rm NICMOS Cycle 7 Calibration Plan

June 30, 1997

ABSTRACT

This report fully describes NICMOS calibration activities for cycle 7 as well as contingency calibration programs that will be executed only if the cameras show large physical displacements. NIC3 specific calibration programs are also included. These will be executed if NIC3 comes back into the PAM focus range. This report describes the scientific motivation and requirements for each individual calibration program. A revision of this calibration program will be undertaken by the end of the year, after we gain experience during the first 5-6 months of cycle 7.

1. Introduction

Upon the successful completion of the 1997 HST Servicing Mission (SM97), NICMOS went through an on-orbit verification phase as part of the SMOV program. The purpose of this verification phase was to demonstrate NICMOS performance and to enable the Cycle 7 GO/GTO science program.

Early NICMOS SMOV tests revealed unanticipated changes to its characteristics and performance. NICMOS dewar was cooled to a temperature below its anticipated operating temperature prior to launch. The subsequent expansion of the solid nitrogen deformed the dewar leading to a thermal short with the vapor-cooled shield and to changes in the focus of all three cameras. NIC3 has suffered the largest shift in focus and cannot now be focussed with the Pupil Alignment Mechanism (PAM).

As a consequence of the NIC3 defocus, the cycle 7 calibration plan will execute a limited calibration program for NIC3, and focus only in the calibration of NIC1 and NIC2 cameras. This document explains in detail the scientific justification of each of the planned calibration programs as well as the requirements, accuracy and final products. A postscript version of this report is available on the NICMOS WEB page (http://www.stsci.edu/ftp/instrument_news/NICMOS/nicmos_doc.html).
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**TOTAL TIME (including all executions):** 250+5xTBD 821+(80) 5.1+(≥0.1)
Proposal 7703-10/7596: NICMOS Cycle 7: MULTIACCUM Darks

Plan

Purpose: Measure dark current on individual pixels for MULTIACCUM sequences.

Description: Master dark reference files will be generated for all the requested MULTIACCUM sequences. A total of twenty dark frames will be obtained for the eight most requested MULTIACCUM sequences (STEP8, STEP16, STEP32, STEP64, STEP128, STEP256, SPARS64, SPARS256). Ten dark frames for sequences SCAMRR, MCAMRR, STEP1, STEP2, MIF512, MIF1024 and MIF2048 will also be obtained. Dark exposures will be scheduled during occultation periods. Darks for sequences extending beyond the 1800 seconds occultation limit will only be obtained for readouts below this limit, i.e. NSAMP= 9, 17, 23 for SPARS256, STEP256 and STEP128, respectively. A straight extrapolation of the darks will be performed to complete the NSAMP sequences in these cases.

The original proposal has been divided in several small proposals (7703 to 7710) to facilitate the implementation of the program.

The temporal evolution of the darks will be monitored once every 4 weeks (proposal 7596; 3 internal orbits per repeat) with sequences STEP32 (NSAMP=16), STEP128 (NSAMP=16) and STEP256 (NSAMP=17).

Fraction of GO Programs Supported: 90%

Resources:

Observation: This program requires 186 internal orbits (132 orbits to obtain the set of dark frames to generate the master darks and 54 orbits over a 17 months period for the monitoring)

Analysis: Analysis of the observations, plus generation of the corresponding reference files will require 0.5 FTE.

Special Requirements:

Accuracy: The uncertainty in the final dark reference files will be dominated by the presence of a variable extra signal in the darks, the so called “pedestal”. The reference dark frames will be accurate to about 10 DN due to the pedestal. Several observing strategies are being tested but there is no guarantee that any of these will remove or reduce the pedestal.

Products: Reference files will be delivered to CDBS
Proposal 7689/7775: NICMOS Cycle 7: Earth Flats

Plan

Purpose: Obtain earth flats for a subset of filters

Description: A large number of earth flats will be taken to produce high quality flat fields for a subset of filters including (1) NIC1 filters F095N, F097N, F110M, F110W, F108N, F113N, F160W, F164N, F166N, F187N and F190N; (2) NIC2 filters F110W, F160W, F187N, F190N, F212N, F215N, F216N and F222M and (3) NIC3 filters F110W, F160W, F164N, F166N, F187N and F190N. These flat fields will be used to obtain good signal-to-noise flats for the narrow-band filters and also to obtain the OTA illumination pattern for each of the cameras as a function of wavelength.

