NICMOS SM-2 SMOV ALIGNMENT RESULTS

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ABSTRACT

This technical memo documents the alignment calibration, spreadsheet model modifications and the update of aperture tables using results from in-flight NICM alignment tests performed during the Second Servicing Mission Orbital Verification Phase. The chapters address the results of SMOV test 7039, error assessment, and updates to the SIAF.DAT file and onboard target acquisition tables.

Contents

1 Introduction and References

This technical memo documents the alignment calibration, spreadsheet model modifications and the update of aperture tables using results from *in-flight* NICMOS alignment tests performed during the Second Servicing Mission Orbital Verification Phase. The chapters address the results of SMOV test 7039, error assessment, and updates to the SIAF.DAT file and onboard target acquisition tables.

The pre-launch blueprint/laboratory metrology may be found in the technical memo *Pre-Servicing Mission Nicmos Focal Plane Model*(Lupie, Lallo, and Cox 1997, ISR OSG-004). Additional References may also be found in that report. The *audience* for this documentation are the focal plane spreadsheet users, the NIC engineers, instrument science teams and groups familiar with the pointing requirements.

This work was performed in partnership with the NICMOS IDT team and the STScI Instrument Team (G. Schneider-Arizona, E. Bergeron-STScI, K. Noll-STScI) and with the SCIOPSDB processing and support (M. Bielefeld and J. Sandoval). We thank E. Kimmer (PASS-GSFC) and the PASS engineers for their efficient processing of the FGS telemetry and return of V2V3 positions.

1.1 References

Pre-Servicing Mission NICMOS Focal Plane Model, Lupie, Lallo, and Cox, ISR OSG-004, 1997.

STScI NICMOS Instrument Handbook, July 1997.

Space Telescope POCC Applications and Software Support (PASS) Requirements, Revision F Nov 1995: FGS/SI Algorithm description p. 4-144.

2 Summary of NICMOS Focal Plane Geography

The NICMOS apertures are primarily defined by the boundaries of 3 infrared cameras. The Pupil Alignment Mechanism mirror (PAM) relays the light to the Field Offset Mirror (FOM, which has a 26 arcsec offset capability). From the FOM, the light is directed to the Field Divider Assembly which provides three fields of view, one for each camera. The intervening optical elements result in a different focal length and magnification for each camera (description from the NIC Instrument Handbook). The targetable reference positions include the geometric centers of the cameras and several additional off-center positions including the Coronographic Spot on camera 2, the onboard target acquisition reference position and quadrant positions used for engineering purposes. The HST Focal Plane and NIC apertures are shown in Figure 1.

The NICMOS dewar anomaly (described in the NICMOS Instrument Handbook, July 1997), initially recorded in the laboratory, has evolved further in the orbital environment. The dewar expansion became considerably larger than final ground-based measurements. As the NICMOS Handbook clearly describes, the deformation of the dewar has moved the NIC3 focus out of range of the PAM adjustment mirror. The dewar is currently contracting as the instrument stabilizes in orbit and predictions are that NIC3 may come into focus in the coming year if the trend continues. Because the camera foci are now so different, the PAM is commanded to three focus positions (and possibly more in the future) one for each camera when it is the prime (science/pointing) mode. (The initial pre-launch spreadsheet models accommodated three foci but had two set to same focus). Motion of the PAM does result in field point motion across the cameras. The NICMOS IDT measured the field motion as a function of PAM Motion during SMOV (Bergeron, 1997). The relationship is linear and is illustrated in Figure 2 (for cameras 1 and 2) and summarized in Table 1. Note that the large error bars on the NIC3 values are a result of the non-optimal focus.

Table 1: Field Offsets versus PAM Position

Camera	NIC Y shift (asec/mm)	NIC X shift (asec/mm)
NIC1	3.564±0.0008	-0.018±0.0005
NIC2	3.568±0.001	-0.027±0.001
NIC3	3.626±0.033	-0.009±0.0021

The dewar evolution also impacts the coronographic spot. The projection of the coronographic spot onto the detector will shift position any time the detectors shift with respect to the field divider assembly which is external to the dewar. SMOV tests have shown that the projection of the coronographic spot onto NIC2 roughly tracks with the changes in the focus of the NIC2 (Bergeron 1997, in preparation). The field divider assembly itself appears to be very stable with respect to the sky. For each camera, special apertures have been defined which describe the FOV for that camera when the PAM is at a particular focus. This is necessary because the three NICMOS cameras will often be used concomitantly with the result that one camera will be in optimal focus while the remaining one (or two) will not. Note that the out-of-focus apertures have the suffix P1, P2, and P3 for PAM focus 1,2, or 3. The assumption is made that the focus is optimized for the primary camera. The NICMOS apertures are defined in Table 2. Figure 3 is a schematic of the special apertures. It also illustrates the difference between the Detector (electronic) and Image (OPUS) coordinate frames.

Table 2: NICMOS Aperture Definition				
Camera	**Aperture Name**	**Focus***	**Target Ref**	**Comments**
NIC1	NIC1	P1	best pix	
	NIC1FIX	P1	fixed pix	
	NIC1Q1-Q4	P1	1/4 corner	engin only
	NIC1P2	P2	best pix	cam1 at cam2 focus
	NIC1P3	P3	best pix	cam1 at cam3 focus
NIC2	NIC2	P2	best pix	
	NIC2FIX	P2	fixed pix	
	NIC2Q1-Q4	P2	1/4 corner	engin only
	NIC2COR	P2	Cor Spot	FSW Onboard Acq
	NIC2ACQ	P2	TA 128 array	FSW Onboard Acq
	NIC2P1	P1	best pix	cam2 at cam1 focus
	NIC2P3	P3	best pix	cam2 at cam3 focus
NIC3	NIC3	P3	best pix	
	NIC3FIX	P3	fixed pix	
	NIC3Q1-Q4	P3	1/4 corner	engin only
	NIC3P1	P1	best pix	cam3 at cam1 focus
	NIC3P2	P2	best pix	cam3 at cam2 focus

