		137	S/N=30
500		190	S/N=30
510		236	S/N=30
520		322	S/N=30
530		391	S/N=30

FREQUENCY/No. of ITERATIONS:

Measurements of the 200 micron target (uv20s02) will be made during both the ambient and T/Vac campaigns. UV flat fields will be taken in ambient conditions using a custom-built monochromator, mounted directly on the OS integrating sphere, using SMS uv20s01. Similar observations will be obtained in thermal-vacuum using SMS uv20s03. Only one cycle of each SMS is necessary. The flat-field SMS's (uv20s01 and uv20s03) may be repeated to obtain higher integrated counts and therefore higher S/N, if desired.

TOTAL ELAPSED TIME:

UV21S01 – 7.0 hrs

UV21S02 – 3.5 hrs

UV21S03 – 6.4 hrs

VARIANTS:**QUICK-LOOK VERIFICATION:**

Each exposure should be inspected visually – there should be no significant non-uniformities or structure. The signal level on the chip should be ~2500 counts for bias/dark frames and 1,000-30,000 counts above bias for flat fields. The bias level on the overscan should be ~2500 counts. For sub-array exposures, which include a point source generated by the OS, the point source should lie well within the boundaries of the extracted sub-array.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. The raw exposures will need basic processing to remove bias and dark. Basic image combination, statistics, and arithmetic tools are needed to produce the proper image-to-image normalization and construct the flat field data cube.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

The following data products will be produced:

1. Flat Field Data Cube
2. Absolute Flux Calibration

None of these products are used directly by the standard calwf3 calibration pipeline processing, nor are they required for it to operate. These products are used only by the post-pipeline spectral extraction software.

Flat Field Data Cube: Built from a set of full-frame monochromatic flats, taken over a range of wavelengths that spans the sensitivity of each grism.

Absolute Flux Calibration: NICMOS and ACS derive their inverse sensitivity curves (Jy/DN/sec) using an on-orbit technique of ratioing the uncalibrated spectra of standard stars (G191-B2B, P330) to calibrated model spectra of these stars. We can get a rough ground calibration of the WFC3 grism modes by obtaining absolute flux measurements (using the OS photodiode) of the monochromatic point-source exposures from uv21s02.

SMOV/ON-ORBIT FOLLOW-UP:

Flat Fields: There is no possibility to repeat the full flat-field calibration on-orbit. The only analogous type of exposures that we will be able to obtain are filter flats that lie within the wavelength range of the grisms. By comparison with the filter flats obtained during ground cal (3.6.1A) we should be able to provide some amount of tracking of changes to the flat field properties, but the wavelength coverage is far from optimal. The instrument filters that lie within the wavelength range of the UV grism are as follows:

UV G280	200-470 nm	F218W, F225W, F275W, F280N, F336W, F343N, F373N, F390M, F390W, F395N, F410M, F438W
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Absolute Flux Calibration: The ground tests will provide an initial estimate of the absolute flux calibration. On-orbit observations will be required to refine this calibration to the desired accuracy. This will involve grism observations of standard stars.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

UV21S01: Never executed in TV#1. Reworked for use in TV#2.

UV21S02: Never executed in TV#1. Reworked for use in TV#2.

UV21S03: Created for use in TV#2.

2.22 UVIS22: Fringing

CALIBRATION TEST#: 3.6.3

TITLE: Fringing at far-red wavelengths in the WFC3 UVIS CCDs

CATEGORY: Science Calibration

P.I.: R. Hill

REVISION DATE: 23 May 2007

PURPOSE:

Measure UVIS detector fringing beyond 900 nm to compare the observed fringe pattern with the predictions of the model produced from DCL data.

PRIORITY: Medium

CEI SPECIFICATION(s):

4.6.11.1: CCD Detector Uniformity. Detector shall be correctable to a uniform gain per pixel to <2% at all wavelengths and <1% between 400nm and 850nm.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously.

BACKGROUND:

Interference within the wafer structure of the UVIS detectors produces fringe patterns at wavelengths longward of 700 nm. The patterns are repeatable for a given spectral input, but the pattern observed with a given filter will depend on the spectral energy distribution of the source within the filter passband. Thus, for example, the appropriate flat field for an emission line source observed through a broad or medium band filter will not be the same as for a continuum source. The fringe pattern is determined primarily by the structure of the CCD and the spectral energy distribution of the source illumination. The data collected during this test will be used to verify predicted fringe patterns from a model based on DCL data. Verification of the model will increase confidence in using the model to improve the flat field correction of data affected by fringing.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3. The OS should be capable of monitoring to an accuracy of 2% the incident flux in flat-field light sources, and of tuning the central wavelength of the monochromator passband to an accuracy of 0.1 nm.

SOFTWARE REQUIREMENTS:

IRAF and/or IDL can be used to measure image statistics, generate histograms, ratio images, and make line/col plots to help quantify the fringing effect. Will require specialized routine for modeling fringing (Malumuth & Cottingham), combining results from ambient and TV tests with existing DCL fringe flats.

OS CONFIGURATION:

Flat fields provided by fiber-fed integrating sphere; IR fibers; double monochromator (IR) set at 2 nm bandwidth.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

UV22S01, UV22S02

DETAILED TEST PROGRAM:

Flatfield exposures at 28 wavelengths are to be taken between 910 and 1000nm, with 1 exposure at each setting. Bias frames will be acquired before and after the test sequence. The test will require the diffuse source, double monochromator, bandwidth of 2nm, and filters F814W and F850LP.

All images will be taken with an exposure time of 15min, which will result in a S/N of 40-50 over the dataset.

One exposure taken at each of 28 wavelengths, rather than multiple exposures at fewer wavelengths will allow dense sampling of a few fringes as well as some sparse sampling of additional fringes, which will help constrain the model.

EXPOSURES:

SMS	Wavelength	OS Configuration	Exposure time (secs)	Comments
uv22s01	910, 911.5, 913, 914.5, 916, 917.5, 919, 923, 927, 937.5, 941.5	QTH/DoubleIR/2 nm/ VISIR flat	900 secs	F814W
uv22s02	945.5, 947, 948.5, 950, 951.5, 953, 954.5, 958.5, 962.5, 973, 977, 981, 982.5, 984, 985.5, 987, 990	QTH/DoubleIR/2 nm/ VISIR flat	900 secs	F850LP

FREQUENCY/No. of ITERATIONS:

Measurements will be made during the ambient UVIS and thermal-vacuum calibration campaigns. One cycle.

TOTAL ELAPSED TIME:

UV22S01 – 3.6 hours

UV22S02 – 5.3 hours

VARIANTS:

Construct reference frames using DCL detector-only data, supplemented by a limited number of frames taken in ambient calibration.

ANALYSIS:

Basic image statistics (mean, variance) will be measured using standard IRAF/IDL routines. Specialized

routine will be used to model fringing (Malumuth & Cottingham), combining results from ambient and TV tests with existing DCL fringe flats.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

No CDBS files to be delivered but will need sufficient grid of flats to allow for modeling fringes and providing a post-pipeline processing correction.

SMOV/ON-ORBIT FOLLOW-UP:

Data cannot be obtained on orbit. This test can only be undertaken during ground calibration.

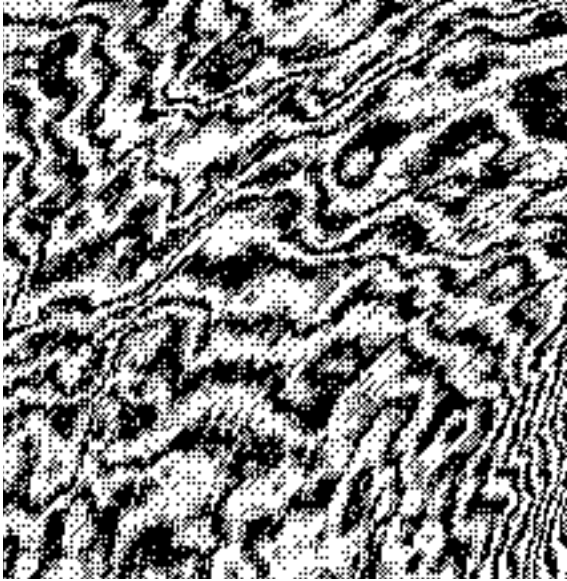
ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns (see appended figures).

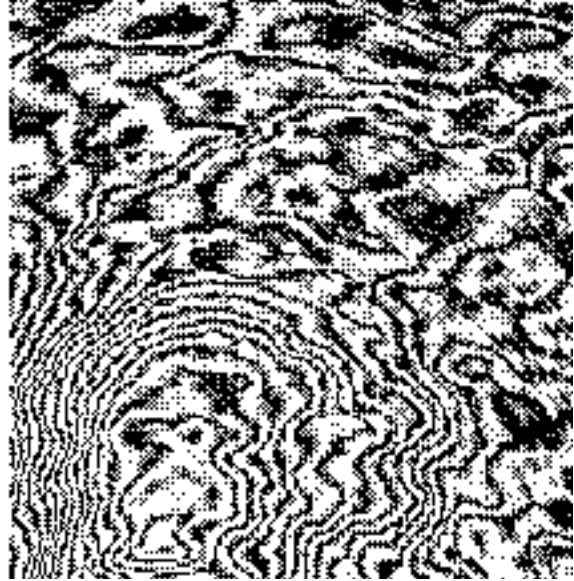
SMS HISTORY:

UV22S01: Created for TV#1, but never used. Updated for TV#2.

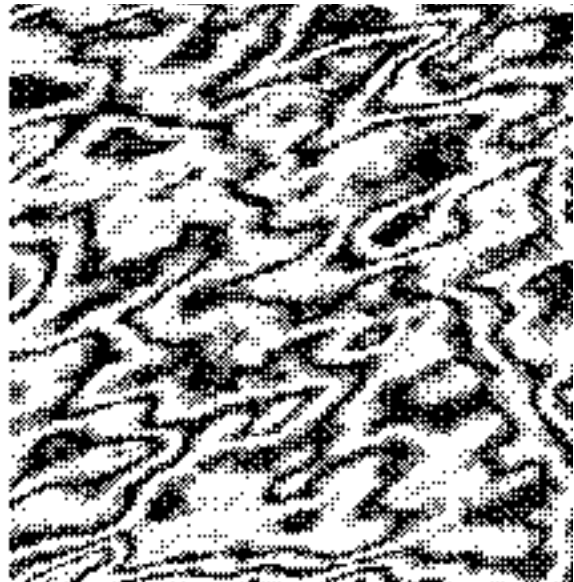
UV22S02: Created for TV#1, but never used. Updated for TV#2.



CCD 18 fringe flat, 901.45 nm (DCL data)



CCD 178 fringe flat, 904.16 nm (DCL data)



2.23 UVIS23: Internal Calibration System

CALIBRATION TEST#: 3.6.3

TITLE: UVIS flat fields: internal calibration system

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: July 2003; validated Sept 2003; updated June 2004, Dec 2006

PURPOSE:

Verify the operational performance of the internal calibration system.

The calsystem images will be used to characterize the high-frequency behavior of the flat fields and track any changes over time; the set obtained during T/V will serve as the reference for subsequent on-orbit data. Comparison with the OS flat fields (from test 3.6.1/UVIS20) will provide a baseline calibration of the internal-lamp illumination pattern.

PRIORITY: High

CEI SPECIFICATION(s):

4.6.11.4, 4.11.4: The calibration subsystem shall provide usable flux from 200-2000 nm, via a cool, red and a hot, blue continuum source. Sufficient flux to achieve a 10,000 e⁻/pixel mean exposure level in less than 10 minutes (17 e⁻/sec/pixel) shall be available for all spectral elements.

CCD Detector Flatfield Stability: the difference between two flat fields taken 60 days apart using the same instrumental configuration shall not exceed 1% rms. No more than 5% of the field of view shall exceed 5% variation.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously; subarray read-out through individual amplifiers.

BACKGROUND:

The internal calibration system will provide the only means of obtaining flat field data while WFC3 is on orbit. There are two light sources: a deuterium lamp, which provides high flux at UV wavelengths; and a tungsten lamp. The data taken during the ambient and T/Vac calibration campaigns serve as a reference compared to flat fields taken with the external optical stimulus, and as a measure of possible time variation when matched against on-orbit data.

Calibration Subsystem Operations (summarized from OPO-1, section 3.8):

Lamps cannot be on concurrently. CARD rules.

Tungsten

- Two redundant lamps for each channel
- Maximum lamp on-time of 255 min
- Each lamp rated to 8000 hrs at nominal operating current and voltage.

- Lamps require 30 sec warm-up period to reach halogen cycle; ground system to allow 1 min. Primary failure mode is cycling before halogen cycle achieved (W atoms can migrate from filament onto inside of window, decreasing output and weakening filament).
- IR: lamp2 to be primary lamp, 4 is backup (DM-05, 2.2.3.3)
- UVIS: lamp1 to be primary, 3 is backup (DM-05 2.2.3.5)
- In-orbit, lamps will be turned ON and OFF at alignment boundaries.

D2 (UVIS)

- Non-redundant lamp, similar to COS lamp
- Three current settings (5, 10, 20 milliamps), no warmup time needed
- Max on-time of 60 min (on high); no restriction on med/low
- Wait of 60min required before operating D2 at high current
- Lamp not to be used during first 14 days of SMOV (to avoid possible polymerization of contaminants on optics)

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3. The internal calibration system should be installed and operational.

SOFTWARE REQUIREMENTS:

IRAF and/or IDL should be sufficient: will need to measure image statistics, generate histograms, ratio images and stack flat fields into reference flat fields as well as visually inspect images to look for any unexpected features or patterns.

OS CONFIGURATION: N/A

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

SMS tests run prior to T/Vac2

- uv23s01 – tungsten short test; priority 1 filters + f656n (part 1 of 2; 1.5 hrs)
- uv23s02 – tungsten priority 1 filters (part 2 of 2; 2.1 hrs; includes f588n)
- uv23s03 – tungsten priority 2 filters
- uv23s04 – tungsten priority 3 filters
- uv23s05 – D2 flats (part 1 of 2, high current)
- uv23s06 – D2 flats (part 2 of 2, high current)
- uv23s07 – D2 flats (subset, high current; 1.2 hrs)
- uv23s08 – D2 flats (subset, med current)
- uv23s09 – D2 worm check (1.2 hrs)
- uv23s10 – tungsten worm check (2.5 hrs)

Updated tests to be run in T/Vac2

- uv23s11 – tungsten short test; priority 1 filters + f656n (part 1 of 2; 1.5 hrs)
- uv23s12 – tungsten priority 1 filters (part 2 of 2, f200lp substituted for f588n)
- uv23s13 – tungsten priority 2 filters
- uv23s14 – tungsten priority 3 filters
- uv23s15 – D2 flats (part 1 of 2, medium current)
- uv23s16 – D2 flats (part 2 of 2, medium current)

uv23s17 – tungsten lamp flux comparison (three filters x four lamps)

DETAILED TEST PROGRAM:

Each SMS obtains flat fields designed to achieve a median level of ~40Ke- (providing a conservative margin in avoiding saturation, given the uncertainties of new lamps and new lamp alignments); a bias is included at the beginning and end of the sequence. Each SMS will need to be executed at least three but preferably nine times, providing not only more signal to noise but allowing for identification of any time-dependent features (e.g., three times early, three times near the middle, and three times near the end of T/Vac calibration).

The table below lists the required UVIS exposure times based upon T/Vac1 results (ISR 2005-09) as well as any subsequent calibration subsystem flats; they have also been corrected for changes expected due to the new replacement filters. The estimates assume that the new lamp fluxes are not significantly different from the old lamps. The D2 estimates assume the T/Vac2 flux levels will be similar to those seen in the higher-flux region (amp C) of the T/Vac1 flats, when the lamp was misaligned and produced significant gradients (factors of 7-10) across the images. Medium current is used for the D2 exposures to preserve the bulb lifetime. Both D2 and tungsten UV exposures will be taken with the same filter when exposure times are not prohibitively long.

The SOC science priority levels for the filters are listed in the ‘P’ column, with highest priority in bold font; exposures are grouped in SMSs using this priority. Filters belonging to one of the five quad filters have ‘Q’ in filter name column; all the quad filters are lowest priority and are contained in a single SMS. Quad filter exposure times are set to the shortest exposure time needed to obtain ~40K e- in one of the four quadrants; if this level is not achieved in all four quadrants, additional flats are taken.

A small spot check SMS obtains flat fields in a few high priority filters in order to validate exposure time estimates. This spot check SMS should be run 3-9 times as the filters in this SMS are not repeated in any of the other, longer SMSs. A quick comparison of the tungsten lamp fluxes is also included (uv23s17: flats in three filters spanning the UVIS wavelength range, using each of the four lamps); this SMS only needs to be run once.

EXPOSURES (times for T/Vac2+):

filter	lamp	wavel	exptime (ccd18)	P	filter	lamp	wavel	exptime (ccd18)	P
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F200LP	D2	2000	0.5	n	F502N	tung	5008	810.	2
F200LP	Tung	2000	0.5	n	FQ508N (Q)	tung	5089	340x3	3
F218W	D2	2201	56.	1	F547M	tung	5452	40.	2
F225W	D2	2263	21.	1	F555W	tung	5206	14.	1
FQ232N (Q1)	D2	2326	1000x3	3	FQ575N (Q)	tung	5756	340x3	3
FQ243N (Q1)	D2	2420	1000x3	3	F600LP	Tung	8430	0.5	1
F275W	D2	2744	46.7	1	F606W	tung	5840	5.0	1
F280N	D2	2796	970.	2	FQ619N (Q4)	tung	6197	75x3	3
F300X	D2	2823	22.4	1	F621M	tung	6207	16.3	2
F336W	D2	3358	78.	1	F625W	tung	6225	6.1	1
F336W	tung	3358	2000.	1	F631N	tung	6306	170.	3
F343N	D2	3378	150.	2	FQ634N (Q4)	tung	6347	75x3	3
F343N	tung	3378	2000.	2	F645N	tung	6452	110.	1
F350LP	tung	6001	1.3	1	F656N	tung	6561	480.	2
F373n	D2	3728	1000.	2	F657N	tung	6557	62.	3
FQ378N (Q1)	D2	3788	1000x3	3	F658N	tung	6585	284.	2
FQ378N (Q1)	tung	3788	2000x3	3	F665N	tung	6657	57.	3
FQ387N (Q2)	D2	3872	1000x3	3	F672N (Q)	tung	6716	340x3	3
F390M	D2	3896	230.	2	F673N	tung	6759	60.	2
F390M	tung	3896	2000.	2	F674N (Q)	tung	6729	340x3	3
F390W	D2	3895	50.	1	F680N	tung	6874	17.	3
F390W	tung	3895	550.	1	F689M	tung	6875	9.3	2
F395N	D2	3953	2000	2	F727N (Q4)	tung	7274	75x3	3
F395N	tung	3953	2000	2	F750N (Q4)	tung	7500	75x3	3
F410M	tung	4110	2000.	2	F763M	tung	7632	5.8	2
F422M (Q2)	tung	4219	560x9	3	F775W	tung	7708	3.3	1
F436N (Q2)	tung	4367	560x9	3	F814W	tung	8236	1.9	1
F437N (Q1)	tung	4371	1000x3	3	F845M	tung	8458	5.4	2
F438W	tung	4306	335.	1	F850LP	tung	8955	4.0	1
F467M	tung	4689	330.	2	F889N (Q3)	tung	8891	60.	3
F469N	tung	4685	2000.	2	F906N (Q3)	tung	9058	60.	3
F475W	tung	4705	45.	1	F924N (Q3)	tung	9246	60.	3
F475X	tung	4779	15.	1	F937N (Q3)	tung	9371	60.	3
F487N	tung	4869	1160.	2	F953N	tung	9530	65.	2
F492N (Q2)	tung	4931	560x9	3					

FREQUENCY/No. of ITERATIONS:

Measurements will be made during both the ambient and T/Vac campaigns – at least three cycles, preferably nine. Test sequences that need to be run in T/Vac2:

UV23S11, UV23S12, UV23S13, UV23S14, UV23S15, UV23S16

UV23S17 should be run once.

UV23S07, 08, 09, and 10 do not need to be run again.

TOTAL ELAPSED TIME:

uv23s11 – 1.4 hours

uv23s12 – 2.3 hours

uv23s13 – 6.0 hours

uv23s14 – 4.1 hours

uv23s15 – 3.0 hours

uv23s16 – 2.8 hours

uv23s17 – 2.4 hours

VARIANTS: none

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure. The background level on the chip should be ~2500 counts for bias/dark frames and ~27,000 counts for flat fields. The background level on the overscan should be ~2500 counts.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. Fourier analysis will be used to search for correlated image structure and differencing will be used to identify filter-specific defects. Reference flat fields will be generated by combining individual images using appropriate filters.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

Set of flat fields to be used as baseline set for SMOV and on-orbit flats. Although not used directly by the OPUS pipeline, calibration system flat fields will be archived in CDBS.

SMOV/ON-ORBIT FOLLOW-UP:

A regular series of flat field images will be taken during SMOV and in standard on-orbit calibration cycles to monitor flat field behavior.

ADDITIONAL COMMENTS:

Note that exptimes may require tweaking if new calsystem lamps have significantly different flux levels from those lamps used in T/Vac1.

SMS HISTORY:

UV23S01: Created for TV#1, but never run. Retired for TV#2.

UV23S02: Ran in Ambient Cal #1. Retired for TV#2.

UV23S03 – UV23S08: Created for TV#1, but never run. Retired for TV#2.

UV23S09: Created and run after TV#1 for filter “worm” check.

UV23S10: Created and run after TV#1 for filter “worm” check.

UV23S11 – UV23S17: Created for TV#2.

2.24 UVIS24: Grism wavelength dispersion calibration

CALIBRATION TEST#: 3.7.1

TITLE: UVIS grism: wavelength dispersion calibration

CATEGORY: Science Calibration

P.I.: H. Bushouse

REVISION DATE: 4 June 2003; validated 9 Sept 2003; revised 4 April 2006

PURPOSE:

To determine the relation between (relative) pixel position and wavelength for the UVIS G280 grism.

PRIORITY: High

CEI SPECIFICATION(s):

4.4.1 Wavelength Range

4.4.1.1 UVIS Channel: 200-1000nm; priority on 200-400nm

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously; sub-array read-out through individual amplifiers.

