VLB ARRAY MEMO No. 456

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15 May 1985

To: VLBA
From: W. D. Cotton
Subject: Data Processing Meeting 14 May 1985.

VLBA Postprocessing Group Meeting
1985 May 14

Participants:

| | |
|---|---|
| CV: | Benson, Burns, Cotton, Greisen, Romney, Wells |
| SAO: | Molnar |
| CIT: | Pearson, Fort |
| GB: | Kellermann |
| NRL: | Johnston, Simon |

The items discussed on the agenda were the following:

The agenda for the next VLBA post processing meeting (14 May, 1600 EST ph (203) 797-0901) is as follows. The secret pass word for CONNEX is "conference code 999P".

Specific items for discussion:

1) VLBA / EVN Technical discussion on May 31 in Charlottesville. This will be an informal discussion with some European VLBIers about the VLBA. Are there any special topics which should be covered? Feedback requested?

2) Continuation of the discussion about the calibration and editing software project. The working document CVAX::UMA3:[VLBA.DATAPROC]NOTE16APR85.TXT has been somewhat updated and renamed CVAX::UMA3:[VLBA.DATAPROC]CALIBRATION.TXT. Several questions concerning the accuracy needed for geometric observables remain unanswered.

3) My current intention is to try and implement as much as possible of the calibration and editing software for VLBI data coming from the current (NRAO but also perhaps CIT) correlator(s). That is, to try to create a datapath whereby data will be put into the form that we expect from the VLBA correlator. Thus, we can get several (perhaps many) years experience before the VLBA comes on line.

4) Other.

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An outline of the long awaited Johnston/Simon document discussing the needed accuracy for geometric observations was distributed via VAX mail before the meeting. This memo is appended to the end of this document.

Item 1)

J. Romney described the upcoming VLBA / EVN technical discussion. Romney pointed out that the EVN was intending to make "calibrated and edited" data their standard product from the correlator rather than fringe fitted correlator output. This may be different from the VLBA standard product. There were no comments from anyone about this meeting.

Item 2)

The principle outstanding problem left from the last meeting on this subject was the question of where the geometric observables (accumulated model) should go. The choices are either to keep them as random parameters or in the gain table. The gain table is the location of choice if the model can be interpolated to sufficient accuracy. Benson claimed that the accuracy need for geometric observations could be obtained if the total model values and their first four derivatives were tabulated every two minutes.

K. Johnston stressed that the parameters of the model used should be preserved in case changes in the model were needed. The consequences of this were not immediately obvious but Johnston promised to give a detailed model in the final document. Johnston also stressed that J2000 (or a modified version) coordinates should be used from the beginning of the VLBA project.

Johnston claimed that the ionisphere would be the most serious calibration problem. He promised to put some information about the ionispheric behavior based on monitoring with the Greenbank inteferometer in the final version of his report. There was some discussion about methods of ionispheric calibration with some concensus that the GPS satellite system might give an acceptable method. More work needs to be done on ionispheric calibration.

Item 3

Cotton outlined a general scheme of converting the output of current correlators into the form of VLBA distribution tapes in order to get some operational experience with the software before the VLBA comes on line. Romney pointed out that this was most important for MKIII correlators since their output is much closer to the data from the VLBA than MKII especially since multiple IFs are recorded. Cotton and Benson offered to make a draft document defining the contents of the distribution tape.

# Requirements on the Accuracy of Geometric Observables with the VLBA

K. J. Johnston and R. S. Simon
Naval Research Laboratory
13 May 1985

We estimate the accuracy achievable in position determination over the entire sky to be approximately 0.1 milliarcsecond. Further, over smaller angles (up ~5 degrees) relative positions of order 10 microseconds accuracy should be possible with the funded VLBA. These desired accuracies imply the following requirement:

The actual geometric delay must be measured, recorded, and recoverable to 1 part in 10**10. That's it.

This corresponds to a delay accuracy of approximately 0.01 picoseconds. This number is arrived at as we expect the limit in accuracy for geometric observables to be determined by error in the atmospheric phase path which is estimated to be about 1 cm. For baselines of order 10,000 km, 1 cm is a part in 10**9. Thus, the error introduced by 0.01 picoseconds accuracy should be roughly a factor of 10 smaller than the expected atmospheric errors.

Some details:

There are four major categories of observables/model parameters which contribute to the total delay. These are:

1) Geometric. These include:

   a) Earth rotation (UT) and polar motion
   b) Precession and nutation
   c) Aberation
   d) Earth tides
   e) Relativity
   f) Axis offsets (and over the top)
   g) etc...

2) Atmospheric corrections

3) Ionospheric corrections

4) Source dependent corrections

   a) Proper motion
   b) Radial velocity
   c) Parallax
   d) Planetary motion (higer order position derivatives)

We plan to evaluate these effects in detail. At first glance, the geometric terms may be lumped together, with the possible exception of the terms for earth rotation and polar motion. The other terms are

smoothly varying functions (except nutation?) which can easily be calculated and post-calibrated after processing, for the purposes of astrometry.

Further, for astrometric measurements, we assume that an "on-line" algorithm will be used at the correlator to search for fringes. Later processing will apply an atmospheric model based on water vapor radiometers; dual frequency observations should be able to remove the effects of the ionosphere to first order.

In the situation where fringe fitting parameters observed for one (calibrator) source are to be applied to another (program) source, it will be necessary to break the delay recorded in the gain file into separate contributions from each of the above effects. If we want to do accurate phase reference mapping, this price must be paid.

Requirements on the Gain Table:

All that is required is that it be possible to derive via interpolation the actual delays which were applied at the time of processing to the data. According to calculations by John Benson, sufficient accuracy in the delays can be achieved if the delay and its first four derivatives are stored in the gain table about once every two minutes.

Available Programs:

Software currently exists to calculate the above parameters to about 0.1 millaroseconds, although it is not really known whether or not either earth rotation or polar motion are smooth at that level, even on time scales of hours.