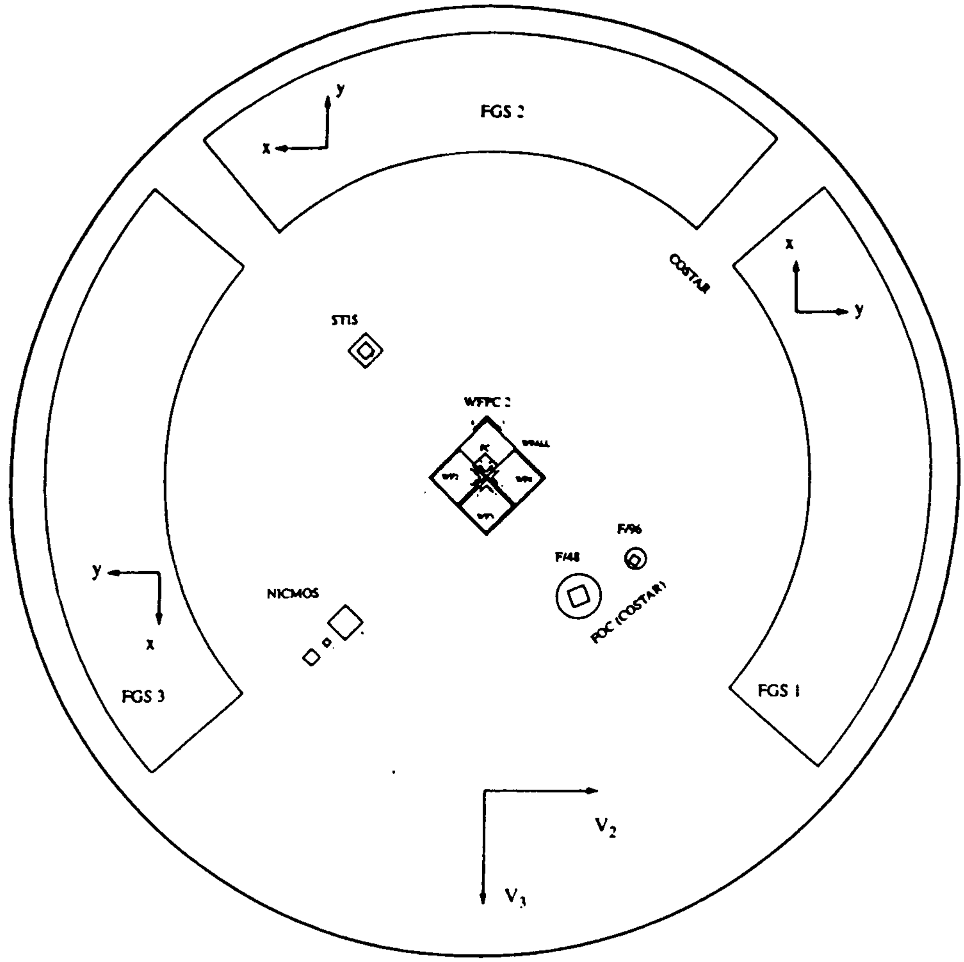
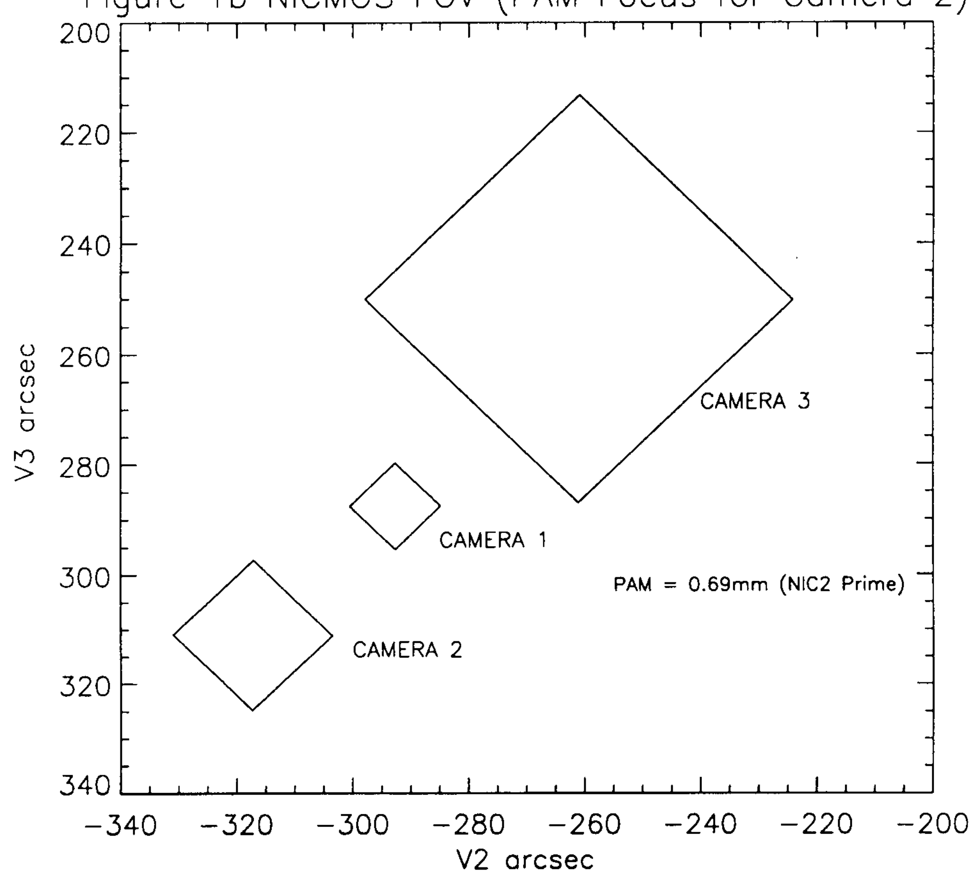


Figure 1b NICMOS FOV (PAM Focus for Camera 2)



