Boresight Analysis
01 January 2010

WSDC T-026

1. Introduction

Stare-mode observations were taken at 13 different positions along a half orbit on the evening of 31 December, 2009 (UTC). Frames were taken every eleven seconds, with each individual pointing lasting for a minute. Pointings were denoted 00526a through 00526m, each pointing consisting of five useable frames. Examination of the individual frames by M. Skrutskie and P. Eisenhardt revealed that the spacecraft had not completely settled (no settling time had been allocated prior to taking exposures) and that frames showed varying degrees of drift. Paradoxically, the degree of drift (as determined from the apparent roundness of the stellar images) was generally found to be minimal for the first exposure in each set of five, becoming more apparent for each subsequent exposure. Since the drift is small compared with the requirements for boresight alignment, and since the spacecraft never completely settled in any set of exposures, no estimates were made of residual drift, and no coordinate adjustments were made to compensate for it.

2. Analysis

The following table summarizes the ADCS-reported frame center positions and position angles, as well as the positions and position angles computed by the WISE Science Data System, for each frame in the stare-mode test. Position reconstruction was done only for band W1; values in other bands were not computed. "Frame" lists the actual level 1b FITS image used, and the Midpoint times are as extracted from the level 1b FITS headers. BFRA0, BFDEC0, and BFPA0 are initial, band 1, Level 0 ADCS frame center RA, Dec, and PA in degrees. BFRAF, BFDCF, and BFPAF are final SFPREX frame center solutions measured by pattern-matching against 2MASS point sources and extracted from the 00526*-meta-sfprex.tbl files.

Frame	Midpoint UTC	BFRA0	BFDEC0	BFPA0	BFRAF	BFDCF	BFPAF
00526a001	2009-365T22:01:38.182	267.577975	66.429303	81.025092	267.674408	66.484931	81.024051
00526b002	2009-365T22:05:18.229	240.061142	61.608981	56.177348	240.105645	61.680947	55.972604
00526c002	2009-365T22:08:36.264	222.167669	53.012734	41.041032	222.177186	53.089883	41.198630
00526d002	2009-365T22:12:05.307	210.707429	42.668823	32.498368	210.695886	42.743549	32.570446
00526e001	2009-365T22:15:23.342	202.646519	31.518744	27.609274	202.633460	31.594112	27.659261
00526f001	2009-365T22:18:41.381	196.348367	19.973380	24.858178	196.331611	20.046475	24.769730
00526g002	2009-365T22:22:21.424	190.926352	8.234976	23.527616	190.911262	83.051676	23.590129
00526h001	2009-365T22:25:28.459	185.820883	-3.569696	23.320891	185.803882	-3.502209	23.229637
00526i002	2009-365T22:29:08.506	180.581268	-15.346800	24.185557	180.564020	-15.281395	24.084602
00526j002	2009-365T22:32:26.541	174.710478	-26.985565	26.318638	174.692580	-26.920382	26.244244
00526k002	2009-365T22:35:55.584	167.487353	-38.325992	30.238483	167.472449	-38.263621	30.220061
00526l002	2009-365T22:39:24.623	157.641207	-49.061467	37.078512	157.635964	-48.999495	37.056840

The correction to be made to the ADCS Boresight is as follows:

RA correction = BFRAF – BFRA0
Dec correction = BFDCF – BFDEC0
PA correction = BFPAF – BFPA0

Visual inspection of the individual frames revealed that in 10 out of 12 cases the first frame (001) at each pointing had the roundest, most compact images. However, Level 1b pipeline products were not available in all cases, and in particular, we were forced to use the second frame for scans 00526b, 00526d, 00526g, 00526k, and 00526l. No Level 1b products were available for 00526m. In at least some cases this was due to pattern matching failures in the SFPREX module, which was used to generate the frame coordinates of interest.