BACKGROUND:

The WFC3 UVIS-channel SOFA includes a grism, providing low-dispersion (R~200) spectra covering UV wavelengths (180 to 500 nm). The grism is the refurbished spare from the WF/PC-1 instrument. Defining the relation between (delta) pixel value and wavelength is a vital step in calibrating grism spectra. Because no line source is available, the calibration will be determined from narrowband (10 nm) point source images.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed in WFC3. The OS should be capable of tuning the central wavelength of the monochromator passband to an accuracy of 0.1 nm. The OS should be capable of placing a point target at a defined aperture on the WFC3 UVIS detector.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines are needed to ratio frames and perform basic statistics (counts, median, mean, sigma). Standard routines for measuring the total flux within an image and determining centroids

OS CONFIGURATION:

Point-source images with the 5-micron target linked to the double monochromator, bandwidth 10 nm. Neutral density filters will be required for some settings to avoid saturation.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

uv24s01, uv24s02, uv24s03, uv24s04, uv24s05, uv24s06

DETAILED TEST PROGRAM:

A series of narrowband (10 nm) 4142x1024 sub-array images will be taken of the 5 micron point target centered at five defined apertures on the UVIS detector. The monochromator will be stepped through the wavelength range 200-530 nm, with measurements made at 30 nm intervals. Measurements will be made with the image located at a central position and near each of the 4 corners of the UVIS field of view.

In addition, a direct image and a dispersed image of a white light point source will be obtained at each of the 5 locations (4 corners plus center) to map the spectrum length and tilt, as well as source offsets between direct and dispersed images.

EXPOSURES:

Taken at 5 positions on the detector – a central position and 4 corners.

Wavelength	OS configuration	Integration time	Comment
200	Xe/DbI UV/5um pinhole/ND0/10 nm	600 sec	S/N=100, G280
230		50	
260		30	
290		30	
320	Xe/DbI UVIS/5um pinhole/ND0/10nm	10	
350		10	
380		10	
410		10	
440		10	
470		10	
500		10	
530		10	
white light	Xe/Mirror noLP/5um pinhole/ND1	2	F300X
white light	Xe/Mirror noLP/5um pinhole/ND2	2, 12	G280

FREQUENCY/No. of ITERATIONS:

Measurements will be made during both the ambient and T/Vac campaigns. SMS's UV24S02 through UV24S06 will each be executed once in a given campaign. UV24S01, which was used in T/V#1, will not be used in subsequent testing.

TOTAL ELAPSED TIME:

uv24s01a – 4.0 hrs

uv24s02 – 1.3 hrs

uv24s03 – 1.3 hrs

uv24s04 – 1.3 hrs

uv24s05 – 1.3 hrs

uv24s06 – 1.3 hrs

VARIANTS:

Take an additional set of unresolved (5 micron target) point-source images centered on the primary aperture and covering the 200-500nm wavelength range.

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually. The background level on the overscan should be ~2500 DN; the point source should lie well within the boundaries of the extracted sub-array and have a signal level of a few hundred to several thousand counts.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. The raw exposures will need basic processing to remove bias and dark. Standard image centroiding tools can be used to measure the spot locations in the various images. Tables of spot pixel position versus wavelength will be fit with a polynomial function to determine the dispersion solution coefficients.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

The main data products are:

1. Dispersion solution, including direct-to-grism image offsets and spectrum trace

None of these products are used directly by the standard calwf3 calibration pipeline processing, nor are they required for it to operate. These products are used only by the post-pipeline spectral extraction software.

Dispersion Solution: The parameters that need to be measured or derived include the x/y offsets of a source in the direct and dispersed images, the tilt of the spectrum with respect to the detector rows, the length of each order, and the actual pixel-to-wavelength solution. Ideally we should also check to see if any of these parameters are field dependent (they almost certainly will be due to the geometric distortion).

NICMOS and ACS use a dispersion solution of the form: $\lambda = \lambda_0 + b \cdot \delta x$, where b is the dispersion (in $\mu\text{m}/\text{pix}$ or $\text{\AA}/\text{pix}$) and δx is the distance, in pixels, from the source in the direct image to the corresponding spectral position in the dispersed image. The dispersion solution can be derived by building a table of x pixel position vs. wavelength, and then fitting this relation with a polynomial (e.g. IRAF tasks POLYFIT or TLINEAR).

Ideally the dispersion solution would be measured from dispersed images of an emission-line source. The ACS ground calibration used a pinhole mask with Hg and Ar line lamps to obtain emission-line spectra at many positions within the field of view. On orbit, NICMOS uses Planetary Nebulae and ACS uses Wolf Rayet stars (given the higher resolution of ACS, PN are resolved sources and therefore not useful).

SMOV/ON-ORBIT FOLLOW-UP:

Dispersion Solutions: As mentioned above, NICMOS and ACS have used Planetary Nebulae and Wolf-Rayet stars as dispersion calibrators on-orbit. We will most likely not be able to use Planetary Nebulae for the same reason as ACS – they're extended sources at the WFC3 resolution. ACS saw a definite change in the dispersion solution from ground to orbit. Therefore I expect that we will want to recalibrate our dispersion solution in SMOV, and perform checks in later calibration episodes to see if there's any temporal drift.

The observing procedures and data analysis would be much the same as in the ground calibration. Observations of a suitable line source (both direct and dispersed) should be obtained in several positions within the field, from which we would perform the same type of pixel position-vs-wavelength analysis.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

UV24S01: Used in TV#1; includes UV02 and UV11 field positions. Retired for TV#2.

UV24S02: Created for TV#2; uses UV02 field position.

UV24S03: Created for TV#2; uses UV11 field position.

UV24S04: Created for TV#2; uses UV12 field position.

UV24S05: Created for TV#2; uses UV08 field position.

UV24S06: Created for TV#2; uses UV07 field position.

2.25 UVIS25: Optical Ghosts

CALIBRATION TEST#: 3.8.1

TITLE: Optical ghosts in the WFC3 UVIS Camera

CATEGORY: Science Calibration

P.I.: T. Brown

REVISION DATE: 4 June 2003; validated 9 Sept 2003; revised 25 Sep 2006

PURPOSE:

To identify artifacts produced by internal reflections in the WFC3 optics.

PRIORITY: High

CEI SPECIFICATION(s):

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously; subarray read-out through individual amplifiers.

BACKGROUND:

The high reflectivity of the UVIS CCDs at all wavelengths (40-50%) leads to stronger ghost images from point sources than with ACS. To determine the extent of this effect, a bright, fibre-generated broadband point source will be placed at various locations on the detector and just outside the field of view.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3. The OS should be capable of placing a fibre-fed point-source at the desired field location.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to view the images and measure positions and profiles for any detected artifacts.

OS CONFIGURATION:

Point-source generated by fibre linked to monochromator, operating in broadband mode. He-Ne/laser diode point sources generated by single-mode fibres.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES: UV25S01/C01, UV25S02/C02, UV25S03/C03

DETAILED TEST PROGRAM:

As a baseline, we assume exposures at 8 standard locations for the F225W, F280N, and F606W filters. The exposures need to be saturated in order to see the fainter ghosts. The total counts in the saturated image will be calculated by using a multiple of an exposure time yielding a known flux for an unsaturated image. Both the long and short exposures will be taken using subarrays.

The second part of the test obtains ghost images at one point on the detector in each of the filters that have shown ghosts in the past (including the filters scanned in part 1 at 8 positions).

The third part of the test obtains an additional 28 exposures in F606W with a point source at 12 specific positions within the detector field of view and 16 just outside the field of view.

EXPOSURES:

Filter	X	Y	OS Configuration	Exposure time	
F225W	-1600	-1600	Xe/5-micron point target/mirror	4,200 sec (F225W)	
F280N				15,150 sec (F280N)	
	-1600	1600			
	1600	-1600			
	1600	1600			
	200	0			
	-200	0			
	1000	0			
	-1000	0			
F606W	-1600	-1600	Xe/10-micron point target/mirror	2,100 sec	
	-1600	1600			
	1600	-1600			
	1600	1600			
	200	0			
	-200	0			
	1000	0			
	-1000	0			
---	---	---	---	---	
F218W F225W	-1600	-1600	Xe/5-micron point target/mirror	2,5,250	1,100
F275W F300X				1,5,150	0,5,50
FQ232N F280N				50,1000	2,5,250
F410M F467M	-1600	-1600	Xe/10-micron point target/mirror	1,100	0,5,50
F547M F606W				0,5,50	0,5,50
F621M F625W				2,200	1,100
F689M F775W				2,200	1,5,150
F814W F656N				0,5,50	1,100
F658N F665N				1,100	1,100
F673N F680N				1,100	0,5,50
FQ232N	+1600	-1600	Xe/5-micron point target/mirror	15,1000	
---	---	---	---	---	
F606W	-1000	-1600	Xe/10-micron point target/mirror	2,100 sec	
	-1000	1600			

	1000	-1600		
	1000	1600		
	-2000	-2000		
	-2000	2000		
	2000	-2000		
	2000	2000		
	-2100	-2100		
	-2100	-2000		
	-2100	-1000		
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	-1000	-2000		
	-1000	2000		
	-1000	2100		
	1000	-2100		
	1000	-2000		
	1000	2000		
	1000	2100		

FREQUENCY/No. of ITERATIONS:

Measurements will be made during both the ambient and T/Vac campaigns.

TOTAL ELAPSED TIME:

UV25S01 – 3.0 hours

UV25S02 – 2.9 hours

UV25S03 – 2.9 hours

VARIANTS:

UV25S02 – all filters at one field point.

UV25S03 – F606W at various points on and off the detector (off detector points done as full frame 2x2).

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually to ensure that it includes a saturated point-source image.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis.

Inspect the images for ghosts and other artifacts; determine the profiles, relative intensities and potential persistence of these artifacts.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

No direct follow-up observations, although full-frame imaging of bright standards could be used to verify predictions based on the ground calibration images.

SMS HISTORY:

UV25S01: Ran in TV#1. Reuse for TV#2.

UV25S02: Ran in TV#1. Reuse for TV#2.

UV25S03: Created for TV#2 to check for edge effects.

2.26 UVIS26: Gap Behavior

CALIBRATION TEST#: 3.8.4

TITLE: Optical artifacts due to bright sources in the UVIS CCD gap

CATEGORY: Science Calibration

P.I.: T. Brown

REVISION DATE: 4 June 2003; validated 9 Sept 2003; validated 4 April 2006

PURPOSE:

To determine the effects of a bright point-source image falling on the gap between the two CCD detectors on the UVIS channel.

PRIORITY: High

CEI SPECIFICATION(s):

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously; subarray read-out through individual amplifiers.

BACKGROUND:

The UVIS detector consists of two Marconi 2051x4096 CCDs. These devices are not buttable, and are separated by ~200 microns (1.2 arcseconds). A bright star falling between the two detectors can produce ghosts through optical reflections. This test is designed to map the extent of this effect by placing a bright point source at several locations in the detector gap.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3. The OS should be capable of placing a fibre-fed point-source at the desired field location.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to view the images and measure positions and profiles for any detected artefacts.

OS CONFIGURATION:

Point-source generated by fiber linked to HeNe laser.

SITS COMMAND MODE: SMS, possibly supplemented by CCL

SITS SMS/OS SCRIPT NAMES:

uv26s01

DETAILED TEST PROGRAM:

A bright, broadband point source generated by the HeNe laser will be placed at 25 locations along the gap between the two CCD detectors, these locations will be on a 5 (across the gap) by 5 (parallel to the gap) matrix. Optical reflections are expected to be largely wavelength-independent. Full-frame images will be taken to explore the full range of potential reflections.

EXPOSURES:

Filter	X	Y	Exposure time
F625W	0	-2000	25 seconds
		-1000	
		0	
		1000	
		2000	
	-22	-2000	
		-1000	
		0	
		1000	
		2000	
	-18	-2000	
		-1000	
		0	
		1000	
		2000	
	18	-2000	
		-1000	
		0	
		1000	
		2000	
	22	-2000	
		-1000	
		0	
		1000	
		2000	

FREQUENCY/No. of ITERATIONS:

Measurements will be made during both the ambient and T/Vac campaigns.

TOTAL ELAPSED TIME:

UV26S01A – 2.1 hours

VARIANTS:

Observations may be made with the point source at additional positions (and at other wavelengths?).

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually to ensure that it includes a bright point-source image lying between the 2 CCD detectors.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. Inspect the images for ghosts and other artifacts; determine the profiles, relative intensities and potential persistence of these artifacts.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

No explicit follow-up observations planned.

ADDITIONAL COMMENTS:**SMS HISTORY:**

UV26S01: Created for Ambient Cal #1 (June 2004).

UV26S01A: Updated source positions for Ambient Cal #1. Reuse for TV#2.

.

2.27 UVIS27: Light leaks

CALIBRATION TEST#: 3.8.5

TITLE: Test for light leaks in WFC3 UVIS Camera

CATEGORY: Science Calibration

P.I.: G. Hartig

REVISION DATE: 16 July 2003; validated 9 Sept 2003

PURPOSE:

A series of images will be taken with a bright light source placed at various exterior locations around the WFC3 instrument, testing for light leaks in the instrument. This test does not require that the detectors run at full science sensitivity, and is logistically simpler with WFC3 in ambient conditions than in T/Vac.

PRIORITY: Medium

CEI SPECIFICATION(s):

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously; subarray read-out through individual amplifiers.

BACKGROUND:

The WFC3 UVIS camera should be impervious to light leaks.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3; the instrument should be shrouded to allow a bright lamp to be placed at unambiguous external locations.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to view the images and measure positions and profiles for any detected artifacts.

OS CONFIGURATION: N/A

SITS COMMAND MODE: CCL

SITS SMS/OS SCRIPT NAMES: N/A

DETAILED TEST PROGRAM:

A fiber light will be moved around to illuminate various locations on the enclosure while full-frame UVIS images, with no filter selected (CLEAR), are obtained. Recommend many 100 sec exposures

covering about a dozen areas around the enclosure. Areas that demonstrate potential light leaks, with increased background signal/structure, will be investigated further to pinpoint the responsible light leak.

EXPOSURES: TBD

FREQUENCY/No. of ITERATIONS:

Measurements will be made during the ambient campaigns. This procedure should be executed as soon as the instrument is fully integrated, to ease implementation of any corrective measures that may be required. It should be repeated if any major disassembly/reassembly occurs to check workmanship of panel seals, etc.

TOTAL ELAPSED TIME:

~4 hrs.

VARIANTS:

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. Visual inspection should permit the identification of any serious light leaks.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook, if significant, uncorrectable light leaks are detected; the results will be documented in an ISR.

SMOV/ON-ORBIT FOLLOW-UP:

No special program; all SMOV images should be perused for abnormalities that may be due to stray light.

2.28 UVIS28: Science Performance Monitor

CALIBRATION TEST#: 3.9.2

TITLE: UVIS Science Performance Monitor (TV and Ambient)

CATEGORY: Systems Performance Monitor

P.I.: H. Bushouse

REVISION DATE: 13 Aug. 2004; revised 10 Apr 2007 for TV#2.

PURPOSE:

To monitor the basic *science* functions and measure science performance of the UVIS channel. The basic science functions include biases, darks, internal and external flat fields, unresolved sources for optical quality and resolved sources for contamination monitoring.

The test emphasizes stability and repeatability monitoring

3.5.2 UVIS Throughput Stability - monitor contamination at UV and Visible wavelengths.

3.6.2 UVIS Flat Field Stability - monitor FF stability through subset of filters.

3.9.2 System Performance Monitoring – short series of bias, dark, flats (internal and external) and point source exposures to monitor performance [before and after thermal cycling and after any major configuration change.]

PRIORITY: High

VARIANTS:

Three versions of the science monitor are available:

SMS	Title	Detector Temp	Environment	Comments
UV28S01	Full Science Monitor	T < -50 C	Cool ambient & TV	Includes contam check using UV filter, therefore need at least partial CCD cooling
UV28S02	Detector Monitor	T < -50 C	Cool ambient & TV	Dark current check requires at least partial cooling
UV28S03	Abbreviated Science Monitor	T < -50 C	Cool ambient & TV	Same as UV28S01

CEI SPECIFICATION(s):

CEI #	CEI Requirement	Specification
	Functional Test Suite - all functions tested periodically throughout the test program and before and after environmental tests.	Requirement to be met by the combination of ground test functionals: system functional, abbreviated functional, science performance monitoring.
6.2.4.1		
4.6.14	CCD Bias Stability	bias over single row repeatable to 2e
		diff between 2 flats 60 days apart < 1%rms,
4.6.11.4	CCD Flat Field Stability	< =5% of the FOV shall not exceed 5% variation.
4.6.11.3	CCD Functioning Pixels	non funct pix < 1% (dead or hot)
		abs qe p-p/1hr < +/-0.5%,
		abs qe p-p/1mo < +/-1%,
		abs qe p-p/mo @300nm < +/-2%,
4.6.10	CCD Detector QE Stability	pix to pix stab 1 sigma/1hr < 0.2%
4.6.4	CCD Dark at 83C	dark<20e/px-hr
4.6.3	CCD Readout Noise	RN<4e/px @ 30Kpx/sec rate
4.4.2.1	UV Channel Optical Throughput	CEI-ST66 see Table 4-3
4.3.2.1	UV Channel Point Source Profile	CEI-ST66 see Table 4-1
		any one month period after 3 mo orbit
		200-300nm <5%/mo, 300-400 <3%/mo
		400-600nm <1%/mo, 600-1000 <1%/mo
4.4.3	UVIS and IR Spectral Range Stability (in-flight req --> what about ground?)	1000-2000nm < 1%/mo
		repeatable to < 0.01 sec: no 2 pixels differ in
4.5.2	UVIS Shutter Repeatability	exp time by more than 0.01sec
4.3.2.5.1	UVIS Long Term Image Drift	registration to 0.25 px RMS over 24 hours

DETECTOR:

Flight detector; standard read-out through all four amps ABCD simultaneously; subarray read-out through individual amplifiers.

BACKGROUND:

The WFC3 UVIS camera must maintain high stability in its performance over month/year-long periods if it is to provide reliable scientific data. The science monitor is *similar to* the imaging portion of “system functional tests” and a related version should be run before and after thermal cycling and after any major configuration change. Separate SMS’s are available for the full test, an abbreviated version and a detector verification part for ease of scheduling.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3. The UVIS channel has passed the system aliveness and functional tests. The OS should be capable of placing a fiber-fed point source at the desired field location, with an accuracy of 0.1 arcseconds (2.5 pixels). The fibers are chosen to give an unresolved point-source image on the detector. The OS and WFC3 internal Calibration System are also required to produce diffuse flat field illumination at UV and visible wavelengths.

SOFTWARE REQUIREMENTS:

The analysis steps are:

- PSF parameters and profiles vs long term intervals, short term intervals, as function of wavelength
- Histograms, statistical measures, Fourier analysis of darks and biases as function of time.
- Histograms, statistical measures, shape, spatial details of internal and external FF as a function of time and wavelength. Compare internal and external flats results.
- Data reduction and analysis may be run using IDL S/W package CCD pipeline and IR Pipeline (Hilbert) or equivalent quick look software provided by ICAL. The goal is for tools that provide essentially “push button” response: rapid data reduction, analysis, and clear presentation of results and conclusions.

OS CONFIGURATION: Diffuse flat-field illumination using Tungsten and Xenon lamps; HeNe laser diode and single-mode fiber; double monochromator mode with 5-micron pinhole and 200-micron fiber.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES: UV28S01, UV28S02, UV28S03

DETAILED TEST PROGRAMS:

UV28S01 – Full Science Monitor

This test contains contamination checks, PSF stability checks in the UV and in the visible, internal and external flat field exposures to verify the lamps and the FF qualities of the channel, and running the warm noise test. Because UV exposures are being obtained, the CCD needs to be partially (Cool Ambient” where $T < -50^{\circ}\text{C}$) to fully (nominal operate in TV) cooled.

General Comments: The F555W filter was selected for visible observations using absolute flux measurements over the F625W or F606W filters, because consistency and repeatability was established in ambient testing for the OS flux PMT detector, the default detector for wavelengths below 600nm.

Bias and Dark: To verify bias and dark current stability. Full-frame, unbinned and binned, and subarray bias and dark exposures are obtained throughout the procedure. Provides overlap with UVIS Bias and Dark (UV01, UV07) procedures.

External Point and Extended Sources: To monitor the PSF and photometric stability.

VIS monochromatic PSF: A monochromatic unsaturated point source using the OS HeNe laser diode in F625W. Provides overlap with UVIS Encircled Energy (UV11S03) procedure.

UV monochromatic PSF: A monochromatic (11nm bandwidth) unsaturated point source using the OS 5-micron pinhole target in F275W. Provides overlap with UVIS Encircled Energy (UV11S01) procedure.

UV throughput: A monochromatic (10nm bandwidth) extended source using the OS 200-micron target in F218W, with OS flux-cal measurement for photometric and throughput stability assessment. Provides overlap with UVIS Broadband Filter Throughput (UV14S02) procedure.

VIS throughput: A monochromatic (10nm bandwidth) extended source using the OS 200-micron target in F555W, with OS flux-cal measurement for photometric and throughput stability assessment. Provides overlap with UVIS Broadband Filter Throughput (UV14S02) procedure.

Internal Flat Fields: To verify relative UVIS FF and internal lamp stability. All exposures taken at nominal gain. Provides overlap with System Functional and UVIS Internal Cal System flat field (UV23) procedures.

VIS FF: F555W flat field using Tungsten Lamp #1.

Red FF: F814W flat field using Tungsten Lamp #1.

UV FF: F218W flat field using the Deuterium lamp at medium current.

External Flat Fields: To illuminate the focal plane as an external source would do and to compare with the internal flats. All exposures at nominal gain. Provides overlap with UVIS Filter Flats (UV20) procedures.

Vis/Red FF: F555W and F814W, full-frame unbinned.

UV FF: F218W and F225W, full-frame, binned 3x3 to increase signal level per pixel.

UVIS Warm Noise Test: Obtain 2 dark images, each read out through a different amp pair, AC and BD. This test utilizes a unique timing pattern written especially to assess as best as one can, the electronic health of the CCD when at warm temperatures. The test consists of special commands to clock the charge toward one set of amps and read out the data through the opposite set, a scenario that should provide a true measurement of the readnoise in an uncooled detector state. Both ambient and TV ground testing will include repetitions of this test for comparison. Provides overlap with the System Functional.

UV28S02: Detector Monitor

A bias, dark, and external flat-field image are obtained at the nominal gain setting to perform a quick check of detector characteristics such as bias level, read noise, dark current, hot pixels, bad columns, and QE uniformity.

UV28S03: Abbreviated Science Monitor

The abbreviated Science Monitor includes a subset of exposures found in the Full Science Monitor (UV28S01). The abbreviated version obtains a visible-light point source for PSF monitoring, a UV and Visible extended source with OS flux-cal measurements for photometric and throughput monitoring, and internal flat field to monitor lamp performance, external UV and Visible flat fields to monitor flat-field stability, as well as bias and dark images to monitor detector performance.

