OVLBI-ES MEMO NO. 19

PROPOSED EARTH STATION TO CORRELATOR INTERFACE
FOR TIMING CORRECTIONS

Larry R. D'Addario
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At any VLBI correlator, the time base that is the independent variable in all geometrical model (delay and phase) calculations is derived from the time stamps on the tape. In ground VLBI, it is common practice to allow for the fact that these times are slightly wrong, so that the correlator model may include provisions for a time offset and a time drift rate for each station, but these can safely be considered fixed for long periods of time. In OVLBI, the tape times are much less accurate and their errors are subject to rapid variation due to the effects of atmospheric turbulence on the time transfer to the satellite. Slower but much larger variations in the errors occur because the satellite orbit was not accurately known during data acquisition. Additional effects may also cause errors in the satellite time.

The time stamp on the tape nominally represents the time at which a particular signal sample was *taken*, and for the orbiting case this is substantially earlier than the time that it was *recorded*. The earth station should initialize the tape-time clock as best it can, based on the predicted satellite range at the initialization epoch. This may produce a fairly large (many microseconds) time offset, even if the earth station UTC clock is set perfectly. Thereafter, the earth station must use the two-way timing link to accumulate a continuous series of measurements of the variation in the time error. This series must be transmitted to the correlator, which must then add it to the tape time as a correction; in this way, the corrected time will have a constant error during the tracking pass, this error being just the one imposed at initialization of the tape-time clock. In practice, this process in imperfect and there will still be fluctuations in the error in the corrected time. But we believe that proper design will enable the fast fluctuations (primarily atmosphere-induced) to be removed sufficiently to prevent significant decorrelation, and the slower variations (primarily from orbit knowledge errors) to be removed sufficiently to avoid the need for repeated fringe searches. [However, repeated fringe searches may still be required if the reconstructed orbit provides inadequate knowledge of the interferometer baseline vector, even if the time error is zero.]

In view of the above, the following specification is proposed for the transfer of this information from an earth station to a correlator. A major principle in this specification is that it should be independent of the architecture of any particular earth station or correlator. Text in square brackets [...] is a comment, not part of the specification.

1. The earth station shall provide a single time series of corrections to the tape time, such that when an element of this series is added to the corresponding tape time the resulting *corrected tape time* will have minimum possible error.

2. The time series shall have a sampling interval of 0.1 UTC second (not 0.1 tape time second), and the underlying measurements should have a bandwidth no greater than 5 Hz. [This is believed to be sufficient to encompass all significant fluctuations.]

3. The time series shall include time stamps at intervals of 10 UTC sec (every 100 samples). These shall give the time of the next succeeding

sample as an integer number of seconds since UTC midnight.

4. Each sample of the time series shall be a 32-bit integer that represents the time correction in units of 0.1 picosecond. [This allows a correction as large as 0.4 msec and a resolution that corresponds to 0.8 deg of phase at 22 GHz.]

5. The correlator shall read the time series, determine the tape time to which each sample applies, and use the result to correct the correlator's geometric model. If the correlator is unable to use the full 5 Hz bandwidth, it may filter the time series to a smaller bandwidth. Interpolation to faster rates for internal use within the correlator is an option of the correlator designer. [Support of the full 5 Hz bandwidth requires sinc interpolation of the 0.1 sec samples, but if the underlying bandwidth is smaller than 5 Hz or if the correlator filters the data to a smaller bandwidth, then simpler interpolation methods may be adequate.]

6. The data shall be organized into a binary file whose detailed format is TBD. This format may include data compression, using a specified algorithm that can be exactly inverted at the correlator. [This recognizes the fact that the more significant bits of the time corrections may be changing slowly, so they need not be transmitted with every sample.]

7. Two methods shall be provided for transfer of this file from the earth station [or earth station control center] to the correlator. The primary method shall be electronic, using the FTP protocol over the Internet. Specified hosts, directory paths, and file names [TBD] shall be used to allow automation of this transfer. The secondary method shall be by transport of a magnetic medium TBD [suggested: 5.25 inch floppy disk in 1.2MB IBM format, due to its worldwide availability]. The primary method shall be used wherever possible; the secondary method is provided for remote (mostly foreign) sites that do not have access to the Internet, and as a backup.