ADC service trip of June 2007

On the night of 5/9 Perry noticed that the east prism was not always tracking properly, especially at lower elevations. The next night things worked OK.
The following night (5/11) the east prism found to be hung up (stuck?) a few degrees away from the desired position. It eventually went back to zero but did not move well on a few tries.

Maureen Conroy's assessment (e-mail dated 5/10) of the motion of the prisms that week

> Perry brought to our attention that the ADC east prism (motor 0, homepos=32.3) is not performing consistently. He noted that at low elevations, it could take 15-30 extra seconds for the east prism to arrive at the target position after the west prism had already arrived.
>
> In looking at the logs for last night there was one field taken at high elevation, commanding the prisms to +/- 48 degrees. As the telescope slews, the prisms usually are commanded about 2 degree/move to track the elevation. The east prism appeared to start missing steps by the time it reached -20 degrees. The behavior appeared to worsen as it moved gradually into the -30 degree range. After repeated commands it finally seemed to "break free" at about -40 degrees and actually moved almost 10 degrees for its final move.
>
> From this position it then slowly tracked from -48 degrees back to -20 degrees at a rate of about 0.05 degrees/move. There didn't appear to any discrepancies in these moves. (This is the normal observing tracking motion.)
>
> Later in the night when commanded to -23 degrees, the prism did show some additionally delays starting around -18, though these were smaller and corrected quite quickly.
>
> I quick look at the log from earlier in the week also shows an instance where the east prism was commanded to -64 degrees, and it apparently never reached that position, appearing to stall around -57 degrees. It then appeared to work normally as it tracked backwards from -57 degrees to -50 degrees.

The ADC continued to run until the end of the run on 5/13 and plans were formulated to evaluate the system.
Suspicions included
Electrical problem –

- Cabling problem – improperly mated connectors, broken wire
- Motor not getting proper current – controller misprogrammed
- Prom failure in control circuit,

Mechanical problem

- something on the bearing races
- another problem with the races or the ball bearings
- damage to the spur gear teeth or ring gear teeth

The motor connections and windings were checked before the ADC was taken off on May 14 by Ken VH with an ohm meter – both phases of both motors were found to be fine (2.8 or 2.9 ohms through the cables & windings)

Lens 3 was next separated from the rest of the Wide Field Corrector lens assembly for access and ease of manipulation. The motors and cables were inspected and nothing odd was found.

I examined the system mechanically on May 16 – the force required to turn the spur gear and thus the ring gear was checked manually and found to be variable – requiring a lot of force in some spots and much less in others. I did not have a convenient means of measuring this so the results are only qualitative.

With some effort, the spur gear was removed from the gear box shaft on May 17 and the force to turn the ring gear was directly checked to verify that the problem was not in the gearbox. The ring gear indeed required less force in some spots and more in other areas.

After consultations in Cambridge it was decided that Bob Fata should come out and look at the ADC assembly and be prepared to disassemble it if necessary.

Bob Fata, Joe Zajac and Kevin Bennett arrived on Friday, June 8.
We examined the ADC. Bob Fata did not like the discoloration of the east gearbox shaft (rust?) under the small gear. The turning force was found to be variable and much larger than they remembered when the unit was new. Joe measured the actual force required to start the motion of the ring prism as well as the amount of force needed to stall the drive motors & gearboxes. He had a special electronic sensor box for this purpose.
ADC zenith pointing – 9 to 20 pounds
ADC near horizon pointing – 15 to 30 pounds.
motor force (with spur gear) 50 pounds.
The Safety factor was less than two and should have been 5 to 8.

The required parts for disassembly of the ADC were gathered – lifting fixtures, covers, stand legs, tools, The lifting fixture was tested. A sheet of foam was attached to the top of the lifting fixture to deflect any dust falling from above as the optics are exposed during moves with the crane. The motors and spur gears were removed from their normal location and reattached on the outside of the retaining ring so that the wires could remain intact. Some of the wires were a little snug after this move.

