Transforming Non-COSTAR Aperture Positions to the New Vehicle Reference

M. Lallo, C. Cox. O. Lupie
October 3, 1996

ABSTRACT

A major effect of the on-orbit FGS to FGS re-alignment of day 105 1996, was the redefinition of the vehicle reference frame, (V_1,V_2,V_3). In support of the plan to perform close-out calibrations using the GHRS and FOC without the COSTAR DOB, we have transformed these "Non-COSTAR" aperture positions of the affected SIs into the current frame. FOS non-COSTAR positions were also calculated to support any possible contingencies. We discuss that process, and compare the results to those predicted by a polynomial fit of aperture shifts resulting from the day 105 FGS-FGS re-alignment project.

1. Introduction

Both at the STScI and at GSFC, there exists software to accurately compute HST's pointing, based on knowledge of guidestar and target positions, and of focal plane geometry and internal FGS calibrations. Cox and Lallo (1994) wrote such an algorithm, and demonstrated that the STScI and GSFC codes produced identical results. GSFC/PASS provides a service for the STScI, using this algorithm to calculate pointing based on operational or, if desired, non-operational FGS to FGS alignment information. This allows us to determine the effect on the SI apertures produced by FGS-FGS alignment matrix changes. It was on this processing method that we based zero-points for the SI aperture positions following the day 105 (15 April) 1996 FGS-FGS realignment, and we again used this procedure to derive the needed non-COSTAR apertures.

A Focal Plane Calibration Observation *(Heptathlon)* from April 1993 (pre-COSTAR) was used as the input observations. From these time periods the code used the guide star telemetry to calculate new aperture positions based on the *current* FGS-FGS alignment. This particular observation was chosen for a few important reasons. It was taken before the servicing mission so positional displacements due to COSTAR are not involved; the observation places targets on reference fiducials in the FOC, GHRS, and FOS; the observation used the same guidestars for the three instruments, and the guidestar and target positions are well determined astrometrically, reducing error in the attitude calculation. Procedurally, accurate celestial coordinates are supplied for the guidestars and target, and the code determines the target's corresponding V_2,V_3 positions, during the time period in question. The images are then examined to find the target star's offset with respect to the reference point, in order to determine the V_2,V_3 position of the aperture reference. Once updated positions for the SIs' apertures in question were found, the same delta can be applied to other apertures on the same plate; the angular distances in the FOV between apertures within an SI plate are small, and neglecting rotation over this scale produces differences only at the milliarcsecond level. FOS blue and red sides were computed independently, as were the HRS LSA and SSA. A small correction of 0.15° is also made to the angle relating each SI's coordinate system to the V_2,V_3 frame, which has been shifted.

In the operational SIAF aperture file, part of the Project Data Base (PDB), the science instruments with and without COSTAR are treated as distinct. This allows us to implement these updates without any impact on current operations. This procedure should be completed by the time of this ISR's release.

Serving as an independent check against gross errors, a bi-linear polynomial was derived from the SI shifts calculated for the April 1996 re-alignment. This polynomial relates V2,V3 positions before and after the re-alignment. There is no reason to believe that a linear fit is adequate but we found fitting errors less than 50 mas in the data (COSTAR-affected FOC, GHRS and FOS.). These points lie only in the +V2 half of the focal plane and therefore, to update the non-COSTAR values, we are relying on aperture positions directly calculated by the GSFC/PASS pointing code, rather than on extrapolation across the field of view from this fit. However, we found agreement to within a few tenths of an arcsecond between extrapolated and calculated positions. See table 1.

2. Results

Table 1 lists the V_2,V_3 PDB pre-COSTAR positions for the apertures in the old vehicle frame, the computed numbers for the new frame, the values predicted from the fit derived from earlier data, and the differences. In updating the PDB, we use the calculated values. The calculated minus predicted is 0.4" for GHRS. FOC and FOS are under 0.25". Given the input apertures' pre-COSTAR positional uncertainty, error budget in the image analyses, small errors in the pointing determination, as well as the possibility of positional changes between the time of the pre-COSTAR input observations and SM97, we expect these aperture determinations to be good to within 1.0".

Figure 1 graphically represents the results of the polynomial fit over the field of view based on the positions of the COSTAR-affected FOS, GHRS, and FOC apertures. Comparing the newly determined non-COSTAR aperture positions in the current frame to the polynomial is interesting, since the non-COSTAR calculations could probe errors resulting from the extrapolation to the -V_2 half. In the figure, vectors represent the shifts which transforms a position in the old frame to the new. Largest vectors within the field of view (observed in outer edge of +,+ quadrant) are ~1.7 arcsec long. Calculated shifts for the non-COSTAR SI general positions are 0.8, -1.1 (FOC), -0.5, 0.6 (GHRS), and 0.2, 0.2 (FOS), derived from table 1. These can be easily qualitatively compared to the fit.

3. References

Cox, C., M. Lallo, 1994, A Multipurpose Pointing Analysis Tool. OSG Instrument Science Report SOB-94-02-15

Table 1. Transformed Aperture Positions

Instrument & Aperture Name	V2,V3 PDB (old frame)	V2,V3 Calculated (new frame)	V2,V3 Predicted from fit.	Calculated minus Prediction
FOC F96	+338.785 +191.701	+339.597 +190.601	+339.55 +190.81	+0.047 -0.209
HRS lsa	-228.600 -234.400	-229.051 -233.881	-229.41 -234.03	+0.349 +0.149
HRS ssa	-225.940 -237.060	-226.420 -236.500	-226.76 -236.70	+0.340 +0.200
FOS 4.3 blu	-129.097 +160.202	-128.883 +160.428	-128.69 +160.40	-0.193 +0.028
FOS 4.3 red	-169.607 +119.377	-169.450 +119.890	-169.35 +119.67	-0.100 +0.220

Figure 1: Polynomial fit over field of view, showing the transformation to the post-day 105 vehicle reference. Vectors represent the offset which transforms a position in the old frame to the new. Largest vectors within field of view (observed in outer edge of +,+ quadrant) are 1.7 arc-sec long. Calculated shifts for the general non-COSTAR SI positions are 0.8, -1.1 (FOC), -0.5, 0.6 (GHRS), and 0.2, 0.2 (FOS). Figures derived from table 1.