The observations will be taken during occultations and will be pointed at bright Earth. This program will obtain 10 frames a month for each of the filters indicated above. A large number of frames per filter are needed to generate high quality S/N flats. WFPC2 experience with Earth observations indicates that only about 5-10% of the Earth flats are good for flat fielding. Earth brightness varies by a factor of 100, and in most cases stripes, with differences of a factor of 10 in the number of counts, are present in most of the images.

The resulting set of Earth flats will be combined with the internal lamp flats to generate a set of flats capable of removing both the pixel-to-pixel variations and the OTA illumination pattern.

Fraction of GO Programs Supported: 100%

Resources:

Observation: This program requires a total of 540 internal orbits.

Analysis: Analysis of the data plus generation of the reference files and preparation of the ISR will require 1.0 FTE.

Special Requirements:

Accuracy: The OTA illumination pattern will be characterized with an accuracy of ~2%.

Products: CDBS reference files and ISR
Proposal 7690: NICMOS Cycle 7: Internal Lamp Flats

Plan

Purpose: Obtain flats for polarizers, broad- and medium-band filters.

Description: Internal lamp flat-fields will be obtained for all NIC1 and NIC2 polarizers, broad- and medium-band filters. The temporal variation of the pixel-to-pixel response as a function of camera and wavelength will be monitored once every four weeks using a subset of filters (NIC1: F110W, F160W; NIC2: F110W, F160W and F222M). No data will be taken for NIC3 filters until the camera is back into the PAM focus range, or close enough to enable NIC3 science observations.

Since NICMOS has no shutter, the internal lamp flats will be obtained with the lamp on followed by an exposure with the lamp off, in order to remove the stellar features in the flat-field frames. A spiral dithering with nine points will be used for both lamp-on and lamp-off observations.

Fraction of GO Programs Supported: >70%

Resources:

Observation: This program requires a total of 44 external orbits (25 to obtain the master flats and an additional 19 orbits for the monitoring part of the program, for a period of 17 months). The number of orbits can be reduced to 29 external orbits if CVZ orbits (10) are used to obtain the master flats.

Analysis: Analysis of the observations, including generation of the reference files and the preparation of an ISR requires 1.0 FTE.

Special Requirements:

Accuracy: The single-pixel noise expected in the flat-fields is less than 1%.

Products: CDBS reference files and ISR
Proposal 7607: NICMOS Cycle 7: Photometric Monitoring

Plan

Purpose: Determine the photometric stability of NIC1 and NIC2.

Description: For the early cycle 7 (i.e. June 1997), two HST standards will be observed through a reduced set of filters with the NIC1 and NIC2 cameras. During the cycle 7, one near-infrared standard will be observed once every four weeks using a subset of NIC1 and NIC2 filters spanning all the wavelength range covered by these cameras. The selected set of filters includes F095N, F110M, F110W, F145M, F160W, F164N and F190N for NIC1, and F110W, F160W, F190N, F205W, F215N, F222M, and F237M for NIC2. Photometric monitoring of NIC3 will be done for filters F110W and F160W while the camera is out of the PAM focus range.

Fraction of GO Programs Supported: 100%

Resources:

Observation: This program requires a total of 40 external orbits (2 orbits per repeat for the monitoring part plus 4 orbits for the first measurement in June 1997) and 38 internal orbits (dark frames for the MULTIACCUM sequences used in the program).

Analysis: Analysis of the observations, including preparation of an ISR requires 0.4 FTE.

Special Requirements:

Accuracy: The program will be able to do photometric measurements with an accuracy of 1% for NIC1 and NIC2. The program should be able to identify discrepancies and temporal changes in the photometric stability of the cameras at the 2% level.

