Instrument Science Report WFC3-2004-03

WFC3 Science Calibration Plan

Part 4: Test Procedures

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by

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PREAMBLE

The WFC3 Science Calibration Plan (ISR WFC3-2002-07) outlines a series of tests designed to calibrate the operational performance of Wide-Field Camera 3. The measurements will be undertaken at Goddard Space Flight Center with WFC3 under both ambient and thermal-vacuum environmental conditions. This document presents a set of baseline procedures for each test included in the SciCalPlan, together with basic procedures covering optical alignment. These serve as templates for the individual tests. Each WFC3 calibration campaign incorporates subsets of those tests, modified as necessary to accommodate prevailing circumstances. In particular, exposure times and exact exposure sequences are adapted to exigent circumstances.

Procedure	Test name	PI	SciCal ref.	Comments
UVAL01	UVIS focus sweep	Hartig		Alignment
UVAL02	UVIS tip/tilt sweep	Hartig		Alignment
IRAL01	IR focus sweep	Hartig		Alignment
IRAL02	IR tip/tilt sweep	Hartig		Alignment
UVAL03	UVIS basic monitor			Performance monitor
UVAL04	UVIS abbreviated functional			Performance monitor
IRAL02	IR basic monitor			Performance monitor
IRAL04	IR abbreviated functional			Performance monitor
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 mitigation	Robberto	3.1.9	Science calibration
UVIS07	UVIS sub-array darkcount and readnoise	S. Baggett	3.1.11	Science calibration
UVIS08	UVIS shutter performance	Reid	3.2.1/3.2.2	Science calibration
UVIS09	UVIS FOV location & orientation	Stiavelli/Brown	3.3.1	Science calibration
UVIS10	UVIS Geometric distortion	Stiavelli/Brown	3.3.2	Science calibration
UVIS11	UVIS Encircled energy	Hartig	3.4.1	Science calibration
UVIS12	UVIS Image stability	Stiavelli/Brown	3.4.3	Science calibration

UVIS13	UVIS PSF wings & halo	Hartig	3.4.4	Science calibration
UVIS14	UVIS throughput calibration: filters	Reid	3.5.1A	Science calibration
UVIS15	UVIS throughput calibration: system	Reid	3.5.1B	Science calibration
UVIS16	UVIS throughput calibration: detector-defined passbands	Reid	3.5.1C	Science calibration
UVIS17	UVIS throughput calibration: narrowband filters	Reid	3.5.1D	Science calibration
UVIS18	UV throughput stability	Reid	3.5.2	Science calibration
UVIS19	UVIS UV blocking	Reid	3.5.3	Science calibration
UVIS20	UVIS flat fields: photometric filters	Reid	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	Stiavelli/Brown	3.8.1	Science calibration
UVIS26	UVIS Gap behaviour	Stiavelli/Brown	3.8.4	Science calibration
UVIS27	UVIS Light leaks	Hartig	3.8.5	Science calibration
UVIS28	UVIS System performance monitoring	Lupie	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
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	Stiavelli/Brown	3.3.1	Science calibration
IR07	IR Geometric distortion	Stiavelli/Brown	3.3.2	Science calibration
IR08	IR Encircled energy	Hartig	3.4.1	Science calibration
IR09	IR Image stability	Stiavelli/Brown	3.4.3	Science calibration
IR10	IR PSF wings & halo	Hartig	3.4.4	Science calibration
IR11	IR Throughput calibration: filters	Reid	3.5.1A	Science calibration
IR12	IR Throughput calibration: detector-defined passbands	Reid	3.5.1B	Science calibration
IR13	IR Flat fields: photometric filters	Reid	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	Stiavelli/Brown	3.8.1	Science calibration

IR18	IR Light leaks	Hartig	3.8.5	Science calibration
IR19	IR System performance monitoring	Lupie	3.9.2	Science calibration
IR20	Bias as f(gain)	Robberto		Science calibration
IR21	Readnoise as f(gain)	Robberto		Science calibration

1. Optical alignment, system monitoring and functionality

1.1 UVAL01-- UVIS focus sweep

PROCEDURE#: UVAL01

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 overshot 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 2hrs. 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

1.2 UVAL02-- UVIS tip/tilt sweep

PROCEDURE#: UVAL02

TITLE: UVIS tip/tilt sweep.

TEST CATEGORY: Alignment/Calibration.

DATE: 12/31/2002.

PURPOSE: This procedure is executed manually with the Mini-stimulus at Ball and as an SMS with the OS/RIAF/SITS at GSFC. The procedure uses the mini-stimulus or OS to provide an unresolved point source fiber located initially on axis (The center field point is the UF1 position. Note that 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 purpose of the procedure is to symmetrize the image and optimize the coma correction at the UVIS field center location by adjusting the inner and outer cylinder positions of the corrector mechanism.

FREQUENCY: Note: this procedure may not be necessary since tip and tilt adjustments are made initially prior to the focus sweeps in order to optimize the image quality. This procedure can be run at the start up of calibration activities to verify the sensitivities of the inner and outer cylinders that will be needed to symmetrize and minimize coma content in the images.

DETECTOR: UVIS Surrogate and Flight Build#1, Amp TBD.

PREREQUISITES: See the note in Procedure UV01 regarding focus and image quality. This procedure may be done as a first step in the focus determination so that the focus curve is not compromised by comatic images. The procedure can be iterated to achieve the desired image quality. Otherwise, the best focus must have been determined as well as the nominal, "best guess" positions for the inner and outer cylinders, and the mechanisms set to these positions.

HARDWARE REQUIREMENTS: The instrument must be installed in the WFAS at Ball with the mini-stimulus, or integrated with 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: Hartig's IDL Phase Retrieval software for PSF analysis.

COMMAND MODE: Manual (at Ball) and SMS (at GSFC).

PROCEDURE/EXPOSURES: The tip and tilt corrections are performed using the UVM1 mirror on the UVIS channel corrector mechanism. The inner cylinder controls the tilt and the outer cylinder controls the tip. An Encircled Energy and PSF are generated with the point source positioned at the field

center (UF1). The tip and tilt are varied through eleven consecutive positions in motor steps of 3 in the sequence depicted below. The sequence begins at the "best guess" value (0, 0) (position 1) and cycles through positions 2 to 10 and ends at the initial position (0, 0) (position 11) as a repeatability check.

```
          Outer
  8         |        10
  o       9 o        o
            |
            |
            |
            |
---o----------o---------o--- Inner
  5        1|11       7
          6|
            |
            |
  o       3 o        o
  2         |        4
```

At each position of the cylinders, two consecutive exposures of 0.1sec are acquired through the WFC3 UVIS narrow band (TBD) filter and the aberration content of the PSF is determined with IDL Phase Retrieval routines. The optimal cylinder positions are found when the coma is minimized and the PSF is the most symmetric.

VARIANTS: a: irhh02a.xls only.

IRHH02A: 1 point source fiber position x 2 exposures/fiber x 11 positions = 22 UVIS exposures.

TOTAL EXPOSURES: 22 UVIS exposures

TOTAL TIME: One execution of the procedure takes approximately 25 min:

Setup (600 sec) + 22*Overhead (41 sec, from previous SMSs) = 25 min

ANALYSIS: For each of the eleven combinations of tip and tilt, the
PSF is analyzed with IDL routines to assess residual coma using phase retrieval techniques and measured encircled energy. All images need to measure and remove bias and background counts.

1.3 UVM03 UVIS Basic Detector Monitor

CALIBRATION TEST#: N.A.

DATE: 01/15/2003

TITLE: UVM03 Basic UVIS Detector Monitor

CATEGORY: Monitor

PURPOSE: Routinely measure the basic performance parameters of the Marconi CCDs. These include dark count rate, read out noise, bias level, gain, internal flat fields, and hot pixel/cosmetic defect locations. This procedure will be developed after DCL optimization of the CCDs and their recommendations to evaluate those parameters that best monitor the health and performance of the CCDs.

FREQUENCY: This procedure should be run after every major instrument set up or integration change, any instrument moves, and any changes in instrument environment.

DETECTOR: UVIS Flight#1 using all four amps (ABCD).

PREREQUISITES: Fully integrated instrument under FSW and SITS control.

HARDWARE REQUIREMENTS: None

SOFTWARE REQUIREMENTS: Use standard statistical analysis tool such as WFC3GAIN.PRO and STSDAS hst_calib.ctools.msbadpix)(or IDL equiv.)

COMMAND MODE: SMS

PROCEDURE/EXPOSURES:

Tungsten lamp (#TBD) on
"standard" filter selected : SDSS r (F625W)

1. bias 0 s
2. dark 1375 s
3. flat 1.0 s
4. flat 1.0 s
5. flat 2.0 s
6. flat 2.0 s
7. bias 0 s
8. dark 1375 s

VARIANTS: a- gain = 1.5
b- gain = 2
c- gain = 4
d- gain = 8
e- gain =1.5, two more biases - one after exposure#1, exposure#7.

TOTAL EXPOSURES: 8

TOTAL TIME: setup + 8*overhead + 2706s = 1.19 hr
(Setup = 10min, overhead = 2min)

ANALYSIS:

(1) Run statistical analysis tool on all images (calculates mean & rms in boxes). For the biases this gives a first estimate of read noise and bias level. For darks, this gives estimate of dark-rate.

(2) Subtract mean overscan or bias level (or master bias frame made by combining lots of biases, if one is available) from all frames.

(3) Use all 8 images as input to noise model program. This will calculate read noise and gain from image pairs taken at the same exposure levels by modeling the light transfer curve.

(4) Combine multiple exposures to remove Cosmic Rays. Result gives one of each bias, dark, 1s flat, and 2s flat.

(5) Find bad pixels as those that deviate by (say) 5sigma in either
a. combined bias (mostly hot pixels)
b. combined bias subtracted darks (mostly hot pixels)
c. ratio of combined (bias subtracted) flats 1s/2s
(other pixels that don't FF).

(5) Compare derived parameters with previously determined values.
Compare bias and darks before and after flats to check for fluorescence, delayed charge injection. Plot results as a function of date, T_CCD, T_env. Make History file; note any trends, and ring alarm bells for serious discrepancies.

1.4 UVF04--UVIS Abbreviated Functional

CALIBRATION TEST#: N.A.

DATE: 01/15/2003

TITLE: UVF04 Abbreviated functional and aliveness test for mechanisms and the UVIS detector.

CATEGORY: Monitor

PURPOSE: Verify aliveness and functionality of detectors and mechanisms. This procedure is a subset that will be derived from Tim Schoenweis's Comprehensive System Functional test. See Tim for details.

FREQUENCY: Do prior to and after each significant move or modification to the instrument.

PREREQUISITES: None

HARDWARE REQUIREMENTS: None

SOFTWARE REQUIREMENTS: None

COMMAND MODE: Manual, Real Time (early); SMS (later for comprehensive functional test)

PROCEDURE/EXPOSURES: None

VARIANTS: None

TOTAL EXPOSURES: None

TOTAL TIME: 10min (estimated)

ANALYSIS: None, log the data into the record.

1.5 IRAL01--IR Focus Sweep

PROCEDURE#: IRAL01

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 TBD.

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 2hrs. 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.

1.6 IRAL02--IR Tip/Tilt Sweep

PROCEDURE#: IRAL02

TITLE: IR tip/tilt sweep.

TEST CATEGORY: Alignment/Calibration.

DATE: 12/31/2002.

PURPOSE: This procedure is executed manually with the Mini-stimulus at Ball and as an SMS with the OS/RIAF at GSFC to determine the inner and outer cylinder positions that optimize the coma correction at the UVIS field center. Only one point source fiber location, A1 (on axis) is used.

FREQUENCY: Note: this procedure may not be necessary since tip and tilt adjustments are made initially prior to the focus sweeps in order to optimize the image quality. This procedure may be run at the start up of calibration activities to map and verify the sensitivities of the inner and outer cylinders that will be needed to symmetrize and minimize coma content in the images.
Normally, this procedure would be run as needed to update and verify the best positions for the corrector mechanisms.

DETECTOR: IR Surrogate and Flight Build#1, Amp TBD.

PREREQUISITES: The best focus must have been determined as well as the nominal, "best guess" positions for the inner and outer cylinders, and the mechanisms set to these positions.

HARDWARE REQUIREMENTS: The instrument must be installed in the WFAS at Ball with the mini-stimulus, or integrated with 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 EE and Phase Retrieval software for PSF analysis.

COMMAND MODE: Manual and SMS

PROCEDURE/EXPOSURES: The tip and tilt corrections are performed with mirror IRM1 using the corrector alignment mechanism. The inner cylinder controls the tilt and the outer cylinder controls the tip. A PSF is generated with fiber A1 near the field center and the tip and tilt are varied through eleven consecutive positions in motor steps of
3 in the sequence depicted below. The sequence begins at the "best guess" value (0,0) (position 1) and cycles through positions 2 to 10 and ends at the initial position (0,0) (position 11) as a repeatability check.

```
          Outer
  8         |        10
  o       9 o        o
            |
            |
            |
            |
---o----------o---------o--- Inner
  5        1|11       7
           6|
            |
            |
  o       3 o        o
  2         |        4
```

At each position of the cylinders, two consecutive exposures of 0.1sec are acquired through the IR narrow band (TBD) filter and the residual coma (asymmetry) of the PSF is measured with IDL routines. The optimal cylinder positions are found when the coma is minimized and the PSF is the most symmetric. The full chip is read-out with Amp TBD for each exposure.

VARIANTS: none

TOTAL EXPOSURES: 22 IR exposures.

TOTAL TIME: One execution of the procedure takes approximately 25 min:

Setup (600 sec) + 22*Overhead (41 sec, from previous SMSs) = 25 min.

ANALYSIS: For each of the eleven combinations of the tip and tilt, the
PSF is analyzed with IDL routines to assess residual coma with phase retrieval techniques and measured encircled energy analysis.

1.7 IRM03 IR Basic Detector Monitor

CALIBRATION TEST#: N.A.

DATE: 01/15/2003

TITLE: IRM03 IR Basic Detector Monitor

CATEGORY: Monitor

PURPOSE: Measure basic performance parameters of IR FPAs. These include dark count, read noise, reference pixel levels, gain, hot pixels and cosmetic defect locations. This procedure will be developed after DCL optimization of the detectors and their recommendations to evaluate those parameters that best monitor their health and performance.

FREQUENCY: Run after every major instrument set up change, and before and after all major environmental tests.

DETECTOR: IR Flight Build #1

PREREQUISITES: None

HARDWARE REQUIREMENTS: None

SOFTWARE REQUIREMENTS: Use standard statistical analysis tool such as WFC3GAIN.PRO and STSDAS hst_calib.ctools.msbadpix)(or IDL equiv.)

COMMAND MODE: SMS

PROCEDURE/EXPOSURES:

Tungsten lamp (#TBD) on
"standard" filter selected : IR Flight Build#1(F125W)

1. Reference pixel 0 s
2. dark 1375 s
3. flat 1.0 s
4. flat 1.0 s
5. flat 2.0 s
6. flat 2.0 s
7. Reference pixel 0 s
8. dark 1375 s

VARIANTS: a- gain = 1.5
b- gain = 2
c- gain = 4
d- gain = 1.5 Do two more biases, one after exp#1, exp#7.

TOTAL EXPOSURES: 8

TOTAL TIME: setup + 8*overhead + 2706s = ~1.2 hr
(setup = 10min, overhead = 2min)

ANALYSIS:

(1) Run statistical analysis tool on all images (calculates mean & rms in boxes). For the reference pixels this gives a first estimate of read noise. For darks this gives estimate of dark-rate.

(2) Subtract mean reference pixel level from all frames according to Massimo Roberto's technique.

(3) Use all 8 images as input to noise model program. This will calculate read noise and gain from image pairs taken at the same exposure levels by modeling the light transfer curve.

(4) Combine multiple exposures to remove Cosmic Rays. Give one of each reference pixel, dark, 1s flat, 2s flat.

(5) Find bad pixels; those that deviate by (say) 5sigma
a. combined reference pixel (mostly hot pixels)
b. combined reference pixel subtracted darks (mostly hot pixels)
c. ratio of combined (reference pixel subtracted) flats 1s/2s
(other pixels that don't FF).

(5) Compare derived parameters with previously determined values.
Compare bias and darks before and after flats to check for anomalies. Plot results as a function of date, T_IR, T_env. Make History file; note any trends, and ring alarm bells for serious discrepancies.

1.8 IRF04--IR Abbreviated Functional Test

CALIBRATION TEST#: N.A.

DATE: 01/15/2003

TITLE: IRF04--Abbreviated functional and aliveness test for mechanisms and IR detector.

CATEGORY: Monitor

PURPOSE: Verify aliveness and functionality of detectors and mechanisms.

FREQUENCY: Do prior to and after each significant modification to the instrument. This procedure is a subset that will be derived from Tim Schoenweis' Comprehensive System Functional test. See Tim for details.

