To: File
From: Jon Hagen
Date: May 31, 2002
Subject: Elevation drive pinion torques with new hydraulic damper system

The Gregorian drive system uses 8 independent motor/transmission/drive pinion units. Load sharing is accomplished by sending essentially the same torque command to every motor. (The actual torque commands are slightly different to provide bias against backlash). Each drive pinion therefore supports 1/8 of the Gregorian's downhill component of weight.

**Dampers on all motors**
As originally conceived, the hydraulic damper system was to consist of a torsion damper connected to the shaft of each motor. Each damper would provide a force proportional to the square of the velocity. The damping coefficient would be chosen such that the damping force produced at maximum rated slew speed would be equal to the torque needed to counteract gravity at 20 degrees, the maximum elevation angle. That way, if the electric drive system were to fail with the dome at 20 degrees, the dome's downhill slide would immediately be limited to the normal maximum slew speed. Throughout the downward slide, the velocity would be controlled according to

reaching zero as the dome reached the bottom of the arm. Throughout the free descent, the force on the pinions is just the normal gravitational load.

To slew downhill at the maximum slew rate, the motors would supply downhill torque (pushing the dome downhill, against the damper resistance). This torque, which is a maximum at the bottom of the azimuth arm, is be given by

where $T_{20}$ is the torque needed to hold at 20 degrees. Note that the motor torque is never greater than when the system had no dampers and that the torques in the transmissions and drive pinions are exactly the same as in the system without dampers.

**Dampers on half the motors**
When only half the motors are fitted with dampers, the maximum stress on the pinions and gear boxes on these motors is twice what it was without the dampers. This, of course, occurs at 20 degrees, moving downhill at slew speed.