VLB ARRAY MEMO No. 341

National Radio Astronomy Observatory
Charlottesville, Virginia

22 March 1984

To: VLBA Project

From: R. C. Walker

Subject: NBS Global Time Service

The attached letter and specs were sent to me by David Allan of the NBS. He is wondering if we are interested in their time transfer system. He also enclosed several papers on the system. These papers are listed below and are available from Carolyn at the VLBA Project Office. Are we interested?

The papers sent were:

Davis, D. D., Weiss, M., Clements, A., and Allan, D. W. 1981, Proceedings of some symposium whose name was not copied. "Construction and Performance Characteristics of a Prototype NBS/GPS Receiver".

Davis, D. D., Weiss, M., Clements, A., and Allan, D. W. "Remote Synchronization Within a Few Nanoseconds by Simultaneous Viewing of the 1.575 GHz GPS Satellite Signals."

Weiss, M. "Position Location Using Sequential GPS Measurements."

Allan, D. W. "National and International Time and Frequency Comparisons."

"National Bureau of Standards Dissemination Report No. 84-1.2 Haystack Observatory Clock at NBS Receiver Haystack, Mass." For report period Jan 1984.

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
325 Broadway
Boulder, Colorado 80303

March 13, 1984

Reply to the attention of:

Dr. Craig Walker
NRAO
Edgemont Road
Charlottesville, VA 22901

Dear Dr. Walker:

Per our telephone conversation of 16 February 1984 please find enclosed some information on the NBS Global Time Service. As I mentioned to you, Professor Counselman is now using this service for the Haystack maser. Please find enclosed a copy (with his permission) of the January '84 report on his clock. Please also find enclosed some other relevant papers and a data sheet on this calibration service.

This service would allow you to know the time and frequency of every clock in your VLBI system with respect to any other clock in that system. Given the quality of hydrogen masers now being constructed, the accuracy of the frequency should be about a part in 10^{14} for all integration times longer than about 10 s. Given the ten proposed sites, the 10 nanosecond absolute time between any two sites should also be very realistic. Typical day-to-day rms time fluctuations within the continental United States are of the order of 3 to 6 nanoseconds.

For $20k per year over the first three years NBS would supply and maintain the receiver equipment and provide a monthly report on your clock. You would also be able to telephone the NBS time scale computers and access an estimate of the time and frequency of your clock or of any other clock in your system. Hence, you could determine the frequency and time difference between any two sites. At each site, you would need to supply 5 MHz and 1 pps signals from the clock you wish to have calibrated, an antenna pole within nominally 100 feet of the receiver and a dedicated telephone line through which we could access the common-view GPS data for processing against the NBS clock ensemble. The net result of such a calibration service would be to have in effect the same clock at all sites with a part in 10^{14} stability both in short term and in long term for indefinite integration times. In passing, I might mention that we have observed for the GPS common-view measurement noise between Paris and Boulder a part in 10^{15} for 32- day integration time.

Please give me a call if you have any questions regarding these papers or the Haystack report. If we can be of any assistance we would be happy to work with you.

Sincerely yours,

D. W. Allan

David W. Allan
Time and Frequency Division

Encl.

GPS Calibration Package Sheet

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
325 Broadway
Boulder, Colorado 80303

TWX - 9109405906 NBS TFDIV BLDR
Reply to the attention of: 524

November 1, 1983

NATIONAL BUREAU OF STANDARDS (NBS)
GPS TIME DISSEMINATION SERVICE

Concept: A GPS receiver, provided by NBS and installed at the user's site, is interfaced to the users clock. The receiver is programmed to make measurements on a set of GPS satellites which are simultaneously measured by a receiver in Boulder, Colorado. NBS collects the data from each receiver, then stores, processes and filters the values and provides daily estimates of the time of the user's clock with respect to UTC(NBS).

Performance: Experiments between Boulder, Colorado and the District of Columbia, California, France and Germany indicates that the noise of the reference provided by this technique is given by

$$\text{Mod } \sigma_y(\tau) \sim 1 \times 10^{-13} \tau^{-3/2} \text{ for } 1 \leq \tau \leq 4 \text{ days and}$$

$$\sigma_y(\tau) \sim 1 \times 10^{-14} \text{ for } 4 \leq \tau \leq 30 \text{ days}$$

Equipment and Service Provided by NBS: GPS receiver, antenna, printer, 30 meter calibrated cable, telephone modem, assistance with installation, data acquisition and processing, determination of receiver position, on-line user access to the daily time differences between the user's clock and UTC(NBS), monthly reports, and repair service.

Equipment provided by User: (1) Local clock with one pulse per second output (3 volts into 50 ohm load) and with 5-MHz signal (1 volt rms into 50 ohm load). If the user wishes to realize UTC(NBS) at its full accuracy, then the local clock stability at one day should be approximately 10^{-13} or better. Otherwise the instability of the local clock will be the dominant source of noise. (2) Direct dial telephone line. (3) Antenna mounting pole.

Cost: This service is being provided by NBS at cost. The price is published in the Appendix to NBS Special Publication 250, published October 1983. The current cost of $20,000 for a one-year contract will be in effect through March 1984.

General: The GPS receivers used in this service were developed by NBS. Prototype receivers were built by NBS but additional units have been acquired from a commercial vendor.