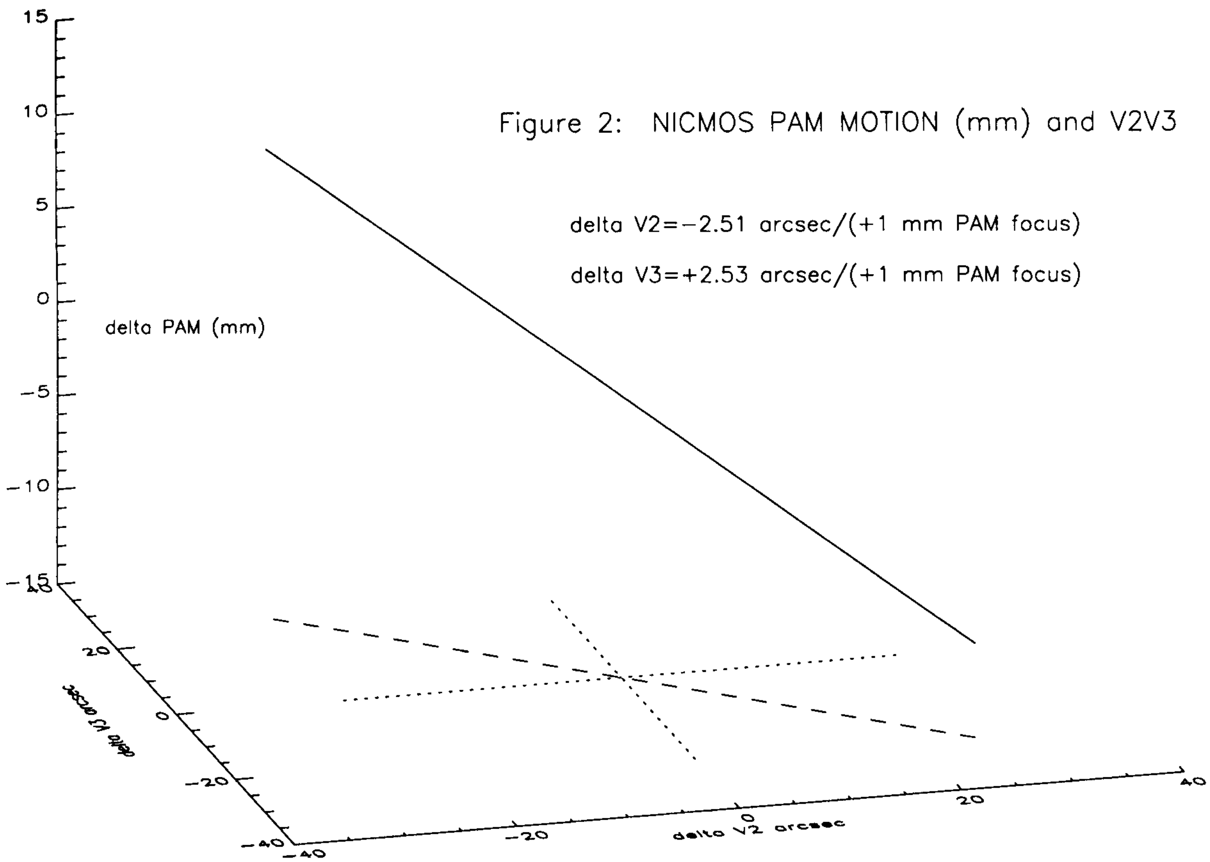
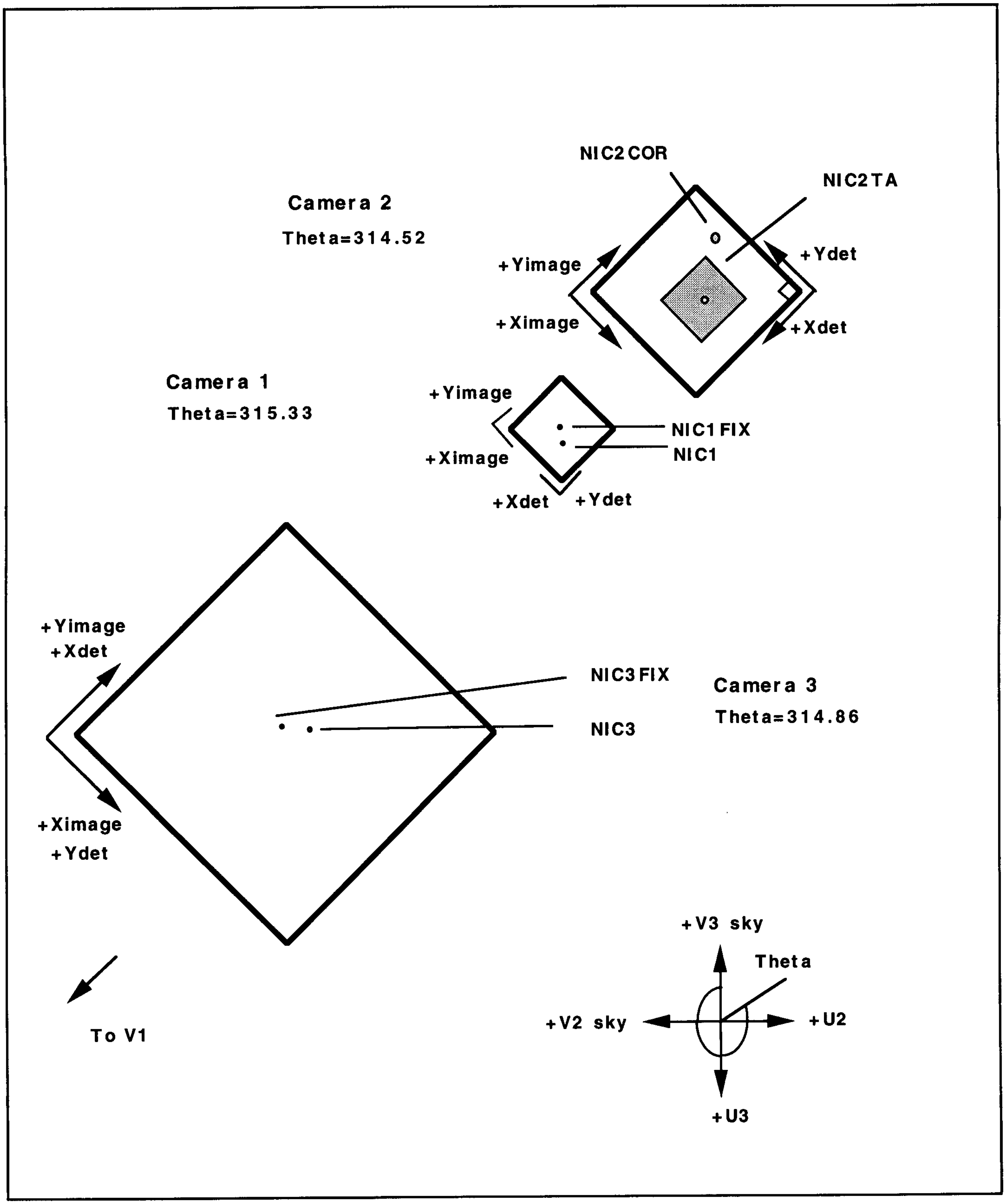


Figure 2: NICMOS PAM MOTION (mm) and V2V3

Figure 3: Schematic of NIC Special Apertures



3 Pre-Launch versus In-Flight Input Data, a General Note

The input to the **pre-launch** focal plane models are (1) the measured aperture positions in the focal plane (metrology) corrected for OTA A-latch alignments and (2) the coordinate locations of apertures projected onto the detector through the instrument optics. The metrology is transformed into V2V3 coordinates via polynomial coefficients (or Code V tracings) which describe the OTA (Ritchey Chretian distortion coefficiencts modified by spherical aberration). The transformation between image coordinates (measured in the lab) and the derived V2V3 coordinates become the basis for the pre-launch focal plane models and SIAF.DAT file. The model and pre-launch input data are described in ISR OSG-004.