FREQUENCY/No. of ITERATIONS:

The Full or Abbreviated Science Monitor will be run during ambient and TV campaigns, pre and post testing periods, during thermal testing and after any major instrument or stimulus changes.

TOTAL ELAPSED TIME:

UV28S01C: 2.7 hours per execution

UV28S02:

UV23S03:

ANALYSIS:

A variety of techniques will be used to analyze these data in a consistent manner:

Histogram and statistical analysis on the backgrounds and flat fields, encircled energy, PSF, and photometry will be performed on the point source images. IDL, IRAF, and Excel will be used for the reduction and analysis.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in Instrument Science Reports and the Instrument Handbook. Description of trend analysis and statistical analysis results as a function of time and other environmental parameters. Running updates to trend plots will be provided at each repetition of the test. Relevant temperatures and other telemetry items will be recorded and trended. The collected data are not used directly as calibration products.

SMOV/ON-ORBIT FOLLOW-UP:

A version of the performance monitoring test will be continued in SMOV. The timescale of the monitoring depends on the results of the TV stability tests.

ADDITIONAL COMMENTS:

A subset of SYSTEM FUNCTIONAL (Schoenweis and Pugliano) exposures overlaps the science monitoring test. These images will be included as part of the science monitoring test suite as long as they are obtained in a nominal temperature environment.

SMS HISTORY:

UV28S01: Ran in Ambient Cal #1.

UV28S01A: Optimized for and ran in TV#1.

UV28S01B: Corrected OS-Wait times; ran in TV#1.

UV28S01C: Optimized for TV#2.

UV28S02: Created for TV#1, but never used. Revised for TV#2.

UV28S03: Created for TV#1, but never used. Revised for TV#2.

2.29 UVIS29: Bias as a function of temperature

CALIBRATION TEST#: 3.1.5

TITLE: Bias level as a function of detector temperature in the UVIS CCDs

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: 24 July 2003; validated 9 Sept 2003

PURPOSE:

Verification of DCL characterization results for biases and overscans as a function of gains and temperatures.

PRIORITY: Medium

CEI SPECIFICATION(s):

4.6.14: Single row bias repeatable to 2 e⁻ RMS and bias level for entire array correctable to 1 e⁻ RMS.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously; subarray read-out through individual amplifiers.

BACKGROUND:

The baseline characteristics of the Marconi flight CCD detectors have been measured by the GSFC Detector Characterization Laboratory (DCL). Those measurements include a determination of the bias level of the flight-candidate CCDs over the full on-orbit operating temperature range. The current test procedure is designed to verify the performance of the flight detectors once integrated in the WFC3 system. These tests will be undertaken under both ambient and T/Vac conditions.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed, and the detector temperature should be controlled to an accuracy of 1° C.

SOFTWARE REQUIREMENTS:

Standard IRAF and/or IDL routines should be sufficient. Display images to look for any patterns in the darks. Fourier analysis may be required to evaluate any structure evident in the data frames.

OS CONFIGURATION: N/A

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

See UV01 and UV03 procedures.

DETAILED TEST PROGRAM:

This test will be undertaken using bias frames taken as part of UVIS01 (dark count as $f(T_{\text{det}})$) and UVIS03 (gain as $f(T_{\text{det}})$). Those test procedures envisage acquiring bias frames at five temperatures: T_{nom} , the nominal on-orbit operating temperature (-83°C); $T_{\text{nom}} \pm 3 \text{ K}$; $T_{\text{nom}} + 6 \text{ K}$; and $T_{\text{nom}} + 15 \text{ K}$. The off-nominal temperatures listed are only approximate; final values will be determined during the instrument testing. Data will also be taken at T_{nom} with the detector binned 2×2 and 3×3 to verify performance under those configurations.

EXPOSURES:

See UVIS01 and UVIS03.

FREQUENCY/No. of ITERATIONS:

Measurements will be made during both the ambient and T/Vac campaigns.

TOTAL ELAPSED TIME:

See UVIS01 and UVIS03.

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure.

The background level on the chip should be ~ 2500 counts for bias/dark frames.

The background level on the overscan should be ~ 2500 counts.

VARIANTS:

Bias frames from the system performance monitor (UVIS28) may also be included in the analysis.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis.

The analysis procedures will involve measurement of basic image statistics (bias levels and the distribution of noise on a pixel-by-pixel basis); generation of histograms; plotting results as function of time to search for any trends; and stacking images for the generation of a superbias frame

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook. Those will include:

- Tabulated bias levels as function of temperature and as a function of gain. Summary of any bias frame trends at T with time.
- Average bias levels needed for CDBS CCD characteristics table (CCDTAB).
- Overscan areas defined for overscan region table (OSCNTAB).
- Initial TV superbias file needed for CDBS, in full-frame and binned modes; the binned mode may not be derivable from full-frame and so, would need to be constructed from the binned observations (from UVIS01 – 3.1.2 & 3.1.5) and serve as a placeholder until SMOV data is taken. Noise in the TV full-frame CDBS bias is expected to be on the order of $1e^-$, assuming no structure is present in the bias and that the system readnoise is $\sim 4e^-$.

SMOV/ON-ORBIT FOLLOW-UP:

SMOV and on-orbit observations are anticipated only at T_{nom} unless some problem arises or unless a temperature change is required for other reasons. A large number (~ 100) of images are required for CDBS superbias.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

2.30 UVIS30: Readnoise as a function of gain

CALIBRATION TEST#: 3.1.6

TITLE: Readnoise as a function of detector gain in the UVIS CCDs

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: 24 July 2003; validated 9 Sept 2003

PURPOSE:

Measure readnoise at the system level, as a function of CCD gain at various temperatures.

PRIORITY: High

CEI SPECIFICATION(s):

4.6.3: Readnoise $< 4e^-/\text{pix}$ (goal: 3) at 30000 pix/sec readout.

DETECTOR:

Flight build detector UVIS#2 at standard gain setting ($1.5 e^-/\text{DN}$); standard read-out through all four amps ABCD simultaneously; subarray read-out through individual amplifiers.

BACKGROUND:

The baseline characteristics of the Marconi CCD detectors have been measured by the GSFC Detector Characterization Laboratory (DCL). Those measurements include a determination of the readnoise of the flight-candidate CCDs over the full on-orbit operating temperature range. The current test procedure is designed to verify the performance of those detectors once integrated in the WFC3 system. These tests will be undertaken under both ambient and T/Vac conditions.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed, and the detector temperature should be controlled to an accuracy of 1°C .

SOFTWARE REQUIREMENTS:

Standard IRAF and/or IDL routines should be sufficient. Display images to look for any patterns in the darks. Fourier analysis may be required to evaluate any structure evident in the data frames.

OS CONFIGURATION: N/A

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

See UV01 and UV03.

DETAILED TEST PROGRAM:

This test will be undertaken using data taken as part of UVIS01 (dark count as $f(T_{\text{det}})$) and UVIS03 (gain as $f(T_{\text{det}})$).

EXPOSURES:

See UVIS01 and UVIS03.

FREQUENCY/No. of ITERATIONS:

Measurements will be made during both the ambient and T/Vac campaigns.

TOTAL ELAPSED TIME:

See UVIS01 and UVIS03.

VARIANTS: none**QUICK-LOOK VERIFICATION:**

Each exposure should be inspected visually – there should be no significant non-uniformities or structure.

The background level on the chip should be ~2500 counts for bias/dark frames.

The background level on the overscan should be ~2500 counts.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis.

The analysis procedures will involve measurement of basic image statistics (bias levels and the distribution of noise on a pixel-by-pixel basis); generation of histograms; and plotting results as function of time to search for any trends.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook, including a table of readnoise as function of gain and temperature.

Populate CDBS characteristics table (CCDTAB) with average gain and readnoise value for each amp.

SMOV/ON-ORBIT FOLLOW-UP:

At nominal temperature only, unless circumstances dictate otherwise.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

2.31 UVIS31: Electronic Crosstalk Check

CALIBRATION TEST#: N/A

TITLE: UVIS Electronic Crosstalk Check

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: Oct 2006

PURPOSE:

Verify that the fix to the CCD electronics box has reduced the crosstalk levels.

PRIORITY: High

CEI SPECIFICATION(s):

DETECTOR:

Flight build detector UVIS#2 with standard read-out through all four amps ABCD simultaneously as well as two-amp readouts, binned modes, alternate gains and offsets.

BACKGROUND:

Images taken during previous TV testing revealed two types of electronic crosstalk: 1) a source in one amplifier which generates low level electronic mirror images in the three other amplifier outputs and 2) highly saturated pixels which generate crosstalk in the adjoining amp only in the CCD containing the source. Both types of crosstalk were relatively low level ($<10\text{DN/pix}$ at gain 1.5) but highly nonlinear. The problem was identified in the CEB, fixed, and tested under ambient conditions in mid-2006: no evidence for the first type of crosstalk was seen and the residual type-2 crosstalk was very low ($\sim 0.1\text{DN}$). This test is to confirm that the crosstalk levels remain low.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3.

SOFTWARE REQUIREMENTS:

IRAF and/or IDL should be sufficient.

OS CONFIGURATION: HeNe laser

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

Three scripts were run previously for crosstalk testing

UV31S01 – crosstalk quick check

UV31S02 – timing pattern test with tungsten lamp

UV31S03 – crosstalk quick gain check

Add a more complete check, including observing modes not already in UV31S01:
UV31S04 – expanded crosstalk check

DETAILED TEST PROGRAM:

UV31S01 – heavily saturated point source placed in D quadrant
 five images with F625W, one in each gain (two at default gain 1.5, varying db)
 two images with F625W: one 2x2 + ABCD readout
 one 3x3 +2 amp readout (BD)

UV31S03 – heavily saturated point source placed in D quadrant
 five images with F625W, one at each gain (two at default gain 1.5, varying db)

UV31S04 – F625W, saturated point source in D, default gain 1.5
 one baseline images (F625W, gain 1.5, ABCD, heavily saturated)
 no binning: 2 amp readouts (AD, BC, AC, BD)
 2x2 binning: 2 amp readouts (AD, BC, AC, BD)
 3x3 binning: 4 amp readout plus two amp (AD, BC, AC)
 Offset check: 4 amp readout, varying CCD offsets from 0 through 7
 NOTE: SMS will require manual processing to insert required CCD offsets

FREQUENCY/No. of ITERATIONS:

UV31S01 should be run in ambient and TV while UV31S04 could be run under ambient conditions only. There is no requirement to run any more iterations of UV31S02 and UV31S03.

TOTAL ELAPSED TIME:

uv31s01 – 0.9 hrs
uv31s02 – 1.7 hrs
uv31s03 – 0.8 hrs
uv31s04 – 2.2 hrs

VARIANTS: none

QUICK-LOOK VERIFICATION:

Each exposure must be inspected visually – there should be no unexpected non-uniformities or structure. PSF should be saturated and positioned in amp D, thereby generating extra features (optical and filter ghosts) which serve as additional sources for any potential crosstalk.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. Images will need to be displayed and compared to earlier frames; statistics and plotting routines will be needed to quantify remaining crosstalk levels

TEST RESULTS AND DATA PRODUCTS:

Test images should allow verification that the crosstalk fix has been successful. Any residual crosstalk will be quantified and described in ISR and WFC3 data handbook.

FOLLOW-UP:

Repeats of test should not be necessary.

ADDITIONAL COMMENTS: *Required HeNe attenuation level must be determined in OS verification SMS before running UV31; current SMS's contain db=50 as before. Relevant images and data analyses obtained prior during instrument-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.*

SMS HISTORY:

UV31S01: Ran in TV#1. Reuse for TV#2.

UV31S02: Ran after TV#1 in ambient testing.

UV31S03: Ran after TV#1 in ambient testing.

UV31S04: Created for TV#2.

2.32 UVIS32: Bias level vs. instrument voltage

CALIBRATION TEST#: N/A

TITLE: Bias level as a function of WFC3 input voltage

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: 6 April 2007

PURPOSE:

Determine whether the UVIS CCD bias level varies as a function of WFC3 instrument voltage.

PRIORITY: Medium

CEI SPECIFICATION(s): #4.6.14 (CCD Detector Bias Stability)

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously, as well as single amp subarray readouts.

BACKGROUND:

Other HST instruments have shown that the detector bias level can be dependent on the instrument input voltage as the input voltage varies over the course of an HST orbit. This test is designed to determine whether the WFC3 UVIS detector CCD bias level has such a dependency.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3.

SOFTWARE REQUIREMENTS:

Standard IRAF or IDL routines can be used to measure bias levels in the exposures.

OS CONFIGURATION:

None.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

UV32S01

DETAILED TEST PROGRAM:

A continuous series of 25 full-frame bias exposures will be taken while a CCL script is used to vary the WFC3 input voltage in a manner that mimics on-orbit variations. Bias frames will be obtained about every 8 minutes over the course of ~3.5 hours, which will encompass several orbital periods of voltage variations.

FREQUENCY/No. of ITERATIONS:

Measurements will be made during the ambient UVIS calibration campaign and during thermal-vacuum testing.

TOTAL ELAPSED TIME:

UV32S01 – 3.4 hours

VARIANTS:

Sub-array bias exposures could be used in place of the full-frame images – or mixed in with them – in order to decrease the CCD read-out and buffer dump times, thereby increasing the frequency of sampling of the bias level during the voltage cycling.

ANALYSIS:

Mean bias levels in each image will be correlated against WFC3 voltage at the time of the exposure.

TEST RESULTS AND DATA PRODUCTS:

No data products. Verification only.

SMOV/ON-ORBIT FOLLOW-UP:

A similar series of bias exposures could be executed during on-orbit spacecraft bus voltage cycling.

ADDITIONAL COMMENTS:

None.

SMS HISTORY:

UV32S01: Created for TV#2.

2.34 UV34S01: UVIS filter wedge check

CALIBRATION TEST#: N/A

TITLE: UVIS filter wedge check

CATEGORY: Science Calibration

P.I.: J. Kim Quijano

REVISION DATE: June 6, 2007

PURPOSE:

Verify that the UVIS filters meet the CEI specification for image displacement.

PRIORITY: Low

CEI SPECIFICATION(s):

4.4.5.4: Performance of UVIS Spectral Elements. Once properly mounted, no spectral element shall relatively displace the image by more than 0.5 detector pixels or degrade the image quality by more than 0.02 waves at 633 nm of the transmitted wavefront error.

DETECTOR:

UVIS flight detector at standard gain setting (1.5 e⁻/DN); sub-array 400x400 read-out through amp D at the CASTLE alignment fiber (AF) field position. No charge injection needed.

BACKGROUND:

Spectral elements were tested before installation in the instrument. The wedge image deflection was measured for each filter and orientation of the wedge was recorded. Each filter was installed in the WFC3 SOFA with the wedge oriented in the same direction to minimize displacement. This test is a check of how well this was done.

HARDWARE REQUIREMENTS:

The UVIS flight detector should be installed. The OS should be capable of placing and monitoring the location of a point source at the AF position in amp D of the CCD.

SOFTWARE REQUIREMENTS:

IRAF and/or IDL profile-fitting routines to determine point-source location in the images relative to each filter and do basic image processing.

OS CONFIGURATION:

The 5- and 10-micron targets will be used in conjunction with the OS setup to maximize count rates. Neutral density filters may be used to adjust the flux level to make sure the point-source is observable in all images and does not saturate the detector.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

UV34S01

DETAILED TEST PROGRAM:

A series of point-source images are taken with each full-framed UVIS spectral element on WFC3. The target is located at the CASTLE alignment fiber (AF) field position, which enables monitoring of the source position during the test. This places the source in the amp D quadrant of the UVIS CCD detector. A 400x400 pixel sub-array is read out around the source position. A reference bias frame will be taken at the start and end of the test. After images are taken, relative displacement of the source between all filters will be measured, after correction for any drift in the CASTLE source position.

EXPOSURES:

All exposures are taken with the OS Xenon lamp, 5- or 10-micron pinhole source, and Mirror_noLP monochrometer mode.

FREQUENCY/No. of ITERATIONS:

Test UV34S01 to run once during both the ambient and thermal vacuum science calibration campaigns.

TOTAL ELAPSED TIME:

UV34S01 – TBD

VARIANTS:

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be a point-source in every image and the source should not be saturated.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. The data will be bias-subtracted using standard techniques, and standard software tools will be used to measure the location of the point-source in each image.

TEST RESULTS AND DATA PRODUCTS:

Wedge displacement measurements will be published in an ISR and may be published in the Instrument Handbook and/or WFC3 website.

SMOV/ON-ORBIT FOLLOW-UP: None.

ADDITIONAL COMMENTS:

A few images from previous ambient and thermal vacuum tests might be available for comparison to the new data.

SMS HISTORY:

UV34S01: Created for TV#2.

2.35 UVIS35: Subarray Locations

CALIBRATION TEST#: N/A

TITLE: UVIS Subarray Location Verification

CATEGORY: Science Calibration

P.I.: H. Bushouse

REVISION DATE: 14 November 2006

PURPOSE:

Verify that UVIS subarrays are located at the commanded CCD detector coordinates.

PRIORITY: Low

CEI SPECIFICATION(s): #4.10.2.3 (CCD Subarray Readout Capability)

DETECTOR:

Flight build detector UVIS#2 at standard gain setting (1.5 e⁻/DN); standard read-out through all four amps ABCD simultaneously, as well as single amp subarray readouts.

BACKGROUND:

The WFC3 Flight Software (FSW) allows a user to readout only a portion of each CCD chip. These subarray readouts are specified by the detector coordinates corresponding to the starting corner of the subarray and the size of the subarray in each axis. The purpose of this test is to verify that the correct region of physical detector pixels is being read out when using subarray commanding.

HARDWARE REQUIREMENTS:

The UVIS Flight detector should be installed in WFC3. The OS should be capable of producing full-field illumination using white-light.

SOFTWARE REQUIREMENTS:

IRAF and/or IDL can be used to verify the location and matching of flat-field patterns in the full-frame and subarray images.

OS CONFIGURATION:

Flat fields provided by fiber-fed integrating sphere using the Xenon lamp as the light source. No neutral density filters used.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

UV35S01/UV35C01

DETAILED TEST PROGRAM:

One full-frame, 4-amp (ABCD) flat-field exposure will be taken to use as a reference for the detector flat-field pattern over the entire field of the two CCD chips. Two flat-field images will be taken in each of the 4 individual amplifier quadrants, using the nearest amplifier for read out. One subarray exposure in each quadrant will be located as close as allowable to the corner of the readout amp, while the second will be located near the middle of the quadrant.

EXPOSURES:

SMS	Filter	OS Configuration	Exposure time (secs)	Amp	Comments
UV35S01	F606W	Xe/Mirror/UV Flat	6 secs	ABCD	Full-frame
				A	corner
				A	Middle
				B	Corner
				B	Middle
				C	Corner
				C	Middle
				D	Corner
				D	Middle

FREQUENCY/No. of ITERATIONS:

Measurements will be made during the ambient UVIS calibration campaign. One cycle.

TOTAL ELAPSED TIME:

UV35S01 – 0.35 hours

VARIANTS:

Point-source images could be used instead of flats to verify location of subarrays relative to the full-frame.

ANALYSIS:

Simple visual matching will be used to verify that the subarray flats correspond with the correct region of the full-frame flat field image, using the pixel-to-pixel QE variations as a reference.

TEST RESULTS AND DATA PRODUCTS:

No data products. Verification of FSW functionality only.

SMOV/ON-ORBIT FOLLOW-UP:

A similar test could be performed on-orbit using internal Calibration Subsystem flats.

ADDITIONAL COMMENTS:

None.

SMS HISTORY:

UV35S01: Created for TV#2.

3 Science calibration procedures for IR channel

The scientific and technical justification for the overall test program encapsulated in these procedures is given in the Science Calibration Plan, Part 1; the Science Calibration Plan, Part 3, provides a summary of the main goals of the individual procedures. The exposure times listed are based on measurements of the intensities of the Optical Stimulus light sources, of the WFC3 throughput and the detector quantum efficiencies. They have been validated using either the CASTLE Exposure Time Calculator or results of previous WFC3 ground testing.

3.1 IR01: Dark current

CALIBRATION TEST#: 3.1.2

TITLE: General evaluation of the dark count rate as a function of detector readout sequences, sub-arrays, temperature, filter, cold enclosure temperature.

CATEGORY: Science Calibration

P.I.: M. Robberto

IPT REVISION DATE: 13 June 2003; 13 Oct 2006

REVISION HISTORY

- Added MIFS sequences; improved tables and checked consistency with SMS. (13 June 2003; mr)
- Major revision with new tables (Oct. 2006)

PURPOSE:

To verify that the dark count rate is within CEI specifications for detector temperatures spanning the range that may be used on orbit. Test the stability and repeatability of dark current vs. a variety of instrumental parameters and configurations.

PRIORITY: High

CEI SPECIFICATION(s):

4.8.4: dark rate + instrument background: mean rate < 0.4 e/pix/sec

4.8.5: amplifier glow - < 10 e/pix/read @ center, < 10% of pixels with > 400 e/pix/read

4.8.11.3: non-functional pixels - < 2% dead or with dark rate > 100x mean dark rate

4.8.14: bias stability – bias within a quadrant correctable to < 3 e RMS

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

The baseline characteristics of the Rockwell IR detectors have been measured by the GSFC Detector Characterization Laboratory (DCL). Those measurements include a determination of the dark count rate of the flight-candidate devices over the full range of on-orbit operating temperatures. The current test procedure is designed to verify the performance of the flight detectors once integrated in the WFC3 system. Quantitative measurements from these tests will be made only under T/Vac conditions, since the WFC3 IR detector cannot be cooled to operating temperature under ambient conditions.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3 and the temperature controlled to an accuracy of +/- 0.1° C.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to determine the noise statistics; custom software for analysis of multiaccum data. Pre-processing software, dark rate calculator, masking software, amp glow checking software all exist.

OS CONFIGURATION: N/A

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

ir01s01, ir01s02, ir01s03, ir01s04, ir01s05, ir01s06, ir01s07, ir01s08, ir01s09

DETAILED TEST PROGRAM:

1. ir01s01: 1 dark is taken for each of the 15 Multiaccum sample sequences (Sampseqs) available to the IR detector.
2. ir01s02: 1 “Master dark”: dark is taken in the STEP400 and RAPID sequences.
This is mainly intended to test the dark current at different detector temperatures.
3. ir01s03: 3 darks are taken in RAPID mode and then on each of the SPARS sequences: SPARS10, SPARS25, SPARS50, SPARS100 and SPARS200.
4. ir01s04: 3 darks are taken in each of the STEP sequences: STEP25, STEP50, STEP100, STEP200 and STEP400.
5. ir01s05: 3 darks are taken in each of the MIF sequences: MIF600, MIF900, MIF1200 and MIF1500.
6. ir01s06: 2 darks are taken in SPARS100. Similar to ir01s02, but intended to monitor the dependence of dark current on the Cold Enclosure temperature.
This SMS may also be used as “UDF simulator”.
7. ir01s07: a miscellaneous set of dark current ramps to test SUBARRAY modes: 10xRAPID (SQ64); 10xRAPID (SQ256); 10xRAPID (SQ512); 5xRAPID (FULL); 10xSPARS10 (SQ512); 5xSPARS10 (FULL); 5xSTEP50 (FULL).
8. ir01s08: Monitor the infrared background through the entire collection of filters. Alternate SPARS100 ramps with filter and dark current ramps are executed. **REQUIRES ALL LIGHT OFF IN THE CASTLE.**
9. ir01s09: Monitor dark current vs. other instrumental parameters, runs 7xSPARS50, 4xSPARS50, 7xSPARS50 with 5, 8 and 5 readout respectively.

