ABSTRACT
This document describes the NICMOS calibration activities for Cycle 11. It complements the SMOV3b and the NICMOS Cycle 10 interim calibration programs. These activities cover a period of 13 months and pursue the following major objectives: i) to monitor the main instrument properties, ii) to test the model for generating darks, iii) to analyze in detail the intra-pixel sensitivity effects for cameras 2 and 3, iv) to calibrate the polarimetry mode, and v) to establish NICMOS stability when tracking differential (spectrophotometric) changes over time. In addition, a contingency program (‘Pupil Transfer Function’) will be activated if differential photometry over the chips obtained from SMOV data does not reach the required levels of accuracy.

Introduction
After the successful completion of the 2002 HST Servicing Mission, NICMOS went through an on-orbit verification phase as part of the SMOV3b program. This program has fulfilled all the expectations, and NICMOS is ready for science observations.

During Cycle 10 an interim calibration program (hereafter ICP) is being executed (NICMOS ISR-002). The main objectives of ICP are to enable the imaging and grism modes for science. The program described in this document will complement and expand such objectives, taking into account the calibration needs of the proposals approved by the TAC for Cycle 11. In short, the TAC approved 12, 16, and 1 programs for which NICMOS is
primary, secondary, or a parallel instrument, respectively. For each of these three categories the number of assigned orbits is about 500. The imaging mode is used by 26 programs, polarimetry by 4, and grism by 3. No approved program required the use of the coronagraphic mode. 42 out of 54 available spectral elements will be used, including all narrow band filters for Camera 1.

**Objectives**

i)- **Monitor Programs**: A major objective during Cycle 11 is to monitor the main properties of the instrument. These programs (‘darks’, ‘flats’, ‘focus’, ‘photometry’) are continuation of the corresponding ICP programs and they are considered key to understanding the behavior and stability of the instrument after the installation of the NCS. Preliminary analysis of the data obtained during SMOV indicates good thermal stability and, therefore, the frequency of some of these programs has been reduced with respect to the corresponding programs for Cycle 10 (ICP). In particular the ‘Dark’ program (9636) will be executed monthly (instead of weekly), and the ‘focus stability’ will be executed bi-monthly after the first six months of Cycle 11.

ii)- **Intrapixel sensitivity**: Data obtained during Cycles 7 and 7N demonstrate that one of the major factors limiting the photometric accuracy was the non uniform intra-pixel sensitivity. This is especially true for NIC3, for which the PSF is more severely undersampled. Although this limitation may be overcome by dithering, this approach is quite demanding in terms of observing time. Calibrations of intra-pixel sensitivity may result in acceptable photometric accuracy without the need of dithering.

iii)- **Multiaccum Darks**: In order to generate the dark reference files for all the MULTI-ACCUM readout sequences a model, the so called ‘Dark Generator Tool’, is used. One of the goals of the present plan is to test the accuracy of such an approach for obtaining darks.

iv) - **Polarimetry mode**: One of the major objectives of the present plan is to recalibrate the polarimetry mode of NICMOS (for both NIC1 and NIC2). This calibration is outsourced to Dr. Dean Hines (University of Arizona). Calibrations needed for using simultaneously the polarizers and coronagraph are not included.

v)- **High S/N Capability Characterization**: The goal here is to establish the (differential) photometric accuracy in the very high S/N regime. This is a pushing the envelope program that could enable future science.

In case that the analysis of the SMOV data indicates a photometric accuracy over the detectors lower than expected, a contingency program to characterize the ‘Pupil Transfer Function’ will be activated.
## NICMOS Cycle 11 Calibration Plan

<table>
<thead>
<tr>
<th>ID</th>
<th>Proposal Title</th>
<th>Frequency</th>
<th>Estimated Time (orbits)</th>
<th>Scheduling Required</th>
<th>Resources Required (FTE)</th>
<th>Products</th>
<th>Accuracy Required</th>
<th>Notes</th>
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<tr>
<td>9636</td>
<td>Multiaccum Darks</td>
<td>monthly</td>
<td>39</td>
<td>0.3</td>
<td>CDBS</td>
<td>4-5%</td>
<td>Input for ‘Dark Generator Tool’</td>
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<tr>
<td>9637</td>
<td>Focus Stability</td>
<td>monthly &amp; bi-monthly</td>
<td>27</td>
<td>0.3</td>
<td>ISR</td>
<td>1mm</td>
<td>Monthly from Sept. 02 to Febr 03, then bi-monthly.</td>
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<tr>
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<td>Photometry Stability</td>
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<td>0.3</td>
<td>CDBS</td>
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<tr>
<td>9640</td>
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<td>13</td>
<td>0.3</td>
<td>IR / ISR</td>
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### Routine Monitoring Programs

