WIYN Project

Wisconsin **Indiana** **Yale** **NOAO**

MEMORANDUM

TO: For the record
FROM: Dan Blanco
SUBJECT: Elevation axis polar moment of inertia
DATE: August 6, 1994

Recently there has been some debate over the polar moment of inertia of the WIYN telescope elevation axis. This memo documents calculations done to experimentally determine this quantity.

The torque applied to the elevation axis while tracking at some arbitrary acceleration, speed and position can be modeled by:

$$MotorDemand = \sum M = I\alpha + T_f(\omega) + T_b(\theta)$$

Where M, the sum of the moment, is comprised of the torque required to accelerate the telescope ($I\alpha$); a torque needed to overcome friction (T_f) which is usually speed (ω) dependent; and a torque required to overcome any imbalance (T_b) which is dependent on the elevation angle θ.

Tests were done to determine the unknown quantities T_f and T_b in the following way; snapshot data were obtained while tracking the OSS at constant speed for several speeds thus isolating the unknown quantities. The snapshot resolution was adjusted for each set so that data was gathered over the full range from 85 to 20 d elevation. These tests were repeated for five rotational speeds at 1 d/s, 0.5 d/s, 0.25 d/s, 0.125 d/s and 0.0625 d/s.

The measured torque demand for three speeds (1, .25 and 0.0625 d/s) tracking down are shown in figure 1. There is a clear and repeatable variation of the demand torque depending on elevation angle indicating the telescope was out of balance. However there is apparently no dependency of torque on speed over this range. The average torque for the five speeds was constant within a 3% standard deviation.

We can conclude that the friction torque T_f remains constant over the speed range from 0.0625 to 1 d/s. This greatly simplifies the calculation of the moment of inertia. We can rearrange equation 1 to the differential form;

$$M_1 - M_2 = I(\alpha_1 - \alpha_2)$$

Which can be solved for the polar moment, I.

Tests were done tracking the OSS at constant acceleration for several accelerations. Snapshot resolution was adjusted to obtain data sets over a small range from 80 to 68 d elevation. Snap shot data was taken over the first five degrees of travel ensuring a constant acceleration throughout the test. This was repeated for acceleration rates of 0.1, 0.025, 0.00625 and 0.0015625 d/s^2 tracking upward as well as down.

Six determinations of the polar moment of inertia were made by solving equation 2 using torque and actual acceleration values measured at 0.1 d/s^2 compared to the slower accelerations for tracking up and tracking down. Values at lower acceleration rates were not compared to each other since these measurements were more effected by noise. The result based on these numbers is a polar moment of inertia:

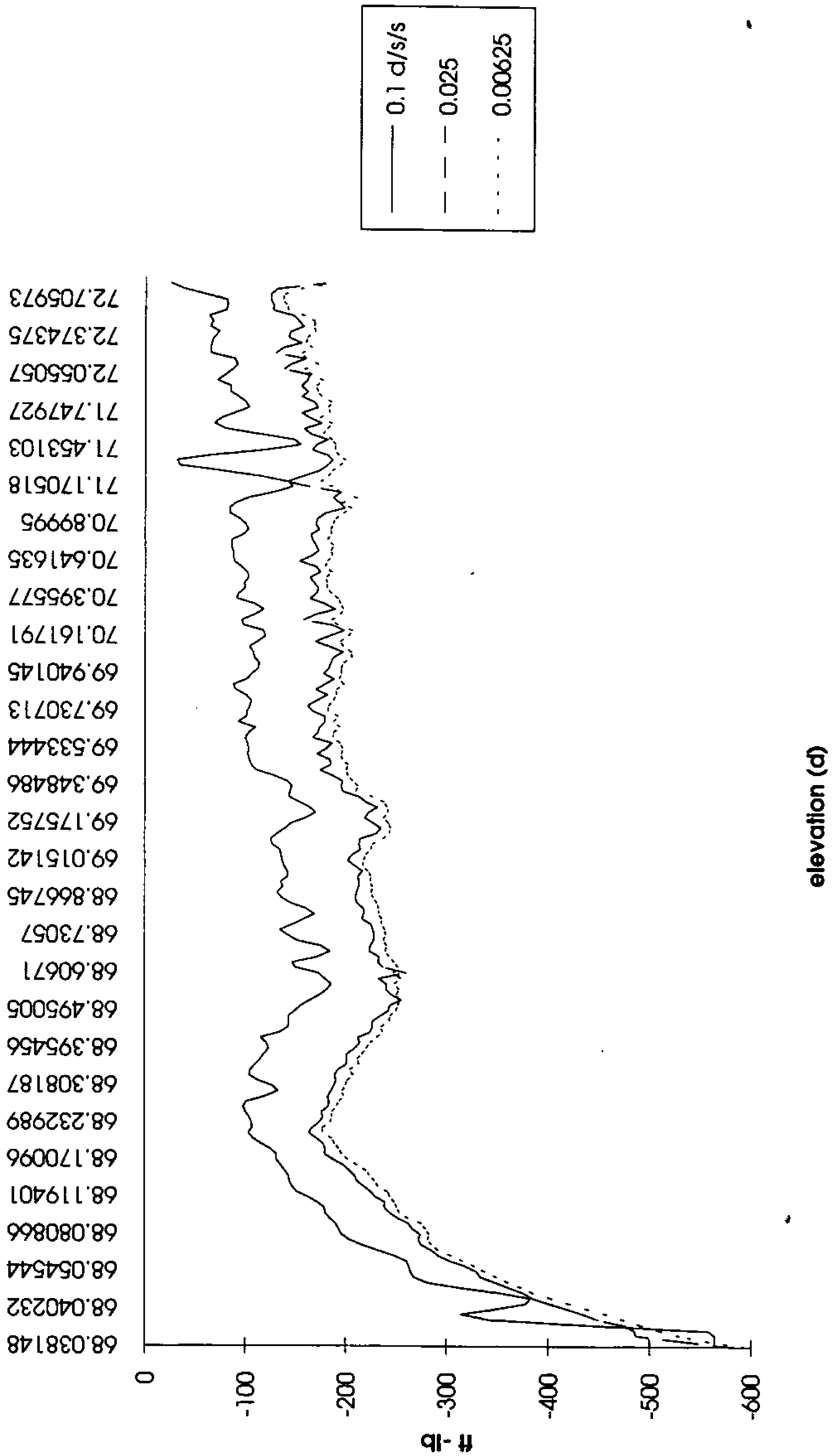
$$I = 6.4 \times 10^5 \text{ in lb s}^2 \text{ +/- } 7.6\% \text{ standard deviation.}$$

Several values of the elevation polar moment of inertia have been stated. The value given in the final FEA report (Gunnels, 1992) was 5.9×10^5 in lb s^2; due to a typographic error the value stated in the control system design requirements document was 5.5×10^5.

The value recorded here shows fair agreement to Gunnel's value (8.4% difference) . Considering the additions to the OSS in the form of the OSS electronics box, cabling, fixed counterweights, and the small increase due to moving the primary mirror cell one inch away from the elevation axis, which were not included in the FEA model, the value presented here seems reasonable.

XUP2.XLS Chart 1

Torque Demand @ Constant Acceleration (tracking up)



Torque Demand @ Constant Acceleration (tracking down)