Products: ISR. Sensitivity trends provided.
Proposal 7608: NICMOS Cycle 7: Focus Monitoring

**Plan**

**Purpose:** Monitor and determine the optimal focus for all three cameras.

**Description:** The goal of this proposal is to monitor the focus evolution of the NICMOS cameras as a function of time. The physical motions of the cameras will be measured using different techniques (plate scale, phase retrieval and encircled energy). Since the NICMOS camera focii will continue to change as cryogen vents, this program will continue into the indefinite future until the dewar is fully relaxed. The cluster NGC 3603 will be observed every other week with the three cameras (NIC1: F095N; NIC2: F110W; NIC3: F108N).

For each camera a 17-point focus sweep will be performed about the PAM mechanical zero point. The range of the scans will be from -8mm to +8mm with 1mm increments. A scale factor of 910 steps per 1mm of PAM travel is being applied. The spacecraft is moved by 3.6” for every 1mm of PAM travel, to keep the images at the same location in the detector. For each Delta-Focus from best focus the PAM is tilted in INT[0.5 + Delta-Focus*1.4] steps in both X and Y axis.

**Fraction of GO Programs Supported:** 100%

**Resources:**

- **Observation:** This program requires a total of 114 external orbits (i.e. 3 orbits per repeat and one repeat every two weeks for a period of 18 months). The observational strategy and frequency of this program will be revised after the first two months, i.e. in August 1997.

- **Analysis:** Analysis, including phase retrieval, encircled energy and plate scale techniques, requires 0.6 FTE.

**Special Requirements:**

- **Accuracy:** This program will measure the physical motions of the cameras and will allow to know the best focus position of the three cameras with an uncertainty of 1 mm due to breathing effects and motion of the cameras.

- **Products:** Update the PDB with new best focus positions for the three cameras when required.
Proposal 7688: NICMOS Cycle 7: ACCUM Darks

Plan

Purpose: Measure dark current on individual pixels for a limited set of ACCUM exposure times.

Description: Master dark frames will be generated for a set of 8 exposure times (1.071, 2.038, 4.963, 9.715, 25.714, 58.142, 110.246, and 229.68 secs) with a single initial and final readout (NREAD=1), and for a set of 14 exposure times (9.939, 12.075, 15.157, 18.339, 22.533, 30.274, 44.969, 62.702, 88.335, 114.806, 163.642, 234.24, 365.156, and 485.148 secs) with nine initial and final readouts (NREAD=9). A total of 20 dark frames will be obtained for each of the 14 NREAD=9 and 8 NREAD=1 exposure times. This program will be executed during earth occultations. Dark frames for exposure times different from those indicated above will be generated by interpolation/extrapolation from the darks obtained in this program.

Fraction of GO Programs Supported: 10%

Resources:

Observation: This program requires a total of 33 internal orbits.

Analysis: Analysis of the observations plus generation of the corresponding reference files will require approximately 0.10 FTE.

Special Requirements:

Accuracy: The uncertainty in the final dark reference files will be dominated by the presence of a variable extra signal in the darks, so called pedestal. The reference dark frames will be accurate to about 10 DN due to the pedestal. Several observing strategies are being tested but there is no guarantee that any of these will remove or reduce the pedestal. The accuracy mentioned above will decrease for the dark frames generated by interpolation/extrapolation.

Products: Reference files will be delivered to CDBS
Proposal 7691: NICMOS Cycle 7: Photometric Zeropoint

Plan

Purpose: Obtain the photometric zeropoint of NIC1 and NIC2 set of filters

Description: Images of two HST standards, one white dwarf (G191-B2B) and one solar analog (P330-E), will be obtained for all the NIC1 and NIC2 filters requested by the GO/GTO cycle 7 programs. A bright red star (OPH-S1) will also be observed to detect the presence, and measure the effects, of red-leaks in the filters.

Photometric transformations between the JHK HST system (F110W, F160W and F222M) and ground-based JHK systems will also be obtained as part of this program.