PRE-REQUISITES: None

HARDWARE REQUIREMENTS: None

SOFTWARE REQUIREMENTS: None

COMMAND MODE: Manual, Real Time; SMS (later for comprehensive functional test)

PROCEDURE/EXPOSURES: None

VARIANTS: None

TOTAL EXPOSURES: None

TOTAL TIME: 10min

ANALYSIS: None, log data into the record.

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 preliminary measurements of the intensities of the Optical Stimulus light sources, of the WFC3 throughput and the detector quantum efficiencies. These values will be updated using the WFC3 Exposure Time Calculator as improved empirical data become available.

2.1 UVIS01: Darkcount rates 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: 25 July 2003; validated 9 Sept 2003

PURPOSE:
To verify that the darkcount 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 measurements at other temperatures.

CEI SPECIFICATION(s):
4.6.4: Dark current <20 e^-/pix/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 +/-1C 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# 1 at standard gain setting (1.5 e^-/DN); standard read-out through all four amps ABCD simultaneously.

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. 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:
uv01s01,uv01s02,uv01s03,uv01s04

DETAILED TEST PROGRAM:
A series of bias-level and dark frames will be taken, exposure times 0, 600, 1000 and 3000 seconds, with the detector temperature set to five values: T_{nom}, the nominal on-orbit operating temperature (-83°C); T_{nom}+/- 3 K; T_{nom}+6 K; and T_{nom}+15 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 2x2 and 3x3 to verify performance under those configurations.
The ground-based superdark will be generated by combining the 3000 second T_{nom} exposures; the ground-based superbias will be constructed from the appropriate 0 second exposure.

EXPOSURES:

Name	SMS	Exp. time (sec.)	Comments
UV01A	uv01s01	0	Detector temperature = T_{nom}
		1000	
		3000	
		0	
UV01B	uv01s01	0	Detector temperature = T_{nom}+/-3, +6
		1000	
		3000	
		0	
UV01C	uv01s02	0	Detector temperature = T_{nom} + 15
		600	
		1000	
		0	
UV01D	uv01s03	0	Detector temperature = T_{nom}
		3000	
		3000	
		0	
UV01E	uv01s04	0	Detector temperature = T_{nom}: 2x2 & 3x3 binning
		1000	
		0	

FREQUENCY/No. of ITERATIONS:
Three cycles of UV01A
Two cycles of UV01B at each detector temperature setting (6 cycles total)
Two cycles of UV01C
Four cycles of UV01D
Three cycles of UV01E at each binning setting (4 cycles total)
Totals:
full-frame, no binning: 30 x 0 seconds

4 x 600 seconds
13 x 1000 seconds
17 x 3000 seconds
2x2 binning: 6 x 0 seconds
3 x 1000 seconds
3x3 binning: 6 x 0 seconds
3 x 1000 seconds

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

TOTAL ELAPSED TIME:

uv01s01 – 10.0 hrs exposure time, 15.8 hrs execution
uv01s02 - 0.9 hrs exposure time, 2.2 hrs execution
uv01s03 - 6.7 hrs exposure time, 9.2 hrs execution
uv01s04 - 1.7 hrs exposure time, 3.4 hrs execution
total - 19.3 hrs 30.6 hrs

VARIANTS:

An SMS to take a series of dark frames at T_{nom} with total duration of 8-10 hours should be constructed to take advantage of overnight opportunities during the ambient testing phase for WFC3.

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 chip should be ~400 for both darks and biases.
The background level on the overscan should be a few hundred 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 (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 superdark frame. 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. The binned mode files will be constructed from the full-frame data. Assuming system readnoise of 4 e^- /pix/readout, a full-frame CDBS file generated from the eleven 3000 s darks obtained in this test 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; the binned mode may not be derivable from full-frame and so, would need to be constructed from the binned observations in 3.1.4/UVIS03 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 ~$4e^-$.

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}. Images will be taken for a range of exposure time. A total of >100 images will be required to generate the superdark.
On-orbit: dark frames will be taken regularly at T_{nom} for a set exposure time to monitor performance.

ADDITIONAL COMMENTS:
Dark frames 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.
Only 4-amp readouts are being taken in these tests, under the assumption that other full-frame combinations (AC, AD, BC, BD) will be covered as part of the functional test (3.9.2). Single amp readouts are obtained as part of the subarray test (3.1.11).

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: 1 September 2003; validated 9 Sept 2003

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.

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

	At launch		After 5 years	
Signal level	**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# 1 at standard gain setting (1.5 e^-/DN); standard read-out through all four amps ABCD simultaneously for full frame 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, and the expectation is that CTE degradation will not be measurable at this stage.

HARDWARE REQUIREMENTS:
The UVIS flight detector should be installed, and the detector temperature should be controlled to an accuracy of 1° C. The CASTLE OS should be capable of providing both flat field illumination and point source images which 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.

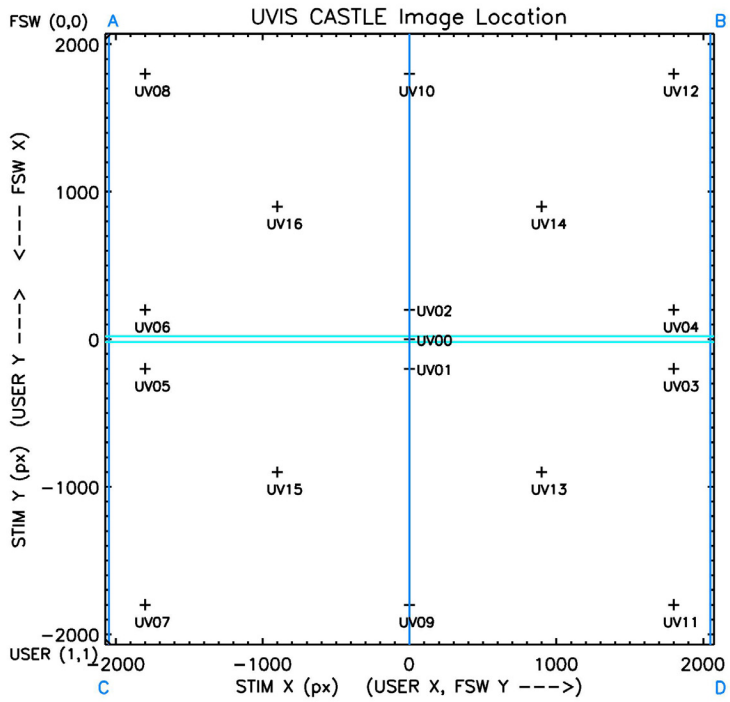
OS CONFIGURATION:
Flat field images will be taken with the monochromator in mirror mode, and using the IRIS fibres to feed to integrating sphere. The flux will be adjusted to the appropriate levels using neutral density filters at the monochromator source.
Point source images will be taken with the He-Ne laser and single-mode fibre.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
UV02S01: EPER flat fields
UV02S04: Point sources: standard 16 point pattern
UV02S05: Point sources: 2x4 corner pattern

DETAILED TEST PROGRAM:
Flat field images will be taken using the F606W filter with the detector operating at T_{nom}.
Exposures will be taken at 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 low signal level, ~300 e- total, at the 15 standard positions on the WFC3 detectors, from UV01 to UV16 in the figure



To probe CTE at higher flux signals, namely 3000 and 30000 e- total, the point source will be positioned at the 4 corners of each array, i.e. at UV07,UV05, UV03 and UV11 for the lower chip, and UV06, UV08, UV12 and UV04 for the upper chip.

EXPOSURES:

Name	SMS	OS Configuration	Filter	Exp.time (secs)	Comments
UV02A	UV02S01	QTH lamp/mirror/IRIS fibres/ ND2 filter in F/W 1 (10 e^- /pix/sec)	F606W	10	100 e^-
			F606W	25	250 e^-
			F606W	50	500 e^-
		QTH lamp/mirror/IRIS fibres/ ND1 filter in F/W 1 (120 e^- /pix/sec)	F606W	9	1000 e^-
			F606W	27	3000 e^-
UV02B	UV02S04	He-Ne/single-mode fibre/~100dB(?) attenuation	F606W	~1	16 point pattern 16 subarrays. 300 e^- at peak
UV02C	UV02S05	He-Ne/single-mode fibre/~80dB attenuation	F606W	1	2x4 point pattern 8 subarrays 3,000 e^- at peak
UV02D		He-Ne/single-mode fibre/~90dB(?) attenuation	F606W	1	2x4 point pattern 8 subarrays 30,000 e^- at peak

FREQUENCY/No. of ITERATIONS:

Two cycles of flat field measurements (UV02A)

One cycle each of point source measurements (UV02B, UV02C, UV02D)

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

TOTAL ELAPSED TIME:

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 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.

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: 20 Sept 2003

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 UVI detectors (nominally 1, 1.5, 2, and 4 e^-/DN).

DETECTOR:
Flight build detector UVIS# 1 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 fibres to feed to integrating sphere. No neutral density filters are required.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
UV03S01

DETAILED TEST PROGRAM:
A pair of flat fields will be taken through the F606W filter at each of the four available gain settings for the UVIS channel. These measurements will be taken at four detector temperatures: T_{nom}; T_{nom}+/- 3 K; and T_{nom} + 6 K. These match the detector temperatures from UVIS01, dark countrate measurements.

EXPOSURES:

Name	SMS	OS Configuration	Filter	Exp. time (sec)	Comments
UV03A	uv03s01	N/A	N/A	0	Reference bias frame, gain=1.0
		QTH lamp/singleUVIS/VISIR fibres/ no ND filter (250 photons/pix/sec)	F606W	40	Flat field, gain=1.0
			F606W	40	Flat field, gain=1.0
		N/A	N/A	0	Reference bias frame, gain=1.5
		QTH lamp/singleUVIS/VISIR fibres/ no ND filter (250 photons/pix/sec)	F606W	40	Flat field, gain=1.5
			F606W	40	Flat field, gain=1.5
		N/A	N/A	0	Reference bias frame, gain=2.0
		QTH lamp/singleUVIS/VISIR fibres/ no ND filter (250 photons/pix/sec)	F606W	40	Flat field, gain=2.0
			F606W	40	Flat field, gain=2.0
		N/A	N/A	0	Reference bias frame, gain=4.0
		QTH lamp/singleUVIS/VISIR fibres/ no ND filter (250 photons/pix/sec)	F606W	40	Flat field, gain=4.0
			F606W	40	Flat field, gain=4.0

FREQUENCY/No. of ITERATIONS:
One cycle of UV03A at each temperature setting: T_{nom}; T_{nom}- 3 K; T_{nom} + 3 K; and T_{nom} + 6K. (i.e. 4 cycles in total).
The full test will be undertaken during both the ambient and T/Vac science calibration campaigns

TOTAL ELAPSED TIME:
uv03s01 – 5 mins exposure time, 1hr elapsed time x 4 cycles

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 a few hundred counts for bias/dark frames and 10,000-30,000 counts for flat fields.
The background level on the overscan should be a few hundred counts.

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, combined with the calibration of the incident flux, give the relative gain settings.

TEST RESULTS AND DATA PRODUCTS:
Tabulated gain ratios vs temperature (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 ~4.5e^-, are flown).

SMOV/ON-ORBIT FOLLOW-UP:
SMOV: the relative gains will be checked at T_{nom} using either flat fields taken with the internal lamps or images of standard star fields.
On-orbit: the relative gains will be checked at T_{nom} using either flat fields 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

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: 25 July 2003; validated 9 Sept 2003

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# 1 at standard gain setting (1.5 e^-/DN); standard read-out through each of Amp 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 behaviour 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 arithmetic to measure the pixel to pixel linear response range.

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 606 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 using the OS flux monitor.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
uv04s01 – Amp A
uv04s02 – Amp B
uv04s03 – Amp C
uc04s04 – Amp D

DETAILED TEST PROGRAM:
A series of point-target images will be taken at 11 specific ADU levels. The target will be centred on each quadrant of the UVIS CCD flight detector, with the appropriate amplifier used to read out the 512x512 sub-array that includes the target image. Reference bias frames will be taken at the start and conclusion of each set of image data. The exposure times given below are derived form the CASTLE ETC and assume that the point target covers approximately 300 pixels on the detector; empirical verification of the inferred flux is required before implementing these procedures.

EXPOSURES:

Name	OS Configuration	Filter	Exp. time (sec)	N_{exp}	Comments
UV04	N/A	N/A	0	1	reference bias frame
	UVIS Double mode, 13 nm bandwidth, 606 nm, QTH lamp, ND 4 (4 e^-/pix/sec)	F606W	2.5	10	10 e^-
	UVIS Double mode, 13 nm bandwidth, 606 nm, QTH lamp, ND 4 (4 e^-/pix/sec)	F606W	25	10	100 e^-
	UVISDouble mode, 13 nm bandwidth, 606 nm, ND 3 (60 e^-/pix/sec)	F606W	16	10	1,000 e^-
	UVIS Double mode, 13 nm bandwidth, 606 nm, ND 2 (500 e^-/pix/sec)	F606W	20	3	10,000 e^-
		F606W	40	3	20,000 e^-
		F606W	100	3	50,000 e^-
		F606W	120	3	60,000 e^-
		F606W	140	3	70,000 e^-
		F606W	160	3	80,000 e^-
		F606W	170	3	85,000 e^-
		F606W	180	3	90,000 e^-
		F606W	190	3	95,000 e^-
	N/A	N/A	0	1	reference bias

FREQUENCY/No. of ITERATIONS:

One cycle for each quadrant; the appropriate amplifier is used to read out each set of measurements.
The full test will be undertaken during both the ambient and T/Vac science calibration campaigns

TOTAL ELAPSED TIME:
uv04s01 – 0.8 hrs exposure time, 4.8 hrs elapsed time
uv04s02 – 0.8 hrs exposure time, 4.8 hrs elapsed time
uv04s03 – 0.8 hrs exposure time, 4.8 hrs elapsed time
uv04s04 – 0.8 hrs exposure time, 4.8 hrs elapsed time
total - 3.2 hrs 19.2 hrs

VARIANTS:
If time permits, run a subset of these tests for alternate gain settings. Add flat field measurements.

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 a few hundred counts.
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 to be measured via standard log(DN) vs log(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).
Data from UVIS04 will 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 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.

2.5 UVIS05: Detector linearity – areal behaviour

CALIBRATION TEST#: 3.1.7B

TITLE: Linearity of response of the WFC3 UVIS CCD detectors

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: 20 Sept 2003

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 flat fields to test for variations in linearity as a function of location on the detector; the absolute response is addressed 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# 1 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 behaviour 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 monochromator in mirror mode, and using the VISIR fibres to feed to integrating sphere. Flux calibration is not necessary.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
uv05s01

DETAILED TEST PROGRAM:
A series of flat field images will be taken at 11 specific ADU levels. The full frame image will be read out. The OS is used in mirror mode, overfilling the wavelength range defined by the F606W. This is not important for the current test, since the absolute calibration of the linear response can be determined from the point target images taken as part of UVIS04. The present measurements test for relative non-linearity's as a function of position over the full UVIS CCDs. The exposure times given below are derived form the CASTLE ETC and assume that the point target covers approximately 300 pixels on the detector; empirical verification of the inferred flux is required before implementing these procedures.

EXPOSURES:

Name	OS Configuration	Filter	Exp. time (sec)	N_{exp}	Comments
UV04	N/A	N/A	0	1	reference bias frame
	Mirror mode, QTH, IRIS, ND 2 (11 e^- /pix/sec)	F606W	10	10	100 e^-
	Mirror mode, QTH, IRIS, ND 1 (110 e^- /pix/sec)	F606W	9	10	1,000 e^-
	Mirror mode, QTH, IRIS, no ND, (1100 e^- /pix/sec)	F606W	9	3	10,000 e^-
		F606W	18	3	20,000 e^-
		F606W	45	3	50,000 e^-
		F606W	54	3	60,000 e^-
		F606W	63	3	70,000 e^-
		F606W	72	3	80,000 e^-
		F606W	77	3	85,000 e^-
		F606W	81	3	90,000 e^-
		F606W	85	3	95,000 e^-
	N/A	N/A	0	1	reference bias

FREQUENCY/No. of ITERATIONS:
One cycle
The full test will be undertaken during both the ambient and T/Vac science calibration campaigns

TOTAL ELAPSED TIME:
uv05s01 – 3.3 hrs exposure time, 8.6 hrs elapsed time

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 a few hundred counts for bias/dark frames and 10,000-30,000 counts for flat fields. The background level on the overscan should be a few hundred counts.

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 to be measured via standard log(DN) vs log(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 by the DCL during detector-level calibration should be available for comparison during the ambient and T/Vac science calibration campaigns.

2.6 UVIS06: CTE mitigation

CALIBRATION TEST#: 3.1.9

TITLE: Charge injection/postflash CTE mitigation

CATEGORY: Science Calibration

P.I.: M. Robberto

IPT REVISION DATE: 1 September 2003; validated 9 Sept 2003

REVISION HISTORY:
- Discrete injection test is every 10th , 15th , and 25th row, 5 frames.