In contrast to the pre-launch models, the **in-flight calibration** is driven by direct V2V3 measurements and image coordinates of astrometric targets. The in-flight calibration usually consists of the measurement of an astrometric field and the use of guide stars which are also part of that astrometric field. The accuracy of relative positions of stars in an astrometrically calibrated field is usually 2-3 mas. The V2V3 coordinates of the target positions are calculated from the guide star telemetry and the astrometric coordinates of the guide star and target star. The relationship between the V2V3 reference frame and image reference frame is directly derived from the image of the astrometric field. Sometimes a step/dwell pattern is initiated in an image or across an aperture. At least 3 points are necessary to derive angle and scale in X and Y. More points are desired for error analysis. The original metrology of the focal plane (mm measurents from blue prints or ground based measurements) is usually only used, in conjunction with the inflight data, to derive *relative* aperture positions in detector and V2V3 space, e.g., to extrapolate to those apertures that are not measured in-flight. The V2V3 positions can be derived by relating these apertures to the measured apertures using the original metrology. This method is only used if it can be shown that the *relative* metrology has a higher precision than any in-flight measurement (which it usually does).

4 NICMOS SMOV Alignment Results

4.1 SMOV Proposal NIC 7039

The NICMOS alignment test, entitled *NICMOS to FGS Astrometric Calibration - Aperture Locations* (Investigators J. Mackenty-STScI, G. Schneider U-of-Az, E. Bergeron-STScI, and K. Noll-STScI), was executed on multiple occasions during SMOV. Other SMOV and cycle 7 tests that directly affect the NICMOS aperture positions are the Intermediate and Fine Optical Alignment Tests (SMOV 7042 and 7035). These tests optimize the PAM position for each camera (and hence shift the position of the cameras in V2V3 coordinates). The PAM optimization tests are documented elsewhere. The NICMOS apertures were updated 3 times during SMOV and these are listed in Table 3.

Table 3: SIAF.DAT Deliveries during SMOV

Model Id	Effective SMS	7039 Visit	Comments
n970109.w20	pre-launch model		metrology
n970324.w20	97090 3/31/97	3/97	V2V3, scale, angle, PAM
		4/97	small changes, no update
n970528.w20	97160 6/9/97	5/97	V2V3, scale, angle, PAM
n970605.w20	97174 6/23/97	none	Revise non-FIX pix pos

Proposal 7039 consisted of obtaining images of a field in the standard astrometric cluster NGC188. A cluster star was moved in a step/dwell pattern across each camera (NICMOS SPIRAL-DITH Patterns). Guide Stars which were also cluster members were used for fine lock tracking. The astrometric coordinates of the target and guide stars (J2000) and catalog IDs are listed in Table 4.

Table 4: NGC188 Targets

7039 Date	Target	ID	ZZZZ ID	RA*	DEC*
3/20/97	FGS2	245	00055	0 41 51.7864	85 27 7.158
	FGS3	100	00153	0 50 43.9239	85 17 42.925
	NIC	16	00264	0 43 26.8632	85 09 17.811
4/17/97	FGS2	15	00129	0 43 29.9173	85 19 50.911
	FGS3	292	00266	0 53 20.3494	85 08 55.435
	NIC	269	00296	0 47 53.1707	85 04 02.551
5/15/97 NIC1,2,3	FGS2	14	00204	0 36 03.3999	85 14 45.967
NIC1,2	FGS3	73	00192	0 47 57.0041	85 14 56.096
NIC3	FGS3	292	00266	0 53 20.3494	85 08 55.435
	NIC	269	00296	0 47 53.1707	85 04 02.551

* astrometric coordinates, J2000, relative error 2-3 mas.

The steps in the data reduction are:

1. Convert Guide Star encoder positions into V2V3 coordinates. The algorithm used by the GSFC PASS SI-FGS Alignment Procedure (see the PASS Requirements Documentation) converts the FGS encoder positions into vehicle V2V3 coordinates using the Optical Field Angle Distortion Calibration (OFAD) coefficients, the FGS/FGS alignment matrices, plate scales, and PMT calibrations. The code then uses the astrometric angular separation of the

target star and guide stars to derive the V2V3 position of the target star (solving a spherical triangle). The error estimates are derived by differencing the measured angular separation of the guidestars and the astrometric relative positions of those stars (plus some additional corrections). The V2V3 positions (at the times we requested) were provided by E. Kimmer (PASS, GSFC).

2. Process the images to extract image coordinates as a function of time. The images were processed by the STScI NICMOS team.

3. Calculate the transformation (plate scale, orientation, zero-point) coefficients which relate image coordinates and V2V3 coordinates. The transformation coefficients, parameter calculations, error analysis, verification procedures, and spreadsheet and SIAF generation were handled by Lallo, Cox, and Lupie.

4. Extrapolate results to different PAM foci and unmeasured apertures and derive intermediate coordinate reference frames required in the SIAF.DAT file.

4.2 7039 Test Results

The 7039 test results are listed in Table 5. The PAM setting during the 7039 visit is listed in column 2. All other data in this table are appropriate for that PAM setting. The *adopted* values for the PAM focus and extrapolated aperture positions are listed in Table 6. These data were derived from the data in Table 5 and form the basis for the SIAF.DAT deliveries.

Table 5: 7039 Test Results

Date	PAM mm	X_{im}	Y_{im}	X Sc "/px	Y Sc "/px	V2 asec	V3 asec	Angle
NIC CAMERA 1								
3/24/97 NIC1	1.89	128	128	0.043438	0.432760	-296.251	290.696	315.24
4/17/97 NIC1	2.78	128	128	0.043386	0.043220	-297.366	292.508	315.33
5/28/97 NIC1	2.78	128	128	0.043328	0.043131	-297.950	292.870	315.33
NIC CAMERA 2								
3/24/97 NIC2	1.89	128	128	0.076448	0.075770	-320.742	314.276	314.50
4/17/97 NIC2	0.52	128	128	0.076320	0.075655	-316.121	309.960	314.51
5/28/97 NIC2	0.52	128	128	0.076216	0.075502	-316.860	310.610	314.52
NIC CAMERA 3								
3/24/97 NIC3	-5.45	128	128	0.206468	0.205330	-245.870	233.950	314.91
4/17/97 NIC3	-9.5	128	128	0.205502	0.205004	-235.398	224.075	314.96
5/28/97 NIC3	-9.5	128	128	0.204538	0.203916	-235.590	224.340	314.86