Fraction of GO Programs Supported: 100%

Resources:

Observation: This program requires 12 external orbits and 2 internal orbits (dark frames for the MULTIACCUM sequences used in this program).

Analysis: Analysis, including ISR preparation and SYNPHOT updates requires 0.30 FTE.

Special Requirements:

Accuracy: The goal is to achieve absolute photometry accurate to 5-10%. The accuracy is limited by uncertainties in flat-fielding (~1-2%), uncertainties in the absolute spectrophotometry of the standard stars (3-5%), and variations in the intrapixel sensitivity.

Products: ISR. SYNPHOT and NICMOS Exposure Time Calculator updates.
Proposal 7692: NICMOS Cycle 7: Polarizers

Plan

Purpose: Measure the instrumental polarization and zero position angle of NIC1 and NIC2 polarizers

Description: Observations of two bright near-infrared polarized standards will be taken with the NIC1 and NIC2 polarizers to measure the zero point angle for each polarizer. These observations will be repeated at a second epoch, with a different roll angle. Additional measurements of two HST unpolarized standards will be obtained to measure the instrumental polarization caused by NICMOS fore-optics. An extended polarized source will also be observed to compute the accuracy of polarization measurements for extended sources. Changes in the polarization as a function of position within the chip will be measured by moving one of the polarized sources in a spiral pattern across the chip.

Fraction of GO Programs Supported: 15%

Resources:

Observation: This program requires 12 external orbits.

Analysis: Analysis of the data plus ISR preparation will require 0.30 FTE.

Special Requirements:

Accuracy: High intrinsic precision in polarimetry measurements should be possible, to an accuracy of ~1%, because NICMOS detectors have a high dynamic range (MULTI-ACCUMs) and the images are formed on the same position on the detector. However, uncertainties in the dark frames (pedestal effect) and in flat-fielding could degrade the performance of the polarizers and reduce therefore the level of accuracy mentioned above.

Products: ISR.
Proposal 7693: NICMOS Cycle 7: Pupil Transfer Function

Plan

Purpose: Measure as a function of wavelength the leaks of NICMOS cold mask when illuminated by a diffuse source.

Description: Flatfielding is used to transfer the photometric calibration performed by imaging a star at one point (or usually just a handful of points) to all areas on a camera. NICMOS employs a cold pupil stop to reduce background, and the rays from a star are forced to travel from the primary to the secondary and through this pupil before landing on the array. However, rays from a diffuse illuminator (e.g., either the earth, the sky, or a NICMOS internal lamp) may not follow this path and may "leak" into the image. This effect is seen at the 1-10% level in virtually all groundbased near-infrared cameras. It is calibrated by imaging a star over a fine grid of positions across the entire face of a camera. Assuming that the pupil geometry does not change, this function will be stable and need not be repeated. However, the leakage path for thermal background radiation may be different from reflected or zodaical background light so the test must be performed as a function of wavelength. Changes in the PSF as a function of position within the cameras will also be measured.

One standard star (P330E) will be observed through the filter F160W with NIC1 and filters F110W and F222M with NIC2. Observations with NIC3 F110W and F222M filters are on hold. For each camera and filter combination, the star will be observed in 144 positions (36 per quadrant).

The output of this program 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%, or better. If needed, this two-dimensional correction could be applied to the flat-fields obtained with the internal lamp flat and Earth flat programs. The application of this two-dimensional correction will improve the photometric accuracy for extended sources.

Fraction of GO Programs Supported: 100%

Resources:

Observation: This program requires 15 external orbits and 10 additional orbits if science with NIC3 is enabled.

Analysis: Analysis of the data plus additional ISR preparation will require 0.3 FTE.

Special Requirements:

Accuracy: Measure the large scale structure of possible leakages to 1% accuracy.

Products: ISR. Two-dimensional photometric correction, if needed.
Proposal 7611: NICMOS Cycle 7: Thermal Background

Plan

Purpose: Monitor the stability of the HST thermal background for the three NICMOS cameras.