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# 1 at standard gain setting (1.5 e^-/DN); standard read-out 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 CRs, either by illuminating the detector briefly before or after each exposure (pre- or post-flash), or by injecting ~10^5 electrons into specific rows of the CCD. WFC3 has chosen to implement the latter procedure. The scheme has been characterised 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:

UV02S02: Charge injection full field
UV02S03: Charge injection: discrete rows

DETAILED TEST PROGRAM:
A set of three full-frame images will be taken in the full field charge-injection mode. In the discrete row injection, charge will be injected every 10th, 15th, and 25th row in the device, and 5 frames will be taken.

EXPOSURES:

Name	SMS	Exposure time (sec)	N_{Exp}	Comments
UV06A	uv02s02	0	3	Full field charge injection
UV06B	uv02s03	0	5	Discrete row charge injection, 10 rows
			5	Discrete row charge injection, 15 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:

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

ANALYSIS:
New 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.

2.7 UVIS07: Subarray darkcount rates and bias

CALIBRATION TEST#: 3.1.11

TITLE: Dark count rate and readnoise for UVIS subarrays

CATEGORY: Science Calibration

P.I.: S. Baggett

REVISION DATE: 25 July 2003; validated 9 Sept 2003

PURPOSE:
To 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 e^-/pix/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 +/-1C 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# 1 at standard gain setting (1.5 e^-/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 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:
uv07s01 (Amp A), uv07s02 (Amp B), uv07s03 (Amp C), uv07s04 (Amp D)

DETAILED TEST PROGRAM:
A series of bias-level and dark frames will be taken at the default gain setting, with exposure times 0 and 2000 seconds, and with the detector temperature set to the nominal on-orbit operating value. Subarray images with format 64x64, 128x128 and 512x512 will be taken centred on each quadrant of the array. In addition, 2kx4k images of the individual CCD will be taken using each of the two available amplifiers.

EXPOSURES:

Name	Format	Exposure time (secs)	N_{exp}	Comments
UV07	2kx4k	0, 2000	2 x 3	Full CCD: bias + dark exposure
	2k x 2k	0, 2000	2 x 3	
	512x512	0, 2000	2 x 3	
	256x256	0, 2000	2 x 3	
	128x128	0, 2000	2 x 3	
	64x64	0, 2000	2 x 3	
				total of 36 exposures:
				18 x 0 sec; 18 x 2000 sec

FREQUENCY/No. of ITERATIONS:
UV07 exposure sequence repeated for each amplifier: A, B, C and D
The measurements will be undertaken during both the ambient and T/Vac science calibration campaigns.

TOTAL ELAPSED TIME:
uv07s01 – 11.7 hrs exposure time, 13.1 hrs elapsed time
uv07s02 – 11.7 hrs exposure time, 13.1 hrs elapsed time
uv07s03 – 11.7 hrs exposure time, 13.1 hrs elapsed time
uv07s04 – 11.7 hrs exposure time, 13.1 hrs elapsed time
total – 46.8 hrs exposure time, 52.4 hrs elapsed time

VARIANTS: fewer iterations

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 few hundred counts for bias/dark frames.
The background level on the overscan should be a few hundred counts.

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

More detailed 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 superdark frame.

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 programmes.

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.

2.8 UVIS08: Shutter performance

CALIBRATION TEST#: 3.2.1/3.2.2

TITLE: UVIS shutter performance

CATEGORY: Science Calibration

P.I.: I. N. Reid

REVISION DATE: 20 Sept 2003

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# 1 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; singleUVIS + Xe lamp is predicted to give a countrate of ~1300 photons/pixel/second with no ND filters (~850 e^-/pixel/sec at gain 1.5). Since we will use 3x3 on-chip binning (7,800 e^-/pix/sec), source attenuation with well-calibrated neutral density filters is required for the 32 second exposures.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
uv08s01

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 32-second exposures.

EXPOSURES:

Name	Filter	OS Configuration	Exp. time (s)	N_{exp}	Comments
UVIS08	F606W	Xe/singleUVISr/VISIR/no ND	0.5	8	~3,900 cts/pixel
	F606W		0.7	4	
	F606W		0.8	4	
	F606W		1.0	4	~7,800 cts/pixel
	F606W		1.2	4	
	F606W		1.4	4	
	F606W		2.0	2	
	F606W		4.0	2	
	F606W	Xe/singleUVIS/VISIR/ND 1	4.0	8	~3200 cts/pixel
	F606W	Xe/singleUVIS/VISIR/ND 1	32.0	4	~26,000 cts/pixel

FREQUENCY/No. of ITERATIONS:
One cycle
Measurements made in both ambient and T/Vac science calibration campaigns

TOTAL ELAPSED TIME:
uv08s01 – 0.1 hrs exposure time, 3.2 hrs elapsed time

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 a few hundred counts for bias/dark frames and 3,000-30,000 counts for flat fields.
The background level on the overscan should be a few hundred counts.

ANALYSIS:
The data will be processed initially using the standard WFC3-UVIS IPT pipeline 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 32-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.

TEST RESULTS AND DATA PRODUCTS:

SMOV/ON-ORBIT FOLLOW-UP:
Shutter performance will be verified through observations of standard star fields, notably in 47 Tucanae.

ADDITIONAL COMMENTS:

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 e^-/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 e^-/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 +-?% 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 UVIS 11

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# 1 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:
uv11s01, uv11s02, uv11s03, uv11s04

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:

uv11s01 – 1.3 hrs exposure time, 3.6 hrs elapsed time
uv11s02 – 0.7 hrs exposure time, 2.9 hrs elapsed time
uv11s03 – 0.3 hrs exposure time, 2.6 hrs elapsed time
uv11s04 – 0.3 hrs exposure time, 2.6 hrs elapsed time
total – 2.6 hrs exposure time, 11.7 hrs elapsed time

VARIANTS:
None

QUICK-LOOK VERIFICATION:

Each exposure should be inspected visually – there should be no significant non-uniformities or structure in the background.
The background level on the chip should be a few hundred counts; 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:

2.12 UVIS12: Image stability

CALIBRATION TEST#: 3.4.3

TITLE: UVIS image stability

CATEGORY: Science Calibration, technical performance

P.I.: Brown

REVISION DATE: 2 September 2003

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# 1 at standard gain setting (1.5 e^-/DN); 200x200 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 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:
The He-Ne laser single-mode fibre will be used to provide a point source image at the specific location on the UVIS CCDs.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES: UV12S01, UV12C01

DETAILED TEST PROGRAM:
A point source generated by the HeNe laser will be centered on the nominal aperture. A continuous series of 100 sub-array images (200 x 200) will be taken at approximately 2 minute intervals (determined by the readout and dump time) resulting in a total test duration of ~200 minutes.

EXPOSURES:

Filter	Exposure time	OS Configuration	No. of exposures
F606W	1 seconds	He-Ne laser, point-source centred on reference aperture	100

FREQUENCY/No. of ITERATIONS:
Execute once.
Measurements will be obtained during both the ambient and T/Vac science calibration campaigns.

TOTAL ELAPSED TIME: ~200 minutes – set by stability requirements

VARIANTS:
none

ANALYSIS:
Simple PSF-fitting routines can be used to determine the centroids of the point-source images in detector co-ordinates. A script for automatic analysis needs to be 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:

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 e^-/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 background level on the chip should be a few hundred counts; 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: Throughput of the UVIS broad- and mediumband filters

CATEGORY: Science Calibration

P.I.: I.N. Reid

REVISION DATE: 28 July 2003; validated 9 Sept 2003

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# 1 at standard gain setting (1.5 e^-/DN); standard read-out through all four amps ABCD simultaneously and subarray readout through individual amplifiers.

BACKGROUND:
WFC3 is designed to have high throughput over the full wavelength range covered by the UVIS channel. This calibration item will be performed in early measurements at GSFC, using flight build detector UVIS#2. Images will be acquired using all the wideband and mediumband UVIS filters. The fibre spot will be centred on the nominal aperture, and the input flux measured to an accuracy of better than 5%.
An initial estimate of the relation between input fibre 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 fibre-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 point sources.

OS CONFIGURATION:
200-micron point target generated by fibre bundle linked to monochromator, operating in double mode, with bandwidth of 13 nm. The light source (Xe/QTH) and type of monochromator (UVIS/VIS/IR) will be set to match the appropriate wavelength range of the individual filters.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
uv14s01

DETAILED TEST PROGRAM:
512-square subarray images will be taken of the extended image produced by the 200-micron point target, centred on a defined aperture. Bias frames should be taken at the start and conclusion of the full sequence of exposures. 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 the CASTLE ETC and are set to give S/N>100. A total of at least 3 images will be taken for each UVIS filter during each science calibration campaign.
The images will be centred on point UV16: X=1170, Y=1172

EXPOSURES:

Filter	OS wavelength	OS setup	Exposure time (secs)	No. of exposures
F218W	218 nm	UVPT1/Xe/UV/no ND	30	3
F225W	225	UVPT1/Xe/UV/no ND	12	3
F275W	275	UVPT1/Xe/UVis/ND1	10	3
F336W	336	UVPT1/Xe/UVis/ND2	7	3
F390W	390	UVPT1/Xe/UVis/ND2	6	3
F438W	438	UVPT1/Xe/UVis/ND2	7	3
F555W	555	UVPT1/QTH/Vis/ND2	8	3
F606W	606	UVPT1/QTH/Vis/ND2	8	3
F814W	814	IRPT1/QTH/Vis/ND2	12	3
F475W	475	UVPT1/QTH/Vis/ND2	10	3
F625W	625	IRPT1/QTH/Vis/ND3	20	3
F775W	775	IRPT1/QTH/Vis/ND2	10	3
F850LP	880	IRPT1/QTH/Vis/ND2	14	3
F390M	390	UVPT1/Xe/UVis/ND2	6	3
F410M	410	UVPT1/Xe/UVis/ND2	6	3
F467M	467	UVPT1/Xe/UVis/ND2	8	3
F547M	547	UVPT1/Xe/UVis/ND2	8	3

F621M	621	IRPT1/QTH/Vis/ND3	20	3
F689M	689	IRPT1/QTH/Vis/ND3	20	3
F763M	763	IRPT1/QTH/Vis/ND2	8	3
F845M	845	IRPT1/QTH/Vis/ND2	8	3

FREQUENCY/No. of ITERATIONS:
Measurements will be made during both the ambient and T/Vac campaigns.
uv14s01 specifies only one integration per filter. That SMS will be run on at least three occasions (as indicated in the above table), included two measurements well separated in time to measure throughput stability.

TOTAL ELAPSED TIME:
uv14s01 – 0.2 hrs exposure time, 2.6 hrs elapsed time

VARIANTS:
Determine absolute throughout for an aperture centred on the second CCD detector. Sub-arrays centred on the fibre image can be obtained if the OS snapshot files can be associated easily with the appropriate data frame. A second set of measurements may be made with the target centred on the second CCD detector.

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 10,000-30,000 counts for flat fields.
The background level on the overscan should be a few hundred counts.

ANALYSIS:
The data will be processed initially using the standard WFC3-UVIS IPT pipeline analysis.
Determine the total counts by aperture photometry of the spot produced by the 200-micron fibre-bundle.
Standard routines in the *apphot* package in IRAF will be adequate for this purpose.

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.

2.15 UVIS15: System throughput

CALIBRATION TEST#: 3.5.1B

TITLE: Throughput of the WFC3 UVIS camera

CATEGORY: Science Calibration

P.I.: I.N. Reid

REVISION DATE: 28 July 2003; validated 9 Sept 2003

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

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.
This calibration item will be performed in early measurements at GSFC, using flight build detector UVIS#2. Images will be acquired at eleven wavelengths between 200 and 1000 nm with the CLEAR position set in the SOFA. The fiber spot will be centred on the nominal aperture, and the OS will provide absolute flux measurements accurate to better than 5%.
An initial estimate of the relation between input fibre 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 fibre-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 integrate total fluxes of point sources. The aperture photometry routines provided in *apphot*, for example, should suffice to measure total counts.

OS CONFIGURATION:
Extended source generated by 200-micron pinhole target, fed by an optical fibre linked to the OS monochromator, operating in double mode with bandwidth of 13 nm. Expected total fluxes range from ~20 photons/sec/nm at 200 nm to ~20000 photons/sec/nm at 800 nm. The 200-micron target projects to an ~10-pixel radius image on the detector.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
uv15s01

DETAILED TEST PROGRAM:
Five 512x512 subarray images will be taken at each wavelength setting. Bias frames should be taken at the start and conclusion 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 estimated using the CASTL ETC and will require verification.
The images will be centred on point UV16: X=1170, Y=1172

EXPOSURES:

Filter	OS Configuration	OS Wavelength	Exposure time (secs)	No. of exposures
CLEAR	N/A	N/A	0	1
CLEAR	UVPT1/Xe/UV/no ND	200 nm	30	5
CLEAR	UVPT1/Xe/UV/ND1	250	60	5
CLEAR	UVPT1/Xe/UV/ND1	290	20	5
CLEAR	UVPT1/Xe/UV/ND2	350	7	5
CLEAR	UVPT1/Xe/UV/ND2	400	7	5

CLEAR	UVPT1/QTH/UVis/ND2	500	10	5
CLEAR	IRPT1/QTH/Vis/ND2	600	10	5
CLEAR	IRPT1/QTH/Vis/ND2	700	10	5
CLEAR	IRPT1/QTH/IR/ND2	800	10	5
CLEAR	IRPT1/QTH/IR/ND2	900	10	5
CLEAR	IRPT1/QTH/IR/ND2	1000	10	5

FREQUENCY/No. of ITERATIONS:
Measurements will be made during both the ambient and T/Vac campaigns.

TOTAL ELAPSED TIME:
uv15s01 – 2.5 hrs exposure time, 5.2 hrs elapsed time

VARIANTS:
This program can be repeated for one or more apertures centred on different locations on CCD1 and CCD2 of the UVIS detector system.

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 few hundred counts; the background level on the overscan should be a few hundred counts; 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 total counts by aperture photometry of the spot produced by the 200-micron fibre-bundle.
Standard routines in the *apphot* package in IRAF will be adequate for this purpose.

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:
None

ADDITIONAL COMMENTS:

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.: I.N. Reid

REVISION DATE: 28 July 2003; validated 9 Sept 2003

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# 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:
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. This calibration item will be performed in early measurements at GSFC, using flight build detector UVIS#2. 200-micron pinhole images will be acquired at fourteen wavelengths between 970 and 1060 nm with the F850LP filter. The input flux/exposure time should be adjusted to give an average level of ~30000 DN/pix in each frame.

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 basic image statistics (mean, rms variation, fixed-pattern structure analysis). The aperture photometry routines provided in *apphot*, for example, should suffice to measure total counts, and hence throughput.

OS CONFIGURATION:
200-micron pinhole target generated by fibre linked to monochromator, operating in double mode, with a bandwidth of 13 nm. Broadband flat field, generated by single mode monochromator and integrating sphere.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
uv16s01
uv16s02

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 centred on a defined aperture on CCD1, and 512x512 subarray images taken at 14 wavelength settings between 850 and 1050 nm (uv16s01). Flat field images taken at the same wavelength settings (uv16s02) will test for any significant areal variations in response. The exposure times are derived from the CASTLE ETC, and are set to give S/N~70 for the flat fields and ~100/pixel for the 200-micron target.
The images will be centred on point UV16: X=1170, Y=1172

EXPOSURES:

SMS	Wavelength	OS configuration	Exposure time	N_{exp}	Comments
uv16s01	850 nm	QTH/IRPT (200-micron)/Double/ND3	20 secs	3	F850LP
	890			3	
	910			3	
	930			3	
	950			3	
	970			3	
	980			3	
	990			3	
	1000			3	
	1010			3	
	1020			3	
	1030			3	
	1040			3	
	1050			3	
uv16s02	850 nm	QTH/IRIS (flat field)/Double/ND3	300 secs	1	F850LP
	890			1	
	910			1	
	930			1	
	950			1	
	970			1	
	980			1	

	990			1	
	1000			1	
	1010			1	
	1020			1	
	1030			1	
	1040			1	
	1050			1	

FREQUENCY/No. of ITERATIONS:
Measurements will be made during both the ambient and T/Vac campaigns.
Three sets of point-source images will be taken, but only one set of flat fields.

TOTAL ELAPSED TIME:
uv16s01 – 5.6 hrs exposure time, 7.6 hrs elapsed time
uv16s02 – 5.6 hrs exposure time, 7.6 hrs elapsed time
total - 11.2 hrs 15.2 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 few hundred counts; the background level on the overscan should be a few hundred counts; 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.
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.

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.

2.17 UVIS17: Throughput – narrowband filters

CALIBRATION TEST#: 3.5.1D

TITLE: Throughput of the WFC3 UVIS narrowband filters

CATEGORY: Science Calibration

P.I.: I.N. Reid

REVISION DATE: 28 July 2003; validated 9 Sept 2003

PURPOSE:
To verify the wavelength dependence of the transmission function of the narrowest narrowband filters (<5 nm), a set of extended-source images (200 micron target) will be taken with the double monochromator set to a narrow (0.5-1 nm) bandwidth. Measurements will be made at two wavelengths, tuned to match the expected half-power points of the filter 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# 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. Flat-field images will be acquired at five wavelengths spaced across the expected transmission window of each narrowband filter. 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% and tuning the central wavelength of the monochromator passband to 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). The aperture photometry provided by the standard routines in *apphot* should be sufficient to determine the total counts in a given image.