EXPOSURES:

SMS IR01S01 (All Darks)			
Sampseq	Exposure time	N_{exp}	Comments
RAPID	45 seconds	1 (15 reads)	T _{nom}
STEP25	275	1	T _{nom}
STEP50	500	1	T _{nom}
STEP100	900	1	T _{nom}
STEP200	1600	1	T _{nom}
STEP400	2800	1	T _{nom}
SPARS10	145	1	T _{nom}
SPARS25	350	1	T _{nom}
SPARS50	700	1	T _{nom}
SPARS100	1400	1	T _{nom}
SPARS200	2800	1	T _{nom}

SPARS400	5250	1	T _{nom}
MIFS600	600	1	T _{nom}
MIFS900	900	1	T _{nom}
MIFS1200	1200	1	T _{nom}
MIFS1500	1500	1	T _{nom}
SMS IR01S02 (Master Dark vs. Tdet)			
Sampseq	Exposure time	N_{exp}	Comments
RAPID	45	1 (15 reads)	T _{nom}
STEP400	2800	1	T _{nom}
SMS IR01S03 (SPARS Darks)			
Sampseq	Exposure time	N_{exp}	Comments
RAPID	45 x 3=135	3 (15 reads)	T _{nom}
SPARS10	145 x 3 = 435	3	T _{nom}
SPARS25	350 x 3 = 1050	3	T _{nom}
SPARS50	700 x 3 = 2100	3	T _{nom}
SPARS100	1400 x 3 = 4200	3	T _{nom}
SPARS200	2800 x 3 = 8400	3	T _{nom}
SMS IR01S04 (STEP Darks)			
Sampseq	Exposure time	N_{exp}	Comments
RAPID	45 x 3 = 135	3 (15 reads)	T _{nom}
STEP25	275 x 3 = 825	3	T _{nom}
STEP50	500 x 3 = 1500	3	T _{nom}
STEP100	900 x 3 = 2700	3	T _{nom}
STEP200	1600 x 3 = 4800	3	T _{nom}
STEP400	2800 x 3 = 8400	3	T _{nom}
SMS IR01S05 (MIF Darks)			
Sampseq	Exposure time	N_{exp}	Comments
MIF600	600 x 3 = 1800	3 (15 reads)	T _{nom}
MIF900	900 x 3 = 2700	3	T _{nom}
MIF1200	1200 x 3 = 3600	3	T _{nom}
MIF1500	1500 x 3 = 4500	3	T _{nom}
SMS IR01S06 (Cold Enclosure Dark monitor)			
Sampseq	Exposure time	N_{exp}	Comments
SPARS100	1400 x 2 = 2800	2 (15 reads)	T _{nom}
SMS IR01S07 (Subarray darks)			
Sampseq	Exposure time	N_{exp}	Comments
RAPID	45 x 10 = 450	10 (15 reads)	SQ64
RAPID	45 x 10 = 450	10	SQ256
RAPID	45 x 10 = 450	10	SQ512
RAPID	45 x 5 = 225	5	FULL
SPARS10	145 x 10 = 1450	10	SQ512
SPARS10	145 x 5 =725	5	FULL

STEP50	190 x 5 = 950	5 (6 reads)	FULL
SMS IR01S08A (IR Filter Background)			
Sampseq	Exposure time	N_{exp}	Comments
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F098M	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F105W	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F110W	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F125W	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F126N	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F127M	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F128N	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F130N	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F132N	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F139M	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F140W	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F153M	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F164N	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F167N	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – F160W	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – G102	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SPARS100 – G141	200	1 (3 reads)	T _{nom}
SPARS100	200	1 (3 reads)	T _{nom}
SMS IR01S09 (IR Dark current monitor)			
Sampseq	Exposure time	N_{exp}	Comments
SPARS50	24x7=168	7 (5 reads)	T _{nom}
SPARS50	150x4=600	4 (8 reads)	T _{nom}
SPARS50	24x7=168	7 (5 reads)	T _{nom}

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns. SMS ir01s01 has 1 iteration and must be repeated 5 times. SMS ir02s02 must be repeated 2 times at each temperature, for a total of 6 times.

TOTAL ELAPSED TIME:

ir01s01 – 5.1 hours
ir01s02 – 1.1 hours
ir01s03 – 5.6 hours
ir01s04 – 5.8 hours
ir01s05 – 3.9 hours
ir01s06 – 1.1 hours
ir01s07 – 2.9 hours
ir01s08a – 2.4 hours
ir01s09 – 1.4 hours

VARIANTS:

Most of these SMS must be repeated at different detector temperatures. Suggested:
Nominal (currently 145K); nominal -2K, nominal +5K, nominal +10K.

QUICK-LOOK VERIFICATION:

Differences between reads (2-1, 15-14) should look fairly uniform. The mean flux level should be very low (< 1 ADU/pix/sec) after the first several frames - tables and figures from DCL darks should be available as comparison.

ANALYSIS:

Standard statistical analysis. The data will be processed initially using the standard WFC3-IR IPT pipeline analysis.

TEST RESULTS AND DATA PRODUCTS:

Superdark reference files for CDBS at nominal temperature. A reference file is needed for each sample sequence.

Tabulated dark rates vs. temperature (instrument handbook)

Hot/dead pixel mask for CDBS table and a histogram for the instrument handbook.

All test results will be summarized in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

A full set of darks, including all sample sequences, should be taken during SMOV and subsequent on-orbit calibration, but only at the standard operating temperature.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

IR01S01 through IR01S09 all created for and used in TV#1.

IR01S08A: Changed F093W to F140W for TV#2.

3.2 IR02: Absolute and relative gain

TITLE: Absolute and Relative Gain

CATEGORY: Science Calibration

P.I.: M. Robberto

IPT REVISION DATE: 1 Sept 2003; validated 9 Sept 2003; revised 13 April 2004, 31 May, 2004, May 2006 (major revision after 2004 TV results)

REVISION HISTORY

- 13 June 2003: All the Tnom exposures now have 10 read (before was 10 only at 2.5e/adu, all the others were 2e/adu), for higher accuracy and simplicity (only one SMS); updated table; removed reference to SMS ir02s02; updated time estimate with caveat on thermal setting of detector.
- 13 April 2004: Split in two SMSs:
- 1) ir02s01 is for the ABSOLUTE GAIN, in FULL FRAME mode
 - 2) ir02s02 is for the GAIN AS A FUNCTION OF Tdet, in SUBARRAY mode
- 31 May 2004: this FILENAME: SciCal4rev_IR02-4
fixed the exposure time for ir02s01 by reducing ramps to 10 read (MR)
- 7 June 2006: this FILENAME: SciCal4rev_IR02.03.04-v6
- The procedure concentrates on measuring the standard gain with an absolute measure (mean-variance analysis) and the relative gain with relative count ratio.
 - the original SMSs ir02s01 and ir02s02 (absolute measure of standard gain and relative measure of non standard gain) are now divided in 2 SMS each, depending if external or internal illumination is used.
 - removed references to different temperatures; SMS can be run at different temperatures but control is external (settling time can be an issue and external control seems preferable). In particular, removed measures at 147K, 153K and 156K in the SMS ir02s02 and table 2 in this file.
 - changed Tnom from 150K to 145K.
 - various editing
 - temperature control request changed from ± 1 C to ± 0.1 C
 - number of exposures reduced to 25 (was 100). Illumination level requested 60Ke in ~90s (was saturation in ~40s). Number of read reduced to 9 (was 10). Sequence is SPARS10 (was RAPID)

PURPOSE:

Determine the **absolute** gain for the standard setting (2.5e/adu) for WFC3/IR;
Determine the **relative** gains (nominal values are 2.0, 2.5, 3.0 and 4.0 e/adu) for WFC3/IR.

PRIORITY: High

CEI SPECIFICATION(s):

4.10.3.3 (plus SCN003 and SCN004): four selectable gains of 2, 2.5, 3, 4 e/adu

DETECTOR:

Flight build IR#1 detector at gain settings of 2.0, 2.5, 3.0, and 4.0 e/adu. Full frame readout.

BACKGROUND:

The baseline characteristics of the Rockwell IR detectors have been measured by the GSFC Detector Characterization Laboratory (DCL). Those measurements include a determination of the relative gains of the flight-candidate devices over the full on-orbit operating temperature range. The current test procedure is designed to verify the performance of those detectors once integrated in the WFC3 system. Quantitative measurements from these tests will be made only under T/Vac conditions, since the WFC3 IR detector cannot be cooled to operating temperature under ambient conditions.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3 and the temperature controlled to an accuracy of $\pm 0.1^\circ\text{C}$.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to determine the noise statistics; custom software for analysis of multiaccum data. Pre-processing software, dark rate calculator, masking software, amp glow checking software all exist.

OS CONFIGURATION REQUIREMENT:

SMS ir02s01: CASTLE tungsten lamp, SingleIR, VISIR Flat, ND2, 125 nm bandpass, 1250nm central wavelength, LP1000 order sorting filter.

SMS ir02s02: same as ir02s01

SMS ir02s03: none (internal source)

SMS ir02s04: none (internal source)

SITS COMMAND MODE: SMS**SITS SMS/OS SCRIPT NAMES:**

ir02s01: absolute gain; external (CASTLE) source

ir02s02: relative gain; external (CASTLE) source

ir02s03: absolute gain; internal (Cal Sys) source

ir02s04: relative gain; internal (Cal Sys) source

DETAILED TEST PROGRAM:

All SMSs use an appropriate total exposure time to reach a final signal level of 50-60k e⁻/pix to avoid heavy saturation. For ir02s01 and ir02s02, which use the CASTLE as source, the SPARS10 sequence with 9 reads is used for an exposure time of 83 sec. For ir02s03 and ir02s04, which use the internal Calibration System tungsten lamps, the RAPID sequence with 7 reads is used for an exposure time of 21 sec. [TO BE CHECKED: Substrate removed FPAs may have higher QE and saturate earlier at F125W]

The absolute gain settings of the WFC3/IR detector will be verified in ir02s01 and ir02s03 by taking Multiaccum images on flat fields with constant intensity and using the mean-variance method. All of the data will be taken using the F125W filter, since the gains are not expected to be wavelength dependent. An initial and final dark exposure has been added. Measurements can be made at other detector temperatures ($T_{\text{nom}}=145\text{K}$; $T_{\text{nom}}+2.5$; $T_{\text{nom}}-2.5$ or lowest possible; $T_{\text{nom}}+5$, $T_{\text{nom}}+10$).

EXPOSURES:

IR02S01: External source (CASTLE)			
Gain	Exposure time	N_{Exp}	Comments
2.5 e ⁻ /adu	SPARS10 x 9 = 83 sec	25	T = 145K = T _{nom}

IR02S02: External source (CASTLE)			
Gain	Exposure time	N_{Exp}	Comments
2.0 e ⁻ /adu	SPARS10 x 9 = 83 sec	2	T = 145K = T _{nom}
2.5 e ⁻ /adu	SPARS10 x 9 = 83 sec	10	
3.0 e ⁻ /adu	SPARS10 x 9 = 83 sec	2	
4.0 e ⁻ /adu	SPARS10 x 9 = 83 sec	2	

IR02S03: Internal source (Cal Sys)			
Gain	Exposure time	N_{Exp}	Comments
2.5 e ⁻ /adu	SPARS25 x 6 = 128 sec	25	T = 145K = T _{nom}

IR02S04: Internal source (Cal Sys)			
Gain	Exposure time	N_{Exp}	Comments
2.0 e ⁻ /adu	SPARS25 x 6 = 128 sec	2	T = 145K = T _{nom}
2.5 e ⁻ /adu	SPARS25 x 6 = 128 sec	10	
3.0 e ⁻ /adu	SPARS25 x 6 = 128 sec	2	
4.0 e ⁻ /adu	SPARS25 x 6 = 128 sec	2	

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns. These data can also be used to check detector linearity at low flux levels.

TOTAL ELAPSED TIME:

ir02s01 – 2.3 hours

ir02s02 – 1.6 hours

ir02s03 – 2.3 hours

ir02s04 – 1.6 hours

VARIANTS:

For absolute gain measures (ir02s01) one could use an alternative OS configuration to obtain higher flux levels (e.g. ND4 + ND2 + slit width 1500 microns, giving ~1000 photons/pixel/sec). This could possibly supersede the detector linearity test (SMS IR04)

QUICK-LOOK VERIFICATION:

Subtracting reads of different ramps should give values close to zero if illumination and detector are stable. Verify that signal in last read does not exceed 60k e⁻/pixel.

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis.

The absolute gains will be determined by mean-variance analysis of the 25 multiaccum exposures taken at T_{nom}. The relative gains will be measured by ratioing the average values across the quadrants.

TEST RESULTS AND DATA PRODUCTS:

- 1) An accurate pixel gain map, providing *absolute* gain per pixel at 2.5e/adu setting, 145K
- 2) Relative gain, per quadrants.

The test results will be included in the instrument handbook; the gain map will be an important part of the instrument calibration pipeline. Gain maps at different gain can be obtained from the standard one using average values (relative gain should not be pixel dependent).

SMOV/ON-ORBIT FOLLOW-UP:

The absolute gain will be verified during SMOV through observations of standard stars and standard star fields.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

IR02S01: Ran in TV#1.

IR02S02: Built for TV#1, but never run. Changed from using an extended source to using flat field illumination for TV#2.

IR02S03: New for TV#2.

IR02S04: New for TV#2.

3.3 IR03: Detector linearity

CALIBRATION TEST#: 3.1.7A

TITLE: IR detector linearity: absolute calibration

CATEGORY: Science Calibration

P.I.: M. Robberto

IPT REVISION DATE: 1 Sept 2003; validated 9 Sept 2003; May 2006 for TV2

REVISION HISTORY:

- Defined the 4 positions of the stimulus IR01-IR04 close to the center; reduced IT to 60s, increased nr. of repeat (10 times) for each position.
- 13 April 2004: defined images as subarrays.
- 28 May 2004: created 4 SMS, one per each gain value
- 1 June 2004: uses SPARS10 with 6 read to get ~100,000 electrons/pixel (MR)
- May 2006: ***Will not be used for TV#2***. Better results are achieved from IR04.

PURPOSE:

Verify that the IR detectors meet the CEI specifications for linearity, determine the well depth at the onset of non-linearity and measure the response curve through the non-linear regime to saturation. This test measures a *point source*.

PRIORITY: High

CEI SPECIFICATION(s):

CEIS 4.8.7: The full well capacity shall be a minimum of 100,000 electrons/pixel with a goal of 150,000 electrons.

CEIS 4.8.8: The response shall be linear with input signal to <5% (correctable to <0.3%) over the range 100 to 70,000 electrons and shall be independent on exposure time.

DETECTOR:

Flight build detector IR#1 at gain settings 2, 2.5, 3 & 4 e/adu. Use 512x512 subarrays.

BACKGROUND:

The baseline characteristics of the Rockwell IR detectors have been measured by the GSFC Detector Characterization Laboratory (DCL). Those measurements include a determination of the linearity of the response of the flight-candidate devices. The current test procedure is designed to verify the performance of those detectors once integrated in the WFC3 system. Quantitative measurements from these tests will be made only under T/Vac conditions, since the WFC3 IR detector cannot be cooled to operating temperature under ambient conditions.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3 and the temperature controlled to an accuracy of +/- 0.1° C.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to determine the noise statistics; custom software for analysis of multiaccum data. Pre-processing software, dark rate calculator, masking software, amp glow checking software all exist.

OS CONFIGURATION:

Uses 512x512 subarrays, which are 4x faster to read. CASTLE with Tungsten lamp, 200-micron extended target with IR fibers, monochromator in single mode (125nm) centered on 1250 nm with ND7 and a slit width of 2000 microns. Predicted count-rate 2500 photons/pixel/sec, or ~95,000 in 38 seconds). OS incident flux calibrated using photodiode for each set of observations. (Flat field flux calibration is not sufficiently reliable for either relative or absolute gain determinations).

SITS COMMAND MODE: SMS**SITS SMS/OS SCRIPT NAMES:**

ir03s01, ir03s02, ir03s03, ir03s04

DETAILED TEST PROGRAM:

The linearity of the response of the WFC3/IR detector will be verified by taking Multiaccum images of a source of known intensity, the 200-micron extended target calibrated against the OS flux monitor. The extended source should be centered on a defined aperture. All of the data will be taken using the F125W filter, since no wavelength dependence is expected.

Detector linearity can be determined by comparing the observed slope (in ADU) against the linear slope, based on the incident flux and the exposure time. The point source will be moved to illuminate the four quadrants. The total intensity in the final readout is predicted to correspond to ~60,000 e⁻, so the source should be moved between each exposure to avoid potential problems due to image persistence. The full sequence of linearity exposures will be bracketed by dark frames, to monitor detector performance.

EXPOSURES:**ir03s01**

Gain	Exposure time	N _{Exp}	Comments
2.5 e ⁻ /adu	SPARS10, 6 read (38s)	8	T = 150K , position IR01
	SPARS10, 6 read (38s)	8	position IR02
	SPARS10, 6 read (38s)	8	position IR03
	SPARS10, 6 read (38s)	8	position IR04

ir03s02

Gain	Exposure time	N _{Exp}	Comments
2.5 e ⁻ /adu	SPARS10, 6 read (38s)	8	T = 150K , position IR01
	SPARS10, 6 read (38s)	8	position IR02
	SPARS10, 6 read (38s)	8	position IR03
	SPARS10, 6 read (38s)	8	position IR04

ir03s03

Gain	Exposure time	N _{Exp}	Comments
2.5 e ⁻ /adu	SPARS10, 6 read (38s)	8	T = 150K , position IR01
	SPARS10, 6 read (38s)	8	position IR02
	SPARS10, 6 read (38s)	8	position IR03
	SPARS10, 6 read (38s)	8	position IR04

ir03s04

Gain	Exposure time	N _{Exp}	Comments
2.5 e ⁻ /adu	SPARS10, 6 read (38s)	8	T = 150K , position IR01
	SPARS10, 6 read (38s)	8	position IR02
	SPARS10, 6 read (38s)	8	position IR03
	SPARS10, 6 read (38s)	8	position IR04

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns. Data taken as part of test IR02 can also be used to check detector linearity at low flux levels.

TOTAL ELAPSED TIME:

ir03s01 – 3.0 hours; ir03s02 – 3.0 hours; ir03s03 – 3.0 hours; ir03s04 – 3.0 hours

VARIANTS:

Use an alternative OS configuration to obtain higher or lower flux levels.

QUICK-LOOK VERIFICATION:

The extended source produced by the OS should be centered on the aperture, and should lie well within the extracted image if sub-arrays are used. The background level should look fairly uniform in differences between reads (2-1, 15-14). The flux level should not exceed 35,000 counts in the extended source.

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. The response curve will be determined by using standard techniques to measure the average counts in the extended target as a function of time.

TEST RESULTS AND DATA PRODUCTS:

- 1) Linearity curve and polynomial fit for correction

These results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

The response curve will be verified during SMOV through observations of standard stars and standard star fields.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

IR03S01: Run in TV#1.

IR03S02: Run in TV#1.

IR03S03: Run in TV#1.

IR03S04: Built for but never run in TV#1.

3.4 IR04: Detector linearity – areal response

CALIBRATION TEST#: 3.1.7B

TITLE: IR detector linearity: areal response

CATEGORY: Science Calibration

P.I.: M. Robberto

REVISION DATE: 1 Sept 2003; validated 9 Sept 2003; 13 April 2004: estimated total elapsed time; Oct 2006: updated for TV2

PURPOSE:

Verify that the IR detectors meet the CEI specifications for linearity, determine the well-depth at the onset of non-linearity and measure the response curve through the non-linear regime to saturation. This test uses *flat field images* to determine linearity for the full detector.

PRIORITY: High

CEI SPECIFICATION(s):

CEIS 4.8.7: The full well capacity shall be a minimum of 100,000 electrons/pixel with a goal of 150,000 electrons.

CEIS 4.8.8: The response shall be linear with input signal to <5% (correctable to <0.3%) over the range 100 to 70,000 electrons and shall be independent on exposure time.

DETECTOR:

Flight build detector IR#1 at gain setting = 2.5 e/adu

BACKGROUND:

The baseline characteristics of the Rockwell IR detectors have been measured by the GSFC Detector Characterization Laboratory (DCL). Those measurements include a determination of the linearity of the response of the flight-candidate devices. The current test procedure is designed to verify the performance of those detectors once integrated in the WFC3 system. Quantitative measurements from these tests will be made only under T/Vac conditions, since the WFC3 IR detector cannot be cooled to operating temperature under ambient conditions.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3 and the temperature controlled to an accuracy of 0.1° C.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to determine the noise statistics; custom software for analysis of multiaccum data. Pre-processing software, dark rate calculator, masking software, amp glow checking software all exist.

OS CONFIGURATION:

Flat field produced by integrating sphere fed by VISIR fiber, monochromator in single mode (125nm) centered on 1250 nm with ND2 in F/W 1, open in F/W 2 and a slit width of 1500 microns.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

ir04s01

DETAILED TEST PROGRAM:

The linearity of the response of the WFC3/IR detector will be verified by taking Multiaccum flat-field images. The zeropoint of those images can be calibrated against the extended target images taken for test IR03. All of the data will be taken using the F125W filter, since no wavelength dependence is expected. Detector linearity can be determined by comparing the observed profile (in ADU as $f(\text{time})$) against the expected profile, based on the incident flux and the exposure time. The total intensity in the final readout is predicted to correspond to $\sim 86,000 e^-$, but care should be taken to avoid over illumination that would trigger detector instability. The full sequence of linearity exposures will be bracketed by dark frames, to monitor detector performance.

EXPOSURES:

Gain	Exposure time	N_{Exp}	Comments
2.5 e^-/adu	SPARS10 = 143 secs	10	T = 150K

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns.

TOTAL ELAPSED TIME:

IR04S01 – 1.7 hours

VARIANTS:

Use an alternative OS configuration to obtain higher or lower flux levels.