C. Grillmair verified the SFPREX solutions for all successful runs by over plotting 2MASS sources onto the level 1B images (e.g. those with updated WCS coefficients in their headers) in ds9. Figure 1 shows an example of such an over plot for a frame with noticeable drift and obviously out-of-round images. Despite the smearing of the images, MDET/SFPREX were successfully able to detect and match sources to the 2MASS point source catalog. Systematic deviations on the order of a pixel or more are often seen in stars near the frame edges, presumably due to as-yet uncharacterized focal plane distortions. However, the majority of stars were well matched to 2MASS sources for all frames investigated here, and

the SFPREX field-center coordinates were adopted for offset calibration purposes.

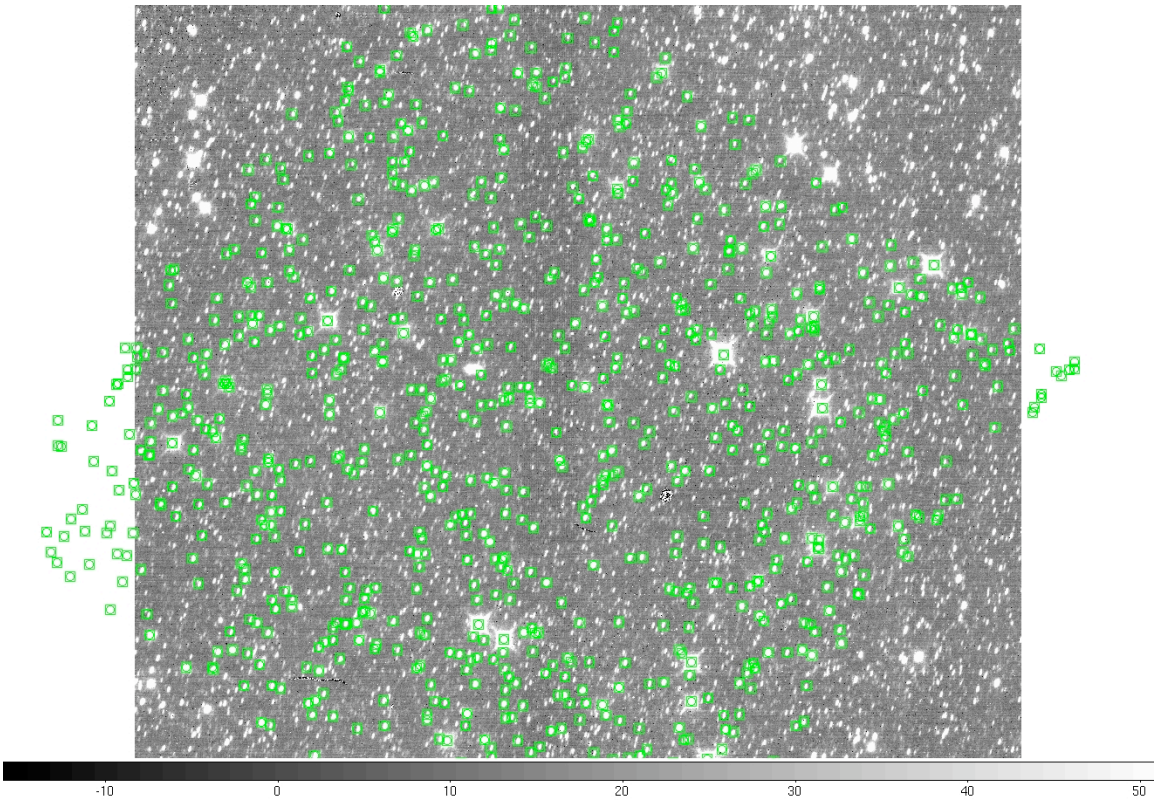

Figure 1. An overlay, using SFPREX-computed WCS coefficients, of 2MASS point sources on 00526l002-w1-int-1b.fits. This is an example of a "second-best" image from the stand point of residual drift but, though the images are noticeably out-of-round, MDET/SFPREX evidently had no difficulty in detecting sources and matching them to the 2MASS catalog. (The offset angle between the image and the 2MASS point source table is a consequence of an IRSA "box" search, which is aligned with the equatorial coordinate system).