Table 6: ADOPTED NIC DATA: SIAF.DAT UPDATES								
Date	**PAM**	**X_{im}**	**Y_{im}**	**X Scale**	**Y Scale**	**V2 asec**	**V3 asec**	**THETA**
NIC CAMERA 1								
pre-launch NIC1	3.94	128	128	0.043	0.043	-300.1	294.6	315.0
3/24/97 NIC1	2.78	128	128	0.043438	0.43276	-298.517	292.962	315.239
5/28/97 NIC1	2.36	128	128	0.043328	0.043131	-296.896	291.806	315.327
6/05/97 NIC1FIX	2.36	128	128	0.043328	0.043131	-296.896	291.806	315.327
NIC1	2.36	162	100	0.043328	0.04313	-297.095	289.911	315.327
NIC CAMERA 2								
pre-launch NIC2	3.94	128	128	0.075	0.075	-324.1	319.1	315.0
3/24/97 NIC2	0.52	128	128	0.076448	0.075770	-317.255	310.789	314.489
5/28/97 NIC2	0.69	128	128	0.076216	0.075502	-317.287	311.041	314.519
6/05/97 NIC2FIX	0.69	128	128	0.076216	0.075502	-317.287	311.041	314.519
NIC2	0.69	149	160	0.076216	0.075502	-320.132	311.593	314.519
NIC CAMERA 3								
pre-launch NIC2	-2.29	128	128	0.20	0.20	-267.7	257.4	315.0
3/24/97 NIC3	-9.5	128	128	0.206468	0.205330	-235.561	223.642	314.9066
5/28/97 NIC3	-9.5	128	128	0.204538	0.203916	-235.59	224.34	314.861
6/05/97 NIC3FIX	-9.5	128	128	0.204538	0.203916	-235.59	224.34	314.861
NIC3	-9.5	140	135	0.204538	0.203916	-238.333	223.607	314.861

4.3 Error Assessment

The internal errors within a camera are very small indicating that a linear transformation between arcsec and image space is adequate for pointing. The fit residuals are consistent with the estimates of the internal errors from centroiding and FGS optical field angle distortion measurements. Fit errors are 0.00004 and 0.00005 arsec/pix per axis for NIC1 and NIC2 respectively and 0.0002 arcsec/pix for NIC3. Internal angle errors are typically 0.04 degrees. The errors on the absolute position and orientation are larger and include: the FGS/FGS misalignments, coordinate errors, NICMOS stability, and resolution of the PAM readout. The FGS/FGS misalignments are by far the largest source of error. The guidestar separation errors (difference between the measured and astrometric separations) for all visits range from 150 to 300 mas. The geometry of the guide stars (different guide stars used) will affect the size of the error. The error bars are addressed in Table 7. *The NIC3 error bars are larger than the NIC1 and NIC2 errors because the images were not at best focus.* We anticipate more accurate values when that camera stabilizes. The NICMOS stability is an important factor in pointing accuracies and it is being monitored at this time.

Table 7: NIC Alignment Error Estimates

Parameter	Source	Error	Comment
Internal Errors			
Plate Scale	centroid image	4-20 mas	~ 0.1-0.2 pixels
	FGS internal distortion	~ 4mas/20 asec	Oper OFAD
	PS fit resid	0.00006 "/px	larger for NIC3
Angle	fit resid	0.03-0.05 deg	within camera
Absolute Errors			
V2V3	Coor Error	3-5 mas	catalog errors
	PAM Encod Error	$\leq$ 2 mas	possible error
	FGS/FGS Align Acc	100-300 mas	GS Geometry
Theta	Angle error	~ 0.07 deg	V2V3 and image angle
	NIC Stability	TBD	

5 Summary of Current NICMOS Aperture Data

The **latest (SIAF-23.0, n970605.w20) NIC focal plane data** are listed in the Appendix. Table 8 summarizes these data (implemented in SMS 97174). The NIC Cameras at the three focus positions are plotted in Figure 4a-c and Figure 5 illustrates the spread in NIC camera positions at 4 focus positions (3 current foci and 1 foci to be implemented in the future). The dots indicate the reference positions for each unique NIC aperture.

Table 8: NICMOS Alignment 8/97

Aperture	PAM	Image Pix	Det Pix	V2V3 asec	THETA	X Pl Sc	Y Pl Sc
NIC1	2.36	162,100	94,99	-297.10,289.91	315.33	0.04333	0.04313
NIC1FIX		128,128	128,127	-296.90,291.81	315.33	0.04333	0.04313
NIC2	0.69	149,160	96,107	-320.13,311.59	314.52	0.07622	0.07550
NIC2FIX		128,128	128,128	-317.29,311.04	314.52	0.07622	0.07550
NIC2COR		73,213.7	42.3,182.6	-318.98,318.55	314.52	0.07622	0.07550
NIC2ACQ		157,128	128,99	-318.84,309.47	314.52	0.07622	0.07550
NIC3	-9.5	140,135	134,139	-238.33,223.61	314.86	0.20454	0.20392
NIC3FIX		128,128	127,127	-235.59,224.34	314.86	0.20454	0.20392

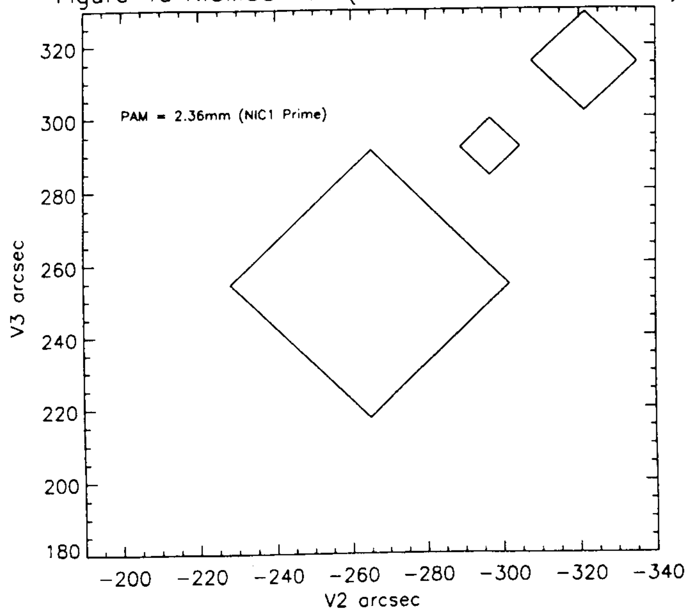


Figure 4b NICMOS FOV (PAM Focus for Camera 2)