QUICK-LOOK VERIFICATION:

The background level should look fairly uniform in differences between reads (2-1, 15-14).

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. The response curve will be determined by using standard techniques to measure the average counts as a function of time.

TEST RESULTS AND DATA PRODUCTS:

- 1) Linearity plot per quadrant at 2.5 e^-/adu setting, 150K
- 2) Analytic expression (e.g. polynomial) for the linearity correction per pixel to be incorporated into CDBS reference file.

These results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

The response curve will be verified during SMOV through observations of standard stars and standard star fields.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

IR04S01: Run in TV#1. No changes for TV#2.

3.5 IR05: IR subarray readout noise

CALIBRATION TEST#: 3.1.11

TITLE: Readnoise for IR subarrays

CATEGORY: Science Calibration

P.I.: M. Robberto

IPT REVISION DATE: 13 June 2003; revision for TV2 in October 2006

REVISION HISTORY:

- Specified 5 sequences (mr)
- Oct. 2006:
 - Removed dark current test: only readout noise with subarray
 - Number of iterations increased to 10.
 - Long ramps changed to SPARS10 (was STEP25).

PURPOSE:

To verify that the readout noise remains within CEI specifications in subarray mode.

PRIORITY: High

CEI SPECIFICATION(s):

4.8.3: Readnoise – single pair readnoise < 15 e-/pix at 90K to 100K pix/sec readout rate.
Sequence of 10 non-destructive reads shall have readout noise < 10e-/pix at the same readout rate.

4.8.4: dark rate – mean rate < 0.4 e-/pix/sec

4.8.5: non-functional pixels - < 2% dead or with dark rate > 100X mean dark rate

4.8.14: bias stability – bias within a quadrant correctable to < 3 e- RMS

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

The baseline characteristics of the Rockwell IR detectors have been measured by the GSFC Detector Characterization Laboratory (DCL), including determinations of dark count and readnoise for selected subarray formats. The current test procedure is designed to verify the performance of the flight detectors once integrated in the WFC3 system. Quantitative measurements from these tests will be made only under T/Vac conditions, since the WFC3 IR detector cannot be cooled to operating temperature under ambient conditions.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3 and the temperature controlled to an accuracy of +/- 0.1° C.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to determine the noise statistics; custom software for analysis of multiaccum data. Pre-processing software, dark rate calculator, masking software, amp glow checking software all exist.

OS CONFIGURATION: N/A

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

ir05s03

DETAILED TEST PROGRAM:

A series of darks will be taken for four sub-array formats using two sample sequences – SPARS10, with a total integration time of 100 seconds, and RAPID, where the total time varies with the sub-array size. All of the measurements will be made with the detector at T_{nom} . The expectation is that there should be minimal differences with respect to results obtained with full-frame imaging.

EXPOSURES:

Sampseq	Total Exposure time	N _{exp}	Comments
RAPID	0.9x10=9	10 x 15 reads	64x64
RAPID	1.7x10=17	10 x 15 reads	128x128
RAPID	4.2x10=42	10 x 15 reads	256x256
RAPID	12.8x10=128	10 x 15 reads	512x512
SPARS10	100x10=1000	10 x 15 reads	64x64
SPARS10	100x10=1000	10 x 15 reads	128x128
SPARS10	103x10=1030	10 x 15 reads	256x256
SPARS10	112x10=1200	10 x 15 reads	512x512

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns. The sequence of 8 dark ramps contained in SMS ir05s03 will be repeated 10 times.

TOTAL ELAPSED TIME:

ir05s03 – 0.3 hours

VARIANTS:

Repeat at different temperatures: T_{nom} , $T_{nom}-2K$, $T_{nom}+5K$, $T_{nom}+10K$

QUICK-LOOK VERIFICATION:

Differences between reads (2-1, 15-14) should look fairly uniform. The mean flux level should be very low (< 1 ADU/pix/sec) after the first several frames - tables and figures from DCL darks should be available as comparison.

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. Differences between reads (2-1, 15-14) should look fairly uniform. Mean flux level should be very low (< 1 ADU/pix/sec) after the first several frames. Tables and figures from DCL darks should be available as comparison.

TEST RESULTS AND DATA PRODUCTS:

Bias and dark values for subarrays, for comparison to full-frame values.

All test results will be summarized in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

A comparable sequence of darks will be taken during SMOV and, if necessary, subsequent on-orbit calibration programs.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

IR05S01: Ran in TV#1. Replaced by ir05s03 for TV#2.

IR05S02: Ran in TV#1. Replaced by ir05s03 for TV#2.

IR05S03: Created for TV#2.

3.6 IR06: IR Field of View Size, Location and Orientation

CALIBRATION TEST#: 3.3.1

TITLE: IR Field of View Size, Location and Orientation

CATEGORY: Science Calibration

P.I.: M. Stiavelli/T. Brown

REVISION DATE: 13 June 2003; validated 9 Sept 2003

PURPOSE:

To determine the the plate scale and the size, location and orientation of the IR detectors with respect to the field of view of the WFC3 instrument. A point-source image produced by the OS will be moved to known locations on the simulated HST focal plane, and measurement will be made of the position on the detector of the resulting image.

PRIORITY: High

CEI SPECIFICATION(s):

4.3.1.1.2: IR plate scale

4.3.1.2.2: IR unvignetted FOV

4.8.1: relative orientation of the UVIS and IR FOVs

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

A determination of the orientation of the IR detector in the HST V2/V3 co-ordinate system is essential to permit reliable target acquisition on-orbit; confirmation of the unvignetted region within the full FOV of the detectors is essential for accurate photometry. Data obtained during the ground-based calibration campaign will provide initial estimates of both quantities; final calibration will be undertaken during SMOV, using observations of moderate-density star fields.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3; see IR08

SOFTWARE REQUIREMENTS:

Existing IDL (acs_gaussintfit, ms_center, wfc3_tv) or IRAF (display, imexam) tools can display images and measure the PSF centers.

OS CONFIGURATION:

see IR08

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

see IR08

DETAILED TEST PROGRAM:

see IR08

EXPOSURES:

No specific images taken for this procedure. Data taken for procedure IR08/3.4.1 will be analysed to verify the detector orientation; data from procedure IR13/3.6.1A will allow determination of the area of the FOV subject to less than 5% vignetting.

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns.

TOTAL ELAPSED TIME:

see IR08

VARIANTS:

ANALYSIS:

Simple PSF-fitting routines can be used to determine the centroids of the point-source images in detector co-ordinates; match against the known input positions permits determination of the detector orientation, platescale and field of view.

Vignetting can be estimated through analysis of flat field images, searching for systematic deviations with radial distance from the optical axis (reduced flux with increasing radius).

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

The detector plate scale is required by the Exposure Time Calculator (ETC), in the SIAF file and other CDBS tables.

SMOV/ON-ORBIT FOLLOW-UP:

A final determination of the detector orientation and of the vignetting function will be made using observations of standard star fields (e.g. 47 Tucanae) obtained during SMOV and in subsequent on-orbit photometric calibration campaigns.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

3.7 IR07: Geometric distortion

CALIBRATION TEST#: 3.3.2

TITLE: Geometric distortion on the IR detector

CATEGORY: Science Calibration

P.I.: T. Brown / G. Hartig

REVISION DATE: 13 June 2003; validated 9 Sept 2003

PURPOSE:

To determine the geometric distortion of the IR channel with respect to the field of view of the WFC3 instrument. A point-source image produced by the OS will be moved to known locations on the simulated HST focal plane, and measurement will be made of the position on the detector of the resulting image.

PRIORITY: Medium

CEI SPECIFICATION(s):

4.3.1.1: IR plate scale

4.8.1: relative orientation of the UVIS and IR fields of view

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

The optical design of the IR channel results in appreciable geometric distortion in the image plane, resulting in a predicted change of $\pm 1\%$ in the pixel scale. These predictions can be tested to some extent during the ground calibration campaign, by determining the image centroids of point sources positioned at pre-determined locations. Since measurements are proposed at only a limited number of positions, the data will not allow derivation of the geometric distortion from first principles, but should be sufficient to verify the optical model.

HARDWARE REQUIREMENTS:

see IR08

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines will be used to ratio frames and perform basic statistics (counts, median, mean, sigma) and, if necessary, undertake Fourier analysis of the images.

OS CONFIGURATION:

see IR08

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

see IR08

DETAILED TEST PROGRAM:

see IR08

EXPOSURES:

see IR08

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns. Execute once. Repeat if any changes are made to the instrument that would affect the FOV or location/alignment of the chips.

TOTAL ELAPSED TIME:

see IR08

VARIANTS:**ANALYSIS:**

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. Simple PSF-fitting routines can be used to determine the centroids of the point-source images in detector co-ordinates; match against the known input positions permits determination of the detector orientation, platescale and field of view.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

A final determination of the geometric distortion will be made using observations of standard star fields (e.g. 47 Tucanae, NGC 1850) obtained during SMOV.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

3.8 IR08: Encircled energy

CALIBRATION TEST#: 3.4.1

TITLE: Point-source encircled energy on the WFC3/IR detector

CATEGORY: Science Calibration

P.I.: G. Hartig

REVISION DATE: 16 July 2003; validated 9 Sept 2003

PURPOSE:

To determine the radial profile of a point source as a function of position on the detector and as a function of wavelength. Sixteen images will be taken, in a regular grid centered on the nominal aperture, at each of three wavelengths.

PRIORITY: High

CEI SPECIFICATION(s):

4.3.2.2: IR channel point source profile (see table)

Specification	Center of FOV	Edge of inscribed square
Inner Core @633nm in 0.25 arcsec diameter	67% Goal: 81%	67% Goal: 81%
Outer Core @633nm in 0.40 arcsec diameter	78% Goal: 84%	78% Goal: 84%
Inner Core @1000nm in 0.25 arcsec diameter	56% Goal: 61%	56% Goal: 61%
Outer Core @1000nm in 0.37 arcsec diameter	72% Goal: 80%	72% Goal: 80%
Inner Core @1600nm in 0.25 arcsec diameter	48% Goal: 54%	48% Goal: 54%
Inner Core @1600nm in 0.60 arcsec diameter	75% Goal: 80%	75% Goal: 80%
Wing @ 1000nm in 0.5 arcsec radius	>=88%	>=88%
Wing @ 1000nm in 1.0 arcsec radius	>=95%	>=95%
Wing @ 1000nm in 2.0 arcsec radius	>=96%	>=96%
Wing @ 1000nm in 3.0 arcsec radius	>=97%	>=97%
Wing @ 1600nm in 0.5 arcsec radius	>=80%	>=80%
Wing @ 1600nm in 1.0 arcsec radius	>=92%	>=92%
Wing @ 1600nm in 2.0 arcsec radius	>=96%	>=96%
Wing @ 1600nm in 3.0 arcsec radius	>=97%	>=97%

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

The encircled energy distribution of a point source provides a key test of the optical quality of the WFC3 IR camera. This calibration item will be performed in SLTV at GSFC, using the flight build IR detector. It is assumed that the detector and corrector alignments have been optimized with earlier testing. Images will be acquired through the F110W and F160W filters to test for chromatic effects. The spot will be displaced to cover a regular grid on the detector.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3 and IR corrector previously optimized. The OS should be capable of placing a fiber-fed point source at the desired field locations, with an accuracy of 0.1 arcsec (0.8 px). The stimulus configuration will be chosen to produce unresolved point-source images on the detector.

SOFTWARE REQUIREMENTS:

Special IDL EE tools previously developed and successfully used for earlier HST instruments. The relatively large central obscuration (0.46) reduces the expected EE in the core significantly; the expected OTA+WFC3 EE will be estimated from PSF modeling.

OS CONFIGURATION:

Laser diode/single-mode fibers used for measurements at 1064 and 1310 nm; 10 μ pinhole used at 1600 nm, with 30 nm monochromator passband and QTH lamp.

SITS COMMAND MODE: SMS**SITS SMS/OS SCRIPT NAMES:**

ir08s01, ir08s02, ir08s03

DETAILED TEST PROGRAM:

After a few manually-commanded trial images to set the CASTLE illumination level to achieve the correct exposure (~30k DN in peak px), an SMS will be used to obtain one full-frame, 4 readout, RAPID IR image at each field location.

EXPOSURES:

Measurements will be made at 16 field points, IR01 through IR16, at locations indicated in the table below, which lists the offsets, in px, from nominal field center (IR00). Full frame, four readout, RAPID images will be obtained at each field point.

FP ID	dX (px)	dY (px)
IR00	0	0
IR01	100	100
IR02	100	-100
IR03	-100	-100
IR04	-100	100
IR05	400	400
IR06	100	400
IR07	-100	400
IR08	-400	400
IR09	-400	100

IR10	-400	-100
IR11	-400	-400
IR12	-100	-400
IR13	100	-400
IR14	400	-400
IR15	400	-100
IR16	400	100

Separate SMSs are defined for each wavelength/CASTLE configuration. It is assumed that the point source flux will be high enough for all wavelengths that RAPID mode will yield high SNR images in at most 4 samples. The CASTLE source and fiber/aperture for each wavelength, and the WFC3 IR filter and initial exposure time estimates are shown below:

Wavelength	Source	Fiber/aper	Filter	Expo (s)
1064 nm	LD1064	SMF	F105W	10
1310 nm	LD1310	SMF	F125W	10
1600 nm	QTH/mono	10 μ	F160W	10

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns.

TOTAL ELAPSED TIME:

ir08s01 – 0.8 hrs exposure time, 2.1 hrs elapsed time

ir08s02 – 0.8 hrs exposure time, 2.1 hrs elapsed time

ir08s03 – 0.8 hrs exposure time, 2.1 hrs elapsed time

total - 2.4 hrs 6.3 hrs

VARIANTS:

None

QUICK-LOOK VERIFICATION:

The point source produced by the OS should be centered near the specified pixel location and should attain peak intensity >10kDN. The background level should look fairly uniform in differences between reads (2-1, 4-3). The flux level should not exceed 35kDN in the point source.

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. Determine the centroid and measure the radial intensity profile and encircled energy at specified radii for the point source on each image. The measured positions and positional offsets between the images can also be combined with model predictions, to verify the plate scale, geometric distortion and orientation of the WFC3 IR camera and detector. These data constitute the requirements for IR06,07 (FOV, orientation, and geometric distortion check).

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook and used by the ETC.

SMOV/ON-ORBIT FOLLOW-UP:

Observations of standard stars and standard star fields will provide encircled energy/PSF measurements for both SMOV and on-orbit calibration.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

IR08S01: Ran in TV#1.

IR08S01A: Modified source intensities; ran in TV#1. Reuse for TV#2.

IR08S02: Ran in TV#1.

IR08S02A: Modified source intensities; ran in TV#1. Reuse for TV#2.

IR08S03: Ran in TV#1.

IR08S03A: Modified source intensities; ran in TV#1. Reuse for TV#2.

3.9 *IR09: Image stability*

CALIBRATION TEST#: 3.4.3

TITLE: Image stability on WFC3/IR

CATEGORY: Science Calibration

P.I.: T. Brown

REVISION DATE: 13 June 2003

PURPOSE:

To verify the optical stability of WFC3 in a changing thermal environment is within the CEI specifications. The stability of the IR channel is tested at the same time as the stability of the UVIS channel. See UV12 for details.

PRIORITY: High

CEI SPECIFICATION(s):

4.3.2.5.2: IR image drift – less than 20 mas over 2 orbits

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

WFC3 will be subjected to a range of thermal environments on-orbit, with significant variation possible during the course of moderate to long exposures. This test aims to verify the stability of the optical system using a series of point-source images.

HARDWARE REQUIREMENTS:

The IR flight detector should be installed in WFC3 and capable of producing subarray images. The instrument temperature needs to be changed during the drift monitoring.

SOFTWARE REQUIREMENTS:

Existing IDL (acs_gaussintfit, ms_center, wfc3_tv) or IRAF (display, imexam) tools can display images and measure the PSF centers.

OS CONFIGURATION: See UV12.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES: UV12

3.10 IR10: PSF wings and halo

CALIBRATION TEST#: 3.4.4

TITLE: Extended PSF for WFC3/IR channel

CATEGORY: Science Calibration

P.I.: G. Hartig

REVISION DATE: 16 July 2003; validated 9 Sept 2003

PURPOSE:

To determine the radial profile of a saturated point source as a function of wavelength. Deep images will be taken with the simulated point source near nominal field center, together with bias frames, at each of three wavelengths.

PRIORITY: High

CEI SPECIFICATION(s):

4.3.2.2: IR channel point source profile (see table for IR08)

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

Extremely bright stellar images produce extended halos. This calibration item will be performed in SLTV at GSFC, using the flight build IR detector. It is assumed that the IR channel is optically aligned (detector and corrector) to optimize image quality over the field. Deep, point source images will be acquired at 3 wavelengths spanning the IR channel spectral range.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed and aligned in WFC3. The OS should be capable of placing a fiber-fed point source at the desired field location.

SOFTWARE REQUIREMENTS:

Special IDL EE tools previously developed and successfully used for earlier HST instruments. This measurement provides a check for gross scattering or ghosting effects, but will not correctly predict the on-orbit PSF wing profiles, which are expected to be dominated on-orbit by OTA mid-frequency error and in these measurements by scatter in the stimulus optics.

OS CONFIGURATION:

Laser diode/single-mode fibers used for measurements at 1064 and 1310 nm; 10 μ pinhole used at 1600 nm, with 30 nm monochromator passband and QTH lamp.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

Included in ir08s01, ir08s02 and ir08s03.

DETAILED TEST PROGRAM:

A set of seven exposures will be taken with each filter in the following order: two over-exposed images, one dark frame, three over-exposed images, and a second dark frame. The dark images serve both to flush the detector and to check for residual images. These frames are a logical extension of the point source images obtained for IR-08, and will be obtained with the same set of SMSs developed for that program.

EXPOSURES:

All exposures are full-frame at gain of 2.5 e-/DN. The measurements obtained at each of the three wavelengths are obtained at different field positions in case persistence is strong and to sample the field dependence of the PSF wings, ghosts, etc., as well as examine cross-talk from 3 different amps. It is assumed that full well is reached in ~10 s.

FP ID	filter	obstype	expo (s)	sam pat	comment
IR01		dark	400	STEP100	get bkgd
IR01	F105W	pt src	100	STEP25	10x full well
IR01		dark	400	STEP100	check persistence
IR01	F105W	pt src	1000	STEP400	100x full well
IR01		dark	400	STEP100	meas. persistence decay
IR02		dark	400	STEP100	get bkgd
IR02	F125W	pt src	100	STEP25	10x full well
IR02		dark	400	STEP100	check persistence
IR02	F125W	pt src	1000	STEP400	100x full well
IR02		dark	400	STEP100	meas. persistence decay
IR03		dark	400	STEP100	get bkgd
IR03	F160W	pt src	100	STEP25	10x full well
IR03		dark	400	STEP100	check persistence
IR03	F160W	pt src	1000	STEP400	100x full well
IR03		dark	400	STEP100	meas. persistence decay

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns.

TOTAL ELAPSED TIME:

Included in IR08 estimate.

VARIANTS:

At low priority, investigate other field positions (e.g., near field corners).

QUICK-LOOK VERIFICATION:

The point source produced by the OS should be centered on the aperture, and should lie well within the extracted image if sub-arrays are used. The background level should look fairly uniform in differences between reads (2-1, 15-14).

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. Determine the radial profile for each point source image; inspect dark frames for residual images; examine full field for evidence of ghosts, scatter, or cross-talk.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

No specific follow-up observations are scheduled. Incidental observations of bright stars obtained during other SMOV activities will provide on-orbit verification of the PSF profile at large radii.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

3.11 IR11: IR Throughput – photometric filters

CALIBRATION TEST#: 3.5.1A

TITLE: IR throughput calibration – photometric filters

CATEGORY: Science Calibration

P.I.: T. Brown

REVISION DATE: 19 Sep 2006; validated 9 Sept 2003; revised 25 Sept 2006

PURPOSE:

To determine the throughput for the photometric filters available with the WFC3/IR channel.

PRIORITY: High

CEI SPECIFICATION(s):

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument.

4.4.2.2: IR channel optics throughput shall exceed tabulated values:

Wavelength (microns)	Throughput
0.80	0.61
0.90	0.63
1.00	0.68
1.10	0.70
1.20	0.72
1.30	0.72
1.40	0.73
1.50	0.73
1.60	0.73
1.70	0.73
1.80	0.73
1.90	0.73

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

WFC3 is designed to have high throughput over the full wavelength range covered by the IR channel.

This calibration item will be performed in thermal-vac at GSFC, using flight build detector IR#1.

Images will be acquired using all the wideband and mediumband IR filters. The fiber spot-source will be centered on field point IR01, and the input flux measured to an accuracy of 2 percent. An initial estimate of the relation between input fiber position (on the OS) and spot location on the detector is required.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3. The OS should be capable of placing a fiber-fed point-source at the desired field location, and of monitoring the incident flux to an accuracy of better than 2%.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to view the images and measure positions and profiles for point sources.

OS CONFIGURATION:

Point-source generated by 200-micron fiber bundle linked to monochromator, operating in double mode (bandwidth of 5 nm).

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

ir11s01a, ir11s02a

DETAILED TEST PROGRAM:

Full-frame MULTIACCUM images will be taken for each filter, interspersed with DARKs to measure image persistence. Three cycles of measurements will be made.

EXPOSURES:

Filter	Wavelength	Sampseq	N-read	OS Configuration
F160W	1600 nm	RAPID	7	Tu/DoubleIR/200micronVISIR/ND5/5nm
F125W	1250 nm	RAPID	7	...
F140W	1400 nm	RAPID	7	...
F110W	1100 nm	RAPID	9	...
F127M	1270 nm	RAPID	7	...
F139M	1390 nm	RAPID	7	...
F098M	980 nm	RAPID	15	...
F153M	1530 nm	RAPID	7	...
F164N	1640 nm	RAPID	7	...
F167N	1670 nm	RAPID	7	...
F128N	1280 nm	RAPID	7	...
F130N	1300 nm	RAPID	6	...
F126N	1260 nm	RAPID	7	...
F132N	1320 nm	RAPID	6	...

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns.

TOTAL ELAPSED TIME:

IR11S01A – 3.1 hrs

IR11S02A – 3.1 hrs

VARIANTS:

IR11S02A – same test at IR11 instead of IR01

QUICK-LOOK VERIFICATION:

The extended source produced by the OS should be centred on the aperture, and should lie well within the extracted image if sub-arrays are used. The background level should look fairly uniform in differences between reads (2-1, 15-14). The flux level should not exceed 35,000 counts in the extended source.

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. Determine the total counts by fitting each point source image. The image profile will also provide information on variations in the PSF as a function of wavelength.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

IR11S01: Ran in TV#1.