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<th>Products</th>
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<tr>
<td>9641</td>
<td>‘Dark Generator Tool’ test</td>
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<td>15</td>
<td>0.20</td>
<td>ISR</td>
<td>2%</td>
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<tr>
<td>9638</td>
<td>Intra-pixel sensitivity</td>
<td>once</td>
<td>6</td>
<td>0.30</td>
<td>ISR</td>
<td>1-5%</td>
<td>NIC3 &amp; NIC2</td>
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<tr>
<td>9642</td>
<td>High S/N Capability Characterization</td>
<td>once</td>
<td>3</td>
<td>0.15</td>
<td>ISR</td>
<td>S/N ~10000</td>
<td>PI R. Gilliland</td>
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<td>9644</td>
<td>Polarimetry</td>
<td>once</td>
<td>7</td>
<td>0.0</td>
<td>Polarize P. Coeff.</td>
<td>1%</td>
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<td>PI D. Hines</td>
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### Special Calibration Programs

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<th>Resources Required (FTE)</th>
<th>Products</th>
<th>Accuracy Required</th>
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<tr>
<td>9643</td>
<td>Pupil Transfer Function</td>
<td>once</td>
<td>6</td>
<td>0.15</td>
<td>CDBS, ISR</td>
<td>1-2%</td>
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**TOTAL TIME (including all executions)**: 88 54 2.0
Proposal ID 9636: NICMOS Cycle 11: MA Darks

Plan

Purpose
The purpose of this proposal is to monitor the dark current, read noise, and shading profile for all three NICMOS detectors throughout the duration of Cycle 11. This proposal is a continuation of PID 9321 which covers the period between the end of SMOV3B and the onset of Cycle 11.

Description
Each iteration of this proposal consists of ten dark exposures of 1088s (sample sequence of SPARS64 and NSAMP=19) for all 3 cameras. In addition, a set of 3 SCAMRR, NSAMP=25 sequences for each camera will be obtained in order to obtain an accurate estimate of the read noise. Finally, in order to characterize the shading profile of the NICMOS detectors, a set of 5 STEP256, NSAMP=12 sequences for each camera are taken. These contain all commonly used NICMOS Delta-times, except the shortest one (0.2s) which is covered by the SCAMRR sequences. As an additional benefit, the dark exposures will allow us to estimate the cosmic ray rates outside the SAA. This sequence will be repeated once a month for 13 months to allow the monitoring of NICMOS detector behavior as a function of time and temperature throughout Cycle 11.

FractionGO-Supported 100%

Resources
Each monthly visit will require 3 internal orbits.

Required:
Therefore 39 internal orbits are required from 1-Sep-02 to 1-Oct-03

Observation
0.3 FTE

Analysis

Products
Darks for all readout sequences.

Accuracy
4-5% per visit for the linear component of the dark current. In principle S/N ~ 50, but degradation due to CR lower this figure. S/N ~ 35 (12) for the amplifier glow at the corner (center).

Scheduling & Special Requirements
Monthly. SAA free orbits
Proposal ID 9637: NICMOS Cycle 11: Focus Stability

Plan

Purpose The purpose of this activity is to determine the best focus for the three cameras

Description Steps:

a) Use refined target field positions as determined in Cycle 7
b) Use MULTIACCUM sequences of sufficient dynamic range to account for defocus
c) Do a 17-point focus sweep, +/- 8mm about the PAM mechanical zero point for both cameras 1 and 2, in 1mm steps. (10-point focus sweep from -0.5 to -9.5 for camera 3).
d) Use PAM X/Y tilt and OTA offset slew compensations refined from previous focus monitoring/optical alignment activities.
e) Use encircled energy (and phase retrieval) algorithms to establish PAM focus and X/Y tilt positions for each camera.

Fraction 100%

GO/GTO Programs Supported

Resources Each visit will be 3 external orbits. d

Observation Required: 0.3 FTE

Analysis Products ISR, Update of focus as needed

Accuracy Goals The best focus should be known within 1 mm

Scheduling& Special Requirements During the first six months monthly, then bimonthly. SAA free orbits.
Proposal ID 9639: NICMOS Cycle 11: Photometric Stability

Plan

Purpose  To verify the stability of the NICMOS photometric calibration over a broad range of wavelengths.

