VLB ARRAY MEMO No. 160

National Radio Astronomy Observatory

Very Large Array

December 14, 1982

To: VLBA Antenna Group, VLBA Coordinating Group

From: W. G. Horne

Subject: Slew rates for VLBA antennas

VLBA Memo No. 154 sets forth considerably more stringent requirements on slew rates in both Azimuth and Elevation than has previously been considered for the VLB antenna. I do not attempt to evaluate the need for such requirements but will point out the impact of such requirements on the design of drive and control systems, servo accuracy and structural systems.

(1) For purposes of discussion only let us assume that the antenna configuration is similar to the existing VLA antennas ie a "Yoke end alidade" type rather than a wheel and track antenna.

For the existing VLA antenna the wind torgue constants are:

EL. Tc = 142 Ft. lbg. x (Wind Velocity in MPH)² AZ Tc = 174 ft. lbs x (WInd Velocity in MPH)²

In sheet 2 of Memo 154 the Azimuth and Elev. slew rates for a VLA 34m (which I assume should be 25m) are given as 0.7 deg/sec and 0.3 deg/sec (40°/min and 20°/min) while the VLBA goal is proposed as 12° /sec (720° /min). If the VLBA, has similar design constants as the VLA antenna and the capability of driving in up to 60 MPH wind is held then the Az Axis torgue

$$T = 174(60)^2 = 626$$
, 400 ft. lbs.

Reg'd HP = $\frac{T \times N}{5252} = \frac{626,400}{5252} = \frac{720}{360} = 238.5$ H.P.

Even allowing for configuration changes and using 150% for motor load, since the gear reducers are only about 80% efficient, we will require about 200 H.P. per axis compared to the 10 H.P. per axis used on the VLA antennas. Type of drive to be used on the antennas also presents a problem; with a slewing speed of $12^{\circ}/\sec(720^{\circ}/\min)$ and the tracking speed remaining unchanged the dynamic range of a DC motor for a standard motor/gearbox type of drive goes form the approximate 150 to 1 used on the VLA to 2700 to 1 for the VLBA antenna. IF an 1800 RPM motor is used as the drive source driving through a common gear box the low speed of the motor would have to be $\frac{1800}{2700} = 0.67$ RPM. The old rule

of thumb was that the speed range of a DC drive could not be greater than 100 to 1. With modern DC Servo drives this ratio can be exceeded (obviously since the VLA ratio is higher) but I don't think the servo and motor can handle a 2700 to 1 ratio.

In order to avoid the use of hydraulic drives we would have to provide a more complicated and expensive system by either using a separate slewing and tracking system with clutches and shifting from system to system or by using 4 motors per axis and installing 2 differentials between the gearboxes and the motors. Either of these methods of driving add considerable cost because of additional hardware components, require additional space to mount the components and complicate the servo design because of the added modes of operating.

(2) Memo No. 154, does not set forth acceleration requirements which we usually specify as either 0.25/sec² or as reaching full speed in 2 seconds of time. In the case of the VLBA antenna for a velocity of 12°/sec this requires an acceleration rate of 6°/Sec². I have not yet run through the torques this acceleration but if we interpret the acceleration to be required against a wind of 40 M.P.H.,

We will increase the motor H.P. required considerably above the 200 H.P. previously mentioned.

(3) My design experience has been limited to the field of relatively slow moving radio telescopes but I am aware. of one antenna at 85ff;diameter (missile or satellite tracking) which, had an acceleration rate of 12°/Sec² which had to have its acceleration rate changed to a much lower figure because of structural damage.

WGH/bmg