IR11S01A: Updated for TV#2 – replaced F093W with F140W.

IR11S02: Ran in TV#1.

IR11S02A: Updated for TV#2 – replaced F093W with F140W.

IR11S03: Used in TV#1 for throughput crosscheck between UVIS and IR channels.

3.12 IR12: Throughput – detector-defined passbands

CALIBRATION TEST#: 3.5.1B

TITLE: IR throughout – detector-defined passbands

CATEGORY: Science Calibration

P.I.: T. Brown

REVISION DATE: 10 April 2007

PURPOSE:

To determine the throughput as a function of wavelength at the short wavelength limit of the six IR filters having the most significant blue leak: F153M, F164N, F167N, F126N, F128N & F139M.

PRIORITY: High

CEI SPECIFICATION(s):

4.4.3: Spectral range stability

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument.

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

Matching the predicted sensitivity of WFC3 against standard photometric systems requires accurate knowledge of photometric passbands. The IR filters all exhibit a significant blue leak in the vicinity of 700-850 nm, but with the old IR detector, the lack of QE at these wavelengths rendered this blue leak irrelevant. Now that we have switched to thinned detectors with significant short-wavelength response, there are situations where the counts from blue photons can comprise a non-negligible fraction of the total counts detected. The worst-case estimates predict the fraction of blue leak counts can be as high as ~5% when observing blue sources with narrow-band filters. However, the filter curve data are very noisy at the blue leak wavelengths, making it difficult to provide observers with an accurate calibration of the blue leak. This test will finely sample the 6 most egregious bandpasses at short wavelengths to fully characterize the blue leak. IR12S04 characterizes F153M, F164N, & F167N, while IR12S05 characterizes F126N, F128N, & F139M. A sample sequence of STEP25 is used due to the uncertainty in the OS flux and filter curves at these wavelengths.

Note that the earlier versions of IR12 (IR12S01, IR12S02, & IR12S03) were written to test the blue leak in F093W, but that filter has now been replaced with F140W in the instrument, so those versions are no longer relevant.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3. The OS should be capable of monitoring the incident flux provided by the diffuse source to an accuracy of better than 5% and of tuning the monochromator to the required central wavelength and bandwidth with an accuracy of 0.1 nm.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to view the images and measure basic image statistics (mean, rms variation, fixed-pattern structure analysis).

OS CONFIGURATION:

200 micron VISIR fiber with the Tungsten lamp. DoubleIR monochromator from 740-850 nm and DoubleVIS monochromator from 700-730 nm. Flux calibration should be obtained for each measurement. Steps of 10 nm across the 700-850 nm range.

SITS COMMAND MODE: SMS**SITS SMS/OS SCRIPT NAMES:**

IR12S04, IR12S05

VARIANTS:

IR12S01, IR12S02, IR12S03 (F093W tests, now obsolete)

TOTAL ELAPSED TIME:

IR12S04 – 8.9 hours

IR12S05 – 8.9 hours

QUICK-LOOK VERIFICATION:

The extended source produced by the OS should be at field point IR01. The background level should look fairly uniform.

ANALYSIS:

The data will be processed initially using the WFC3-IR IPT pipeline analysis. Simple image arithmetic, coupled with measurements of the input flux, will give the absolute throughput as a function of wavelength.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

No direct follow-up observations. The on-orbit photometric performance will be determined through observations of isolated bright photometric standards and photometric sequences in star clusters.

ADDITIONAL COMMENTS: None**SMS HISTORY:**

IR12S01: Prototype created for TV#1, but not used. Updated for TV#2, but then retired.

IR12S02: Prototype created for TV#1, but not used. Updated for TV#2, but then retired.

IR12S03: Prototype created for TV#1, but not used. Updated for TV#2, but then retired.

IR12S04: Created for TV#2.

IR12S05: Created for TV#2.

3.13 IR13: IR Flat Fields

CALIBRATION TEST#: 3.6.1A

TITLE: IR flat fields – photometric filters

CATEGORY: Science Calibration

P.I.: H. Bushouse

REVISION DATE: 11 October 2006 for TV#2

PURPOSE:

To obtain reference flat fields for on-orbit calibration, and to identify cosmetic defects in either filters or CCD detectors.

PRIORITY: High

CEI SPECIFICATION(s):

4.8.11.1: HgCdTe detector uniformity – the detector shall be correctable to uniform gain per pixel to better than 2% at all useable wavelengths, and to <1% between 1000 and 1800 nm (goal <0.5%). No more than 5% of pixels shall have response outside 5-200% of the mean response (goal <1% outwith 95-105%).

4.8.11.2: Low spatial frequency flat field structure – large-scale flat field uniformities shall be correctable to <2%.

4.8.11.3: HgCdTe non-functional pixels – no more than 2% (goal 0.5%) of pixels may be non-functional (hot, dead, uncorrected QEs <25% or more than 400% of mean).

4.8.11.4: Flat field stability – the difference between two flat fields taken 60 days apart using the same instrument configuration shall not exceed 1% rms (goal 0.5%). Further, no more than 5% of the FOV shall differ by more than 5%.

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

Calibrating the response of the IR HgCdTe detector as a function of position is vital to establishing WFC3 as a photometric instrument. Flat fields – images taken while the detector is illuminated uniformly – allow calibration of the differential areal response. This calibration item will be performed in T/Vac at GSFC, using flight build detector IR#1. Ambient calibration is not possible since the detector cannot be cooled to operating temperature. Flat-field images will be obtained in all of the IR filters.

HARDWARE REQUIREMENTS:

The IR flight detector should be installed in WFC3. The OS should be capable of providing uniform (<1%) flat field illumination, monitored to an accuracy of 5%. The OS specifications require a uniformity of <3%, but the OS Acceptance Test Report indicates that the OS meets the higher specification.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines will be used to ratio frames and perform basic statistics (counts, median, mean, sigma) and, if necessary, undertake Fourier analysis of the images.

OS CONFIGURATION:

Diffuse, flat-field illumination generated by the OS tungsten lamp, operating in mirror mode. A range of neutral density filters are required to obtain the appropriate exposure levels, ranging from clear to ND4.

SITS COMMAND MODE: SMS**SITS SMS/OS SCRIPT NAMES:**

IR13S01A – all filters

IR13S02A – F139M under different OS flux levels

IR13S03 – Flat field vs detector temperature

IR13S04 – Flat field stability

DETAILED TEST PROGRAM:

IR13S01: Flat field images will be taken with every IR filter, with the exception of the grisms. A minimum of four exposures will be taken for each filter, with the individual exposures divided into two campaigns to provide a measure of the long-term stability. The flat field exposures will be interspersed with darks to provide a measure of image persistence. The exposure times are set to limit the number of electrons/pixel to less than ~60,000.

IR13S02: A short sequence of flats will be taken with the F139M filter using different sample sequences and OS neutral density filters. This will verify that the flat field structure does not depend on the incident flux level.

IR13S03: A set of four F139M flats will be taken, with each exposure reaching a level of ~60,000 e/pix. The SMS can be repeated at different detector temperatures.

IR13S04: Three sets of F139M flats will be taken, interspersed with darks, so as to obtain sets of flats about once every hour over a two-hour period. Each set of coadded flats will reach a total signal level of ~300,000 e/pix.

EXPOSURES: IR13S01A

Filter	Sample sequence	Time	OS ND filter setting
F098M	SPARS10 (6)	53 sec	ND1
F105W	RAPID (6)	18	ND1
F110W	SPARS10 (7)	63	ND2
F125W	SPARS10 (9)	83	ND2
F140W	SPARS10 (5)	43	ND2
F160W	SPARS10 (7)	63	ND2
F127M	SPARS10 (5)	43	ND1
F139M	SPARS10 (5)	43	ND1
F153M	RAPID (11)	32	ND1
F126N	RAPID (9)	26	Open
F128N	RAPID (7)	20	Open
F130N	RAPID (7)	20	Open

F132N	RAPID (7)	20	Open
F164N	RAPID (5)	15	Open
F167N	RAPID (5)	15	Open

IR13S02A

Filter	OS Configuraton	Sampseq	Time	Comments
F139M	QTH/mirror/ND3	SPARS100 (6)	503 sec	medium flux, ~50 e/sec
F139M	QTH/mirror/ND4	SPARS100 (15)	1403 sec	low flux, ~7 e/sec
F139M	QTH/mirror/ND2	SPARS10 (15)	143 sec	high flux, ~175 e/sec

IR13S03

Filter	OS Configuration	Sampseq	Time	Comments
Blank	N/A	SPARS10 (5)	43 sec	dark
F139M	QTH/mirror/VISIR Flat/ND1	SPARS10 (5)	4 x 43 sec	4 x 60k e/pix

IR13S04

Filter	OS Configuration	Sampseq	Time	Comments
F139M	QTH/mirror/VISIR Flat/ND1	SPARS10 (5)	5 x 43 sec	5 x 60k e/pix
Blank	N/A	SPARS10 (15)	4 x 143 sec	dark
Blank	N/A	SPARS25 (15)	2 x 353 sec	dark
F139M	QTH/mirror/VISIR Flat/ND1	SPARS10 (5)	5 x 43 sec	5 x 60k e/pix
Blank	N/A	SPARS10 (15)	3 x 143 sec	dark
Blank	N/A	SPARS25 (15)	2 x 353 sec	dark
F139M	QTH/mirror/VISIR Flat/ND1	SPARS10 (5)	5 x 43 sec	5 x 60k e/pix

FREQUENCY/No. of ITERATIONS:

Measurements can only be made during the T/Vac campaigns. IR13S01 will be executed at least 4 times in order to study temporal stability. IR13S02 will be executed once. IR13S03 may be executed at different detector temperatures. IR13S04 will be executed once.

TOTAL ELAPSED TIME:

IR13S01A – 2.1 hrs execution time; 8.4 hrs total time for 4 iterations

IR13S02A – 1.7 hrs execution time

IR13S03 – 0.3 hrs per execution

IR13S04 – 2.5 hrs execution time

VARIANTS:

The single monochromator source may be used instead of the mirrors.

QUICK-LOOK VERIFICATION:

The background level should look fairly uniform in differences between reads (2-1, 15-14). The detected signal level should not exceed ~24,000 DN/pix (~60,000 e/pix).

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. Fourier analysis will be used to search for correlated image structure and differencing will be used to identify filter-

specific defects. Reference flat fields will be generated by combining individual images using appropriate filters. The goal is to provide <1% accuracy flat fields in all filters.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook. Flat fields are required for each filter for CDBS.

SMOV/ON-ORBIT FOLLOW-UP:

Flat fields with the internal calibration lamps will be taken during SMOV and in subsequent on-orbit calibration campaigns (see IR15); sky flats will be constructed from deep imaging data for many of the filters. However, the ground calibration images may be the only flat fields available for some narrowband filters.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

IR13S01: Executed successfully in TV#1.

IR13S01A: For TV#2, the F093W filter exposures were replaced with F140W exposures and the exposure times adjusted for all exposures to account for the change in detector readout time. The decrease in sample times for RAPID mode has made it necessary to use the SPARS10 sample sequence for some filters.

IR13S02: Executed in TV#1, but the exposure parameters did not fulfill the original goal of the test, which was to obtain flats at very different levels of incident flux.

IR13S02A: Rewritten for TV#2 to obtain flats at incident flux levels varying by a factor of 25.

IR13S03: Created for TV#2.

IR13S04: Created for TV#2.

3.14 IR14: IR Grism Flat Fields

CALIBRATION TEST#: 3.6.1A

TITLE: IR flat fields – spectroscopic filters

CATEGORY: Science Calibration

P.I.: H. Bushouse

REVISION DATE: 11 Oct 2006 for TV#2

PURPOSE:

To obtain a series of narrowband flats spanning the wavelength range covered by the IR G102 and G141 grisms, for the purpose of calibrating the wavelength dependence of the background response.

PRIORITY: High

CEI SPECIFICATION(s):

4.8.11.1: HgCdTe detector uniformity – the detector shall be correctable to uniform gain per pixel to better than 2% at all useable wavelengths, and to <1% between 1000 and 1800 nm (goal <0.5%). No more than 5% of pixels shall have response outside 5-200% of the mean response (goal <1% outwith 95-105%).

4.8.11.2: Low spatial frequency flat field structure – large-scale flat field uniformities shall be correctable to <2%.

4.8.11.4: Flat field stability – the difference between two flat fields taken 60 days apart using the same instrument configuration shall not exceed 1% rms (goal 0.5%). Further, no more than 5% of the FOV shall differ by more than 5%.

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

The WFC3 IR-channel filter set includes two grisms, providing low-dispersion spectra covering the 800-1200 nm (G102) and 1100-1700 nm (G141) regimes. Since grism spectra are slitless, accurate flux calibration requires knowledge of the pixel-by-pixel wavelength response of the detector. That response is determined by combining flux-calibrated images taken with the 200 micron target with narrowband (10 nm) flat fields, which provide the spatial response.

HARDWARE REQUIREMENTS:

The IR flight detector should be installed in WFC3. The OS should be capable of providing uniform (<1%) flat field illumination, monitored to an accuracy of 5%. The OS specifications require uniformity if <3%, but the OS Acceptance Test Report indicates that the OS meets the higher specification.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines will be used to ratio frames and perform basic statistics (counts, median, mean, sigma) and, if necessary, undertake Fourier analysis of the images.

OS CONFIGURATION:

Diffuse, flat-field illumination generated by the monochromator, operating in double mode with a bandwidth of 10 nm. Flux calibration measurements will require the 200 micron target coupled to the double-mode monochromator, with 10 nm bandwidth. Neutral density filters will be required for most of the observations.

SITS COMMAND MODE: SMS**SITS SMS/OS SCRIPT NAMES:**

IR14S01: G102 flat fields, 800 to 1180 nm

IR14S02: G141 flat fields, 1060 to 1700 nm

IR14S03: G102 absolute flux calibration

IR14S04: G141 absolute flux calibration

DETAILED TEST PROGRAM:

A series of narrowband (10 nm) full-frame flat field images will be taken at 20 nm intervals spanning the wavelength range 800-1180 nm (G102) and 1060-1700 nm (G141). These will be combined with 256-square sub-array images taken of the 200 micron target at a central location on the detector, with the data having similar spectral resolution and covering the same wavelength range. The extended target data will provide absolute calibration; the flat field data provide information on spatial response.

EXPOSURES:

Integration times will be set to give 10,000 e/pixel for both the flat field and extended target observations at each wavelength. Initial exposure times have been calculated using the CASTLE ETC. Various Multiaccum sample sequences and numbers of readouts are used to achieve the necessary exposure time for each observation. Flat field exposure times range from 10 – 1200 sec, depending on wavelength, with most in the 10 – 30 sec range. Extended target flux calibration exposure times range from 1 – 10 sec, with most in the 1 – 3 sec range.

FREQUENCY/No. of ITERATIONS:

The SMS's can only be run during thermal-vacuum campaigns. The flat field SMS's will be executed multiple times to obtain $S/N > 100$ and to assess flat field stability.

TOTAL ELAPSED TIME:

IR14S01 – 2.3 hours per iteration

IR14S02 – 2.7 hours per iteration

IR14S03 – 2.8 hours

IR14S04 – 4.5 hours

VARIANTS:

Full-frame images of the 200 micron target may be taken, rather than sub-arrays, depending on operational convenience.

QUICK-LOOK VERIFICATION:

The background level should look fairly uniform in differences between reads (2-1, 15-14). The flux level should not exceed 25,000 DN (65,000 e).

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. The raw exposures will need basic processing to remove bias and dark. Basic image combination, statistics, and arithmetic tools are needed to produce the proper image-to-image normalization and construct the flat field data cube.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

The following data products will be produced:

3. Flat Field Data Cube
4. Absolute Flux Calibration

None of these products are used directly by the standard calwf3 calibration pipeline processing, nor are they required for it to operate. These products are used only by the post-pipeline spectral extraction software.

Flat Field Data Cube: Built from a set of full-frame monochromatic flats, taken over a range of wavelengths that spans the sensitivity of each grism.

Absolute Flux Calibration: NICMOS and ACS derive their inverse sensitivity curves (Jy/DN/sec) using an on-orbit technique of ratioing the uncalibrated spectra of standard stars (G191-B2B, P330) to calibrated model spectra of these stars. We will obtain an initial ground calibration of the WFC3 grism modes by obtaining absolute flux measurements (using the OS photodiode) of the monochromatic point-source exposures in the IR14S03 and IR14S04 SMS's.

SMOV/ON-ORBIT FOLLOW-UP:

Flat Fields: There is no possibility to repeat the full flat-field calibration on-orbit. The only analogous types of exposures that we will be able to obtain are filter flats that lie within the wavelength range of the grisms. By comparison with the filter flats obtained during ground cal (3.6.1A) we should be able to provide some amount of tracking of changes to the flat field properties, but the wavelength coverage is far from optimal. A list of the instrument filters that lie within the wavelength ranges of the grisms is shown below.

IR G102	800-1100 nm	F098M, F105W, F110W
IR G141	1100-1700 nm	F105W, F110W, F125W, F126N, F127M, F128N, F130N, F132N, F139M, F153M, F160W, F164N, F167N

Absolute Flux Calibration: The ground tests will provide an initial estimate of the absolute flux calibration. On-orbit observations will be required to refine this calibration to the desired accuracy. This will involve grism observations of standard stars.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

IR14S01: Original SMS created to obtain flats for both G102 and G141 grisms. Never executed in TV#1. Rewritten for TV#2 to obtain flats for G102 only (G141 flats split off into IR14S02).

IR14S02: Created for TV#2 to obtain G141 flats.

IR14S03: Created for TV#2 to obtain G102 flux calibration.

IR14S04: Created for TV#2 to obtain G141 flux calibration.

3.15 IR15: IR Internal Calibration System

CALIBRATION TEST#: 3.6.4

TITLE: Internal calibration system – IR flat fields

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: 24 July 2003; validated Sept 2003; updated Oct 2006

PURPOSE:

Verify the operational performance of the internal calibration system.

The calsystem images will be used to characterize the high-frequency behavior of the flatfields and track any changes over time; the set obtained during T/V will serve as the reference for subsequent on-orbit data. Comparison with the OS flatfields (from test 3.6.1/IR13) will provide a baseline calibration of the internal-lamp illumination pattern.

PRIORITY: High

CEI SPECIFICATION(s):

4.11.4: The calibration subsystem shall provide usable flux from 200-2000 nm, via a cool, red and a hot, blue continuum source. Sufficient flux to achieve a 10,000 e⁻/pixel mean exposure level in less than 10 minutes (17 e⁻/ sec/pixel) shall be available for all spectra.

4.8.11.4: IR Detector Flatfield Stability: the difference between two flatfields taken 60 days apart using the same instrumental configuration shall not exceed 1% rms. No more than 5% of the field of view shall exceed 5% variation.

DETECTOR: FPA64 at standard gain=2.5.

BACKGROUND:

The internal calibration system will provide the only means of obtaining internal flat field data while WFC3 is on orbit. There are two light sources: a deuterium lamp, which provides high flux at UV wavelengths; and a tungsten lamp for visual and near-infrared wavelengths. Data taken during the T/Vac calibration campaign serve as a reference compared to flat fields taken with the external optical stimulus, and as a measure of possible time variation when matched against on-orbit data.

Calibration Subsystem Operations (summarized from OPO-1, section 3.8):

Lamps cannot be on concurrently.

- Redundant lamp for IR channel
- Maximum lamp on-time of 255 min
- Each lamp rated to 8000 hrs at nominal operating current and voltage.
- Lamps require 30 sec warm-up period to reach halogen cycle; ground system to allow 1 min. Primary failure mode is cycling before halogen cycle achieved (Tu atoms can migrate from filament onto the inside of window, decreasing output and weakening the filament). The instrument state reconfiguration rules enforce this requirement.
- IR: lamp3 to be primary lamp, 4 is backup (DM-05, 2.2.3.3)

- In-orbit, lamps will be turned ON and OFF at alignment boundaries.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3. The internal calibration system should be installed and operational.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines will be used perform basic statistics (counts, median, mean, sigma) and image manipulation (ratios, stacking) and, if necessary, Fourier analysis of the images.

OS CONFIGURATION: N/A

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

IR15S01 (TV#1)

IR15S02 (TV#2; lamp 2)

IR15S03 (TV#2; lamp 4)

IR15S04 (TV#2, all lamps)

IR15S05 & IR15S06 (TV#2, lamp 2, parts 1 & 2)

IR15S07 & IR15S08 (TV#2, lamp 4, parts 1 & 2)

DETAILED TEST PROGRAM:

Three ramps in each of 14 IR filters plus total of 6 dark ramps, using SPARS25, STEP100, and STEP400 modes. Sequences and nreads listed below were chosen to achieve $\sim 65K e^-$ in the final ramp (based upon the sequence times listed in IR_Sample_Sequences_FSW_3_0C.pdf emailed to group Oct 13, 2006), while minimizing the number of patterns used. Exposure sequences have been adjusted based upon T/Vac1 results with FPA64 (Baggett, ISR 2005-09) and estimates of the new lamp + calsource ND filter behavior (~ 7 -7.5 times less light from cal source than during previous T/Vac).

EXPOSURES:

filter	wavelength (microns)	exptime, s (for $65K e^-$)	samp-seq	nsamp
F098M	0.985	~ 850	step100	14
F105W	1.045	311	step100	9
F110W	1.150	130	spars25	6
F125W	1.250	173	step100	8
F126N	1.257	4066	2xstep400	13
F127M	1.270	723	step100	13
F128N	1.280	3473	2xstep400	13
F130N	1.300	3197	2xstep400	12
F132N	1.320	3204	2xstep400	12
F139M	1.385	777	step400	10
F140W	1.400	96	spars25	5
F153M	1.530	520	step100	11
F160W	1.545	130	spars25	6
F164N	1.643	1768	step400	13
F167N	1.667	1670	step400	12

FREQUENCY/No. of ITERATIONS:

The SMS can be tested during the ambient calibrations, but measurements can only be made during T/Vac campaigns. At least 3 iterations, preferably more, are needed of S02 (or S05+S-6) and at least one each of S03 (or S07+S08) and S04.

TOTAL ELAPSED TIME:

IR15S01 – 3.7 hrs

IR15S02 – 9.1 hrs

IR15S03 – 9.1 hrs

IR15S04 – 1.2 hrs

IR15S05 – 5.4 hrs

IR15S06 – 5.7 hrs

IR15S07 – 5.4 hrs

IR15S08 – 5.7 hrs

VARIANTS:

QUICK-LOOK VERIFICATION:

The background level should look fairly uniform in differences between reads (2-1, 15-14). The flux level should not exceed 35,000 counts in the last read.