OS CONFIGURATION:
The 200-micron point target, generated by fibre-bundle(s) linked to the monochromator, operating in double mode with a bandwidth of 1.0 nm, will be used for these measurements. The optics (monochromator/fibres) will be chosen to match the relevant wavelength setting.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
uv17s01

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 expected half-power points of each narrowband filter. Data will be taken in 512x512 subarrays centred on the target position. For full aperture filters, 4 images (per wavelength setting) will be taken, centred on each quadrant; single images will be taken at each wavelength setting for the quad filters.

EXPOSURES:

Filter	OS wavelength	Exposure time	Comments
F373N	371.5 nm	20 secs	1.0 nm bandwidth, UVPT1, Xe
F373N	374.5		Double UVIS, no ND
F469N	467	15 secs	1.0 nm bandwidth, UVPT1, Xe
F469N	470		Double UVIS, no ND
F656N	655	30 secs	0.5 nm bandwidth, IRPT1, QTH
F656N	657.5		Double VIS, no ND
F658N	657	30 secs	0.5 nm bandwidth, IRPT1, QTH
F658N	659		Double VIS, no ND
F437N, quad	435	15 secs	1.0 nm bandwidth, UVPT1, Xe
F437N	437		Double UVIS, no ND
F232N, quad	231	600 secs	1.0 nm bandwidth, UVPT1, Xe
F232N	233		S/N~30/pix
F243N, quad	242	600 secs	1.0 nm bandwidth, UVPT1, Xe
F243N	244		S/N~40/pix
F387N, quad	386	20 secs	1.0 nm bandwidth, UVPT1, Xe
F387N	388		Double UVIS, no ND
F575N, quad	574.8	30 secs	0.5 nm bandwidth, IRPT1, QTH
F575N	576.2		Double VIS
F672N, quad	671	30 secs	0.5 nm bandwidth, IRPT1, QTH
F672N	672		Double VIS
F674N, quad	672.5	30 secs	0.5 nm bandwidth, IRPT1, QTH
F674N	673.5		Double VIS

F280N	278	200 secs	1 nm bandwidth, UVPT1, Xe, Double UV
F280N	282	200 secs	1 nm bandwidth, UVPT1, Xe, Double UV
F487N	485	16 secs	1 nm bandwidth, UVPT1, Xe, Double UVIS
F487N	489	16 secs	1 nm bandwidth, UVPT1, Xe, Double UVIS
F502N	500	20 secs	1 nm bandwidth, UVPT1, Xe, Double UVIS
F502N	504	20 secs	1 nm bandwidth, UVPT1, Xe, Double UVIS

FREQUENCY/No. of ITERATIONS:
One set of measurements only.
Measurements will be made during both the ambient and T/Vac campaigns.

TOTAL ELAPSED TIME:
uv17s01 – 5.0 hrs exposure time, 8.0 hrs elapsed time

VARIANTS:
Add a third measurement for each quadrant, at the central wavelength of each filter.

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 few hundred counts; the background level on the overscan should be a few hundred counts; 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.
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.

TEST RESULTS AND DATA PRODUCTS:
The test results will be reported in the instrument handbook.

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.

2.18 UVIS18: Throughput stability in the UV

CALIBRATION TEST#: 3.5.2

TITLE: Throughput stability at UV wavelengths

CATEGORY: Science Calibration

P.I.: I.N. Reid

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:
Each exposure should be inspected visually – there should be no significant non-uniformities or structure.
The background level on the chip should be a few hundred counts; the background level on the overscan should be a few hundred counts; 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.
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.: I.N. Reid

REVISION DATE: 28 July 2003; validated 9 Sept 2003

PURPOSE:
To determine the extent of stray light due to red leaks in the UV filters. All of the ultraviolet-centred 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# 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. The input flux on the 200-micron OS point target should be measured to an accuracy of 5 percent and the wavelength tuneable to 0.1 nm.

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 0.1 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 fibre-fed point-source at the desired field location, and should provide a measurement of the absolute flux accurate to better than 5%.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
uv19s01, uv19s02, uv19s03, uv19s04

DETAILED TEST PROGRAM:
All of the ultraviolet-centred 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, producing a spot ~10 pixels in radius, with the 125 nm-bandwidth single monochromator. A series of long (~15 minute) exposures will be taken with the spot imaged at a defined position on the UVIS CCD, and with the central wavelength stepped from ~400 to 750 nm.
As a check for filter pinholes, a single full-frame 600 second exposure will be taken of each filter, with the OS set to a central wavelength of 600 nm.

EXPOSURES:

Filter	**Wavelength**	**OS Configuration**	**Exposure time**	**Comments**
F218W	400 nm	QTH/UVPT1/No ND	900 seconds	512-subarray, Amp A
F218W	500 nm			
F218W	600 nm			
F218W	700 nm			
F225W	400 nm			
F225W	500 nm			
F225W	600 nm			
F225W	700 nm			
F275W	450 nm			
F275W	550 nm			
F275W	650 nm			
F275W	750 nm			
F336W	450 nm			
F336W	550 nm			
F336W	650 nm			
F336W	750 nm			

F280N	400 nm			
F280N	500 nm			
F280N	600 nm			
F280N	700 nm			
F343N	400 nm			
F343N	500 nm			
F343N	600 nm			
F343N	700 nm			
F232N	350 nm			
F232N	450 nm			
F232N	550 nm			
F232N	650 nm			
F243N	350 nm			
F243N	450 nm			
F243N	550 nm			
F243N	650 nm			
F218W	600 nm	UVIS/QTH	600 seconds	full-frame
F225W	600 nm	UVIS/QTH	600 seconds	full-frame
F275W	600 nm		600 seconds	full-frame
F336W	600 nm		600 seconds	full-frame
F280N	600 nm		600 seconds	full-frame
F232N	600 nm		600 seconds	full-frame
F243N	600 nm		600 seconds	full-frame

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 – 2.5 hrs exposure time, 4.5 hrs elapsed time
uv19s02 – 2.5 hrs exposure time, 4.5 hrs elapsed time
uv19s03 – 2.5 hrs exposure time, 4.5 hrs elapsed time
uv19s04 – 2.5 hrs exposure time, 4.5 hrs elapsed time
total - 10 hrs 18 hrs

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.
The background level on the chip should be a few hundred counts; the background level on the overscan should be a few hundred counts; 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.
Direct inspection of the output images should be sufficient to identify any flux due to a significant red leak. 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 image.

TEST RESULTS AND DATA PRODUCTS:
Test results on red leaks in UV filters will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:
No direct follow-up. Photometric colour terms (including potential red leaks) can be derived through imaging of standard stars with extreme colours.

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.

2.20 UVIS20: Flat fields – photometric filters

CALIBRATION TEST#: 3.6.1A

TITLE: Flat field response for UVIS photometric filters

CATEGORY: Science Calibration

P.I.: I.N. Reid

REVISION DATE: 28 July 2003; validated 9 Sept 2003

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):
4.6.11.1: 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# 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:
Calibrating the response of the UVIS CCDs 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 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 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, operated either in white light mode (2 mirrors) or, for a few narrowband-UV filters mounted in quads, with the double monochromator tuned to specific narrowband ranges. The Xenon lamp, together with either the UVIS or VIS monochromator optics, will be used for wavelengths $\lambda<500$ nm; 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

DETAILED TEST PROGRAM:
Flat field images will be taken with every UVIS photometric filter. Four 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. At least 40 exposures will be obtained with the F606W filter (grouped in 10s – uv20s08) to investigate limits in noise reduction from combining multiple exposures.
Exposure times are generally set to give ~ 30,000 DN; exceptions are noted in the comments column. The estimated total exposure times are based on the CASTLE ETC – we adopt a maximum of 60 minutes for individual exposures. No neutral density filters are used.

EXPOSURES:

SMS	Filter	OS Configuration	Central Wavelength	Exposure time (secs)	Comments
uv20s01	F218W	UVIS fibre/Xe	220 nm	4 x 3600	S/N=100
	F225W	UVIS/Xe	220 nm	2 x 3000	S/N=100
	F275W	UVIS/Xe	275 nm	2 x 360	
	F280N	UVIS/Xe	275 nm	2 x 2000	S/N=100
uv20s02	F232N	UVIS/double – 13nm/Xe	232 nm	6 x 3600	Quad 42b S/N=30
	F243N	UVIS/double – 13nm/Xe	243 nm	4 x 3600	Quad 42c S/N=30
uv20s03	F336W	UVIS/single/Xe	336 nm	60	
	F390W		390 nm	20	
	F438W		438 nm	20	
	F555W		555 nm	7	
	F475W		475 nm	10	
	F390M		390 nm	90	

	F410M		410 nm	100	
	F467M		467 nm	45	
	F547M		547 nm	20	
	F343N		343 nm	110	
	F373N		373 nm	500	S/N=100
	F395N		395 nm	200	S/N=100
	F469N		469 nm	220	S/N=100
	F487N		487 nm	200	S/N=100
	F502N		502 nm	200	S/N=100
	F588N		588 nm	160	S/N=100
uv20s04	F437N	VIS/double/Xe	437 nm	600	Quad 42a S/N=100
	F378N		378 nm	220	Quad 42d S/N=100
	F387N		387 nm	380	Quad 43a S/N=30
	F422M		408 nm	160	Quad 43b S/N=100
	F436N		436 nm	440	Quad 43c S/N=30
	F492N		492 nm	110	Quad 43d S/N=100
	F508N		508 nm	100	Quad 44a S/N=100
	F575N		575 nm	70	Quad 44b S/N=30
uv20s05	F300X	UVIS/mirror/Xe	300 nm	145	
	F350 LP	UVIS/mirror	350 nm	2	
	F475X	VIS/mirror/Xe	475 nm	10	
	F600LP	VIS/mirror	600 nm	5	
uv20s06	F606W	IR/single/QTH	606 nm	9	
	F814W		814 nm	9	
	F625W		625 nm	11	
	F775W		775 nm	23	
	F621M		621 nm	25	
	F689M		689 nm	29	
	F763M		763 nm	38	
	F845M		845 nm	200	
	F631N		631 nm	150	
	F645N		645 nm	215	
	F656N		656 nm	1200	
	F658N		658 nm	950	
	F665N		665 nm	140	

	F673N		673 nm	165	
	F680N		680 nm	55	
	F953N		953 nm	250	
	F657N		657 nm	150	
uv20s07	F672N	IR/double/QTH	672 nm	990	Quad 44c S/N=100
	F674N		674 nm	1550	Quad 44d S/N=100
	CH4A-a		889 nm	240	Quad 45a
	CH4A-b		906 nm	170	Quad 45b
	CH4A-c		924 nm	150	Quad 45c
	CH4A-d		937 nm	180	Quad 45d
	CH4B-a		619 nm	275	Quad 46a
	CH4B-b		634 nm	270	Quad 46b
	CH4B-c		727 nm	730	Quad 46c
	CH4B-d		750 nm	750	Quad 46d
uv20s08	F606W	IR/single/QTH	606 nm	9	10 exposures

FREQUENCY/No. of ITERATIONS:
Measurements will be made during both the ambient and T/Vac campaigns.

TOTAL ELAPSED TIME:
uv20s01 – 21.3 hrs exposure time, 26.7 hrs elapsed time
uv20s02 – 20.0 hrs exposure time, 24.7 hrs elapsed time
uv20s03 – 22.5 hrs exposure time, 33.9 hrs elapsed time
uv20s04 – 12.6 hrs exposure time, 19.1 hrs elapsed time
uv20s05 – 2.7 hrs exposure time, 8.0 hrs elapsed time
uv20s06 – 7.9 hrs exposure time, 18.8 hrs elapsed time
uv20s07 – 6.0 hrs exposure time, 13.7 hrs elapsed time
uv20s08 – 90 second exposure time, 1.2 hours elapsed time
Total - 93.0 hrs 144.9 hrs

VARIANTS:
In several cases, quad-filter flats can be combined (eg Quad 46a/b and Quad 46c/d).

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 few hundred counts for bias/dark frames and 10,000-30,000 counts for flat fields.
The background level on the overscan should be a few hundred 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. 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. However, the ground calibration images 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.

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

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 background response.

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# 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:
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 re-furbished spare from the WF/PC 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-mciron target with narrowband (10 nm) flat fields. The latter measure the areal 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 fibre-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

DETAILED TEST PROGRAM:
A series of narrowband (10nm) flat-field full-frame images will be taken at 10-nm intervals spanning the wavelength range 200-500 nm. These will be combined with 512-square sub-array images taken of either the 200-micron point target or the 5-micron point source. The latter data having similar spectral resolution and cover the same wavelength range as the flat-field exposures. The point target data will provide absolute calibration and will also be used for wavelength calibration (UVIS24/3.7.1). 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 set-up (fibre-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 (although as yet uncalibrated) integration times.

EXPOSURES:

SMS	**Wavelength**	**OS configuration**	**Integration time (secs)**	**Comment**
uv21s01	200	Xe/doubleUV/ 10 nm/ no ND	10^6	S/N=10 / pixel
flat fields	210		10^5	S/N=10
	220		10^4	S/N=10
	230		8000	S/N=20
	240		8000	S/N=30

	250		4500	S/N=30
	260		2500	S/N=30
	270		1500	S/N=30
	280	Xe/double UVis/10 nm/ no ND	800	S/N=30
	290		500	S/N=30
	300		350	S/N=30
	310		300	S/N=30
	320		230	S/N=30
	330		205	S/N=30
	340		190	S/N=30
	350		190	S/N=30
	360		190	S/N=30
	370		190	S/N=30
	380		190	S/N=30
	390		180	S/N=30
	400		180	S/N=30
	410		180	S/N=30
	420		175	S/N=30
	430		175	S/N=30
	440		170	S/N=30
	450		150	S/N=30
	460		135	S/N=30
	470		170	S/N=30
	480		180	S/N=30
	490		180	S/N=30
	500		210	S/N=30

SMS	**Wavelength**	**OS configuration**	**Integration time (secs)**	**Comment**
uv21s02	200	Xe/doubleUV/ 10 nm/ no ND	400	S/N=100
200-micron target	210		50	
	220	Xe/double UV/10 nm/ND1	200	
	230		55	
	240		24	
	250		14	
	260	Xe/double UV/10 nm/ND2	30	
	270		155	
	280		85	
	290		55	
	300	Xe/double UVis/10 nm/ ND2	25	

	310		16	
	320		12	
	330		10	
	340		10	
	350		9	
	360		9	
	370		9	
	380		9	
	390		9	
	400		8	
	410		8	
	420		8	
	430		9	
	440		9	
	450		9	
	460		9	
	470		9	
	480		9	
	490		9	
	500		9	

FREQUENCY/No. of ITERATIONS:
Measurements of the 200-micron target will be made during both the ambient and T/Vac campaigns. UV flat fields will be taken in ambient comditions using a custom-built monochromator, mounted directly on the OS integrating sphere.

TOTAL ELAPSED TIME:
uv21s01 – X hrs exposure time, Y hrs elapsed times
uv21s02 – X hrs exposure time, Y hrs elapsed times

VARIANTS:
A subset of the longer-wavelength flat-field frames may be taken during T/Vac using the conventional, fibre-fed light source.

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 few hundred counts for bias/dark frames and 1,000-30,000 counts for flat fields.
The background level on the overscan should be a few hundred counts.
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 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

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.

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: 9 September 2003

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# 1 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/cool 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 fibre-fed integrating sphere; IR fibres; double monochromator (IR) set at 2 nm bandwidth.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
uv22s01/uv22s01_Osconfig
uv22s02/uv22s02_OSconfig

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/ IRIS	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/ IRIS	900 secs	F850LP

FREQUENCY/No. of ITERATIONS:
Measurements will be made during the ambient UVIS calibration campaign.
One cycle (at most).

TOTAL ELAPSED TIME:
uv22s01 – 7 hrs exposure time, Y hrs elapsed time

VARIANTS:

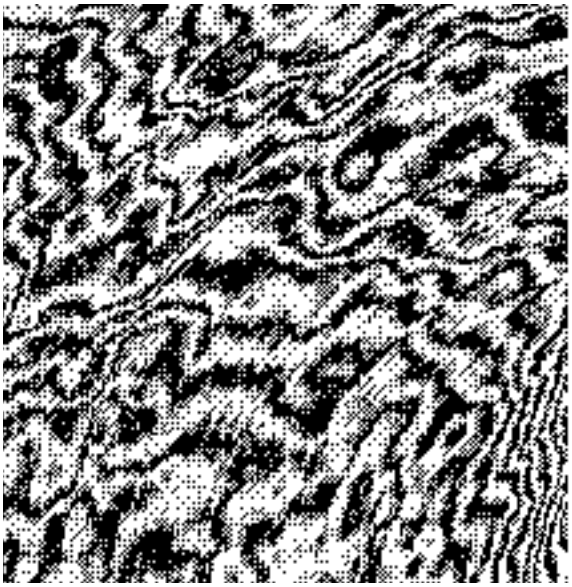
Construct reference frames using DCL detector-only data, supplemented by a limited number of frames taken in ambient calibration.

