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Results of WFC3 Thermal Vacuum Testing - Repeatability of the Channel Select Mechanism

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ABSTRACT

The channel select mechanism (CSM) on WFC3 is used to divert the optical path of the incoming beam to the WFC3 IR channel. The contract end item (CEI) specification for the CSM is that the position of point sources in the IR channel should vary by less than 20 milliarcsec after movement of the CSM. As part of the 2004 campaign of WFC3 thermal-vacuum tests, the image stability of both WFC3 channels (UVIS & IR) was measured over a wide range of environmental temperatures, simulating thermal variations that could occur in flight due to orbital occultations and slewing between hot and cold orientations. Some of these tests involved rapid switching between the WFC3 channels to track the image stability over large slews in temperature. These data imply that the CSM meets its CEI specification for repeatability.

During the 2004 campaign of WFC3 thermal-vacuum tests, we measured the image stability via a variety of tests (see Brown 2005, ISR WFC3 2005-11). In all of the tests, images were obtained in both the UVIS and IR channels while the thermal environment was varied to simulate changes due to orbital occultation and telescope slews. The speed of the channel cycling was increased considerably for the tests involving large temperature variations, in order to track accurately in both channels any induced motion. These data are thus useful for providing a conservative estimate of the channel select mechanism (CSM) repeatability.

The contract end item (CEI) specification for the CSM requires that the position of point sources in the IR channel be repeatable to better than 20 milliarcsec after movement of the CSM. The CSM is a reflective element in the WFC3 optical path when imaging in the IR channel, and it is removed from the path when imaging in the UVIS channel. Thus, the CSM repeatability is only an issue for the IR channel.

An inspection of the image stability tests (Brown 2005, ISR WFC3 2005-11) shows that the 7th, 8th, 9th, & 10th iterations of the nominal test (Figures 9-12 in Brown 2005) were not associated with any significant anomalies in the CASTLE, and involved rapid switching between the detectors. The WFC3 image sequences in these tests consisted of 10 UVIS images, 3 IR images, 10 UVIS images, 3 IR images, etc., with the cycle repeated for several hours in each test. A CSM motion occurred at each transition between detectors. In the tests above, there are 105 IR image pairs where the first IR image in a set of 3 was obtained 23.6 minutes after the last IR image in the previous set of 3; the remaining such pairs (13 in all) have longer time intervals, ranging up to an hour. These 105 pairs can be used to place an upper limit on the motion due to the CSM non-repeatability. It is an upper limit because the position of the point source in these images will vary from both the CSM non-repeatability and the induced image drift, which is occurring over a longer timescale. In these tests, the image drift in the IR channel (due to the varying thermal conditions) can cause 5-10 milliarcsec of drift in the 23.6 minute interval between paired images. These drifts are systematic and track the sense of the drifts in the UVIS channel, so the long-timescale drift should not be attributed to CSM non-repeatability. One can fit the long-timescale drift and subtract this motion before measuring the repeatability of the CSM, but this is not necessary, because the CSM clearly meets its CEI specification even with the drift unsubtracted. However, we did subtract the motion of the optical stimulus, which is not inherent to WFC3 (i.e., we use the data in Figure 9b, 10b, 11b, and 12b from Brown 2005).

Of the 105 image pairs, the point source motion was ≤ 5.6 milliarcsec in 68% of the pairs, ≤ 7.9 milliarcsec in 90% of the image pairs, ≤ 8.3 milliarcsec in 96% of the image pairs, and ≤ 8.8 milliarcsec in 99% of the image pairs. In one image pair the point source motion was 13 milliarcsec - a clear outlier in the distribution. The CEI specification was met in all 105 image pairs, even though the long-term drifts from changes in the thermal environment was not subtracted. If one approximates the long-term thermal drift vs. time using a 3rd-order polynomial, and subtracts that drift from the measurements above (which leaves small but non-negligible residuals on the order of a few milliarcsec), the repeatability of the CSM looks even better: Of the 105 image pairs, the point source motion was ≤ 2.6 milliarcsec in 68% of the pairs, ≤ 4.8 milliarcsec in 90% of the image pairs, ≤ 6.0 milliarcsec in 95% of the image pairs, and ≤ 6.8 milliarcsec in 100% of the image pairs.

The image stability test data imply that the CSM meets its repeatability requirements.