Description: Pure parallel observations will be obtained with thermal filters in cameras NIC2 (F237M) and NIC3 (F222M). No specific pointings are requested. This set of parallel observations will be used to monitor the stability of the thermal emission from the telescope. Dependencies of the intensity and structure of the thermal background on (1) changes in the physical position of the cameras within the solid nitrogen dewar, and (2) on temperature variations induced by fast/slow slews and different pointings will be monitored.

This program will obtain 20 NIC2 and NIC3 frames at different pointings in June 1997. An additional 80 frames could be taken if the data obtained during SMOV and June 1997 are not enough to measure the stability of the thermal background.

Fraction of GO Programs Supported: >50%

Resources:

  Observation: This program requires 20 +(80) internal orbits

  Analysis: Analysis of the data, including documentation, requires 0.1 FTE.

Special Requirements:

Accuracy: n/a

Products: ISR. NICMOS exposure time calculator updates, if required. Master thermal background files if background is stable.
Proposal 7609: NICMOS Cycle 7: NICMOS to FGS Astrometry

Plan

Purpose: Measure aperture locations for the three cameras in the V2V3 plane.

Description: Observations of a star in the standard astrometric field NGC188 will be obtained. A series of exposures at offset field pointings will be taken to facilitate the location of the NICMOS apertures and to measure the rotation angle of the apertures. MULTI-ACCUM exposures (2 per pointing) and a SPIRAL-DITH of 9 points separated by 4, 6, and 10 arcsec will be obtained for NIC1, NIC2 and NIC3, respectively.

This proposal will be on hold and it will only be executed at the request of NICMOS team, if large physical displacements of the cameras occur during cycle 7.

Fraction of GO Programs Supported: 100%

Resources:

Observation: This program requires 1 orbit per iteration.

Analysis: Analysis, including TIPS presentation and PDB update, requires 0.02 FTE per iteration.

Special Requirements:

Accuracy: The position and rotation of the cameras will be known with an accuracy of 100 mas and 0.5 degrees, respectively.

Products: PDB updates, if needed.
Proposal 7610: NICMOS Early Cycle 7: Plate Scale Calibration

**Plan**

**Purpose:** Determine the plate scale, field rotation and field distortion for each of the NICMOS cameras.

**Description:** The observations of an astrometric field will be obtained in all three cameras. The selected astrometric field is the cluster NGC 1850, used to find WFPC2 plate scale and intercamera astrometric solution (relative astrometry accurate to 10 mas). The optical plate scales at each of the detector focal planes shall be measured with a precision of a 1/4 of a Camera 2 pixel (i.e 18.8 mas).

The selected cluster will be observed in five different positions with each of the three NICMOS cameras. The first pointing in each camera will be centered in the center of the cameras. The offset pointings will be offset from the central one by a quarter the field-of-view in detector coordinates (2.5 arcsec for NIC1; 5 arcsec for NIC2 and 12.5 arcsec for NIC3). Comparing the relative positions of the stars in each sector will yield the plate scale and distortions. MULTIACCUM exposures with the filter F160W will be used in all three cameras. Exposure times are such that 20-21 mag stars will be detected with a S/N of ~ 20.

This proposal will be on hold and it will only be executed at the request of NICMOS team if large physical displacements, and therefore focus changes, occur in the cameras during the cycle 7.

**Fraction of GO Programs Supported:** 100%

**Resources:**

- **Observation:** This program requires 4 external orbits per iteration.

- **Analysis:** Analysis, including ISR preparation and TIPS presentation, requires 0.10 FTE per iteration.

**Special Requirements:**

- **Accuracy:** An accuracy of 18.8 mas is required to enable NIC2 coronograph observations. A relative astrometry accuracy of 10-15 mas can be obtained.

- **Products:** ISR and STSDAS astrometric tool. Accurate position of NIC2 coronographic hole.
Proposal 7694: NICMOS Cycle 7: Coronograph Stability Verification

**Plan**

**Purpose:** Measure the stability of the coronograph performance if large physical motions in NIC2 are detected.

**Description:** A series of stellar images will be taken in a pattern with displacements behind and near the Camera 2 occulting spot. Exposures will be sufficiently deep to allow determination of the magnitudes of both the diffracted energy rejection outside of the hole and the scattering floor, as well as to look for local structures in the PSF as a function of target decentration.