On Saturday, the ADC was flipped over in its support fixture. Legs were attached to the fixture and it was set down on the plastic covered floor. Hair nets and masks were put on by all 4 of us. Bob and Joe put on Tyvek suits since they would be working more closely with the exposed optics. The bottom retaining ring with the motors, home sensors and wiring was removed. The home cable was tugged at before we realized the wires were not limited to the retaining ring. The appropriate connector was found and the sensor was disconnected. The cover plate and lifting fixture were attached to the east prism and it

was lifted out and trunions were attached. The prism set on the plastic covered crate lid. and then lifted via the trunions and turned over to access the bearings. A temperature sensor wire was broken at its connector while covering the ADC with L3 and the West prism with the bottom cover to protect the

No obvious problems were seen with the ball bearings or the gear, though visibility was not great. A small amount of Krytox LVP grease was applied to every other ball in the bearing and then the bearing was rotated. It turned much better. The required force was lower and uniform. The exposed optical surface was cleaned. A small brush was used to pick up the larger contaminants on the glass and then the surface was swept with a stream of UHP nitrogen gas. A bird cage structure was put over the prism and covered with the Wide Field Corrector plastic while we worked on the second prism.

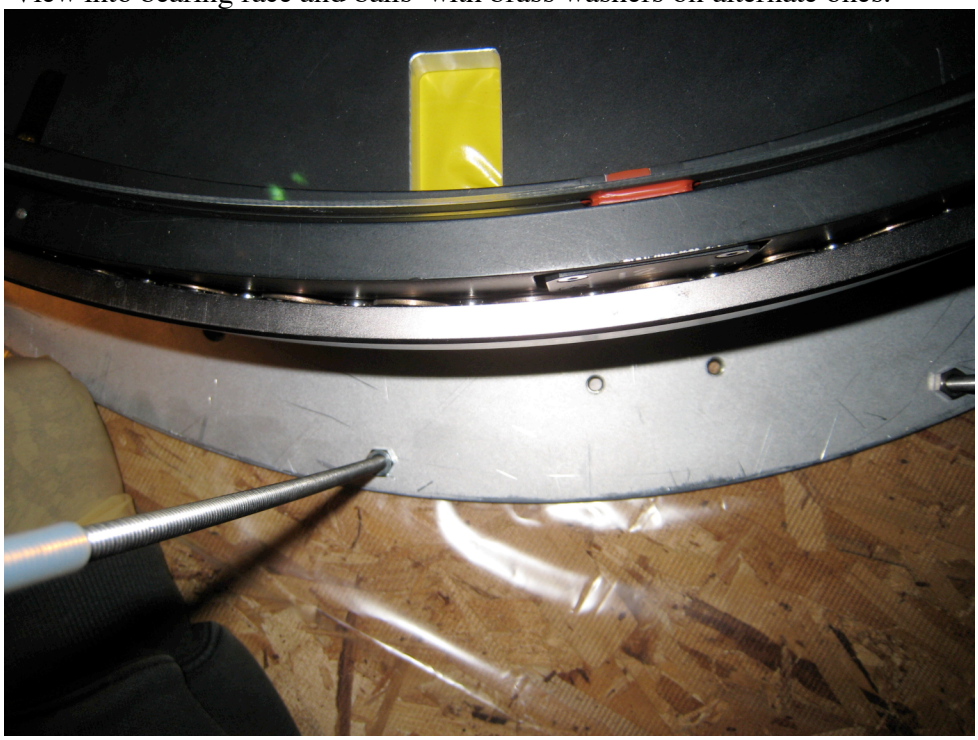
The spacer ring between the bearings was removed and the safety screw was backed out prior to lifting out the second prism. We attached the trunions from the ADC since we did not have a full set and set the second prism down on plastic spread out on the floor. The second prism was also flipped over, the bearing greased, and the optical surface cleaned.

The inner surface of L3 was then cleaned, then the west prism was reinserted. The second surface of this prism was cleaned (without blowing), the safety screw repositioned and the spacer ring cleaned and reinserted. The east prism was then inserted and its second surface cleaned. The retaining ring was finally reinstalled and a couple of wires which had been damaged in the handling were fixed. The motors were reinstalled (a larger pin was put into the replacement gear assembly) and connected up. The ADC was tested with John Roll at the controls and found to be working well.

pictures of procedure
Crane picking up unit with ADC lifting fixture.

Bob Fata and Kevin Bennett preparing trunions for the prism lifting fixture prior to extracting the east prism.