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis, measuring countrates to verify lamp performance. Reference flat fields will be generated by combining individual images using appropriate filters. Fourier analysis can be used to search for correlated image structure and differencing will be used to identify filter-specific defects.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

Set of flatfields to be used as baseline set for SMOV and on-orbit flats. Although not used directly by the OPUS pipeline, calibration system flatfields will be archived in CDBS.

SMOV/ON-ORBIT FOLLOW-UP:

A regular series of flat field images will be taken during SMOV and in standard on-orbit calibration cycles to monitor flatfield behavior.

ADDITIONAL COMMENTS:

Relevant images and data analysis results from previous T/Vac campaign should be available for comparison to the new images. A check for hysteresis, in the red and the blue, should be done for both UVIS and IR (planned as part of the flatfield procedure using the external lamps - UVIS20, IR13 - where the lamp output can be monitored).

SMS HISTORY:

IR15S01: Original SMS used for TV#1.

IR15S02: Improved version of IR15S01 for use in TV#2, using Cal Source tungsten lamp #2; updated to include new F140W filter and new exptimes for change in Cal Source ND filters.

IR15S03: Copy of IR15S02, but using tungsten lamp #4; for use in TV#2.

IR15S04: Check of relative flux levels in all 4 tungsten lamps; for use in TV#2.

IR15S05: First half of IR15S02, to decrease execution time.

IR15S06: Second half of IR15S02, to decrease execution time.

IR15S07: First half of IR15S03, to decrease execution time.

IR15S08: Second half of IR15S03, to decrease execution time.

3.16 IR16: IR Grism wavelength dispersion relations

CALIBRATION TEST#: 3.7.2

TITLE: IR grisms: wavelength dispersion calibration

CATEGORY: Science Calibration

P.I.: H. Bushouse

REVISION DATE: 13 October 2006 for TV#2

PURPOSE:

To determine the relation between (relative) pixel position and wavelength for the IR G102 and G141 grisms.

PRIORITY: High

CEI SPECIFICATION(s):

4.4.1 Wavelength Range

4.4.1.2 IR Channel: 850-1700nm; priority on 1000-1600nm

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

The WFC3 IR-channel filter set includes two grisms, providing low-dispersion spectra covering the wavelengths 800-1100 nm (G102) and 1100-1700 nm (G141). Defining the relation between (delta) pixel value and wavelength is a vital step in calibrating grism spectra. Since no line source is available, the calibration will be determined from narrowband (10 nm) point source images.

HARDWARE REQUIREMENTS:

The IR flight detector should be installed in WFC3. The OS should be capable of tuning the central wavelength of the monochromator passband to an accuracy of 0.1 nm. The OS should be capable of placing a point target at a defined aperture on the WFC3 IR detector.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines will be used to perform basic statistics (counts, median, mean, sigma). Standard routines for determining centroids of the point sources will be used.

OS CONFIGURATION:

Point-source images with the 20 micron IR target linked to the double monochromator, bandwidth 10 nm. Neutral density filters will be required for all passbands to avoid over-illumination of the detector.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

IR16S10, IR16S11, IR16S12, IR16S13, IR16S14: G102

IR16S20, IR16S21, IR16S22, IR16S23, IR16S24: G141

DETAILED TEST PROGRAM:

A series of narrowband (10 nm) full-frame images will be taken of the 20 micron point target centered on 5 defined apertures on the IR detector: on the central detector aperture and in each of the four corners. The monochromator will be stepped at 20 nm intervals over the wavelength range 800-1160 nm (G102) at the central location, with 40 nm steps over the same wavelength range in the 4 corners. For the G141 grism, 50 nm steps will be employed to cover the 1100-1700 nm wavelength range at all field locations.

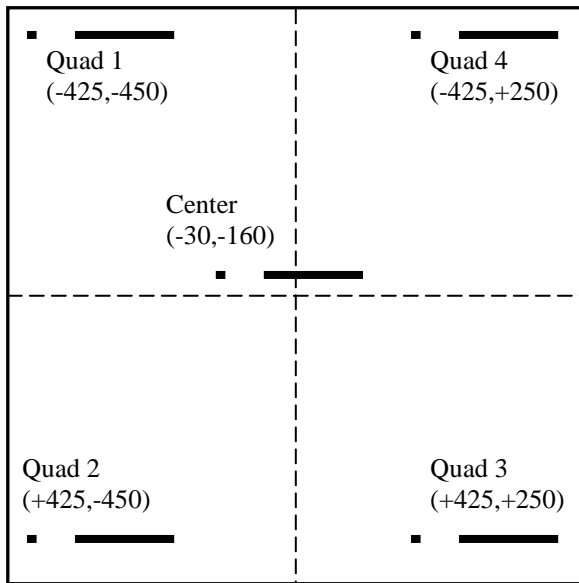
In addition, a dispersed image of a white light point source will be obtained at the 5 locations on the detector (4 corners plus center), in order to map the spectrum length and tilt. Direct images will also be obtained at each of the 5 white light point source positions, in order to measure source offsets between direct and dispersed images.

EXPOSURES:

The following table lists basic parameters for each of the SMS's. Field (aperture) locations refer to the location of the point source in a direct image and have been chosen so as to always have both the direct image spot and the extent of the +1st order spectrum lie within the field of view. With wavelength increasing to the right in the field, this implies that observations located at the corners of detector quads 1 and 2 will also contain the +2nd (and possibly +3rd) order spectra, while those located in the corners of quads 3 and 4 will also contain the -1st order spectra.

SMS	Grism	Aperture	OS Configuration
IR16S10	G102	IR (-30,-160): centered	QTH/DoubleIR/10um pinhole/10nm bandpass
IR16S11	G102	IR (-425,-450): quad 1	
IR16S12	G102	IR (+425,-450): quad 2	
IR16S13	G102	IR (+425,+250): quad 3	
IR16S14	G102	IR (-425,+250): quad 4	
IR16S20	G141	IR (-30,-160): centered	QTH/DoubleIR/10um pinhole/10nm bandpass
IR16S21	G141	IR (-425,-450): quad 1	
IR16S22	G141	IR (+425,-450): quad 2	
IR16S23	G141	IR (+425,+250): quad 3	
IR16S24	G141	IR (-425,+250): quad 4	

The following diagram shows the approximate locations of the spectra within the IR field of view. The dot to the left of each spectrum trace indicates the expected location of the direct image spot and corresponds to the aperture locations specified in the table above.



FREQUENCY/No. of ITERATIONS:

The SMS's can only be executed during the T/Vac campaigns.

TOTAL ELAPSED TIME:

IR16S10: 1.6 hours; IR16S11 – IR16S14: 1.0 hours each; 5.6 hours total

IR16S20 – IR16S24: 1.5 hours each; 7.5 hours total

VARIANTS:

Because the grism dispersion is known to be very linear, coarser sampling in wavelength space could be used to decrease execution time if necessary.

QUICK-LOOK VERIFICATION:

The point source produced by the OS should fall near the desired aperture locations within the field, and should step vertically within the image as wavelength increases. The background level should look fairly uniform in differences between reads (2-1, 15-14). The flux level should not exceed 30,000 DN (75,000 e/pix).

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. The raw exposures will need basic processing for zero-level subtraction. Standard image centroiding tools can be used to measure the spot locations in the various images. Tables of spot pixel position versus wavelength will be fitted with a polynomial function to determine the dispersion solution coefficients.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

The main data products are:

2. Dispersion solution, including direct-to-grism image offsets and spectrum trace.

None of these products is used directly in the standard calwf3 calibration pipeline processing, nor are they required for it to operate. These products are used only by the post-pipeline spectral extraction software.

Dispersion Solution: The parameters that need to be measured or derived include the x/y offsets of a source in the direct and dispersed images, the tilt of the spectrum with respect to the detector rows, the length of each order, and the actual pixel-to-wavelength solution. Ideally we should also check to see if any of these parameters are field dependent (they almost certainly will be due to the geometric distortion).

NICMOS and ACS use a dispersion solution of the form: $\lambda = \lambda_0 + b \cdot \delta x$, where b is the dispersion (in $\mu\text{m}/\text{pix}$ or $\text{\AA}/\text{pix}$) and δx is the distance, in pixels, from the source in the direct image to the corresponding spectral position in the dispersed image. The dispersion solution can be derived by building a table of x pixel position vs. wavelength, and then fitting this relation with a polynomial (e.g. IRAF tasks POLYFIT or TLINEAR).

Ideally the dispersion solution would be measured from dispersed images of an emission-line source. The ACS ground calibration used a pinhole mask with Hg and Ar line lamps to obtain emission-line spectra at many positions within the field of view. On orbit, NICMOS uses Planetary Nebulae and ACS uses Wolf Rayet stars (given the higher spatial resolution of ACS, PN are resolved sources and therefore not useful).

SMOV/ON-ORBIT FOLLOW-UP:

Dispersion Solutions: As mentioned above, NICMOS and ACS have used Planetary Nebulae and Wolf-Rayet stars as dispersion calibrators on-orbit. We will most likely not be able to use Planetary Nebulae for the same reason as ACS – they're extended sources at the WFC3 resolution. ACS saw a definite change in the dispersion solution from ground to orbit. Therefore I expect that we will want to recalibrate our dispersion solution in SMOV, and perform checks in later calibration episodes to see if there's any temporal drift.

The observing procedures and data analysis would be much the same as in the ground calibration. Observations of a suitable line source (both direct and dispersed) should be obtained in several positions within the field, from which we would perform the same type of pixel position-vs-wavelength measurements.

SMS HISTORY:

IR16S01: Abbreviated G102 dispersion measurements, executed in TV#1. Contained measurements at field center and one corner. Results in WFC3 ISR 2005-07.

IR16S02: Abbreviated G141 dispersion measurements, executed in TV#1. Contained measurements at field center and one corner. Results in WFC3 ISR 2005-07.

IR16S03: G102 focus sweep executed in TV#1. Results in WFC3 ISR 2005-06.

IR16S04: G141 focus sweep executed in TV#1. Results in WFC3 ISR 2005-06.

IR16S05: G102 focus vs. field position, executed in TV#1. Results in WFC3 ISR 2005-06.

IR16S06: G141 focus vs. field position, executed in TV#1. Results in WFC3 ISR 2005-06.

IR16S10 – IR16S14: G102 dispersion at each of 5 field locations, created for TV#2.

IR16S20 – IR16S24: G141 dispersion at each of 5 field locations, created for TV#2.

3.17 IR17: Ghost images

CALIBRATION TEST#: 3.7.2

TITLE: Ghost images in the IR system

CATEGORY: Science Calibration

P.I.: T. Brown

REVISION DATE: 27 Sep 2006

PURPOSE:

To identify artifacts produced by internal reflections in the WFC3 optics.

PRIORITY: High

CEI SPECIFICATION(s):

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument.

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

Reflections of bright stars, either within or just outside the FOV, by the WFC3/IR optical system can produce a variety of ghost images. This test aims to quantify the extent of this problem by placing a bright, fiber-generated point source at various locations on the detector and just outside the field of view.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3. The IR Flight detector should be installed in WFC3. The OS should be capable of placing a fiber-fed point-source at the desired field location.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to view the images and measure positions and profiles for any detected artifacts.

OS CONFIGURATION:

Point-source generated by 10 micron fiber, operating in broadband mode with Tungsten lamp.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES: IR17S01/C01, IR17S02/C02, IR17S03/C03, IR17S04/C04

DETAILED TEST PROGRAM:

In the first SMS (S01A/C01A), a series of images will be taken with a bright point source on and near the IR detector. As a baseline, we will obtain exposures at 19 pointings on the detector (2 unsaturated, 17 saturated) and at an additional 16 points outside the field of view. These exposures will be taken with

the F110W filter. The same SMS then does 5 pointings (1 unsaturated, 4 saturated) on the detector for the F125W and F140W (because both were not measured previously).

In the second SMS (S02/C02), we repeated the F110W pointings for the F160W, and also do a scan across the leading edge of the tilted detector to check for internal reflection.

In the third SMS (S03/C03), we obtain 5 pointings (1 unsaturated, 4 saturated) on the detector for each of the remaining IR filters (i.e., all filters except for the F110W, F125W, F140W, and F160W).

NB: Since over-illumination can lead to significant image persistence in the IR detector, this test should be scheduled appropriately within the full T/Vac science calibration test plan.

EXPOSURES:

Filter	X	Y	Exposure time
F110W, F160W	20	20	Log-linear series up to 150 sec
	-400	-400	
	-400	400	
	400	-400	
	400	400	
	200	-400	
	200	400	
	-200	-400	
	-200	400	
	-20	-20	
	-550	-550	
		-500	
		-200	
		200	
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F126N, F127M, F128N, F130N, F132N, F139M, F153M, F164N, F167N, F140W, F125W			to 150 sec
	-200	200	
	200	-200	
	200	200	
	20	20	Rapid series

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns.

TOTAL ELAPSED TIME:

IR17S01A – 3.8 hours

IR17S02 – 4.6 hours

IR17S03A – 5.0 hours

IR17S04 – 6.4 hours

VARIANTS:

None

QUICK-LOOK VERIFICATION:

Aside from image reflections, the background level should look fairly uniform in differences between reads (2-1, 15-14).

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. Inspect the images for ghosts and other artifacts; determine the profiles, relative intensities and potential persistence of these artifacts.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

No direct follow-up observations, although full-frame imaging of bright standards could be used to verify predictions based on the ground calibration images.

ADDITIONAL COMMENTS:

SMS HISTORY:

IR17S01: Ran in TV#1.

IR17S01A: Updated for TV#2: Added F125W and F140W exposures.

IR17S02: Ran in TV#1. Reuse for TV#2.

IR17S03: Ran in TV#1.

IR17S03A: Updated for TV#2: Removed F093W and F125W exposures.

IR17S04: Ran in TV#1. Reuse for TV#2.

3.18 IR18: IR Light Leaks

CALIBRATION TEST#: 3.8.5

TITLE: Test for light leaks in the WFC3 IR Camera

CATEGORY: Science Calibration

P.I.: G. Hartig

REVISION DATE: 16 July 2003; validated 9 Sept 2003

PURPOSE:

A series of images will be taken with a bright light source placed at various exterior locations around the WFC3 instrument, testing for light leaks in the instrument. This test does not require that the detectors run at full science sensitivity, and is logistically simpler with WFC3 in ambient conditions than in T/Vac. Nevertheless, *it is not expected that this test will be performed*, due to logistical difficulty of maintaining the IR detector at sufficiently cold temperature to produce meaningful results in the ambient environment required to investigate the light leak characteristics.

PRIORITY: Low

CEI SPECIFICATION(s):

WFC3 will provide high photometric performance over the full wavelength range covered by the instrument.

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

The WFC3 IR camera should be impervious to light leaks.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3; the instrument should be shrouded to allow a bright lamp to be placed at unambiguous external locations.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines to view the images and measure positions and profiles for any detected artifacts.

OS CONFIGURATION: N/A.

SITS COMMAND MODE: CCL

SITS SMS/OS SCRIPT NAMES:

N/A

DETAILED TEST PROGRAM: TBD

EXPOSURES: TBD

FREQUENCY/No. of ITERATIONS:

If feasible, measurements will be made during the ambient campaigns.

TOTAL ELAPSED TIME: TBD

VARIANTS:

ANALYSIS:

Visual inspection should permit the identification of any serious light leaks.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

None

ADDITIONAL COMMENTS:

3.19 IR19: IR System Monitor

PROCEDURE #: Calibration procedures that call out stability or monitoring:

3.6.2 UVIS and IR Flat Field Stability-monitor FF stability through subset of filters.

3.9.2 System Performance Monitoring – short series of bias, dark, flats (internal and external) and point source exposures to monitor performance – to be run at least 10 times, before and after thermal cycling and after any major configuration change.

TITLE: WFC3 IR Performance Monitoring

CATEGORY: Science Performance Monitor

P.I.: H. Bushouse

REVISION DATE: 25 August 2003; validated 9 Sept 2003; revised 11 Oct 2006

PURPOSE: To monitor the scientific performance of the IR channel in TV at operational temperatures. The basic science functions include darks, internal and external flats at multiple wavelengths, and unresolved sources to monitor the optical quality.

PRIORITY: High.

CEI REQUIREMENTS: See Table 1.

VARIANTS: The IR Science Performance Monitoring test has two variations:

1. Ambient Conditions – emphasis on Darks and Warm Noise test only. IR19S04.
2. TV at Nominal Operating Temperatures – (darks, PSF, internal and external FF).

DETECTOR: IR Flight #2 using nominal gain = 2.5e-/DN at the nominal cooled temperature of 150K.

BACKGROUND: Internal and external flats are monitored to assess stability and to provide FFs for the point source exposures. The PSF provides a measure of optical quality stability. Monochromatic point sources will be measured to reveal PSF details and as a check against the encircled energy results. Filter F160W was chosen because it is the premier filter of the set. F105W was selected to represent the bluer wavelengths. A point source through F105W is also acquired as a check against the encircled energy test PSFs. Flats and point sources are obtained in full frame and 64x64 subarrays, the latter to be used for bright standard star calibrations. The *Multiaccum* sample sequence patterns include RAPID and STEP25: the RAPID sequence was chosen to minimize test duration and as a representative mode for observations of standard stars. The STEP25 sequence is a logarithmic sampling of charge and is representative of the buildup of dark background.

PREREQUISITES: The IR channel is cooled to its nominal operating temperatures and has passed the system aliveness and functional tests.

SCHEDULING CONSTRAINTS: Perform in TV only.

HARDWARE REQUIREMENTS: SITS system, Optical Stimulus, WFC3 in TV Chamber. The OS should be capable of placing a fiber-fed point source at the desired field location, with an accuracy of

0.1 arcseconds (0.8 pixels). The fibers should be chosen to give an unresolved point-source image on the detector [ref. G. Hartig Encircled Energy Test]. The OS is also required to produce diffuse flatfield sources.

SOFTWARE REQUIREMENTS: The analysis steps are:

- PSF parameters and profiles vs. long term intervals, short-term intervals, as function of wavelength. Use PSF analysis tools (from G. Hartig).
- Histograms, statistical measures, Fourier analysis of darks as a function of time.
- Histograms, statistical measures, shape, spatial details of internal and external FF as a function of time and wavelength. Compare internal and external flats results.

Data reduction and analysis may be run using IDL S/W package CCD pipeline and IR Pipeline (Hilbert) or equivalent quick look software provided by ICAL.

OS CONFIGURATIONS:

Ext Flat Field: Tungsten lamp, Mirror mode (LP340 long-pass order-sorting filter), VISIR Flatfield, with clear and ND2 settings.

Point Source: Tungsten lamp, Double-IR monochromator mode, 10 micron pinhole target, ND3, 10 nm bandpass, central wavelengths of 1050 and 1600 nm, at IR02 and IR04 field locations.

Extended Source: Tungsten lamp, Double-IR monochromator mode, 200 micron VISIR fiber target, ND4 and ND5 settings, 5 nm bandpass, central wavelengths of 1050 and 1600 nm, at IR01, IR11, and central field locations.

SITS COMMAND MODE: SMS

DETAILED TEST PROGRAM:

Darks: To verify dark current and readnoise stability. Uses the “standard star” setup and a logarithmic setup.

RAPID Subarray: Take 1 64x64 subarray dark, RAPID sequence, 15 reads (~1 sec)

RAPID Full: Take 2 full-frame darks, RAPID sequence, 15 reads (~44 sec). The pair of ramps will be used to measure readnoise.

STEP25 Subarray: Take 1 64x64 subarray dark, STEP25 sequence, 15 reads (231 sec).

STEP25 Full: Take 1 full-frame dark, STEP25 sequence, 15 reads (~300 sec).

Internal Flat Fields: To verify relative FF and internal lamp stability. Select exposure times to achieve ~25,000 DN/pix (~62,000 e/pix) in each filter. All exposures are taken at nominal gain.

F160W FF: Take 2 full-frame F160W flats, using RAPID sequence and Tungsten lamps 2 and 4. Provides Cal Sys lamp monitoring. F160W samples the red end of the sensitivity range and provides overlap with both the System Functional and the IR Cal System flats procedure IR15.

F098M FF, subarray: Take 2 F098M 64x64 subarray flats, using STEP25 sequence and Tungsten lamps 2 and 4. F098M samples the blue end of the sensitivity range.

F167N FF, subarray: Take 2 F167N 64x64 subarray flats, using STEP25 sequence and Tungsten lamps 2 and 4. F167N samples the red end of the sensitivity range and, in conjunction with the blue-end F098M flats, allows for monitoring of the Cal System Tungsten lamp color temperatures.

External Flat Fields: To illuminate the focal plane as an external source would do and to compare with the internal flats; to verify absolute flat field stability. Select exposure times to achieve ~25,000 DN/pix (~62,000 e/pix) in each filter. All exposures are taken at nominal gain.

F105W FF: Take 1 F105W flat, RAPID sequence. Provides overlap with IR Flat Fields (IR13) procedure.

F160W FF: Take 1 F160W flat, RAPID sequence. Provides overlap with IR Flat Fields (IR13) procedure.

F160W FF, subarray: Take 1 F160W 64x64 subarray flat, RAPID sequence, to compare with preceding full-frame flat. Also provides monitoring of the “bright standard star” setup.

External Point and Extended Sources: To monitor the PSF and photometric stability at different positions on the camera. Select exposure times to achieve 15000-25000 DN in peak pixel. All exposures at nominal gain. Note: 64x64 subarrays simulate standard star observations.

F105W PSF: Take 1 monochromatic (10nm bandwidth) unsaturated pt source, RAPID sequence. Provides overlap with IR Encircled Energy (IR08S01) procedure.

F160W PSF: Take 1 monochromatic (10nm bandwidth) unsaturated pt source, RAPID sequence. Provides overlap with IR Encircled Energy (IR08S03) procedure.

F160W Phot: Take 1 monochromatic (5nm bandwidth) extended source, RAPID sequence, with CASTLE flux-cal measurement for photometric stability assessment. Provides overlap with IR Throughput (IR11S01) procedure.

F105W Phot: Take 1 monochromatic (5nm bandwidth) extended source, RAPID sequence, with CASTLE flux-cal measurement for photometric stability assessment. Provides overlap with IR Throughput (IR11S01) procedure.

F105W Phot, subarray: Take 1 monochromatic (5nm bandwidth) extended source, RAPID sequence, in 64x64 subarray, with CASTLE flux-cal measurement for photometric stability assessment. Compare with preceding full-frame measurement to verify accuracy of “standard star” mode.

FREQUENCY: run after major instrument or major stimulus configuration adjustments or corrections, as a monitor through TV, after thermal cycling intervals.

TEST RESULTS/DATA PRODUCTS: Description of trend analysis and statistical analysis results as a function of time and other environmental parameters. Running updates to trend plots will be provided at each repetition of the test. Relevant temperatures and other telemetry items will be recorded and trended. **Calibration Products:** The data are used for trending purposes.

