2002 HST Calibration Workshop
Space Telescope Science Institute, 2002
S. Arribas, A. Koekemoer, and B. Whitmore, eds.

NICMOS Cycle 10 and Cycle 11 Calibration Plans

S. Arribas,[1] S. Malhotra, D. Calzetti, E. Bergeron, T. Boeker,[1] M. Dickinson, L. Mazzuca, B. Mobasher,[1] K. Noll, E. Roye, A. Schultz, M. Sosey, T. Wiklind,[1] C. Xu

Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218

Abstract. The NICMOS calibration activities performed after the completion of the Servicing Mission and On-orbit Verification program SMOV-3b are described. In particular, we present the generic objectives pursued with the Cycle 10 (interim) and Cycle 11 calibration plans, the specific programs involved, and the accuracy goals for Cycle 12.

1. Introduction

After the successful completion of the 2002 *HST* Servicing Mission, NICMOS went through an on-orbit verification phase as part of the SMOV-3b program. The NICMOS SMOV-3b program was intended to demonstrate that the instrument was functioning as expected after the installation of the NICMOS Cooling System (NCS). Although this program included many calibration-related activities, it did not provide a full calibration of the science modes.

Full calibration of the instrument is being performed thanks to the programs included in the calibration plans for each cycle. In the NCS era the first such plans were the Cycle 10 (interim) and the Cycle 11 (routine) calibration plans. Here we summarize the generic objectives pursued with these plans, the specific proposals involved, and the accuracy goals for Cycle 12.

2. Objectives of the Cycle 10 (Interim) Calibration Plan

The Cycle 10 interim calibration plan (ICP) lasted approximately five months and pursued the following objectives:

i) Calibration of the imaging mode for the three cameras and all the spectral elements. The imaging mode is by far the most commonly used NICMOS science mode. During Cycles 7 and 7N more than 80% of the exposures taken with NICMOS were in this mode. A full calibration of this mode requires a number of individual activities (e.g., obtaining high S/N darks and flats, optimizing the image quality, evaluating photometric stability, etc). The ICP provided high S/N flats for all narrow band filters (SMOV program 8985 provided wide, medium, and polarizer filter flats), improved the accuracy of the darks obtained during SMOV, and allowed a detailed study of the image quality and photometric stability of the instrument.

ii) Calibration of the spectroscopic mode. This science mode was the second most used during Cycles 7 and 7N with about 5.6% of the total number of exposures. The ICP provided the flats for the narrow band filters for NIC3 which, together with those

[1]Affiliated with the Space Telescope Division, Research and Science Support Department of the European Space Agency (ESA)

obtained with program 8991 (SMOV), allowed the calibration of this mode (see Thompson and Freudling 2003).

iii) Monitoring the main instrument properties. ICP included four monitor programs (*darks*, *flats*, *focus*, *photometry*). These programs are considered key for understanding the behavior and stability of the instrument after the installation of NCS. The *dark* program (ID 9321), which provided the linear component of the dark current, the shading, and the amplified glow, was executed weekly. The other three monitor programs were executed monthly.

iv) Special calibrations. The ICP also included two special calibrations: 1) the *gain test* was aimed at demonstrating the benefits of implementing a new gain value, and 2) high quality ACCUM darks were needed to calibrate the cosmic ray persistence effects in post-South Atlantic Anomaly (SAA) observations.

v) ICP also provided the data necessary to implement the *Dark Generator* and the *Flat Generator* tools, which allow users to create synthetic darks and flats, respectively.

Table 1. Cycle 10 (interim) and Cycle 11 (regular) Calibration Programs. Some SMOV calibration-related programs are also included. Details on individual programs can be obtained via the *HST*-STScI web site at http://www.stsci.edu/hst

Activity title	ID (Cycle/Program)	Comments
Multiaccum Darks	9321 (C10), 9636 (C11)	Monitor programs. Linear component of the dark current, shading, ampified glow. Include all the information needed for the *Dark Generator tool*
Flats	8995 (SMOV)	Flats for the broad and medium-band filters
Flats for NIC1 and NIC2	9327 (C10)	Narrow band filter flats. Broad and medium band filter flats were obtained during SMOV
Flats for NIC3	9557 (C10)	Narrow filters
Photometry Test	8996 (SMOV)	Photometric zero points for all the spectral elements
Aperture Location	8981 (SMOV)	Location of the NICMOS apertures in the V2-V3 plane
Plate Scale	8982 (SMOV)	Plate scale, field rotation, and field distortion
Grism Calibration	8991 (SMOV)	Recalibration of the spectroscopic mode
Polarimetric Calibration	9644 (C11)	Recalibration of the polarimetric mode
Coronagraphic focus	8979 (SMOV)	Determination of optimum focus for coronagraphy
Coronagraphic Performance Assessment	8984 (SMOV)	Quantitative re-evaluation of the coronagraphic mode
Focus Stability	9323 (C10), 9637 (C11)	Monitor programs
Photometric Stability	9325 (C10), 9639 (C11)	Monitor programs. Observations of P3003E with selected broad filters
Flat Fields Stability	9326 (C10), 9640 (C11)	Monitor programs, using a few selected filters
Dark Generator Test	9641 (C11)	To characterize the accuracy of this tool
SAA-CR Persistence Test	8987 (SMOV)	Calibration for mitigating the effects of cosmic ray induced persistence after passage of the SAA
Accum Darks	9322 (C10)	Darks needed for the calibration of the Cosmic Ray Persistence
Thermal Background	8989 (SMOV)	Characterization of the thermal background at the NICMOS focal plane
Intra Pixel Sensitivity	9638 (C11)	For cameras 2 and 3
High S/N Capability Characterization	9642 (C11)	Characterization of temporal photometric variations at very high S/N regime
Gain Test	9324 (C10)	Engineering test to analize the advantages of a new gain value
Pupil Transfer Function	9643 (C11)	To correct large scale flat-field residuals (contingency program)