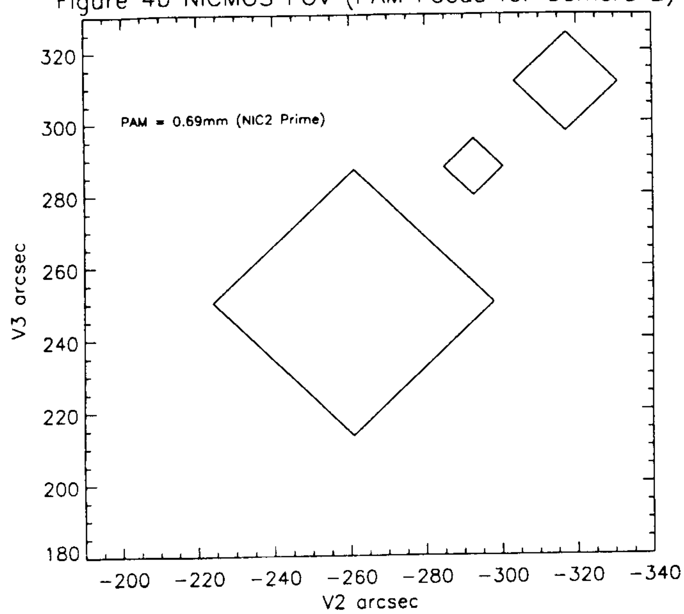
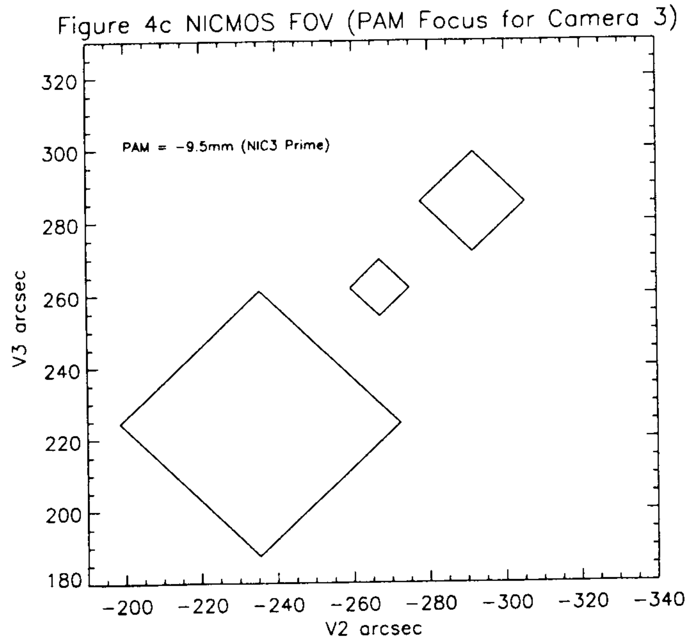
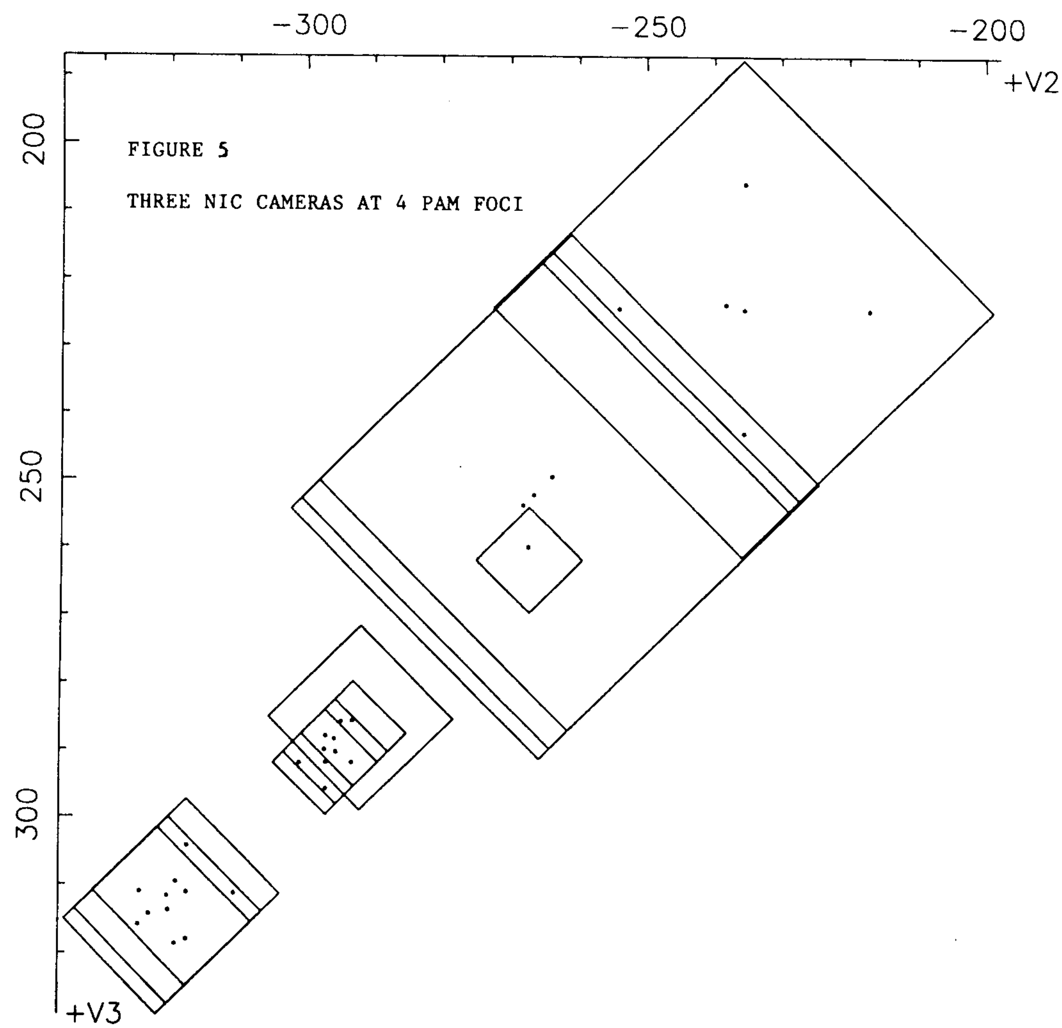


Figure 4c NICMOS FOV (PAM Focus for Camera 3)





-300
-250
-200
+V2
200
250
300
+V3
FIGURE 5
THREE NIC CAMERAS AT 4 PAM FOCI

6 NIC Onboard Target Acquisition Parameters

6.1 NSSC-1 Rotation Matrix Update

As a result of the SMOV alignment tests, the NIC flight software rotation matrices were updated. A detailed description of the NSSC-1 FGS/SI rotation matrices maybe found in NSSC-1 User's Guide DM03D. The NICMOS NSSC-1 matrix elements are simply the combination of the parity and the sine/cosine of the angle between V3 and the NIC Y direction (in base Detector coordinates). The NIC flight software algorithms convert the desired offset slew from NIC rows and columns in pixels to units of 2^{-27} radians (short intgers rounded to the nearest 2^{-27} radians). The NSSC-1 matrix elements (Row, Column) are then:

$$\delta V2 = R1C1(\delta X) + R1C2(\delta Y),$$
$$\delta V3 = R2C1(\delta X) + R2C2(\delta Y).$$

The matrix elements were calculated in the following way:

$$R1C1 = pcos\theta, \quad R1C2 = sin\theta,$$
$$R2C1 = -psin\theta, \quad R2C2 = cos\theta,$$

where p is the parity and θ the angle between the detector and vehicle axes and $\delta X, Y$ are along the detector axes but already converted into arcseconds. The matrix elements and other target acquisition flight software parameters were updated in the summer of 1997. The parity, angle and matrix elements for the FSW tables are listed in Table 9.