SMOV ON-ORBIT FOLLOWUP: A version of the performance monitoring test will be continued in SMOV. The timescale of the monitoring depends on the results of the TV stability tests.

ADDITIONAL COMMENTS: Note, a subset of SYSTEM FUNCTIONAL (Schoeneweis and Pugliano) exposures will overlap the science monitoring test. These images will be included as part of the science monitoring test suite as long as they are obtained in a nominal temperature environment.

Table 1. Relevant CEI Specifications (includes UVIS and IR).

WFC3 Performance Monitor: CEI Requirements Verification Table		
CEI #	CEI Requirement	Specification
6.2.4.1	Functional Test Suite - all functions tested periodically throughout the test program and before and after environmental tests.	Requirement to be met by the combination of ground test functionals: system functional, abbreviated functional, science performance monitoring.
4.6.14	CCD Bias Stability	bias over single row repeatable to 2e
4.6.11.4	CCD Flat Field Stability	diff between 2 flats 60 days apart < 1%rms, < =5% of the FOV shall not exceed 5% variation.
4.6.11.3	CCD Functioning Pixels	non funct pix < 1% (dead or hot)
4.6.10	CCD Detector QE Stability	abs qe p-p/1hr < +/-0.5%, abs qe p-p/1mo < +/-1%, abs qe p-p/mo @300nm < +/-2%, pix to pix stab 1 sigma/1hr < 0.2%
4.6.4	CCD Dark at 83C	dark<20e/px-hr
4.6.3	CCD Readout Noise	RN<4e/px @ 30Kpx/sec rate
4.4.2.1	UV Channel Optical Throughput	CEI-ST66 see Table 4-3
4.3.2.1	UV Channel Point Source Profile	CEI-ST66 see Table 4-1
4.4.3	UVIS and IR Spectral Range Stability (in-flight req --> what about ground?)	any one month period after 3 mo orbit 200-300nm <5%/mo, 300-400 <3%/mo 400-600nm <1%/mo, 600-1000 <1%/mo 1000-2000nm < 1%/mo
4.5.2	UVIS Shutter Repeatability	repeatable to < 0.01 sec: no 2 pixels differ in exp time by more than 0.01sec
4.3.2.5.1	UVIS Long Term Image Drift	registration to 0.25 px RMS over 24 hours
	Sofa Repeatability Req	No explicit repeatability requirement
4.8.14	HgCdTe Bias Stability	diff between pair readouts < 3 elect with goal 1
4.8.11.4	HgCdTe Flat Field Stability	60 days apart < 1% RMS, no more than 5% of FOV varies by 0.5%
4.8.10	HgCdTe Detector QE Stability	abs qe p-p/1hr < +/-0.5%, abs qe p-p/1mo < +/-1%, pix to pix stab 1 sigma/1hr < 0.2%
4.8.4	HgCdTe Dark	dark < 0.4e/px-sec at cold temp, 10% variation over 30 days
4.8.3	HgCdTe Read Noise	RN < 15 e/pix at 90-100K px/sec readout rate
4.3.2.5.1	IR Long Term Image Drift	registration to 0.125 px RMS over 24 hours
4.3.2.2	IR Channel PSF Profile	CEI-ST66 see Table 4-2
4.4.7.3	CSM Repeatability and Stability	accommodate jitter requirements and image stability

3.20 IR20: IR bias level as a function of gain

CALIBRATION TEST#: 3.1.5

TITLE: IR bias/zero level as a function of gain

CATEGORY: Science Calibration

P.I.: M. Robberto

IPT REVISION DATE: 1 Sept 2003; validated 9 Sept 2003

REVISION HISTORY:

PURPOSE:

To measure the zero-read bias level of the WFC3/IR detector as a function of gain

PRIORITY: High

CEI SPECIFICATION(s):

4.8.14: bias stability – Difference in bias between readouts shall be determinable to $< 3e-$

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

The baseline characteristics of the Rockwell IR detectors have been measured by the GSFC Detector Characterization Laboratory (DCL). Those measurements include a determination of the bias level of the flight-candidate detectors over the full on-orbit operating temperature range. The current test procedure is designed to verify the performance of those detectors once integrated in the WFC3 system. These tests will be undertaken under T/Vac conditions.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines will be used to ratio frames and perform basic statistics (counts, median, mean, sigma) and, if necessary, undertake Fourier analysis of the images.

OS CONFIGURATION: N/A

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

ir01s01, ir02s01, etc

DETAILED TEST PROGRAM:

Uses data taken in 3.1.2 or 3.1.4, listed as:

200 micron fiber point source, 2 exposures in RAPID mode

3.1.2 data gives bias level vs temp

3.1.4 data gives bias level vs gain (use parts of image away from pinhole)

EXPOSURES:

see 3.1.2 & 3.1.4

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns.

TOTAL ELAPSED TIME:**VARIANTS:**

The single monochromator source may be used instead of the mirrors.

QUICK-LOOK VERIFICATION:

Differences between reads (2-1, 15-14) should look fairly uniform. The mean flux level should be very low (< 1 ADU/pix/sec) after the first several frames - tables and figures from DCL darks should be available as comparison.

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis.. Standard statistical analysis.

TEST RESULTS AND DATA PRODUCTS:

Bias level as a function of temperature and gain.

Test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

SMOV and on-orbit data will be taken only at the standard operating temperature.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

3.21 IR21: IR readnoise as a function of gain

CALIBRATION TEST#: 3.1.5

TITLE: IR readnoise as a function of gain

CATEGORY: Science Calibration

P.I.: M. Robberto

IPT REVISION DATE: 13 June 2003; Oct 2006 (for TV2)

REVISION HISTORY:

- Specify 4 repeats of the relative SMS ir21s01 (mr)
- Changed Sampseq from SPARS50 to RAPID (Oct 2006)

PURPOSE:

To measure the variation in read noise in the WFC3/IR system as a function of gain.

PRIORITY: High

CEI SPECIFICATION(s):

4.8.3: Read noise – single pair read noise < 15 e-/pix at 90K to 100K pix/sec readout rate. Sequence of 10 non-destructive reads shall have readout noise < 10e-/pix at the same readout rate.

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

The readnoise of the IR FPA at the standard gain setting of 2.5 will be measured using data acquired in the IR01 procedures. This procedure duplicates a subset of those exposures, using the shortest full-frame readout times available, at the four available gain settings in order to measure readnoise as a function of gain.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3.

SOFTWARE REQUIREMENTS:

Pre-processing software (IDL), read noise calculator (IRAF), already exist. IDL and/or IRAF routines will be used to ratio frames and perform basic statistics (counts, median, mean, sigma) and, if necessary, undertake Fourier analysis of the images.

OS CONFIGURATION: N/A

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES: IR21S01

DETAILED TEST PROGRAM:

A set of four RAPID dark exposures will be taken at each gain setting. These data will be analyzed in conjunction with data taken as part of IR01.

EXPOSURES:

Gain	Sampseq	N _{exp}	Time	COMMENTS
2	RAPID	4	44 secs x 4	
2.5	RAPID	4	44 secs x 4	
3	RAPID	4	44 secs x 4	
4	RAPID	4	44 secs x 4	

FREQUENCY/No. of ITERATIONS:

The SMS will be tested during the ambient calibration campaign, but measurements can only be made during the T/Vac campaigns. The SMS will be repeated 4 times.

TOTAL ELAPSED TIME:

IR21S01 – 0.5 hrs execution time x 4 iterations

VARIANTS:

May be repeated at different detector temperatures

QUICK-LOOK VERIFICATION:

Differences between reads (2-1, 15-14) should look fairly uniform. The mean flux level should be very low (< 1 ADU/pix/sec) after the first several frames - tables and figures from DCL darks should be available as comparison.

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. Standard statistical analysis.

TEST RESULTS AND DATA PRODUCTS:

Table of readnoise as a function of temperature and gain. Value of average readnoise and gain for each amp for CDBS table. Test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

Measurements made at standard operating temperature.

ADDITIONAL COMMENTS:

Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

IR21S01: Prototype created for TV#1, but never run. Rewritten for TV#2.

3.22 IR22: IR Subarray Photometry

CALIBRATION TEST#: N/A

TITLE: IR subarray photometry

CATEGORY: Science Calibration

P.I.: M. Robberto, H. Bushouse

REVISION DATE: 10 Oct 2006 – modified for TV#2.

PURPOSE:

To obtain a series of point-source observations in both full-frame and subarray mode, in order to compare the photometric accuracies of the two different readout modes.

PRIORITY: High

CEI SPECIFICATION(s):

DETECTOR:

Flight build detector IR#1 at standard gain=2.5.

BACKGROUND:

On-orbit photometric calibration of the WFC3 IR channel will be achieved through observations of various standard stars. Most available IR standard stars are sufficiently bright to require the use of the WFC3 IR subarray readout mode in order to minimize the exposure times. These standard star observations will be used to calibrate full-frame science exposures and therefore it is vital that the photometric measurements obtained in subarray mode match and are applicable to full-frame readouts. This test procedure will obtain flux-calibrated point source observations in both full-frame and subarray modes, in order to compare the absolute photometry of the two modes.

HARDWARE REQUIREMENTS:

The IR flight detector should be installed in WFC3. The OS should be capable of providing a point source at various locations within the IR field of view and of providing absolute flux measurements of those sources.

SOFTWARE REQUIREMENTS:

IDL and/or IRAF routines will be used to perform aperture photometry of the point sources.

OS CONFIGURATION:

Point (10 micron pinhole) sources at four different locations in the field of view, using the Tungsten lamp, in single monochromator mode (125 nm bandwidth), tuned to a central wavelength of 1050 nm, and a range of neutral density filters to vary the incident flux of the source. Flux calibration measurements will be needed for each source setup.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

IR22S01A

DETAILED TEST PROGRAM:

A series of point-source observations will be taken, varying both the incident source flux and the location of the source in the field. Five sets of exposures will be taken in the 64x64 subarray readout mode, with each set consisting of four point-source exposures and the source moved to a different location within the 64x64 subarray field of view for each of the four exposures, in order to avoid effects due to persistence. Each of the five sets of exposures will use a different incident source flux, achieved by varying the CASTLE neutral density filter setting. The first of the four exposures in each set will use a CASTLE flux calibration measurement to set the absolute photometric scale. At the end of the five sets of subarray exposures a final pair of exposures, one in subarray and one in full-frame mode, will be taken, with the source at the same flux level for the two exposures.

RAPID and SPARS10 multiaccum sample sequences will be used to achieve the necessary integration times. Each set of source exposures will be preceded by a set of three dark exposures; one full-frame RAPID, one 64x64 subarray RAPID, and one 64x64 subarray SPARS10.

EXPOSURES:

Exposure times will be chosen to provide between 3000 and 90,000 e/pix in the final read, with most in the 20,000-30,000 e/pix range, which avoids the heavily non-linear regime of the detector response.

Source	Sampseq	Iterations	N-Read	Exp. Time (s)	Comments
Dark	SPARS10	1	15	143	FULL
Dark	RAPID	5	15	5 x 0.9=4.5	SQ64
Dark	SPARS10	5	15	5 x 100=500	SQ64
F105W	SPARS10	1	12	100	SQ64
F105W	SPARS10	1	12	100	SQ64
F105W	SPARS10	1	12	100	SQ64
F105W	SPARS10	1	12	100	SQ64
Dark	SPARS10	1	15	143	FULL
Dark	RAPID	5	15	5 x 0.9=4.5	SQ64
Dark	SPARS10	5	15	5 x 100=500	SQ64
F105W	SPARS10	1	3	14	SQ64
F105W	SPARS10	1	3	14	SQ64
F105W	SPARS10	1	3	14	SQ64
F105W	SPARS10	1	3	14	SQ64
Dark	SPARS10	1	15	143	FULL
Dark	SPARS10	5	15	5 x 100=500	SQ64
Dark	RAPID	5	15	5 x 0.9=4.5	SQ64
F105W	RAPID	1	15	0.9	SQ64
F105W	RAPID	1	15	0.9	SQ64
F105W	RAPID	1	15	0.9	SQ64

F105W	RAPID	1	15	0.9	SQ64
Dark	SPARS10	1	15	143	FULL
Dark	SPARS10	5	15	5 x 100=500	SQ64
Dark	RAPID	5	15	5 x 0.9=4.5	SQ64
F105W	RAPID	1	15	0.9	SQ64
F105W	RAPID	1	15	0.9	SQ64
F105W	RAPID	1	15	0.9	SQ64
F105W	RAPID	1	15	0.9	SQ64
Dark	SPARS10	1	15	143	FULL
Dark	SPARS10	5	15	5 x 100=500	SQ64
Dark	RAPID	5	15	5 x 0.9=4.5	SQ64
F105W	RAPID	1	8	0.5	SQ64
F105W	RAPID	1	8	0.5	SQ64
F105W	RAPID	1	8	0.5	SQ64
F105W	RAPID	1	8	0.5	SQ64
Dark	SPARS10	1	15	143	FULL
Dark	RAPID	5	15	5 x 0.9=4.5	SQ64
Dark	SPARS10	5	15	5 x 100=500	SQ64
F105W	SPARS10	1	12	78	SQ64
F105W	SPARS10	1	8	73	FULL

FREQUENCY/No. of ITERATIONS:

The SMS can only be run during thermal-vacuum campaigns.

TOTAL ELAPSED TIME:

IR22S01A – 3.5 hours

VARIANTS:

QUICK-LOOK VERIFICATION:

The background level should look fairly uniform in differences between reads (2-1, 15-14). The peak flux levels should not exceed 12,000 DN/pix (30,000 e/pix), except for the setup of exposures at the highest incident flux level, which will reach ~35,000 DN/pix (~87,000 e/pix) in the final read.

ANALYSIS:

The data will be processed initially using the standard WFC3-IR IPT pipeline analysis. The raw exposures will need basic processing to remove bias and dark. Basic aperture photometry routines will be used to measure the total detected counts for the point sources in each exposure.

TEST RESULTS AND DATA PRODUCTS:

Test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:

ADDITIONAL COMMENTS:

SMS HISTORY:

IR22S01: Executed in TV#1. Results in WFC3 ISR 2006-01.

IR22S01A: Updated for TV#2, modifying Samp-Seqs and N-Reads for new timing patterns.

3.23 IR23: IR Electronic Crosstalk Check

CALIBRATION TEST#: N/A

TITLE: Electronic Crosstalk Check

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: Oct 2006

PURPOSE:

Verify that the fix to the detector electronics box has reduced the crosstalk levels.

PRIORITY: High

CEI SPECIFICATION(s): N/A

DETECTOR:

IR flight build detector at standard gain=2.5.

BACKGROUND:

Crosstalk was found in IR images taken during previous TV testing: point sources in one quadrant generate negative mirror images in the adjoining quadrant at a relatively low level (few $\times 10^{-6}$ of input signal) while extended targets produced crosstalk at somewhat higher levels (few $\times 10^{-3}$). This test is to confirm that the DEB fix has been successful in reducing crosstalk levels.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3.

SOFTWARE REQUIREMENTS:

Standard IDL and/or IRAF routines.

OS CONFIGURATION:

10 micron pinhole with tungsten source and double IR monochrometer
200 micron VISIR fiber with tungsten source and double IR monochrometer

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

ir23s01 – intensity and location of crosstalk
ir23s02 – crosstalk as function of gain and subarrays

DETAILED TEST PROGRAM:

ir23s01 – pairs of dark and external F160W RAPID full readout images
done at 4 positions (IR08, IR06, IR10, IR02)
each position at two levels (barely saturated, 100x saturation)
set done with 10um pinhole, then repeated with 200um VISIR fiber
ir23s02 – pairs of dark and external F160W RAPID full readout images, 200 um VISIR fiber
first four pairs sample gains (2.5, 2.0, 3.0, 4.0)
gain 2.5 subarray test:
full frame dark, subarray dark
external barely saturated, dark, external ~100x sat., dark

EXPOSURES: (add table here)

FREQUENCY/No. of ITERATIONS:

SMS can be tested during ambient but measurements can only be made during T/Vac campaigns.

TOTAL ELAPSED TIME:

ir23s01 – 4.5 hrs
ir23s02 – 1.5 hrs

VARIANTS:**QUICK-LOOK VERIFICATION:**

Each exposure must be inspected visually – there should be no unexpected non-uniformities or structure.

ANALYSIS:

The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis. Images will need to be displayed and blinked with earlier frames; statistics and plotting routines will be needed to quantify remaining crosstalk levels.

TEST RESULTS AND DATA PRODUCTS:

Test images should allow verification that the crosstalk fix has been successful. Any residual crosstalk will be quantified and described in ISR and WFC3 data handbook.

SMOV/ON-ORBIT FOLLOW-UP:

Repeats of test should not be necessary.

ADDITIONAL COMMENTS: Exposure levels to be checked in OS verification SMS before running IR23. Relevant images and data analyses obtained prior during instrument-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns.

SMS HISTORY:

IR23S01: Created for and used in TV#1. Reuse for TV#2
IR23S02: Created for and used in TV#1. Reuse for TV#2.

3.24 IR24: Bias level vs. instrument voltage

CALIBRATION TEST#: N/A

TITLE: Bias level as a function of WFC3 input voltage

CATEGORY: Science Calibration

P.I.: M. Robberto

REVISION DATE: 11 April 2007

PURPOSE:

Determine whether the IR FPA bias level varies as a function of WFC3 instrument voltage.

PRIORITY: High

CEI SPECIFICATION(s): #4.8.14 (HgCdTe Detector Bias Stability)

DETECTOR:

Flight build detector IR#1 at standard gain setting (2.5 e⁻/DN); standard full-frame read-out through all four amps.

BACKGROUND:

Other HST instruments have shown that the detector bias level can be dependent on the instrument input voltage as the input voltage varies over the course of an HST orbit. This test is designed to determine whether the WFC3 IR detector bias level has such a dependency.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3.

SOFTWARE REQUIREMENTS:

Standard IRAF or IDL routines can be used to measure bias levels in the exposures.

OS CONFIGURATION:

None.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

IR24S01

DETAILED TEST PROGRAM:

A continuous series of 85 full-frame dark exposures will be taken while a CCL script is used to vary the WFC3 input voltage in a manner that mimics on-orbit variations. The dark exposures will use the full-

frame readout mode, the RAPID sample sequence, and 2 readouts (not counting the initial read following reset). The SMS will utilize serial dumping of the images. This will result in dark frames being obtained once every ~2.5 minutes over the course of ~3.5 hours, which will encompass several orbital periods of voltage variations.

FREQUENCY/No. of ITERATIONS:

Measurements will be made during thermal-vacuum testing. The SMS and CCL script may be repeated as desired, to obtain more cycles.

TOTAL ELAPSED TIME:

IR24S01 – 3.5 hours

VARIANTS:

Sub-array dark exposures could be used in place of the full-frame images – or mixed in with them – in order to decrease the read-out and buffer dump times, thereby increasing the frequency of sampling of the bias level during the voltage cycling.

ANALYSIS:

Mean bias level in the initial readout of each exposure will be correlated against WFC3 voltage at the time of the exposure.

TEST RESULTS AND DATA PRODUCTS:

No data products. Verification only.

SMOV/ON-ORBIT FOLLOW-UP:

A similar series of dark exposures could be executed during on-orbit spacecraft bus voltage cycling.

ADDITIONAL COMMENTS:

None.

SMS HISTORY:

IR24S01: Created for TV#2.

3.25 IR25: Subarray Locations

CALIBRATION TEST#: N/A

TITLE: IR Subarray Location Verification

CATEGORY: Science Calibration

P.I.: H. Bushouse

REVISION DATE: 14 November 2006

PURPOSE:

Verify that IR subarrays are located at the commanded detector coordinates.

PRIORITY: Medium

CEI SPECIFICATION(s): #4.10.3.2 (IR Subarray Readout Capability)

DETECTOR:

Flight build detector IR#1 at standard gain setting (2.5 e⁻/DN); standard read-out through all four amps using full-frame and all available subarray modes.

BACKGROUND:

The WFC3 Flight Software (FSW) allows a user to readout only a portion of the IR detector. The user specifies one of the available subarray sizes of 512x512, 256x256, 128x128, or 64x64 pixels. The subarrays are physically centered on the IR detector, using each of the four readout amplifiers to read one quadrant of the subarray. The purpose of this test is to verify that the correct region of physical detector pixels is being read out when using subarray commanding.

HARDWARE REQUIREMENTS:

The IR Flight detector should be installed in WFC3. The OS should be capable of producing full-field illumination using white-light.

SOFTWARE REQUIREMENTS:

IRAF and/or IDL can be used to verify the location and matching of flat-field patterns in the full-frame and subarray images.

OS CONFIGURATION:

Flat fields provided by fiber-fed integrating sphere using the Tungsten lamp as the light source. Neutral density filters ND1, ND2, and ND3 will be used to adjust the illumination level.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

IR25S01/IR25C01

DETAILED TEST PROGRAM:

One full-frame external flat-field image will be taken to serve as a reference for subsequent subarray flats. One flat-field image will then be taken in each of the 4 subarray readout modes: 512x512, 256x256, 128x128, and 64x64. The F140W filter and the RAPID readout sample sequence will be used, varying the number of readouts per exposure in order to achieve detected signal levels of 40-50,000 e/pix.

EXPOSURES:

SMS	Filter	OS Configuration	Exposure	Subarray
IR25S01	F140W	QTH/Mirror/VISIR Flat/ND3	RAPID, 15 reads, 44 sec	Full
		QTH/Mirror/VISIR Flat/ND2	RAPID, 8 reads, 6.8 sec	Sq512
		QTH/Mirror/VISIR Flat/ND1	RAPID, 4 reads, 1.1 sec	Sq256
		QTH/Mirror/VISIR Flat/ND1	RAPID, 8 reads, 0.9 sec	Sq128
		QTH/Mirror/VISIR Flat/ND1	RAPID, 15 reads, 0.9 sec	Sq64

FREQUENCY/No. of ITERATIONS:

Measurements will be made during the thermal-vacuum campaign. One cycle.

TOTAL ELAPSED TIME:

IR25S01 – 16 minutes (0.25 hours)

VARIANTS:

Point-source images could be used instead of flats to verify location of subarrays relative to the full-frame.

ANALYSIS:

Simple visual matching will be used to verify that the subarray flats correspond with the correct region of the full-frame flat field image, using the pixel-to-pixel QE variations as a reference.

TEST RESULTS AND DATA PRODUCTS:

No data products. Verification of FSW functionality only.

SMOV/ON-ORBIT FOLLOW-UP:

A similar test could be performed on-orbit using internal Calibration Subsystem flats.

ADDITIONAL COMMENTS:

None.

SMS HISTORY:

IR25S01: Created for TV#2.