3. Objectives of the Cycle 11 Calibration Plan

The objectives pursued with this plan are:

i) Monitor Programs: Similar to Cycle 10, an important objective during Cycle 11 has been the monitoring of the main properties of the instrument. The involved programs are a continuation of the corresponding Cycle 10 (and SMOV) programs. Preliminary analysis of the data indicated good thermal stability and, therefore, the frequency of some of these programs has been reduced with respect to the corresponding programs for Cycle 10.

ii) Intrapixel sensitivity: Data obtained during Cycles 7 and 7N demonstrated that one of the major factors limiting the photometric accuracy was the non uniform intrapixel 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 may be quite demanding in terms of observing time. Calibrations of intrapixel sensitivity may result in acceptable photometric accuracy without the need for excessive dithering.

iii) Multiaccum darks: In order to generate the dark reference files for all the multiaccum readout sequences an empirical model, the so called *Dark Generator Tool*, is used. One of the goals of the present plan is to test the accuracy of such a model.

iv) Polarimetry mode: This calibration has been outsourced to Dr. Dean Hines (University of Arizona), and it is aimed at recalibrating the polarimetry mode in both Camera 1 and 2 (see Hines 2003).

v) High S/N Capability Characterization (PI, Ron Gilliland): The goal here is to establish the temporal (differential) photometric accuracy in the very high S/N regime.

In Table 1 we list the individual programs with their corresponding ID numbers. The reader may find further details via the HST- STScI web page at http://www.stsci.edu/hst/ and in Arribas et al. (2002 a,b) and Malhotra et al. (2002).

Table 2. Summary of Cycle 12 Calibration Accuracy Goals

Attribute	Accuracy	Limiting Factors (Notes)
Detector dark	< 10 DN	Temperature fluctuations
Flat Fields	1% broad-band 3% narrow-band	Color and temperature dependence S/N
Photometry	< 6% zero point (filter dependent)	Absolute calibration, Photometric systems, Intrapixel effects
	2% relative over the FoV	
PSF and Focus	maintained within 1 mm for NIC1 and NIC2, 4 mm for NIC3	Breathing and OTA desorption
Coronagraphic PSF	0.013 arcsec pointing in the hole	
GRISM wavelength calibration	0.05 microns	Centroid of target for zero point determination
GRISM photometry	30%	Intrapixel sensitivity
Polarimetry	1%	Residual Flat-Field errors
Astrometry	0.5% plate scale 0.1 arcsec to FGS frame	(After geometric distortion correction)

4. Calibration Accuracies for Cycle 12

In Table 2 we summarize the calibration accuracy goals for Cycle 12. The calibration proposals executed during the SMOV phase, as well as the ones included in Cycles 10 and 11 calibration programs (see Table 1), were aimed at reproducing and possibly improving the level of accuracy achieved during Cycle 7 and 7N. Although at the time of writing this paper only a fraction of these programs have been completed, we do not foresee any problems in meeting these goals. The actual performance of NICMOS is closely related to its temperature stability. The results obtained so far (after 7 months of NCS operations) indicate very good stability (rms fluctuations $\sim$ 0.07 K) and, therefore, the accuracies quoted in Table 2 should be reached.

Acknowledgments. Thanks are due to the members of the IDT group (Dean Hines, Marcia Rieke, Glenn Schneider, and Rodger Thompson) who have contributed to the recalibration of NICMOS after the installation of NCS. The contribution by Wolfram Freudling is also very much appreciated. Thanks are also due to Ron Gilliland who has proposed and designed program 9642.

References

Arribas, S., et al. *2002 NICMOS Cycle 10 Interim Calibration Plan*, NICMOS *Instrument Science Report* 02-02 (Baltimore: STScI)

Arribas, S., et al. *2002 NICMOS Cycle 11 Calibration Plan*, NICMOS *Instrument Science Report* 02-03 (Baltimore: STScI)

Hines, D. 2003, this volume, 259

Malhotra, S., et al. *2002 NICMOS Instrument Handbook, Version 5.0*, (Baltimore: STScI)

Thompson, R. & Freudling, W. 2003, this volume, 241