Table 9: NIC NSSC-1 Matrix Elements 6/97

Descript	Row,Column	NIC1	NIC2	NIC3
par, angle	-	+1,315.327	+1,44.519	+1,224.861
unscaled	R1C1	7.11131096E-01	7.13017941E-01	-7.08820105E-01
	R1C2	-7.03059375E-01	7.01145768E-01	-7.05389261E-01
	R2C1	7.03059375E-01	-7.01145768E-01	7.05389261E-01
	R2C2	7.11131096E-01	7.13017941E-01	-7.08820105E-01
scaled 2^{17}	R1C1	9.32093750E+04	9.34566875E+04	-9.29064688E+04
	R1C2	-9.21513984E+04	9.19005781E+04	-9.24567813E+04
	R2C1	9.21513984E+04	-9.19005781E+04	9.24567813E+04
	R2C2	9.32093750E+04	9.34566875E+04	-9.29064688E+04

 # decim places do not reflect actual accuracy

6.2 Target Acquisition Flight Software Parameters

The NIC onboard target acquisition algorithm is used to place a target behind the coronographic hole. A description of the algorithm may be found in ISR OSG-004 (Lupie et al 1997) and in the target acquisition source code itself (tacq.c, see Wayne Baggett).

The TA algorithm identifies the target in the acquisition aperture and then aaplies a geometric distortion correction to the the raw target coordinates and coronographic hole position. The relevant subroutine, *Evaluate_Polynomial,* evaluates an n'th order two dimensional polynomial whose coefficients are derived from measurements of an astrometric cluster of stars. To date, only the linear terms in X and Y have been implemented. Eventually, for extremely accurate pointing requirements (i.e., behind the coronographic hole), a higher order polynomial will be available. *Note that the coefficients are scaled to unity.* The X and Y plate scales are stored in the flight software as separate parameters. The form of the polynomial is:

$$c_0 + c_1 X + c_2 Y +$$

$$c_3 X^2 + c_4 XY + c_5 Y^2 +$$

$$c_6 X^3 + c_7 X^2 Y + c_8 XY^2 +$$

$$....+$$

$$c_{n(n-1)/2} X^n + c_{n(n-1)/2+1} X^{n-1} Y + c_{n(n-1)/2+2} X^{n-2} Y^2 +$$

$$... + c_{n(n-1)/2+(n-1)} XY^{n-1} + c_{n(n-1)/2+n} Y^n$$

The definition of the most relevant flight sofwtare parameters and their values (7/97) are provided in Table 10. *Note that all pixel coordinates are referenced to the Detector frame (and not the Image frame which emerges from OPUS).*

Table 10: TA-related Flight Software Entries (8/97)

Parameter	FMT	Units	Value	Comments
pcta_Poly_Order	int	1 to n	1	poly degree
pcta_RawHolePosX	float	fract pix	46.43	coron. det coord.
pcta_RawHolePosY	float	fract pix	182.14	coron. det coord
pcta_DetectorPlateScale X	float	rad*2^{-27}/pix arcsec/pix	49.12960 0.075502	lin plate scale
pcta_DetectorPlateScale Y	float	rad*2^{-27}/pix arcsec/pix	49.59420 0.076216	lin plate scale
pcta_FORMinX	int	0-255 pix	66	TA Ap corner
pcta_FORMinY	int	0-255 pix	35	TA Ap corner
pcta_DistortionCorrectCoef X	float	-	$c_1 = 1$, $c_{0,2}..c_n = 0$	unity scaling
pcta_DistortionCorrectCoef Y	float	-	$c_2 = 1$, $c_{0,1,3}..c_n = 0$	unity scaling

7 Future Additions to NICMOS Apertures

Five new NICMOS apertures have been designed and are in the process of testing. Implementation of these new apertures will occur in the fall 1997. These apertures are being added to support a *compromise* focus position that is midway between NIC1 and NIC2 best focus positions. These new apertures are described in Table 11. A current estimate of the PAM focus for these new apertures are 1591 steps per 909 steps/mm or 1.75 mm, although refinements are expected before implementation of the apertures. Lastly, for future consideration, special focus positions could be implemented for use with the coronographic hole or other special NIC apertures.

Table 11: New Apertures, Fall 1997

Aper Name	PAM mm	**Comment**	**Image Pos**	**Det Pos**	**V2V3 (asec)**	Comment
NIC1P12	1.75	best pix	162,100	94,99	-295.564,288.366	focus cam1+2
NIC1FP12	1.75	fixed pix	128,128	128,127	-295.365,290.260	focus cam1+2
NIC2P12	1.75	best pix	149,160	96,107	-322.792,314.279	focus cam1+2
NIC2FP12	1.75	fixed pix	128,128	128,128	-319.947,313.726	focus cam1+2
NIC3P12	1.75	best pix	140,135	134,139	-266.565,252.109	cam3 at 1+2 foc

8. APPENDIX: NIC SPREADSHEET MODEL ENTRIES

6/05/97 SIAF NAME	11:00am PLATE (cam)	CAMFOC KEY (3 foc set)	Measured Image X pix	Measured Image Y pix	Detector X pix	Detector Y pix	InFlight V2 arcsec mac ap correction	InFlight V3 arcsec
NIC1MAC	CAM1	N1P1	128.0	128.0	128.00	127.00	-267.332	259.864
NIC1	CAM1	N1P1	162.0	100.0	94.00	99.00	-297.095	289.911
NIC1FIX	CAM1	N1P1	128.0	128.0	128.00	127.00	-296.896	291.806
NIC1P2	CAM1	N1P2	162.0	100.0	94.00	99.00	-292.904	285.680
NIC1P3	CAM1	N1P3	162.0	100.0	94.00	99.00	-267.332	259.864
NIC1Q1	CAM1	N1P1	192.0	64.0	64.00	63.00	-296.927	287.893
NIC1Q2	CAM1	N1P1	64.0	64.0	192.00	63.00	-292.983	291.793
NIC1Q3	CAM1	N1P1	64.0	192.0	192.00	191.00	-296.865	295.719
NIC1Q4	CAM1	N1P1	192.0	192.0	64.00	191.00	-300.809	291.819
NIC2MAC	CAM2	N2P2	128.0	128.0	128.00	128.00	-267.332	259.864
NIC2	CAM2	N2P2	149.0	160.0	96.00	107.00	-320.132	311.593
NIC2FIX	CAM2	N2P2	128.0	128.0	128.00	128.00	-317.287	311.041
NIC2P1	CAM2	N2P1	149.0	160.0	96.00	107.00	-324.322	315.824
NIC2P3	CAM2	N2P3	149.0	160.0	96.00	107.00	-294.559	285.777
NIC2Q1	CAM2	N2P2	192.0	192.0	64.00	64.00	-324.152	310.951
NIC2Q2	CAM2	N2P2	192.0	64.0	192.00	64.00	-317.261	304.175
NIC2Q3	CAM2	N2P2	64.0	64.0	192.00	192.00	-310.421	311.131
NIC2Q4	CAM2	N2P2	64.0	192.0	64.00	192.00	-317.312	317.907
NIC2COR	CAM2	N2P2	73.4	213.7	42.28	182.64	-318.981	318.548
NIC2ACQ	CAM2	N2P2	157.0	128.0	128.00	99.00	-318.836	309.465
NIC3MAC	CAM3	N3P3	128.0	128.0	127.00	127.00	-267.332	259.864
NIC3	CAM3	N3P3	140.0	135.0	134.00	139.00	-238.333	223.607
NIC3FIX	CAM3	N3P3	128.0	128.0	127.00	127.00	-235.590	224.340
NIC3P1	CAM3	N3P1	140.0	135.0	134.00	139.00	-268.096	253.654
NIC3P2	CAM3	N3P2	140.0	135.0	134.00	139.00	-263.905	249.423
NIC3Q1	CAM3	N3P3	64.0	64.0	63.00	63.00	-217.106	224.413
NIC3Q2	CAM3	N3P3	64.0	192.0	191.00	63.00	-235.607	242.825
NIC3Q3	CAM3	N3P3	192.0	192.0	191.00	191.00	-254.074	224.267
NIC3Q4	CAM3	N3P3	192.0	64.0	63.00	191.00	-235.573	205.855