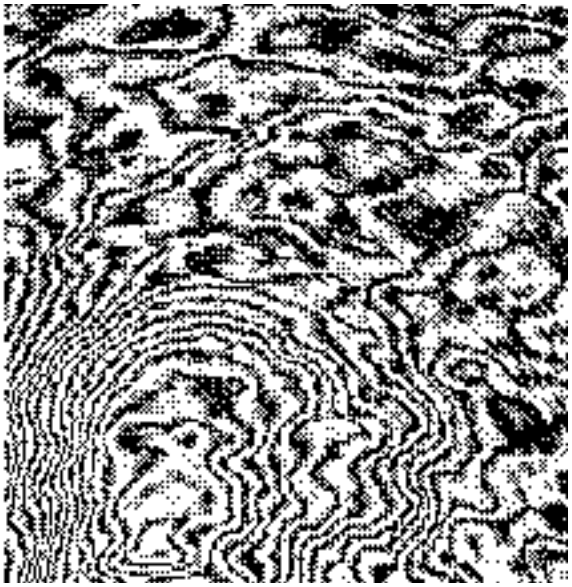
ANALYSIS:
Basic image statistics (mean, variance) will be measured using standard IRAF/IDL routines. Specialized routine will be used to model fringing (Malumuth & Cottingham), combining results from ambient and TV tests with existing DCL fringe flats.

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.

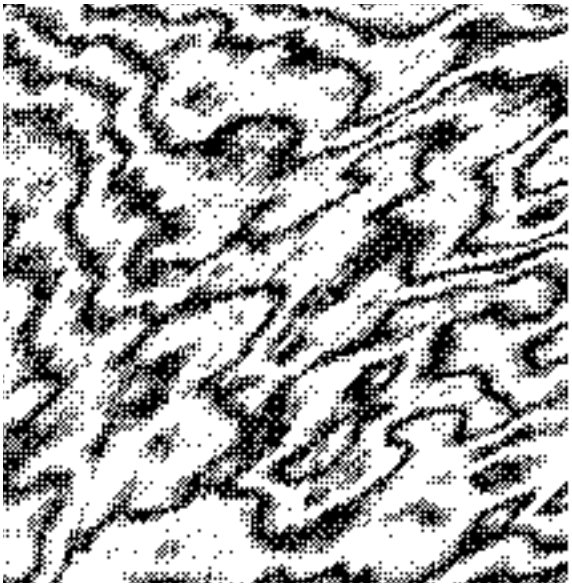
SMOV/ON-ORBIT FOLLOW-UP:
Data cannot be obtained on orbit. This test can only be undertaken during ground calibration.

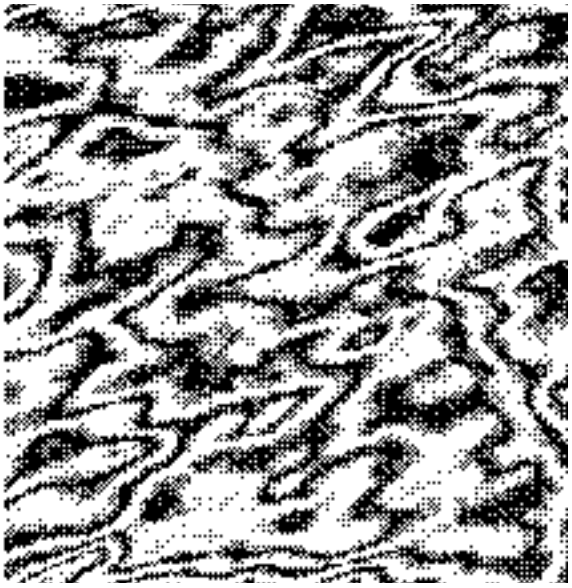
ADDITIONAL COMMENTS:
Relevant images and data analyses obtained by the DCL during detector-level calibration should be available for comparison during the WFC3 ambient and T/Vac science calibration campaigns (see appended figures).





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: 24 July 2003; validated 9 Sept 2003

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/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 shall be available for all spectral elements (that is, minimum countrate of 17 e^-/sec/pixel).
CCD 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:
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:
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.

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 flatfields into reference flatfields 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:
uv23s01 – short test; priority 1 filters (part 1 of 2)
uv23s02 – priority 1 filters (part 2 of 2)
uv23s03 – priority 2 filters
uv23s04 – priority 3 filters
uv23s05 – Deuterium flats (part 1 of 2)
uv23s06 – Deuterium flats (parts 2 of 2)

DETAILED TEST PROGRAM:
Three flatfields will be obtained for all filters plus a bias at the beginning and end of each lamp SMS.

The exposures will be grouped in SMSs using filter science prioritizations (column labeled 'P' in Table below). D2 exposures will be grouped into two 60 min SMSs, in order to minimize lamp cycles and limit D2 high current on time to 60min. Both D2 and Tu UV exposures to be taken with same filter if possible and exptimes are less than ~900 sec.

A small spotcheck SMS (~1/2 hr), to be run in ambient and TV, will obtain flatfields in a few high priority filters, in order to validate exposure time estimates (bench temperature will not be regulated during the ambient testing). This spotcheck SMS must be run at least 3 times as the filters in this SMS are not repeated in any of the other, longer SMSs.

The table provides initial UVIS exposure time estimates. D2 lamp exposures are shaded; priority levels are listed in 'P' column, with highest priority in bold font. Filters belonging to one of the five quad filters have 'Q' plus quad number appended in filter name column.

All the quad filters are lowest priority and in a single SMS. Extra biases are added after every quad filter where saturation will occur in another quadrant and affect subsequent flats. Some quad filters have exptimes appropriate for two quads of a filter simultaneously; in those cases, 3 flats (instead of 6) will cover those two filter quads. Quad filters are grouped together when possible, to minimize filter wheel overheads; however, quad filters that will cause the most saturation in other quadrants are done in the last part of the SMS.

Exposure times listed in the UVIS and IR tables below are estimated to achieve 50,000e^- (S/N ~390; assumes CCD18 and FPA64). These may require tweaking if the spares are used.

EXPOSURES:

filter	lamp	wavel	expt ccd 18	expt ccd 40	P1	filter	lamp	wavel	expt ccd 18	expt ccd 40	Pa
f218w	D2	2201	45.3	56.4	**1**	f508n, Q3	Tu	5089	37.7	40.4	3
f225w	D2	2263	33.1	40.3	**1**	f547m	Tu	5452	4.7	5.0	2
f232n, Q1	D2	2326	725.	893.	3	f555w	Tu	5206	2.0	2.1	**1**
f243n, Q1	D2	2420	562.	667.	3	f575n, Q3	Tu	5756	165.	170.	3
f275w	D2	2744	25.4	28.8	**1**	f588n	Tu	5882	30.5	31.4	**1**
f280n	D2	2796	704.	781.	2	f606w	Tu	5840	0.9	0.9	**1**
f300x	D2	2823	13.8	15.8	**1**	f619n, Q5	Tu	6197	30.2	30.6	3
f336w	D2	3358	25.1	28.0	**1**	f621m	Tu	6207	2.8	2.8	2
f336w	Tu	3358	520.	581.	**1**	f625w	Tu	6225	1.1	1.1	**1**
f343n	D2	3378	55.7	60.0	2	f631n	Tu	6306	30.8	31.0	3
f343n	Tu	3378	704.	781.	2	f634n, Q5	Tu	6347	28.1	28.2	3
f350lp	Tu	6001	0.3	0.3	**1**	f645n	Tu	6452	19.5	19.5	**1**
f373n	D2	3728	382.	424.	2	f656n	Tu	6561	85.3	85.1	2
f378n, Q1	D2	3788	180.	198.	3	f657n	Tu	6557	11.8	11.7	3
f378n, Q1	Tu	3788	650.	715.	3	f658n	Tu	6585	76.8	76.6	2
f387n, Q2	D2	3872	641.	704.	3	f665n	Tu	6657	10.7	10.7	3
f390m	D2	3896	114.	126.	2	f672n, Q3	Tu	6716	72.3	72.1	3
f390m	Tu	3896	228.	251.	2	f673n	Tu	6759	11.5	11.5	2
f390w	D2	3895	30.2	33.4	**1**	f674n, Q3	Tu	6729	103.	103.	3
f390w	Tu	3895	35.7	38.7	**1**	f680n	Tu	6874	3.3	3.3	3
f395n	D2	3953	500.	550.	2	f689m	Tu	6875	1.8	1.8	2
f395n	Tu	3953	510.	556.	2	f727n, Q5	Tu	7274	18.7	18.1	3
f410m	Tu	4110	180.	195.	2	f750n, Q5	Tu	7500	18.8	17.8	3
f422m, Q2	Tu	4219	246.	266.	3	f763m	Tu	7632	1.4	1.4	2
f436n, Q2	Tu	4367	455.	485.	3	f775w	Tu	7708	0.9	0.8	**1**
f437n, Q1	Tu	4371	625.	667.	3	f814w	Tu	8236	0.5	0.5	**1**
f438w	Tu	4306	26.1	28.0	**1**	f845m	Tu	8458	1.4	1.2	2
f467m	Tu	4689	39.5	42.3	2	f850lp	Tu	8955	1.7	1.4	**1**
f469n	Tu	4685	226.	243.	2	f889n, Q4	Tu	8891	16.0	13.5	3
f475w	Tu	4705	4.5	4.8	**1**	f906n, Q4	Tu	9058	17.9	14.8	3
f475x	Tu	4779	2.1	2.2	**1**	f924n, Q4	Tu	9246	22.0	18.2	3
f487n	Tu	4869	121.	130.	2	f937n, Q4	Tu	9371	23.6	19.5	3
f492n, Q2	Tu	4931	58.8	63.3	3	f953n	Tu	9530	54.3	44.6	2
f502n	Tu	5008	91.	97.9	2						

FREQUENCY/No. of ITERATIONS:
Measurements will be made during both the ambient and T/Vac campaigns – at least three cycles.
The test sequences uv23s01 and uv23s05 should be run as early as possible in the calibration campaign to verify exposure times.

Calibration Subsystem Operations (summarized from OPO-1, section 3.8):
Lamps cannot be on concurrently.

Tungsten

1 Filter science priority (1-3, high to low), taken from ISR 02-10.

- 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 (Tu atoms can migrate from filament onto inside of window, decreasing output and weakening filament).
- IR: lamp3 to be primary lamp, 4 is backup (DM-05, 2.2.3.3)
- Tu: lamp1 to be primary, 2 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)

TOTAL ELAPSED TIME:
uv23s01 – 0.1 hrs exposure time, 4.4 hrs elapsed time
uv23s02 – 0.5 hrs exposure time, 5.7 hrs elapsed time
uv23s03 – 1.9 hrs exposure time, 10.0 hrs elapsed time
uv23s04 – 1.6 hrs exposure time, 12.1 hrs elapsed time
uv23s05 – 1.7 hrs exposure time, 6.8 hrs elapsed time
total - 5.8 hrs 39.0 hrs

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 a few hundred counts for bias/dark frames and 10,000-30,000 counts for flat fields.
The background level on the overscan should be a few hundred 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 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.

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

2.24 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

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# 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:
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 re-furbished spare from the WF/PC instrument. 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 UVIS Flight detector should be installed in WFC3. The OS should be capable of monitoring to an accuracy of 2% the incident flux in point target 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 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:
Extended target images provided by the 200-micron fibre-bundle, linked to the double-mode monochromator set to a bandwidth of 10 nm. Point-source images with the 5-micron target linked to the

double monochromator, bandwidth 10 nm. Neutral density filters will be required for all passbands to avoid saturation.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
uv24s01

DETAILED TEST PROGRAM:
A series of narrowband (10nm) 512-square subarray images will be taken of the 5-micron point target centred five defined apertures on the UVIS detector. The monochromator will be stepped through the wavelength range 200-500 nm, with measurements made at the wavelengths listed below. Measurements will be made with the image located at a central position and in each of the 4 corners of the UVIS detectors.
In addition, a dispersed image of a white light point source will be obtained at each location (4 corners plus center) to map the spectrum length and tilt. Direct images will also be obtained at each of the 5 white light point source positions, to measure source offsets between direct and dispersed images. .
Exact integration times for the white light observations remain to be determined.

EXPOSURES:
taken at 5 position on the detector – a central position and 4 corners.

SMS	**Wavelength**	**OS configuration**	**Integration time (secs)**	**Comment**
uv24s01	200	Xe/doubleUV/ 10 nm/ no ND	400	S/N=100, G280
5-micron point target	230	Xe/double UV/10 nm/ND1	50	
	260	Xe/double UV/10 nm/ND2	30	
	290		55	
	320	Xe/double UVis/10 nm/ND2	12	
	350		10	
	380		10	
	410		10	
	440		10	
	470		10	
	500		10	
	white light	Xe/mirror/ND4	2 (?)	G280
	white light	Xe/mirror/ND4	2 (?)	F300X

FREQUENCY/No. of ITERATIONS:
Measurements will be made during both the ambient and T/Vac campaigns.
uv24s01 will be run four times – once for each corner of the detector.

TOTAL ELAPSED TIME:
uv24s01 – 1.0 hrs exposure time, 10.5 hrs elapsed time

VARIANTS:
Take an additional set of unresolved (5-micron target) point-source images centred 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 a few hundred counts; 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. 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
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.

<u>Dispersion Solution</u>: 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: $\lambda = \lambda_0 + b*\delta x$, where b is the dispersion (in μm/pix or Ang/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).

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 diode flux measurements of monochromatic point-source exposures obtained for the dispersion solution.

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.

2.25 UVIS25: Optical ghosts

CALIBRATION TEST#: 3.8.1

TITLE: Optical ghosts in the WFC3 UVIS Camera

CATEGORY: Science Calibration

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

REVISION DATE: 4 June 2003; validated 9 Sept 2003

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# 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:
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:

DETAILED TEST PROGRAM:
As a baseline, we assume exposures at 8 standard locations for all filters, with 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. These exposures should be taken with the F225W, F814W, and F606W filters. The exposures need to be saturated in order to see the fainter ghosts. The total counts in the saturated image can be calculated by using a multiple of an exposure time yielding a known flux for an unsaturated image. The short exposure to calibrate the flux can be taken using subarrays. The count calibration exposures are obtained only for images within the field of view.

EXPOSURES:

Filter	X	Y	OS Configuration	Exposure time
F225W	-1600	-1600	Xe/5-micron point target/Single UVis	60 seconds (?) ~$4x10^4$ phot/sec
	-1600	1600		
	1600	-1600		
	1600	1600		
	200	0		
	-200	0		
	1000	0		
	-1000	0		
F814W	-1600	-1600	QTH/10-micron point target/Single UVis	30 seconds (?) ~$6x10^5$ phot/sec
	-1600	1600		
	1600	-1600		
	1600	1600		
	200	0		
	-200	0		
	1000	0		
	-1000	0		
F606W	-1600	-1600	QTH/10-micron point target/Single UVis	10 seconds (?) ~$3x10^6$ phot/sec
	-1600	1600		
	1600	-1600		
	1600	1600		
	200	0		
	-200	0		
	1000	0		
	-1000	0		
F606W	-1000	-1600		
	-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	-2100		
	-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 – 1.0 hrs exposure time, 10.5 hrs elapsed time

VARIANTS:
Use ND filters instead of known ratio of exposure times in order to evaluate total counts in saturated image.

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.

2.26 UVIS26: Gap behaviour

CALIBRATION TEST#: 3.8.4

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

CATEGORY: Science Calibration

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

REVISION DATE: 4 June 2003; validated 9 Sept 2003

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# 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:
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 fibre linked to He-Ne 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? entirely?) wavelength-independent. Full-frame images will be taken to explore the full range of potential reflections.

EXPOSURES:

Filter	X	Y	Exposure time
F606W	0	-2000	60 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:
uv26s01 – 0.4 hrs exposure time, 2.7 hrs elapsed time

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:
.

