SELECTION OF THE VENDOR FOR THE MIRRORS

Spartan IR Camera for the SOAR Telescope

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This note addresses the vendors' proposals for the mirrors of the Spartan IR Camera and the reasons for choosing Axsys Technologies.

1 Vendor's proposals

The mirrors are collimator and camera mirrors for the f/12 channel, collimator and camera mirrors for the f/21 channel, and two fold mirrors. See Figure 1.

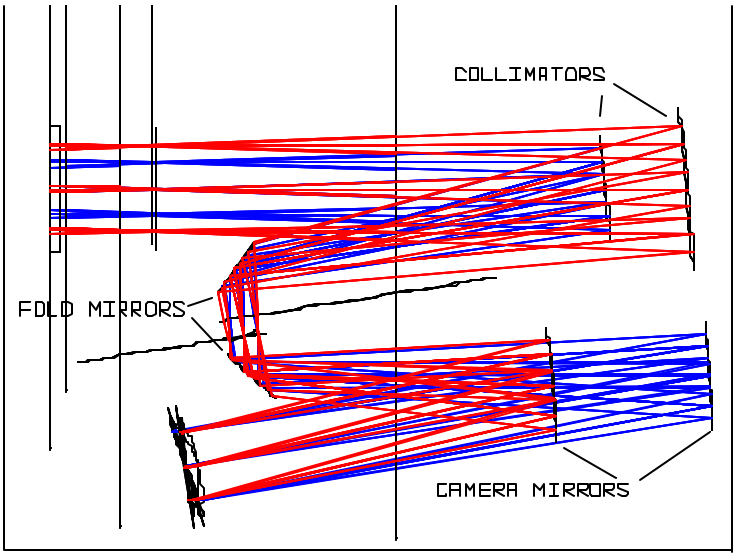

Figure 1 Optical layout.

Request for quotes for the mirrors and aluminum cells were sent to Space Optics Research Laboratory (SORL) of Waltham, MA, Hastings Controls (HCI) of Pittsburgh, PA, REOSC of France, and Axsys Technologies of Rochester Hills, MI. The mirrors are to be delivered in

aluminum cells. By ordering both the mirror and cell from the vendor, we avoid the problem of designing for the thermal contraction between the mirrors and our all-aluminum mounting posts.

1.1 Axsys

Axsys Technologies submitted a quote on 8 January 2002. They propose a one-piece aluminum mirror and mirror cell. The aluminum is turned on a numerical lathe with a diamond bit. A 25-μ layer of nickel is deposited on the aluminum, turned, and then polished and tested. A gold film is deposited on the nickel. They meet all specifications.

Axsys has a superior method for metrology. They pin the aluminum mirror to an aluminum jig, which contains alignment references. The alignment references locate the mirror in the test jig. With this scheme, the mirror position and the position of the vertex of the parent are known to a few μm. We can position the mirror using the same alignment pins.

1.2 Hastings Controls

Hastings Controls submitted a quote on 1 October 2001. Their design of the mirror cell neglected to consider thermal contraction, and it included 6-axis adjustment of the mirror, which was not in the request. We worked with their subcontractor for mechanical design to clarify the requirements, and they submitted a revised concept design.

They submitted two mechanical designs. One uses Invar mirror cells and the other uses a spring to accommodate the glass mirror. The Invar mirror cell will stress the mirror because the cell will cool faster than the mirror. If the contact area between the cell and mirror is less than $1/6^{th}$ of the area of the side, the mirror will crack. Therefore the contact between the cell and mirror must be carefully controlled. The spring is a better design.

1.3 REOSC

REOSC did not respond.

1.4 SORL

SORL submitted a quote and a concept drawing on 24 January 2002. They propose aluminum 6061-T6 tangent bars to hold the mirrors. This concept is technically sound. The tangent bars solve

the problem of differential thermal contraction between glass and aluminum. They propose to glue the glass mirror to Invar pads, and they have done this successfully for other projects.

SORL is not able to meet the specification for metrology, that the location of the vertex of the parent be located to an accuracy of (0.15, 0.55) mm. Their metrology is derived from measurements of the Hindel sphere and other parts of their test setup. Because the errors build up, they guarantee that the mirror position and the vertex of the parent are known to a few mm, a thousand times worse than Axsys.

This means the instrument must be aligned optically. Two parameters, the positions transverse to the optical axis, of each aspheric mirror must be found by means of optical alignment. (The tilts can be set by means of the coordinate measuring machine.) The optical alignment involves measuring the Strehl ratio at 600nm to a precision of ½%.

2 Choice of Vendor

We chose Axsys because of cost and three technical reasons. SORL's quote is 26% higher. HCI's quote is 60% higher.

2.1 Alignment

The accuracy of the location of the off-axis, aspheric f/12 collimator mirror is (±0.15, ±0.55, ±1.) mm, and the accuracy of the tilt is (±0.2, ±0.5, ±4) mrad to achieve a loss in the Strehl at 1.65μ of 4% for 37 alignment parameters. The accuracies of the other mirrors are comparable.

We plan to position the optics with a DEA Diamond 01.02 coordinate measuring machine (CMM). For short strokes, the 1-σ accuracy is 0.75μ independent of direction. The error is linear with the length of the stroke and doubles at a stroke of 300mm.

With Axsys mirrors, the positional errors of the optics are all well within the accuracy of our CMM, and no optical alignment is necessary. The only optical adjustment is focus.

2.2 Focus change between room temperature and 77K

With a glass mirror and aluminum cryogenic optical box, the focus changes between installation at room temperature and operation at 77K. Aluminum shrinks 4mm/m, and the focal lengths of the mirrors are 0.5–0.8 m. Glass shrinks 40 times less.

With the aluminum mirrors from Axsys, the mirror and cryogenic optical box are both made of the same material, and the focus does not shift. Design and fabrication of a focus shifting jig and the cool-down cycles needed to check focus are avoided.

2.3 Project management

Axsys appears to manage its projects professionally. They delivered their quotes close to the promised dates. They respond to questions in a timely fashion. Within 4–6 weeks after recipt of the order, they will deliver drawings and a schedule for our approval. The schedule will have milestones, which we can monitor.