For each of the four visits, a target acquisition in a narrow band (F187N) filter will be performed to position the target in the middle of the coronagraphic hole. Following this, three identical multiaccum imaging sequences will be taken in the acquisition filter to establish the location of the centrally occulted PSF. This will establish a baseline to compare possible shifts in position with F160W filter.

The change in scattering and diffracted energy rejection will be explored as a function of target decentration. Two image sequences with cross patterns will be executed in the F160W filter. The first cross pattern will have 0.0185" (1/4 pixel) steps over the range +/- 1 pixel from center in X and Y. This will be done as two 9-point strip patterns (one in X and one in Y). The second, using the same types of patterns, will have 0.3" steps over the range +/- 1.2" from center in X and Y. The latter cross pattern will place the target at the geometrical edge of the hole on the 4th and 6th points in the X and Y scans.

Three MA images will be taken at each point in each pattern. The exposure depths will approach saturation at the end of the integration at the geometrical edge of the coronagraphic hole. This will require a total of 4 orbits. A total of 12 MA sequences will be obtained with the target centered in the hole over the 4 orbits.

This is a contingency program that will only be executed if NIC2 camera moves physically by more than 1-2 mm in PAM space.

**Fraction of GO Programs Supported:** 3%

**Resources:**

**Observation:** This program requires 4 external orbits.

**Analysis:** Analysis of the data requires 0.2 FTE.

**Special Requirements:**

**Accuracy:** n/a

**Products:** ISR.
Proposal 7695: NICMOS Cycle 7: GRISM Wavelength Calibration

Plan

Purpose: Obtain the wavelength dispersion solutions for NICMOS grisms

Description: A compact planetary nebula (size < 0.25") will be observed with the three grisms to obtain the wavelength dispersion solutions. For the planetary nebula, three spectra, one for each grism, and the associated broad or medium band filters, will be obtained at NIC3-FIX. Spectra of the planetary nebula will be taken at four different positions within the chip, one per quadrant, to measure any changes in the dispersion solution as a function of location in the detector. This program will be executed if NIC3 comes back into the PAM focus range.

Fraction of GO Programs Supported: 20%

Resources:

Observation: This program requires 3 external orbits.

Analysis: Analysis of the data plus generation of the dispersion solutions and preparation of ISR requires 0.1 FTE.

Special Requirements:

Accuracy: The accuracy in the wavelength zeropoint determination is limited by the capability of centering the target in the same position in detector’s space. If NIC3 comes back into the PAM focus range, the wavelength zeropoint could be determined to an accuracy of 0.01 microns.

Products: ISR. Dispersion solutions for pipeline wavelength calibration.
Proposal 7696: NICMOS Cycle 7: GRISM Absolute Sensitivity

Plan

Purpose: Measure NICMOS grisms absolute sensitivity.

Description: Two HST absolute standards, one white-dwarf (G191-B2B) and one solar analog (P330-E), will be observed with NIC3 G096, G141 and G206 grisms. For each of the standard stars, a spectrum will be obtained in each of the quadrants using a SPIRAL-DITH. For each grism, an associated broad or medium band filter will be used. This program will be executed if NIC3 comes back into the PAM focus range.

Fraction of GO Programs Supported: 20%

Resources:

Observation: This program requires 6 external orbits.

Analysis: Analysis of the data, including preparation of the sensitivity curves and ISR will require 0.2 FTE.

Special Requirements:

Accuracy: The final accuracy in the absolute level of the grism’s sensitivity curves depends on the accuracy of the absolute spectral energy distribution of the standard stars (~2%-5%) and the quality of the flat fields (~1%) and mainly on the variability and structure of the background. The absolute spectrophotometric calibration will have a 20-30% uncertainty.

Products: ISR. Absolute sensitivity curves for CALNICC (grism calibration pipeline).