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# 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:
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 s 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: System performance monitor

CALIBRATION TEST#: 3.9.2

TITLE: UVIS system performance monitor

CATEGORY: Science performance Monitor

P.I.: O. Lupie

REVISION DATE: 25 August 2003; validated 9 Sept 2003

PURPOSE:
To monitor the scientific performance of the UVIS channel in TV at operational temperatures (-83C). The basic science functions include biases, darks, internal and external flats at multiple wavelengths, and unresolved sources to monitor the optical quality

PRIORITY: Medium

CEI SPECIFICATION(s):
6.2.4.1: functional test suite – all functions tested periodically throughout test program
4.6.14: CCD bias stability – bias over a single row should be repeatable to $2e^-$
4.6.11.4: CCD flat field stability – the difference between two flat fields taken 60 days apart should b e < 1% rms; <=5% of FOV shall not exceed 5% variation
4.6.11.3: CCD functioning pixels - <1% non functional pixels
4.6.10: CCD detector QE stability – absolute QE stable to <+/-0.5% over 1 hour; to <+/-1% over 1 month; to <+/-2% at 300 nm; pixel-to-pixel stability <0.2% /hour
4.6.4: CCD dark at –83C - <20 e^-/hr
4.6.3: CCD readout noise - < $4e^-$/pixel
4.4.2.1: UVIS channel optical throughput
4.3.2.1: UVIS channel point source profile
4.4.3: UVIS spectral range stability – 200-300 nm <5%/month; 300-400 nm < 3%/month; >600 nm <1%/month
4.5.2: UVIS shutter repeatability - <0.01 sec; no 2 pixels differ in exposure time be more than 0.01 seconds.
4.3.2.5.1: UVIS long term image drift – registration to 0.25 pixels rms over 24 hours.

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:
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 system monitor test is designed to take a small dataset that will verify that the instrument meets the relevant stability criteria.

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 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 flat field sources 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 an 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: Note: OS Slit widths = 2000 for all OS exposures.

Pt Source Exposures: 1) UV **-** Lamp=Xenon, Mode= Double UV, Fiber =200 micron UV, Open, @218nm or 225nm; ND2, bwd=13nm, Source target at pos UV02.
2) VIS monochromatic at Pos UV02 - Lamp=Tungsten, Mode= Double VIS, Fiber =10 micron VISIR, Open, @625nm or 814nm; ND2, bwd=13nm, Source target at pos UV02 and UV11.
3) VIS continuum at Pos UV02 - Lamp=Tungsten, Mode= Single UVIS, Fiber =10 micron VISIR, Open, @625nm; ND3, bwd=125nm, Source target at pos UV02 and UV11

Extended Diffuse: 1) VIS - Lamp=Tungsten, Mode=Mirror, Fiber=UVIS, @625nm and 814nm, bwd=125nm. 2) Lamp=Xenon, Mode=DoubleUV, Fiber=UV Flatfield, @218nm and 225nm; no ND, bwd=13nm.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:

DETAILED TEST PROGRAM:

<u>Configure WFC3 UVIS for observations:</u>

- WFC3 to Operate [TECs on and cooled to nominal operational temperature].
- CSM is in the UVIS configuration.
- SOFA wheels are all in the open configuration.
- Correctors in a predicted flight nominal configuration and initialized.

Bias: Take a full frame and 512 subarray bias (0s) at start of test. Compare with other epochs for long term stability. (No Bias is included for the corner position since this 512 exposure is used to check positional stability).
External Point Source: to monitor the PSF at a single position on the camera.
Red monochromatic PSF: Take monochromatic point source exposure in F625W Position target at UV02. Select exposure time to achieve ~30000 DN/peak pixel.
UV monochromatic PSF: Take monochromatic point source exposure in F218W and 225W to check for contamination. Position target at UV02. Select exposure time to achieve ~30000 DN/peak pixel.
Red continuum PSF: Take continuum point source exposures in F625W to trend standard stellar-like sources on at the central location and the other in a corner to check for positional stability.
Dark: Take a full frame and corner darks. Compare with other epochs for long term stability. Exposure time selected to match the mid-range exposure in the Dark Cal UVIS01.
Internal Flat Fields: To verify relative UVIS FF stability. Select exposure time to achieve ~30000DN/pix in each filter. All exposures taken at nominal gain.
Red FF: Take F625W FF (1.0s), nominal gain using Tungsten Lamp #1. F625W used in UVIS05 (Linearity, FF). Compare relative flux and spatial uniformity with previous epoch internal FFs.
Red FF @ 2nd wavelength**:** Take 1 F814W FF (1.0s) using the same Tungsten Lamp – use to compare to F625W results and delineate anomalous effects.
UV FF: Take 1 F218W using the Deuterium Lamp., medium current. Check relative flux from previous epochs for contamination effects.
External Flat Fields: To illuminate the focal plane as an external source would do and to compare with the internal flats; to verify absolute FF stability (to within OS absolute flux values). Select exposure time to achieve ~30000DN/pix in red filter and *1800 second exposures in UV (do as best as you can)*
Red FF: F625W FF and F814W FF – full frame
UV FF: F218W and F225W – full frame

UVIS Warm Noise Test: Obtain 2 images, each read out through a different amp pair. The special 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. Using an exposure time of 0, two images are generated, one read through AC and the other through BD. Both ambient and TV ground testing will include repetitions of this test for comparison, continuity, and preparation for the SMF WFC3 Functional.

EXPOSURES: See table below

FREQUENCY/No. of ITERATIONS:
Measurements will be made during both the ambient and T/Vac campaigns.
Run after major instrument or major stimulus configuration adjustments or corrections, as a monitor through TV, during thermal cycling intervals.

TOTAL ELAPSED TIME:

VARIANTS:

ANALYSIS:
A variety of techniques will be used to analyse these data in a consistent manner.

TEST RESULTS AND DATA PRODUCTS:
Test results will be included in 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. *[TBD engineering telemetry list]*. **Calibration Products**: The data collected herein are used for trending purposes.

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

MS	Target	Spect	Optional	Exp [3]	Comment	OS Configuration[4]
ine	UVIS FULL TV	Elem	Param	(sec)	ver 8/27/03 - oll	
6	**Bias**	DEF	AMP=ABCD GAIN=1.5	0		None
7	**Bias**	DEF	AMP=A Subarray 512 Ap: IUV1M1	0		None
8	**Point Source Ext Xe [1,2]**	F218W	AMP=A Subarray 512 IUV1M1_512	20	pt source monochroma PSF using laser requires short exp time; S/N-> 200;	Castle ETC: Lamp=Xenon, Mode= Double UV, Fiber =200 micron UV, Open, @218nm; ND2, bwd=13nm, Source target at pos UV02.
9	**Point Source Ext Xe [1,2]**	F225W	AMP=A Subarray 512 IUV1M1_512	8	pt source monochromatic PSF using laser requires short exp time; S/N -> 200;	Castle ETC: Lamp=Xenon, Mode= Double UV, Fiber =200 micron UV, Open, @225nm; ND2, bwd=13nm, Source target at pos UV02.
10	**Point Source Ext HeNe[1,2]**	F625W	AMP=A Subarray 512 IUV1M1_512	20	pt source monochromatic PSF using laser requires short exp time; S/N -> 200;	Castle ETC: Lamp=Tungsten, Mode= Double VIS, Fiber =10 micron VISIR, Open, @625nm; ND2, bwd=13nm, Source target at pos UV02.
11	**Point Source Ext continuum**	F625W	AMP=A Subarray 512 IUV1M1_512	10	pt source wide band source to trend standard stellar-like target PSFs. S/N --> 200	Castle ETC: Lamp=Tungsten, Mode= Single UVIS, Fiber =10 micron VISIR, Open, @625nm; ND3, bwd=125nm, Source target at pos UV02.
12	**Point Source [1] Ext continuum pos stability**	F625W	AMP=D Subarray 512 IUV2CD_512	10	pt source wide band source to trend standard stellar-like target PSFs. S/N --> 200	Castle ETC: Lamp=Tungsten, Mode= Single UVIS, Fiber =10 micron VISIR, Open, @625nm; ND3, bwd=125nm, Source target at pos UV11.
13	**Dark**	DEF	AMP=A Subarray 512 Ap: IUV1M1	300	Low S/N	None
14	**Dark**	DEF	AMP=ABCD	1000	Medium S/N;	None
15	**Tungsten Internal**	F625W	AMP=ABCD	1	FF @ through 2 filters to delineate stability anomalies; need ~30000 DN/pix	None
16	**Tungsten Internal**	F814W	AMP=ABCD	1	FF @ through 2 filters to delineate stability anomalies; need ~30000 DN/pix	None
17	**Deuterium Internal**	F218W	AMP=ABCD	60	UV Flat need ~30000 DN/pix	None
18	**External Diffuse**	F625W	AMP=ABCD	20	Full optical path illumination; compare to internal flat S/N --> 120	Castle ETC: Lamp=QTH, Mode=Mirror, Fiber=UVIS, @625nm, OPEN, bwd=125nm, M-Slit width=2000.
19	**External Diffuse**	F814W	AMP=ABCD	17	Full optical path illumination; compare to internal flat S/N --> 120	Castle ETC: Lamp=QTH, Mode=Mirror, Fiber=UVIS, @814nm, OPEN, bwd=125nm, M-Slit width=2000.
20	**External Diffuse**	F218W	AMP=ABCD	1800	Full optical path illumination; compare to internal flat; check for contamination effects 1800 sec -->S/N<10	Castle ETC: Lamp=Xenon, Mode=DoubleUV, Fiber=UV Flatfield, @218nm, no ND, bwd=13nm, M-Slit width=2000
21	**External Diffuse**	F225W	AMP=ABCD	1800	UV Throughput stability - compare to F218W S/N --> 16	Castle ETC: Lamp=Xenon, Mode=DoubleUV, Fiber=UV Flatfield, @225nm, no ND, bwd=13nm, M-Slit width=2000
22	**Warm Noise Test**	BLANK	AMP=AC GAIN=1.5	0	Special CCL - clock/read opposite amp test duration ?	None
23	**Warm Noise Test**	BLANK	AMP=BD GAIN=1.5	0	Special CCL - clock/read opposite amp test duration ?	None

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# 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:
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 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:

DETAILED TEST PROGRAM:
This test will be undertaken using bias frames taken as part of UVIS01 (dark count as f(T_{det})) and UVIS03 (gain as f(T_{det})). Those test procedures envisage acquiring bias frames at five temperatures: T_{nom}, the nominal on-orbit operating temperature (-83°C); T_{nom}+/- 3 K; T_{nom}+6 K; and T_{nom}+15 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 2x2 and 3x3 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 a few hundred counts for bias/dark frames.
The background level on the overscan should be a few hundred 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 ~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^-/pix (goal: 3) at 30000 pix/sec readout.

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:
The baseline characteristics of the Marconi CCD detectors have been measured by the GSFC Detector Characterisation 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:

DETAILED TEST PROGRAM:
This test will be undertaken using data taken as part of UVIS01 (dark count as f(T_{det})) and UVIS03 (gain as f(T_{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 a few hundred counts for bias/dark frames.
The background level on the overscan should be a few hundred 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.

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 preliminary measurements of the intensities of the Optical Stimulus light sources, of the WFC3 throughput and the detector quantum efficiencies. These values will be updated using the WFC3 Exposure Time Calculator as improved empirical data become available.

3.1 IR01: Dark count as a function of T_{det}

CALIBRATION TEST#: 3.1.2

TITLE: Dark count rate as a function of detector temperature

CATEGORY: Science Calibration

P.I.: M. Robberto

IPT REVISION DATE: 1 Sept 2003; validated 9 Sept 2003

REVISION HISTORY

- Added MIFS sequences; improved tables and checked consistency with SMS.

PURPOSE:
To verify that the darkcount rate is within CEI specifications for detector temperatures spanning the range which may be used on orbit.

PRIORITY: High

CEI SPECIFICATION(s):
4.8.4: dark rate + HST radiation - 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 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. 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 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

DETAILED TEST PROGRAM:
Darks are required for each 15 Multiaccum sample sequences (Sampseqs) available to the IR detector. Five darks will be acquired in each with the detector at the nominal operating temperature (150K); additional exposures at three non-nominal temperatures (T_{nom}+3, T_{nom}+6, T_{nom}-3) will be acquired for two sampseqs.

EXPOSURES:

SMS IR01S01			
Sampseq	**Exposure time**	**N_{exp}**	**Comments**
RAPID	61.3 seconds	5 x 15 reads	T_{nom}
SPARS25	375	5	T_{nom}
SPARS50	750	5	T_{nom}
SPARS100	1500	5	T_{nom}
SPARS200	3000	5	T_{nom}
SPARS400	5250	5	T_{nom}
STEP25	300	5	T_{nom}
STEP50	550	5	T_{nom}
STEP100	1000	5	T_{nom}
STEP200	1800	5	T_{nom}
STEP400	3200	5	T_{nom}
MIFS10	600	5	T_{nom}
MIFS15	900	5	T_{nom}
MIFS20	1200	5	T_{nom}
MIFS25	1500	5	T_{nom}
SMS IR01S02			
Sampseq	**Exposure time**	**N_{exp}**	**Comments**
RAPID	61.3	2 x 15 reads	T_{nom}-3
STEP400	3200	2	T_{nom}-3
RAPID	61.3	2	T_{nom}+3
STEP400	3200	2	T_{nom}+3
RAPID	61.3	2	T_{nom}+6
STEP400	3200	2	T_{nom}+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. SMS ir01s01 has1 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 – 29.6 hrs exposure time, 33.0 hrs elapsed time
ir01s02 – 1.8 hrs exposure time, 2.8 hrs elapsed time

VARIANTS:
Additional measurements at certain sampseqs.

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.

3.2 IR02: Gain as a function of T_{det}

TITLE: Gain as a function of detector temperature

CATEGORY: Science Calibration

P.I.: M. Robberto

IPT REVISION DATE: 1 Sept 2003; validated 9 Sept 2003

REVISION HISTORY

- All the Tnom exposures nom 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.

PURPOSE:
Determine the relative gain of the four settings possible with WFC3/IR; determine the absolute gain for the standard setting (2.5e/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 detector IR# 1 at gain settings 2, 2.5, 3 & 4 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 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 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:

200-micron extended target with IR fibers, monochromator in single mode (125nm) centered on 1250 nm with ND4 in F/W 1 and ND3 in F/W 2 (predicted count-rate 230 photons/pixel/sec, or ~15,000 in 66 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). The intensity level should not lead to over-illumination of the detector.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
ir02s01

DETAILED TEST PROGRAM:
The relative gain settings 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 source should be centered on a defined aperture. All of the data will be taken using the F125W filter, since the gains are not wavelength dependent. Measurements will be made at four detector temperatures (T_{nom}=150K; T_{nom}+3; T_{nom}-3; T_{nom}+6), taking two images at each gain setting. Additional 8 images will be taken at the standard gain setting to allow determination of the absolute gain.

EXPOSURES:

Gain	Exposure time	N_{Exp}	Comments
2.0 e^-/adu	RAPID = 61.5 secs	2	T = 147K
2.5 e^-/adu	RAPID	10	
3.0 e^-/adu	RAPID	2	
4.0 e^-/adu	RAPID	2	
2.0 e^-/adu	RAPID	2	T = 150K = T_{nom}
2.5 e^-/adu	RAPID	10	
3.0 e^-/adu	RAPID	2	
4.0 e^-/adu	RAPID	2	
2.0 e^-/adu	RAPID	2	T = 153K
2.5 e^-/adu	RAPID	10	
3.0 e^-/adu	RAPID	2	
4.0 e^-/adu	RAPID	2	
2.0 e^-/adu	RAPID	2	T = 156K
2.5 e^-/adu	RAPID	10	
3.0 e^-/adu	RAPID	2	
4.0 e^-/adu	RAPID	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 – 0.5 hrs exposure time, 2.5 hrs elapsed time excluding time needed to set the detector at the next temperature

VARIANTS:
Take images as subarrays. Use an alternative OS configuration to obtain higher flux levels (e.g. ND4 + ND2 + slit width 1500 microns, giving ~1000 photons/pixel/sec).

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.
The relative gains will be determined by measuring the ratios of the total counts within each differenced frame, making due allowance for any variations in the incident flux. The absolute gain at the standard setting (nominally 2.5 e^-/adu) will be determined by mean-variance analysis of the 10 multiaccum exposures taken at T_{nom}.

TEST RESULTS AND DATA PRODUCTS:
1) Table of *absolute* gain per quadrant at 2.5e/adu setting, 150K
2) Table of *relative* gain normalized to standard (2.5e/adu) setting at each temperature
3) A preliminary pixel gain map
The test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:
The relative gains 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.

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

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.

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

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 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:
200-micron extended target with IR fibers, monochromator in single mode (125nm) centered on 1250 nm with ND4 in F/W 1, ND2 in F/W 2 and a slit width of 1500 microns (predicted count-rate 1000 photons/pixel/sec, or ~61,000 in 61 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

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:

Gain	Exposure time	N_{Exp}	Comments
2.5 e^-/adu	RAPID = 61.5 secs	10	T = 150K , position IR01
	RAPID	10	position IR02
	RAPID	10	position IR03
	RAPID	10	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 - 1.2 hrs exposure time, 3.2 hrs elapsed time

VARIANTS:
Take images as subarrays. Use an alternative OS configuration to obtain higher or lower flux levels.

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. 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.

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

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 Characterisation 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 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 IR fibres, monochromator in single mode (125nm) centred on 1250 nm with ND2 in F/W 1, open in F/W 2 and a slit width of 1500 microns (predicted count-rate 750 photons/pixel/sec, or ~45,000 in 61 seconds). Flatfield flux level can be monitored using photodiodes mounted on the integrating sphere.

