VLBA TEST MEMO NO. 15

National Radio Astronomy Observatory *MEMORANDUM*

To: VLBA Project *Date:* March 16, 1988

From: Craig Walker

Subject: Test Coordination Meeting, Mar. 15, 1988

Those present: Napier, Clark, Bagri, Walker, Crane, Stetten, Wade, Thompson, Romney, Benson, Goss, D'Addario

I noted that pointing observations at 610 MHz are still being done occasionally, mostly to exercise the system and find problems.

Clark noted that the servo system seems to have a significant mean tracking error. The offset is about 4" to 5" at the sidereal rate and may scale with tracking speed. This may be related to changes in the servo parameters that were made to smooth out the tracking motion. It may be necessary to include a term for this in the pointing equations.

Wade described further tests on the rails. At Pie Town, the rail moves by about 0.020 inch when the drive wheels move over, as measured by dial indicators. Some of this is motion between the rail and the grout that is supposed to support the rail, as evidenced by water squirting out from under the rail when the wheel moves over. Some is also compression of the rail, which is expected. At Kitt Peak, there are effects of similar magnitude and there is a tilt, measured by tilt meters, that is about twice spec. However, at that site, the problem seems to be unevenness of the rail surface rather than motion of the rail. At Fort Davis, the rail was leveled based on targets on the antenna. This should cancel out effects of unevenness and rail motions. Measurements are in progress to determine how well this has worked.

At this time, it is not clear what to do about the rail problem, especially since different things seem to be happening at different antennas. The grout at Pie Town probably needs to be replaced. Napier noted that all of these problems could be eliminated, in principle, by using tilt meters to correct the pointing. Perhaps the money and effort that might be expended on the rails should be put into tilt meters instead.

There was a long discussion of phase and delay stability. Clark presented a memo showing the effect on final group delay and phase measurements of the delay variations likely from each piece of hardware analyzed earlier by Bagri. It is clear that, to meet the 2 ps goal set by the geodesy community, it will be necessary to stabilize several elements of the system or to measure the delay, presumably with a pulse cal system. One interesting result of the memo was that the group delay measurements are rather more sensitive to instrumental effects than are phase delay measurements. This led to a long and inconclusive discussion of how delay measurements should be done with the VLBA. A copy of Clark's memo is attached.

Thompson and Bagri have been thinking about a pulse cal system design that should perform better than the existing systems. It is based on the 500 MHz round trip phase measurement system and on locking the 500 MHz output of the pulse generater to the L.O. signal. It should be possible to reach the 2 ps goal. Note that the current phase cal generator used for Mark III is supposed to give 6 ps C^{-1} and it is not included in a phaselock loop.

Despite the debate over best observing strategies and over system designs, my interpretation of the sense of the meeting (and other discussions) is that we should design a pulse cal system and expect to use it in many types of observations. We still need to analyze how the data from such a system is to be used and, based on that analysis, what some of the parameters of the system should be. For example, what should the frequency spacing be? Should the frequencies be flexible? Where and how

are the signals to be detected? Information that is to be provided by Alan Rogers on the parameters and uses of the current system will be a first step in the analysis.

Related to the stability question, there was a short discussion of the air conditioning system at Pie Town. There are likely to be problems in this area but a serious discussion was postponed until more data is available.

Barry Clark's Memo:

From: VAX1::BCLARK "Barry Clark" 14-MAR-1988 23:11
To: KSTETTEN,ATHOMPSON,CWALKER
Subj: Phase error budget - Examples

B. Clark, 88mar14

Durga's memo of circa 88feb05 makes guesses at the magnitudes of various phase errors in the system. This extremely useful memo may, however, be somewhat misleading to the less thoughtful reader. Clearly, the effect of the various errors does depend on exactly what one is doing. There are too many different cases to attempt a general analysis, so I include three cases which might be taken to be typical. I list below the effect which each type of error has on the observation in question in terms of the picoseconds error in the resulting output.

The three cases are 1). determination of a group delay at 8 GHz with two bands of 700 MHz separation, 4 MHz bandwidth each. 2). determination of a group delay at 2.3 GHz with two bands of 250 MHz separation, 4 MHz bandwidth each. 3). determination of a phase delay at 1.6 GHz, a single band of 4 MHz bandwidth.

For explication, I have converted Durga's coefficients to delay errors assuming temperature stabilities of 10C on the cable wrap, 1C in the vertex room, and 0.3C in the building. I have used the full 40ps variation in the cable wrap with position, and 1mV power supply variation. The procedure is to convert each delay, from Durga's memo, into a phase by multiplying by the representative frequency through the device, then to difference the phases in the two channels, and finally, to convert back to time units by dividing by 700 MHz, 250 MHz, 1600 MHz respectively for the three cases.

Error source	magnitude	1) 8 GHz	2) 2.3 GHz	3) 1.6 GHz
Frontend	1	1	1	1
Cables	2	2	2	2
Synth	3	30	0	3
IF conv	2	20	2	2
Cable, temp	10	10*	10	5
Cable, rotn	40	40	40	18
IF Dist	0.6	0.6	0.6	0.3
BBC IF, temp	0.6	0.6	1.8	0.3
BBC IF, ALC	5	5	15	2.3
BBC Mixer	3	3	9	1.4
BBC Video	200	1.1	1.6	0.3
BBC LO, temp	1	1	3	0.5
BBC LO, volt	2	2*	6*	1
100 MHz xmission	3	0	0	3
5 MHz to BBC	3	3*	9*	1.4
8 MHz synth	6	0	0	0
Samplers	6	0	0	0

* Similar behavior of identical units will cause substantial cancellation, perhaps as much as a factor of three.