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Document Title:	**FTS-2 Mirror Mount Tests**
Document Number:	**SC2/FTS/MEC/002**
Issue:	**Version 1.0**
Date:	**30 October 2006**

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Change Record

Issue	Date	Section(s) Affected	Description of Change / Change Request Reference / Remarks
0.1	17/06/02	All	First draft
1.0	16/10/06	All	CDR version

Contents

1. Introduction

Due to the large size of the FTS-2 mirrors and limited mounting space, custom optical mounts are required. Various designs were considered for the mounts, but a simple kinematic mount based on a fixed spherical bearing was selected as the final design. This design is described in more detail in SC2/FTS/MEC/001. A prototype mount was built in order to test the sensitivity and repeatability of the adjustment using the motorized actuators, and confirm that the maximum mirror mass could be supported. This document presents the results of these prototype tests.

These tests were performed in July 2006, using the Zaber Technologies stepper-motor-based linear actuator. As a result of the pickoff mirror unit redesign in August 2006, smaller piezo-based actuators were selected in order to fit in the available space.

2. Testing Procedure

Testing was done using a small telescope with illuminated reticule configured as an autocollimator aimed directly at a test mirror attached to the mirror mount. The reticule has two sets of crosshair lines 20 μm in width and spaced 200 μm apart, corresponding to a spacing of 135 arc seconds between the lines. The reticule crosshairs are reflected back to the observer, and can be aligned to their own reflection using the technique described in:
http://www.uleth.ca/phy/naylor/pdf/dihedralangle.pdf

Sensitivity was tested by aligning the edges of the reticule cross hairs with the edges of the retro-reflected images. The actuator is then stepped, causing the mirror to tilt and the reflected cross hair images to translate parallel to the cross hairs etched in the reticule. The actuator is stepped until the first reflected cross hair is aligned with the second cross hair etched in the reticule. The recorded number of steps corresponds to a 135 arc second translation, or a 67.5 arc second tilt of the mirror.

Repeatability (and backlash) was tested by aligning the edges of the reticule images as before, then stepping the actuator by a predetermined number of steps in one direction and then the same number of steps in the opposite direction. If there is some residual gap or overlap between the crosshairs, the number of steps required to open or close a gap gives a measure of the repeatability.

Backlash in the actuator was tested by turning the actuator on and off several times with the edges of the cross hairs aligned. Any movement of the reflected cross hairs would indicate backlash in the actuator during start up and shut down operations.

3. Results

The testing of the mirror mount confirmed that it will satisfy all sensitivity and repeatability requirements for a mirror of the expected mass. The sensitivity measurements are given in Table 1.

Table 1. Measured number of actuator steps to traverse the gap between crosshair lines.

Trial #	Start Position	End Position	Number of steps
1	159280	159880	600
2	159260	159860	600
3	159290	159885	595
4	159270	159870	600
5	159290	159890	600
6	159295	159890	595

The sensitivity of the mount is much finer than the 7 arc second width of the reticule line; it was calculated that each step of the actuator corresponds to a mirror tilt of 0.1132 arc seconds, well within the alignment requirements of the optical system, and agreeing well with the theoretical value of 0.1137 arc seconds from the actuator specifications and mount geometry.

To test the repeatability of the mirror mount the cross hairs were aligned on edge, moved a given distance and then returned to their original position. The discrepancy between the initial and final positions for each measurement is shown in Table 2. The largest variance between initial and final position was less than 10 steps, and was observed at the largest displacements. This displacement is much larger than what would be required in normal operation. It should also be noted that there was also small errors introduced in the measurements due to small movements in the setup.

Table 2. Repeatability measurements. The third column indicates the number of extra steps required to re-align the images.

Test #	Initial Position (steps)	Displacement (steps)	Discrepancy (steps)
1	84910	+500	0
2	84910	+500	0
3	84910	-500	0
4	84910	-500	≤ 5
5	84910	+1000	0
6	84910	+1000	0
7	84910	-1000	0
8	84910	-1000	≤ 5
9	84910	+5000	0
10	84910	+5000	$5 \leq x \leq 10$
11	84910	-5000	≤ 5
12	84910	-5000	$5 \leq x \leq 10$

The start up sequence did not have any influence on the position of the actuator. The actuator was both switched on and off through the computer interface as well as manually by disconnecting the power and resulted in no measurable movement.

4. Conclusion

The single spherical bearing design has the potential to be very cost effective, simple and space efficient, and has proven to meet the performance requirements. The machining time and complexity is minimal and can be easily modified for different types of adjusters. The mount will thus be used in both the pickoff mirror assembly and the larger fixed mirror units.