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(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 ~45,000 e^-, so care should be taken to avoid over illumination. 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	RAPID = 61.5 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:

VARIANTS:
Take images as subarrays. 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). 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 as a function of time.

TEST RESULTS AND DATA PRODUCTS:
1) Linearity plot per quadrant at 2.5e/adu setting, 150K
2) Analytic expression (e.g. polynomial) for the linearity correction per quadrant
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.

3.5 IR05: IR subarray readout noise and dark current

CALIBRATION TEST#: 3.1.11

TITLE: Dark count rate and readnoise for IR subarrays

CATEGORY: Science Calibration

P.I.: M. Robberto

IPT REVISION DATE: 1 Sept 2003; validated 9 Sept 2003

REVISION HISORY:
- Specified 5 sequences

PURPOSE:
To verify that the darkcount rate is within CEI specifications for detector temperatures spanning the range which may be used on orbit.

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 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:
ir05s01

DETAILED TEST PROGRAM:
A series of darks will be taken for four sub-array formats using two sample sequences – STEP25, with a total integration time of 300 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	Exposure time	N_{exp}	Comments
RAPID	<60	5 x 15 reads	64x64
RAPID	<60	5	128x128
RAPID	<60	5	256x256
RAPID	<60	5	512x512
STEP25	300	5	64x64
STEP25	300	5	128x128
STEP25	300	5	256x256
STEP25	300	5	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 ir05s01 will be repeated 5 times

TOTAL ELAPSED TIME:
ir05s01 – 1.8 hrs exposure time, 2.6 hrs elapsed time

VARIANTS:

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 summarised 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.

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 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.: M. Stiavelli/T. Brown

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 +-?% 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; 10μ 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, 2.3 hrs elapsed time
ir08s02 – 0.8 hrs exposure time, 2.3 hrs elapsed time
ir08s03 – 0.8 hrs exposure time, 2.3 hrs elapsed time
total - 2.4 hrs 6.9 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.

3.9 IR09: Image stability

CALIBRATION TEST#: 3.4.3

TITLE: Image stability on WFC3/IR

CATEGORY: Science Calibration

P.I.: ?

REVISION DATE: 13 June 2003

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):
4.3.2.5.2: 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:
The 1310 nm laser diode single-mode fibre will be used to provide a point source image at the specific locations on the WFC3/IR detector.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES: IR09S01, IR09C01

DETAILED TEST PROGRAM:
A point source generated by the 1310 laser diode will be centered on the nominal aperture. A continuous series of 100 sub-array images (512 x 512) will be taken at approximately 2 minute intervals (determined by the readout and dump time) resulting in a total test duration of ~200 minutes.

EXPOSURES:

FREQUENCY/No. of ITERATIONS:
Execute each sequence for a period of at least 200 minutes. Measurements can only be made during the T/Vac campaigns.

Filter	Exposure time	OS Configuration	No. of exposures
F125W	RAPID (NSAMP=10)	1310 laser, point-source centered on reference aperture	100

TOTAL ELAPSED TIME: 200 minutes – set by stability requirements

VARIANTS:
Repeat test at different locations on the detector.

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. 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 centroid and radial profile for each image.

TEST RESULTS AND DATA PRODUCTS:
Test results will be included in the instrument handbook.

SMOV/ON-ORBIT FOLLOW-UP:
Repeated observations of moderate-density starfields will verify performance during SMOV. No further on-orbit calibration activities are currently planned.

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.

3.10 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; 10μ 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)	sampseq	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.: I.N. Reid

REVISION DATE: 28 July 2003; validated 9 Sept 2003

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 centred on the nominal aperture, and the input flux measured to an accuracy of 2 percent. An initial estimate of the relation between input fibre 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 fibre-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 fibre bundle linked to monochromator, operating in either single mode (bandwidth 125 nm) or double mode (bandwidth of 13 nm).

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
ir11s01

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	T(50,000e^-)	OS Configuration
F160W	1600 nm	RAPID	50 secs	QTH/single/IRPT1/ND4+ND3/
F125W	1250 nm	RAPID	35	QTH/single/IRPT1/ND4+ND3/
F093W	1050 nm	STEP25	90	QTH/single/IRPT1/ND4+ND2/
F110W	1100 nm	RAPID	63	QTH/single/IRPT1/ND4+ND2/
F127M	1270 nm	RAPID	36	QTH/double(13nm)/IRPT1/ND4+ND1/
F139M	1390 nm	RAPID	42	QTH/double(13nm)/IRPT1/ND4+ND1/
F098M	980 nm	STEP25	140	QTH/double(13nm)/IRPT1/ND4+ND1/
F153M	1530 nm	RAPID	41	QTH/double(13nm)/IRPT1/ND4+ND1/
F164N	1640 nm	RAPID	64	QTH/double(13nm)/IRPT1/ND4+ND1/
F167N	1670 nm	RAPID	67	QTH/double(13nm)/IRPT1/ND4+ND1/
F128N	1280 nm	RAPID	46	QTH/double(13nm)/IRPT1/ND4+ND1/
F130N	1300 nm	RAPID	40	QTH/double(13nm)/IRPT1/ND4+ND1/
F126N	1260 nm	RAPID	49	QTH/double(13nm)/IRPT1/ND4+ND1/
F132N	1320 nm	RAPID	42	QTH/double(13nm)/IRPT1/ND4+ND1/

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:
ir11s01 – 0.6 hrs exposure time, 6.8 hrs elapsed time

VARIANTS:
Determine absolute throughput as a function of wavelength for the narrowband filters.
Use subarrays to reduce overheads.

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.

3.12 IR12: Throughput – detector-defined passbands

CALIBRATION TEST#: 3.5.1B

TITLE: IR throughout – detector-defined passbands

CATEGORY: Science Calibration

P.I.: I.N. Reid

REVISION DATE: 28 July 2003; validated 9 Sept 2003

PURPOSE:
To determine the throughput as a function of wavelength at the short wavelength limit of the F093W, F098W and F098M passbands, 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 IR# 1 at standard gain=2.5.

BACKGROUND:
Matching the predicted sensitivity of WFC3 against standard photometric systems requires accurate knowledge of photometric passbands. Most of the IR passbands are filter-defined, but F093W, F105W and F098M extend shortward of the detector short-wavelength cutoff. As a result, the detector response defines the short-wavelength cutoff. The current test will empirically test the effective response function. This calibration item will be performed in T/V at GSFC, using flight build detector IR#1. Flat-field images will be acquired at ten wavelengths between 830 and 970 nm with the relevant filters. The input flux is measured to an accuracy of better than 5 percent using the flux monitor mounted on the OS integrating sphere.

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:
Diffuse, flat-field illumination generated by fibre linked to monochromator, operating in double mode, with a bandwidth of 10 nm. A series of 200-micron point target measurements may also be undertaken.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
ir12s01A/B (F093W), ir12s02A/B (F105W), ir12s03A/B (F098M)

DETAILED TEST PROGRAM:
Three full-frame IR flat field images, with ramps of either 10 or 15 exposures, will be taken at each wavelength setting. The exposure sequence may be repeated using the 200-micron target, which will provide more reliable flux calibration. In the latter case, the OS is instructed to make flux calibration measurements between each exposure (OS script ir12s01B etc; the same SITS script is used for both). The neutral density filters in the OS are adjusted to give <45,000 e^-/pixel in the final Multiaccum frame.

EXPOSURES:

Filter	Wavelength	Sampseq	OS configuration 200 μ target	OS configuration flat
F093W	830 nm	STEP25 (10)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F093W	840	STEP25 (10)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F093W	850	STEP25 (10)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F093W	860	STEP25 (10)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F093W	870	STEP25 (10)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F093W	880	RAPID (15)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F093W	890	RAPID (15)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F093W	900	RAPID (15)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F093W	920	RAPID (15)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F093W	950	RAPID (10)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F093W	980	RAPID (15)	IRPT1/double/QTH/ND4+ND1	IRIS/double/QTH/ND1
F093W	DARK	RAPID	N/A	N/A
F105W	880 nm	STEP25 (10)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F105W	890	STEP25 (10)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND

F105W	900	STEP25 (10)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F105W	910	RAPID	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F105W	920	RAPID	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F105W	930	RAPID	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F105W	940	RAPID	IRPT1/double/QTH/ND4+ND1	IRIS/double/QTH/ND1
F105W	950	RAPID	IRPT1/double/QTH/ND4+ND1	IRIS/double/QTH/ND1
F105W	960	RAPID	IRPT1/double/QTH/ND4+ND1	IRIS/double/QTH/ND1
F105W	970	RAPID	IRPT1/double/QTH/ND4+ND1	IRIS/double/QTH/ND1
F105W	980	RAPID	IRPT1/double/QTH/ND4+ND1	IRIS/double/QTH/ND1
F098M	850 nm	STEP25 (10)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F098M	880	STEP25 (10)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F098M	890	STEP25 (10)	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F098M	900	RAPID	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F098M	910	RAPID	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F098M	920	RAPID	IRPT1/double/QTH/ND4	IRIS/double/QTH/no ND
F098M	930	RAPID	IRPT1/double/QTH/ND4	IRIS/double/QTH/ND1
F098M	940	RAPID	IRPT1/double/QTH/ND4+ND1	IRIS/double/QTH/ND1
F098M	950	RAPID	IRPT1/double/QTH/ND4+ND1	IRIS/double/QTH/ND1
F098M	960	RAPID	IRPT1/double/QTH/ND4+ND1	IRIS/double/QTH/ND1

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:
ir12s01 – 0.3 hrs exposure time, 3.8 hrs elapsed time
ir12s02 – 0.3 hrs exposure time, 3.9 hrs elapsed time
ir12s03 – 0.3 hrs exposure time, 3.9 hrs elapsed time
each SMS run twice
total 1.8 hrs exposure time, 23.2 hrs elapsed time

VARIANTS:
use sub-arrays for the 200-micron target images.

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 either extended source or flat field images.

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

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:
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.

3.13 IR13: IR Flat Fields

CALIBRATION TEST#: 3.6.1A

TITLE: IR flat fields – photometric filters

CATEGORY: Science Calibration

P.I.: I.N. Reid

REVISION DATE: 28 July 2003; validated 9 Sept 2003

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 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 mirror mode. Neutral density filters are required at all wavelengths – the current exposures are timed for ND3 in F/W 1.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
ir13s01 – all filters
ir13s02 – F127M under different sampseqs

DETAILED TEST PROGRAM:
Flat field images will be taken with every IR filter, with the exception of the grisms. Four exposures will be taken at each wavelength, 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 time limits are derived using the CASTLE ETC and are set to limit the number of electrons/pixel to less than 30,000.
In addition, a sequence of flats will be taken with the F127M filter using several different sample sequences. This will verify that the flat field structure does not depend on the incident flux.

EXPOSURES:

Filter	Wavelength	Exposure sequence	Time (S/N=100)	Comments
F160W	1600 nm	RAPID (15)	30 secs	
F125W	1250 nm	RAPID (15)	26	
F093W	930 nm	STEP25 (15)	190	
F105W	1050nm	STEP25 (9)	56	T_{tot}=150 seconds
F110W	1100 nm	RAPID (15)	22	
F127M	1270 nm	STEP25 (15)	100	
F139M	1390 nm	STEP25 (15)	107	
F098M	980 nm	STEP25 (15)	210	
F153M	1530 nm	STEP25 (15)	117	
F164N	1640 nm	STEP50 (15)	610	
F167N	1670 nm	STEP50 (15)	717	
F128N	1280 nm	STEP50 (15)	448	
F130N	1300 nm	STEP50 (15)	422	
F126N	1260 nm	STEP50 (15)	520	
F132N	1320 nm	STEP50 (15)	425	

Filter	OS Configuration	Sampseq	T (S/N=100)	Comments
F127M	QTH/mirror/ND3	RAPID (15)	100 seconds	medium flux, T_{tot}=60
F127M	QTH/mirror/ND3	STEP25 (15)	100 seconds	medium flux, T_{tot}=300
F127M	QTH/mirror/ND4	STEP200 (15)	755	low flux, T_{tot}=1800
F127M	QTH/mirror/ND4	SPARS100 (15)	755	low flux, T_{tot}=1500
F127M	QTH/mirror/ND2	RAPID (10)	16	high flux, T_{tot}=30
F127M	QTH/mirror/ND3	RAPID (15)	100	medium flux, T_{tot}=60
F127M	QTH/mirror/ND3	RAPID (15)	100	medium flux, T_{tot}=60

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:
ir13s01 – 2.1 hrs exposure time, 8.9 hrs elapsed 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 flux level should not exceed 35,000 counts.

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: 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 IR15); sky flats will be constructed from deep imaging data for visual, red and far-red wavelength 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.

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: 13 June 2003; validated 9 Sept 2003

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 900-1100 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 extended 200-mciron target with narrowband (10 nm) flat fields, which provide the 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 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 13 nm. 200-micron target coupled to double-mode monochromator, 13-nm bandwidth. Neutral density filters will be required for the latter observations.

SITS COMMAND MODE: SMS

SITS SMS/OS SCRIPT NAMES:
ir14s01 (G102 – 860 to 1180 nm)
ir14s02 (G141 – 1100 to 1700 nm)

DETAILED TEST PROGRAM:
A series of narrowband (13nm) flat-field full-frame images will be taken at 20-nm intervals spanning the wavelength range 860-11800 nm (G102) and 1100-1700 nm (G141). These will be combined with 512-square sub-array images taken of the 200-micron point target at a central location on the detector, with the data having similar spectral resolution and covering the same wavelength range. The point target data will provide absolute calibration; the flat field data provide information on areal response. In principle, the same SITS SMS can be coupled with separate OS scripts for each grism.

The integration times given below are based on the CASTLE ETC for the standard set-up (fibre-fed illumination of the integrating sphere).

EXPOSURES:

ir14s01 G102

Wavelength	**Sampseq**	**OS Configuration (flat)**	**OS Configuration (target)**	**Comments**
860	RAPID(15)	QTH/IRIS/.No ND	QTH/IRPT1/ND4+ND1	S/N~80
880	RAPID(15)	QTH/IRIS/.No ND	QTH/IRPT1/ND4+ND1	
900	RAPID(15)	QTH/IRIS/.No ND	QTH/IRPT1/ND4+ND1	
920	RAPID(10)	QTH/IRIS/.No ND	QTH/IRPT1/ND4+ND1	S/N>100
940	RAPID(10)	QTH/IRIS/.No ND	QTH/IRPT1/ND4+ND1	
960	RAPID(15)	QTH/IRIS/.ND1	QTH/IRPT1/ND4+ND1	
980	RAPID(15)	QTH/IRIS/.ND1	QTH/IRPT1/ND4+ND1	
1000	RAPID(15)	QTH/IRIS/.ND1	QTH/IRPT1/ND4+ND1	
1020	RAPID(15)	QTH/IRIS/.ND1	QTH/IRPT1/ND4+ND1	
1040	RAPID(15)	QTH/IRIS/.ND1	QTH/IRPT1/ND4+ND2	
1060	RAPID(15)	QTH/IRIS/.ND1	QTH/IRPT1/ND4+ND2	
1080	RAPID(15)	QTH/IRIS/.ND1	QTH/IRPT1/ND4+ND2	
1100	RAPID(15)	QTH/IRIS/.ND1	QTH/IRPT1/ND4+ND2	

1120	RAPID(10)	QTH/IRIS/.ND1	QTH/IRPT1/ND4+ND2	
1140	RAPID(10)	QTH/IRIS/.ND1	QTH/IRPT1/ND4+ND2	
1160	RAPID(10)	QTH/IRIS/.ND1	QTH/IRPT1/ND4+ND2	
1180	RAPID(10)	QTH/IRIS/.ND1	QTH/IRPT1/ND4+ND2	

ir14s02 G141

Wavelength	**Sampseq**	**OS Configuration (flat)**	**OS configuration (target)**	**Comments**
1100	RAPID	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1120	RAPID	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1140	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1160	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1180	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1200	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1220	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1240	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1260	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1280	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1300	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1320	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1340	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1360	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1380	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1400	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1420	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1440	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1460	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1480	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1500	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1520	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1540	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1560	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1580	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1600	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1620	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1640	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1660	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1680	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	
1700	RAPID(10)	QTH/IRIS/ND1	QTH/IRPT1/ND4+ND2	

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:

ir14s01 –
ir14s02 -

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 35,000 counts.

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 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 ir16s01

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. A list of the instrument filters that lie within the wavelength range of either grism is listed below.

IR G102	900-110 nm	F093M, F098M, F105W, F110W
IR G141	110-170 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.

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 9 Sept 2003

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 shall be available for all spectral elements (that is, minimum countrate of 17 e^-/ sec/pixel).
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:
Flight build detector IR# 1 at standard gain=2.5.