Using the values in Table 1, Figure 2 shows a plot of (cosine corrected) ΔRAs, ΔDecs, and their quadrature sum, as a function of ecliptic latitude (ecliptic latitude decreasing monotonically with time during this exercise). The amplitude of Δr is larger than the 3-arcminute (radius) offset found by Ball in their WISE Boresight Alignment Cal memo. Part of this discrepancy is claimed to be due to velocity aberration (which would contribute up to 22 arcseconds compared to the positions measured in an inertial frame), though the BFRA0 and BFDEC0 values in Table 1 are based on Star Tracker measurements, which should be subject to identical velocity aberrations.

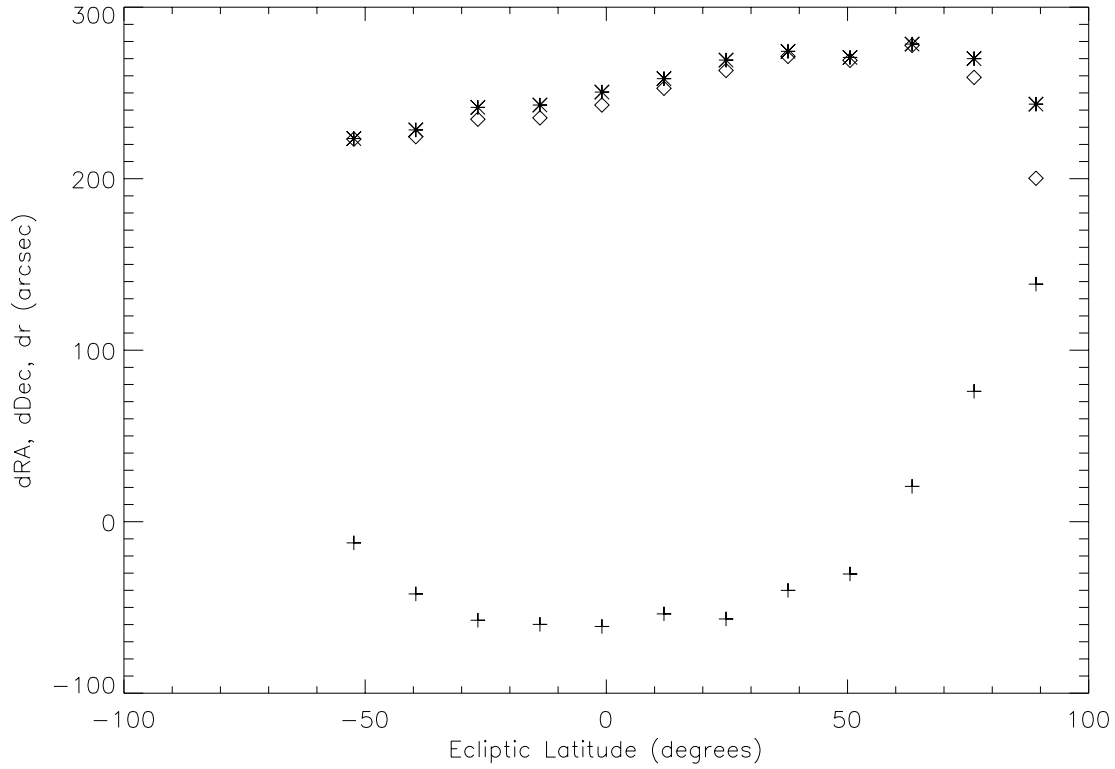

Figure 2. Coordinate offsets computed from Table 1 as a function of ecliptic latitude. Plus signs indicated cosine corrected differences in RA, while diamonds show differences in declination. Asterisks show the quadrature sum of the two.

3. Conclusions

Offsets between ADCS coordinates and SFPREX reconstructed frame centers have been measured for a set of dedicated, staring-mode observations. Ball Aerospace has used the reconstructed positions (though not the offsets) to generate independent, spacecraft x, y, and z offsets, applying corrections into which we currently have no visibility. As of this writing, the Project has apparently decided not to update the spacecraft frame table, since the offset is small enough that spacecraft health and safety are not an issue, and the WSDC pipeline can make appropriate corrections on the ground as necessary.

Authors: C. Grillmair (IPAC/Caltech) & R. McMillan (LPL/Arizona)