6/05/97 SIAF NAME	11:00am PLATE (cam)	CAMFOC KEY (3 foc set)	Measured Image X pix	Measured Image Y pix	V3toSICSY THETA	SIC PAR	Xincr "/pix	Yincr "/pix
NIC1MAC	CAM1	N1P1	128.0	128.0	315.3270	-1	0.043328	0.043131
NIC1	CAM1	N1P1	162.0	100.0	315.3270	-1	0.043328	0.043131
NIC1FIX	CAM1	N1P1	128.0	128.0	315.3270	-1	0.043328	0.043131
NIC1P2	CAM1	N1P2	162.0	100.0	315.3270	-1	0.043328	0.043131
NIC1P3	CAM1	N1P3	162.0	100.0	315.3270	-1	0.043328	0.043131
NIC1Q1	CAM1	N1P1	192.0	64.0	315.3270	-1	0.043328	0.043131
NIC1Q2	CAM1	N1P1	64.0	64.0	315.3270	-1	0.043328	0.043131
NIC1Q3	CAM1	N1P1	64.0	192.0	315.3270	-1	0.043328	0.043131
NIC1Q4	CAM1	N1P1	192.0	192.0	315.3270	-1	0.043328	0.043131
NIC2MAC	CAM2	N2P2	128.0	128.0	314.5190	-1	0.076216	0.075502
NIC2	CAM2	N2P2	149.0	160.0	314.5190	-1	0.076216	0.075502
NIC2FIX	CAM2	N2P2	128.0	128.0	314.5190	-1	0.076216	0.075502
NIC2P1	CAM2	N2P1	149.0	160.0	314.5190	-1	0.076216	0.075502
NIC2P3	CAM2	N2P3	149.0	160.0	314.5190	-1	0.076216	0.075502
NIC2Q1	CAM2	N2P2	192.0	192.0	314.5190	-1	0.076216	0.075502
NIC2Q2	CAM2	N2P2	192.0	64.0	314.5190	-1	0.076216	0.075502
NIC2Q3	CAM2	N2P2	64.0	64.0	314.5190	-1	0.076216	0.075502
NIC2Q4	CAM2	N2P2	64.0	192.0	314.5190	-1	0.076216	0.075502
NIC2COR	CAM2	N2P2	73.4	213.7	314.5190	-1	0.076216	0.075502
NIC2ACQ	CAM2	N2P2	157.0	128.0	314.5190	-1	0.076216	0.075502
NIC3MAC	CAM3	N3P3	128.0	128.0	314.8610	-1	0.204538	0.203916
NIC3	CAM3	N3P3	140.0	135.0	314.8610	-1	0.204538	0.203916
NIC3FIX	CAM3	N3P3	128.0	128.0	314.8610	-1	0.204538	0.203916
NIC3P1	CAM3	N3P1	140.0	135.0	314.8610	-1	0.204538	0.203916
NIC3P2	CAM3	N3P2	140.0	135.0	314.8610	-1	0.204538	0.203916
NIC3Q1	CAM3	N3P3	64.0	64.0	314.8610	-1	0.204538	0.203916
NIC3Q2	CAM3	N3P3	64.0	192.0	314.8610	-1	0.204538	0.203916
NIC3Q3	CAM3	N3P3	192.0	192.0	314.8610	-1	0.204538	0.203916
NIC3Q4	CAM3	N3P3	192.0	64.0	314.8610	-1	0.204538	0.203916

CAMFOC KEY	hand input Image Center Image X pix	hand input Image Center Image Y pix	CALC V2 arcsec	CALC V3 arcsec	Scale PSC X pix (tentative)	Scale PSC Y pix (tentative)	Angle V3toIMAGE Y deg	Parity V3toIMAGE Y
N1P1	128.00	128.00	-296.896	291.806	0.043328	0.043131	315.3270	-1
N1P2	128.00	128.00	-292.705	287.575	0.043328	0.043131	315.3270	-1
N1P3	128.00	128.00	-267.133	261.759	0.043328	0.043131	315.3270	-1
N2P1	128.00	128.00	-321.478	315.272	0.076216	0.075502	314.5190	-1
N2P2	128.00	128.00	-317.287	311.041	0.076216	0.075502	314.5190	-1
N2P3	128.00	128.00	-291.715	285.224	0.076216	0.075502	314.5190	-1
N3P1	128.00	128.00	-265.353	254.387	0.204538	0.203916	314.8610	-1
N3P2	128.00	128.00	-261.162	250.156	0.204538	0.203916	314.8610	-1
N3P3	128.00	128.00	-235.590	224.340	0.204538	0.203916	314.8610	-1

PAM scale mm	V3 to PAM deg
3.566	315.27

	7039 Focus mm	del V2/foc asec/mm_f	del V3/foc asec/mm_f	Image X pix	Image Y pix	Scale X asec/pix	Scale Y asec/pix
CAM1	2.780	-2.51	2.53	128.00	128.00	0.043328	0.043131
CAM2	0.520	-2.51	2.53	128.00	128.00	0.076216	0.075502
CAM3	-9.500	-2.51	2.53	128.00	128.00	0.204538	0.203916

	Decisive focus mm	Meas V2 arcsec	Meas V3 arcsec	Corr V2 for focus	Corr V3 for focus	Meas Beta2 V3-ImageY deg
CAM1	2.360	-297.95	292.87	-296.896	291.806	315.3270
CAM2	0.690	-316.86	310.61	-317.287	311.041	314.5190
CAM3	-9.500	-235.59	224.34	-235.590	224.340	314.8610