Description  Observations of a standard star (P330E) through the following subset of filters: F090M, F110W, F160W and F190N for NIC1; F110W, F160W, F190N, F222M for NIC2 and F110W, F160W, and F222M for NIC3. All observations are done using a spiral dither pattern, with 5 dither points for NIC1 and NIC2, and 7 dithers for NIC3 (to help reduce intra-pixel sensitivity effects on the photometry). The integration times are set to achieve $S/N \approx 200-350$ in the standard photometry apertures for each exposure, while keeping peak pixel counts to $< 66\%$ of saturation level. The NIC1/F190N observation has somewhat lower $S/N$ ($\sim 110$) per exposure. NIC3/F110W may come slightly closer to saturation ($\sim 73\%$ according to the ETC).

Fraction  100%

GO/GTO Programs Supported

Resources  Each monthly visit will require 2 external orbits. Therefore, 26 orbits are required for the complete period.

Observation Resources  0.30 FTE

Required: Analysis

Products  Internal Report or ISR. Updated zero points for CDBS

Accuracy  2%

Goals

Scheduling & Special Requirements  SAA free orbits preferred.
Proposal ID 9640: NICMOS Cycle 11: Flats Stability

Plan

**Purpose**
This calibration proposal is the Cycle 11 NICMOS monthly monitor. A series of Camera 1, 2, & 3 flat fields will be obtained to monitor the health of the cameras.

**Description**
Each 1-orbit visit will obtain pointed flat fields in each camera (NIC1 filters F110M, F110W, F160W; NIC2 filters F110W, F160W, F222M; NIC3 filters F110W, F160W, F222M). Some filters will be rotated through the sequence so that most filters will be used during a year. A four point dither pattern will be used to allow removal of background objects. At each dithered position, observations will be obtained with the lamp off and followed by lamp on observations. The Cameras 1 and 2 will be used in parallel. For almost all the exposures, Lamp 1 (High Intensity) will be used. The exposure times for the lamps-on are for the system powered by the MEB-1 (the nominal flight configuration).

**Fraction**
100%

**GO/GTO Programs Supported**

**Resources Required:**
Each monthly visit will be one orbit. Therefore, 13 orbits are required for the complete period.

**Observation**

**Resources**
0.3 FTE

**Required:**

**Analysis**

**Products**
Depending on the results an internal report or an ISR.

**Accuracy Goals**
1-2%

**Scheduling & Special Requirements**
SAA free orbits.
Proposal ID 9641: NICMOS Cycle 11: Dark Generator Tool Test

Plan

Purpose  This program will test the NICMOS Dark Generator Tool by obtaining dark frames that probe MULTIACCUM sequences not usually observed during the dark monitoring programs.

Description  Three sets of 10 dark frames each, using three different MULTIACCUM sequences, will be obtained in all three NICMOS cameras. The three sequences are: STEP8, STEP16, and STEP32. These are chosen to probe intermediate exposures between the SCAMMR and the SPARS64 usually employed by the standard NICMOS monitoring programs that feed CalnicA and the Dark Generator Tool.

Fraction  100% of the programs require darks.

GO/GTO Programs Supported

Resources  15 internal orbits
Required:
Observation
Resources  0.2 FTE
Required:
Analysis
Products  ISR, Improvement of pipeline
Accuracy  2%
Goals
Scheduling & Special Requirements
SAA-Free Orbits
Proposal ID 9638: NICMOS Cycle 11: Intra-pixel sensitivity

Plan

**Purpose** To determine the variation of pixel response in Camera 3 and 2 as a function of the position of the source within a pixel. NICMOS detectors have significant variation in sensitivity across individual pixels. This is a significant source of photometric errors (up to 30%) in case of undersampled images. Since the detectors are operating at warmer temperatures in Cycle 11, with a significant change in quantum efficiency, we would like to recharacterize the sensitivity change across pixels.

**Description** We will take dithered observations of a star cluster with Camera 3 using filters F110W and F160W, and NIC2 using F110W. We will dither in a pattern of 25 points, displacing the stars by one-fifth of a pixel in each direction for each pixel. The variation of sensitivity will be determined for two filters because of PSF variation with wavelength. In principle, the intra-pixel sensitivity variation is different for each pixel. By observing a cluster of stars we will be able to determine this for 6-12 sources spread across the field. Thus we can get some measure of the spread in the intra-pixel sensitivity from pixel to pixel.