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, 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.
.
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 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:
ir15s01

DETAILED TEST PROGRAM:
Three ramps in each of 12 IR filters plus total of 6 dark ramps, using RAPID, SPARS25, and STEP25 modes. Sequences and nreads listed below were chosen based upon the sequence times listed in v9.0.2 Proposal Instructions (Table 15.5); the sequences and nreads may need to be adjusted once they are finalized on the operational side.

A check for hysteresis, in the red and the blue, should be done for both UVIS and IR. The data will be taken as part of the flatfield procedure using the external lamps (UVIS20, IR13), where the lamp output can be monitored.

EXPOSURES:

filter	wavelength (microns)	exptime	samp-seq	nsamp
f098m	0.985	51.6	rapid	15
f105w	1.045	25.4	rapid	9
f110w	1.150	13.0	rapid	4
f125w	1.250	18.9	rapid	7
f126n	1.257	394.	spars25	15
f127m	1.270	77.6	step25	7
f128n	1.280	354.	spars25	15
f130n	1.300	339.	spars25	14
f132n	1.320	348.	spars25	15
f139m	1.385	77.3	step25	7
f153m	1.530	62.3	step25	6
f160w	1.545	15.6	rapid	6
f164n	1.643	215.3	spars25	9
f167n	1.667	223.7	spars25	9

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. Measurements should be made as early as possible in the calibration campaign to verify exposure times.

TOTAL ELAPSED TIME:
ir15s01 – 3.3 hrs exposure time, 6.2 hrs elapsed time
VARIANTS:
Flat fields using additional sample sequences could be taken.

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.

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.

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

3.16 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 June 2003; validated 9 Sept 2003

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 900-1100 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 monitoring to an accuracy of 2% the incident flux in point target 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 a point target at a defined aperture on the WFC3 UVIS detector.

SOFTWARE REQUIREMENTS:
IDL and/or IRAF routines will be used 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 20-micron 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:
ir16s01, ir16s02

DETAILED TEST PROGRAM:
A series of narrowband (10nm) full-frame images will be taken of the 20-micron point target centred 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.
In addition, a dispersed image of a white light point source will be obtained at 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. Exact integration times for the white light observations remain to be determined.

EXPOSURES:

SMS	Wavelength	OS Configuration	Sampseq	Comments
ir16s01	800 nm	QTH/20-micron/ND3	RAPID	G102/3-pixel PSF - centred
	820 nm		RAPID	
	840		RAPID	
	860		RAPID	
	880		RAPID	
	900		RAPID	
	920		RAPID	
	940	QTH/20-micron/ND4	RAPID	
	960		RAPID	
	980		RAPID	
	1000		RAPID	
	1020		RAPID	
	1040		RAPID	
	1060		RAPID	
	1080		RAPID	
	1100		RAPID	
	1120		RAPID	
	1140		RAPID	
	1160		RAPID	
	800	QTH/20-micron/ND3	RAPID	G102/3-pixel PSF - corners
	840		RAPID	
	880		RAPID	
	920	QTH/20-micron/ND4	RAPID	
	960		RAPID	
	1000		RAPID	

	1040		RAPID	
	1080		RAPID	
	1120		RAPID	
	1160		RAPID	
	white light	QTH/20-micron/ND4 + ND2 (?)	RAPID	G102
	white light	QTH/20-micron/ND4 + ND2	RAPID	F110W

SMS	Wavelength	OS Configuration	Sampseq	Comments
ir16s02	1100 nm	QTH/20-micron/ND4 + ND3	RAPID(10)	G141/3-pixel PSF
	1150	QTH/20-micron/ND4 + ND3	RAPID(10)	
	1200	QTH/20-micron/ND4 + ND4	RAPID	
	1250	QTH/20-micron/ND4 + ND4	RAPID	
	1300	QTH/20-micron/ND4 + ND4	RAPID	
	1350	QTH/20-micron/ND4 + ND4	RAPID	
	1400	QTH/20-micron/ND4 + ND4	RAPID	
	1450	QTH/20-micron/ND4 + ND4	RAPID	
	1500	QTH/20-micron/ND4 + ND4	RAPID	
	1550	QTH/20-micron/ND4 + ND4	RAPID	
	1600	QTH/20-micron/ND4 + ND4	RAPID	
	1650	QTH/20-micron/ND4 + ND4	RAPID	
	1700	QTH/20-micron/ND4 + ND4	RAPID	
	white light	QTH/20-micron/ND4 + ND4	RAPID	narrow slit?
	white light	QTH/20-micron/ND4 + ND4	RAPID	

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:
ir16s01
ir16s02

VARIANTS:

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.

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 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:

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

<u>Dispersion Solution</u>: 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: $\lambda = \lambda_0 + b*\delta x$, where b is the dispersion (in μm/pix or Ang/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).

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 diode flux measurements of monochromatic point-source exposures obtained for the dispersion solution.

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.

3.17 IR17: Ghost images

CALIBRATION TEST#: 3.7.2

TITLE: Ghost images in the IR system

CATEGORY: Science Calibration

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

REVISION DATE: 13 June 2003; validated 9 Sept 2003

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, fibre-generated point source at various 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 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:
ir17s01

DETAILED TEST PROGRAM:
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 22 pointings on the detector and at an additional 12 points outside the field of view. These exposures should be taken with the F110W filter and repeated with the F160W filter. We will also obtain an additional set of 22 non-saturated exposures to evaluate the counts.
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	60
	-400	-400	
	-400	400	
	400	-400	
	400	400	
	200	-400	
	200	400	
	-200	-400	
	-200	400	
	-20	-20	
	-550	-550	
		-500	
		-200	
		200	
		500	
		550	
	550	-550	
		-500	
		-200	
		200	
		500	
		550	
	-200	-550	
		-500	
		-200	
		200	
		500	
		550	
	200	-550	
		-500	
		-200	
		200	
		500	
		550	

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:
ir17s01 – 22.0 hrs exposure time, 24.6 hrs elapsed time

VARIANTS:
Use ND filters instead of known ratio of exposure times in order to evaluate total counts in saturated image.

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:

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:

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 – **Thermal Vac**

CATEGORY: Science Performance Monitor

P.I.: Olivia Lupie

REVISION DATE: 25 August 2003; validated 9 Sept 2003

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. The internal and external lamp exposures may be reduced at times pending the nature of the verification at the time and the schedule.

CEI REQUIREMENTS: Refer to Table 1.

DETECTOR: IR HgCdTe

VARIANTS: The IR Science Performance Monitoring test has two variations:

1. Ambient Conditions – emphasis on Darks and Warm Noise test only. IR19, 03A.
2. TV at Nominal Operating Temperatures – (darks, PSF, internal and external FF).

DETECTOR: IR Flight HgCdTe using nominal gain = 2.0e-/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. Both monochromatic and continuum point sources will be measured, the former to reveal PSF details and as a check against the encircled energy results and the latter to represent stellar fluxes. Filter F160W was chosen because it is the premier filter of the set. F098M was selected to represent the bluer wavelengths in a narrower passband. 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 most

representative of the buildup of dark backgrounds. RAPID and STEP25 dark exposures bracket the illuminated image set for short term repeatability assessment.

SUMMARY OF BASELINE CHANGES: The baseline sequence checks darks and flats at all the gain settings. The proposed test includes exposures at a single (nominal) gain setting and verified internal FF stability, external FF measurement repeatability, and point source measurements as well as darks.

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 FF 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 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 an equivalent quick look software provided by ICAL. The goal is for tools, which provide essentially "push button" response: rapid data reduction, analysis, and clear presentation of results and conclusions..

OS CONFIGURATION:

Ext Diffuse: 1) Lamp=QTH, Mode=Mirror, Fiber=VISIR FF, @1600nm, 980, Order=OPEN, ND3, M-slit width and various NDs.

Pt Source: 1) Continuum Pt source - Lamp=QTH, Mode=Mirror, Fiber=10 mic pin, @1600nm, Order=OPEN, ND7, M-slit width=2000,IR01; Continuum Pt source; Pos IR01 and IR14
2) Monochrom. Pt source - Mode=Double IR, Fiber=10 mic pin, @1050nm, Order=OPEN, ND7, M-slit width=NA, bndps=13, IR01

SITS COMMAND MODE: SMS

PROCEDURES/DETAILED TEST PROGRAM: See Table 2 at end for a summary of WFC3 IR Exposures and OS configuration.

<u>Configure WFC3 IR for observations:</u>

- WFC3 to Operate [TECs on and cooled to nominal operational temperature].

- CSM is in the IR configuration.
- FSM Homed.
- Correctors in a predicted flight nominal configuration and initialized.
- All illuminated images are not to exceed 50000 DN/pix.

Darks: Incorporate the 'standard star" setup and a logarithmic setup:
RAPID Subarray: Take 1 64x64 subarray, RAPID sequence, 15 reads (~20 sec)
RAPID Full: Take 1 Full Frame, RAPID sequence, 15 reads (~50 sec)
STEP25: Take 2 STEP25 (logarithmic), ~300 sec each to characterize the dark signal at the beginning of the monitoring program and 2 at the end of the program.

Internal Flat Fields: To verify relative FF stability. Select exposure time to achieve ~30000DN/pix in each filter. All exposures at nominal gain
F098M FF: Take 1 F098M FF using the Tungsten Lamp 3, multiaccum RAPID, 15 reads. Use F098M to sample FF in a fairly narrow band at the blue end of the sensitivity.
F160W FF: Take 1 F160W FF using the same Tungsten Lamp, multiaccum RAPID, 15 reads. Compare to F098M results and delineate anomalous effects.
F160W Subarray FF: Take 1 F160W 64x64 subarray FF using same Tungsten lamp, multiaccum RAPID, 15 reads. Monitor the 'standard-bright-star" setup.

External Flat Fields: To illuminate the focal plane as an external source would do and to compare with the internal flats; to verify absolute FF stability (to within OS absolute flux values). Select exposure time to achieve ~30000DN/pix in each filter. All exposures at nominal gain.
F098M FF: Take 1 F098M, multiaccum RAPID, 8 reads.
F160W, subarray: Take 1 64x64 subarray, multiaccum RAPID, 8 reads.
F160W: Take 1 F160W, Multiaccum RAPID, 8 reads.

External Point Source: to monitor the PSF at a single position on the camera. Select exposure time to achieve ~30000DN in peak pixel. All exposures at nominal gain. Note, 64x64 subarrays simulate standard star observations.
F098M PSF: Take 1 continuum pt source, RAPID, 16 reads.
F160W PSF, subarray: Take 1 64x64 subarray of point source, RAPID, 16 reads.
F160W PSF: Take 1 continuum pt source, RAPID, 10 reads.
F160W PSF: Take 1 continuum pt source, RAPID, 10 reads at an off-center location (corner – IR146

F160W PSF: Take 1 monochromatic pt source, Multiaccum RAPID, 10 reads.
F105W PSF: Take 1 monochromatic pt source, RAPID, 10 reads (same setup as the encircled energy tests).

Close with 2 STEP25 Darks.

EXPOSURES: 17 images: 13-full frame, 4-64x64 subarrays.

FREQUENCY: run after major instrument or major stimulus configuration adjustments or corrections, as a monitor through TV, after thermal cycling intervals [requires more details for scheduling philosophy].

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. [TBD engineering telemetry list]. **Calibration Products**: The data are used for trending purposes.

Go/NoGO: take all data sets.

SMOV ON-ORBIT FOLLOWUP: Yes – 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.

CYCLE CONTINUATION: Yes – a similar test will be run during each cycle. The frequency will be larger at first, perhaps monthly and then later perhaps twice per cycle. Details TBD.

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

Table 2: IR TV Science Performance Monitor

line#	Target	Ap	Spect	Optional	Est	Exp[1]	Comment Line	OS
SMS	IR FULL TV	FOV	Elem	Param	Total	(sec)		CONFIG[2]
	ver-oll 8/29/2003				(sec)			
6	**Dark**	64x64	BLANK	GAIN=2.5, SAMP-SEQ=RAPID NSAMP=16	3	DEF	Monitor "standard star subarray" dark.	None
7	**Dark**	IR	BLANK	SAMP-SEQ=RAPID, NSAMP=16	67	DEF	Full Frame RAPID - compare to subarray	None
8	**Dark**	IR	BLANK	SAMP-SEQ=STEP25, NSAMP=16	300	DEF	Logarithmic ramp --> best represents dark buildup	None
9	**Dark**	IR	BLANK	SAMP-SEQ=STEP25, NSAMP=16	300	DEF	Repeat logarithmic ramp for repeatability assessment and statistics	None
10	**Tungsten**	IR	F098M	SAMP-SEQ=RAPID, NSAMP=16	67	DEF	Internal Lamp FF Monitor and F098M continuum FF cal.	None
11	**Tungsten**	IR	F160W	SAMP-SEQ=RAPID, NSAMP=16	67	DEF	Internal Lamp FF Monitor and F160W continuum FF cal.	None
12	**Tungsten**	64x64	F160W	SAMP-SEQ=RAPID, NSAMP=16	3	DEF	Monitor "standard star subarray" highest priority filter H	None
13	**External-Diffuse**	64x64	F160W	SAMP-SEQ=RAPID, NSAMP=8	1	DEF	Full optical path illumination; compare to internal FF	Castle ETC: Lamp=QTH, Mode=Mirror, Fiber=VISIR FF, @1600nm, Order=OPEN, ND2, M-slit width=2000
14	**External-Diffuse**	IR	F160W	SAMP-SEQ=RAPID, NSAMP=8	53	DEF	Full optical path illumination; compare to internal FF	Castle ETC: Lamp=QTH, Mode=Mirror, Fiber=VISIR FF, @1600nm, Order=OPEN, ND3, M-slit width=2000
15	**External-Diffuse**	IR	F098M	SAMP-SEQ=RAPID, NSAMP=8	53	DEF	Full optical path illumination; compare to internal FF	Castle ETC: Lamp=QTH, Mode=Mirror, Fiber=VISIR, @980nm, Order=OPEN, ND4, M-slit width=2000
16	**Ext- Point Source**	IR	F098M	SAMP-SEQ=RAPID, NSAMP=16	36	DEF	Wide band pt source - approx stellar target	Castle ETC: Lamp=QTH, Mode=Mirror, Fiber=10 mic pin, @980nm, Order=OPEN, ND6, M-slit width=2000, IR01
17	**Ext- Point Source**	64x64	F160W	SAMP-SEQ=RAPID, NSAMP=16	3	DEF	Wide band pt source - approx stellar target	Castle ETC: Lamp=QTH, Mode=Mirror, Fiber=10 mic pin, @1600nm, Order=OPEN, ND5, M-slit width=2000,IR01
18	**Ext- Point Source**	IR	F160W	SAMP-SEQ=RAPID, NSAMP=10	36	DEF	Wide band pt source - approx stellar target	Castle ETC: Lamp=QTH, Mode=Mirror, Fiber=10 mic pin, @1600nm, Order=OPEN, ND7, M-slit width=2000,IR01
19	**Ext- Point Source**	IR	F160W	SAMP-SEQ=RAPID, NSAMP=10	36	DEF	Wide band pt source - approx stellar target	Castle ETC: Lamp=QTH, Mode=Mirror, Fiber=10 mic pin, @1600nm, Order=OPEN, ND7, M-slit width=2000,IR14
20	**Ext- Point Source**	IR	F160W	SAMP-SEQ=RAPID, NSAMP=10	36	DEF	Monochromatic Point Source - 1600 --> same as the encircled energy calibration	Castle ETC: Mode=Double IR, Fiber=10 mic pin, @1600nm, Order=OPEN, ND5, M-slit width=NA, bndps=13, IR01
	Ext- Point			SAMP-SEQ=RAPID,			Monochromatic Point Source - 1050 --> same as the encircled	Castle ETC: Mode=Double IR, Fiber=10 mic pin, @1050nm, Order=OPEN, ND7, M-slit width=NA,

ADDITIONAL COMMENTS: Note, a subset of SYSTEM FUNCTIONAL (Schoenweis and Pugliano) exposures will overlap the science monitoring test. These images will be included as part of the science monitoring test suite as along as they are obtained in a nominal temperature environment.

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 (61.5 secs)
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.
Master Bias reference file for CDBS.
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: 1 Sept 2003; validated 9 Sept 2003

REVISION HISTORY:
- Specify 4 repeat of the relative SMS ir21s01

PURPOSE:
To measure the variation in readnoise in the WFC3/IR system as a function of gain.

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.

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

BACKGROUND:

.
HARDWARE REQUIREMENTS:
The IR Flight detector should be installed in WFC3.

SOFTWARE REQUIREMENTS:
Pre-processing software (IDL), readnoise 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:

ir01s01, ir02s01, ir21s01

DETAILED TEST PROGRAM:
A set of four SPARS50 exposures will be taken at each gain setting. These data will be analyzed in conjunction with data taken as part of IR02.

EXPOSURES:

Gain	Sampseq	N_{exp}	Time	
2	SPARS50	4	550 secs	
2.5	SPARS50	4	550 secs	
3	SPARS50	4	550 secs	
4	SPARS50	4	550 secs	

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 – 3.3 hrs exposure time, 5.0 hrs elapsed time

VARIANTS:

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.