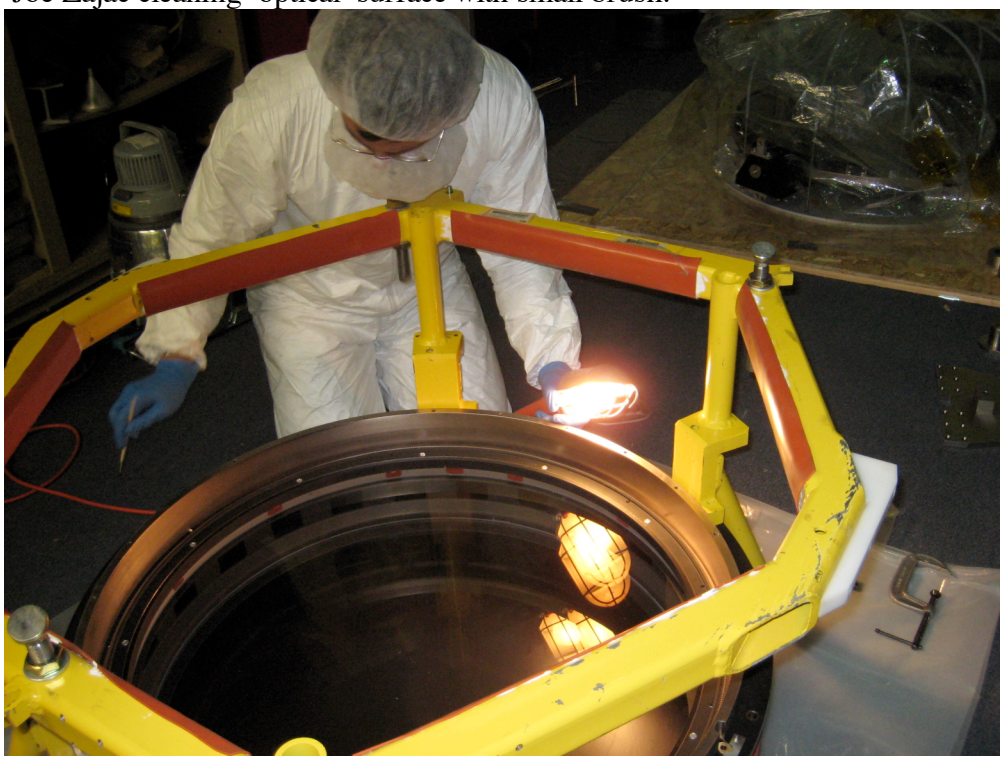
View into bearing race and balls with brass washers on alternate ones.



East prism covered up in its bird cage.

Bob Fata applying grease to bearings the west prism under foam umbrella.

Joe Zajac cleaning optical surface with small brush.



On 5/9 Perry Berlind noticed that the east prism of the ADC was not tracking properly at low elevations. A couple of nights later the prism stuck a few degrees from the target position. Maureen Conroy found that there were problems with the east prism's tracking prior to 5/9. The ADC worked acceptably through the end of the run.

Suspicions for the cause of the problem included cables, connectors, drive circuitry, bearing problems and gear problems. The electrical path to the motor was ohmed out by KVH on 5/14 and found to be good (2.8 or 2.9 ohms through cables and windings. Marc Lacasse looked at the system next and found no visible problems though there was a mechanical binding sensed when turning the spur gear and later, after the spur gear was removed, in turning the prism's ring gear.

Bob Fata, Joe Zajac and Kevin Bennet arrived on 6/8 to work on the ADC.
The force to turn the gear was variable 9-20 pounds when the prism was horizontal and got as high as 30 pounds when the ADC unit was tipped. The motor was also tested and found to deliver 50 pounds of force at the edge of its gear. Bob Fata remembered a lower force to turn the gear and the safety factor was insufficient with the current conditions.

On 6/9 the ADC was carefully disassembled with the fixtures shipped from Cambridge. The two bearings were lightly greased and the six optical surfaces cleaned. The ADC was reassembled and we found that the force required to turn the prism went down a factor of 3 to about 8 pounds and was very uniform. A couple of wires damaged during disassembly were repaired and the unit was successfully tested Saturday evening.

Pictures of the process are available at
http://www.cfa.harvard.edu/~mlacasse/Photos/