**Fraction** 40%
**GO/GTO**
**Resources Required:**
**Observation**
**Resources** 6 external
**Required:**
**Analysis**
**Products** ISR. Guidelines to improve the photometric accuracy
**Accuracy Goals** 1-5% for NIC2 and NIC3 respectively.
**Scheduling & Special Requirements** SAA free orbits
Proposal ID 9642: NICMOS Cycle 11: High S/N Capability Characterization

Plan

Purpose To establish NICMOS stability when tracking differential (spectrophotometric) changes over time.

Description Observations of HD 209458b (V = 7.6) with NIC3- G141 will be taken with SCAMRR providing the shortest (0.2s) possible temporal sampling. NSAMP = 10 will result in ~ detector saturation (2 sec). The first one-half to two-thirds of each orbit will be obtained without dithering, in the second portion of each orbit the telescope will be dithered in the grism cross-disperser direction by the minimum amount to provide good coverage of the telescope induced guiding errors which are likely to be the largest source of noise. Other strategies are under discussion.

Fraction 0% direct. This is a pushing the envelope program that could enable future science

GO/GTO Programs Supported

Resources Required: 3 external. The particular issue is to what S/N spectra taken in one orbit can be related to those taken in an adjacent orbit with exactly the same setup. Thus a two orbit program is the minimum sufficient for the test, three orbits would provide a more robust test. (Note the poorer stability of STIS 1st orbit).

Resources Required: 0.15 FTE

Analysis Products ISR

Accuracy Goals Target S/N of about 10,000 per resolution element orbit-to-orbit. A secondary goal will be to track what the spectrally integrated exposure-to-exposure photometric S/N is and compare this to the Poisson limit.

Scheduling& Special Requirements Full contiguous visibility periods are required for the three orbits. SAA free orbits are strongly preferred
Proposal ID 9644: NICMOS Cycle 11: Polarimetry calibration

Plan

Purpose  The purpose of these observations is to recalibrate the polarimetry modes for NICMOS.

Description  Observations of polarized (BD 32-3739) and unpolarized (CHA-DC-F7) targets at two different epochs (thus spacecraft roll angles) will allow unique determination of the coefficients necessary to derive the Stokes parameters (thus polarization and position angle) from images obtained through the NICMOS polarizers. Polarimetric observations of the Egg Nebula will allow quick assessment of the overall imaging polarimetry over the fields of view of each camera. A primary flux calibrator star should also be measured through each polarizer in each camera to place them in the same flux density scale as the rest of the NICMOS filters. The observations must use a 4 point spiral dither pattern with N+1/2 pixel offsets.

Fraction  14% in Cycle 11.

GO/GTOPro-Supported

Resources  7 orbits. The unpolarized and polarized point sources will require a total of 4 orbits (two epochs in the two cameras). The Egg Nebula will require 1 orbit for each camera (i.e.total 2 orbits). A flux calibrator needs an additional orbit.

Resources  This program is outsourced to Dr. Dean Hines (University of Arizona).

Analysis

Products  Updated version of POLARIZE (which transform pipeline calibrated polarizer images into images of Stokes parameters), and an updated table of polarimetry coefficients.

Accuracy  1%

Goals

Scheduling& Special

Requirements  SAA free orbits.
Proposal ID 9643: NICMOS Cycle 11: Pupil Transfer Function for NIC1 and NIC2

Plan

Purpose This contingency proposal will characterize the large-scale flat-fielding residuals. The output will be a two-dimensional surface fit that will give the large scale corrections needed to flat-field the images to an accuracy of ~1%. Also, changes in the PSF will be measured as a function of position within the cameras. This proposal will be executed if the photometric analysis of the data of proposal 8981 (aperture location) results in photometric errors larger than expected.

Description One standard star (P330E) will be observed through filter F160W with NIC1 and NIC2. For each camera and filter combination, the star will be observed in 100 positions (25 per quadrant). The detailed description will follow closely that of Cycle 7 proposal 7693, with the following changes: i) NIC3 observations are not included as they are dominated by intra-pixel sensitivity, ii) the number of dither positions is reduced from 144 to 100 (i.e. 25 for quadrant), with the corresponding adjustments in the dither step. iii) only one filter for NIC2 is considered enough, iv) flats are not required.

Fraction More than 80% of the programs require accurate photometry.

GO/GTO


Observation

Analysis Resources: 0.15 FTE

Products ISR. It will establish the accuracy of differential photometry over the detectors.

Accuracy Goals

1-2%

Scheduling & Special Requirements A turn around time of 3 weeks is acceptable for this contingency proposal. SAA free orbits required.