PRECISE FREQUENCY TRANSFER USING A WAAS SATELLITE WITH HIGH-GAIN ANTENNAS*

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1 Discussion

Simultaneous measurements were made from the US Naval Observatory (USNO) in Washington, DC, U.S.A., and from the National Institute of Standards and Technology (NIST) in Boulder, Colorado, U.S.A. of the Wide Area Augmentation System (WAAS) satellite. Both sites used two receivers, one employing a high-gain antenna and one with an omni-directional antenna. The receivers logged the carrier and code phases, the broadcast satellite ephemerides, and other parameters both from the satellite and the receivers. The receivers measured the received satellite signals against a local 5 MHz signal from Hydrogen masers (H-masers) in the labs. Hence this a test of time transfer stability or frequency transfer accuracy, and not of time transfer accuracy.

We computed common-view frequency transfer using the broadcast ephemerides and estimates of the ionosphere and troposphere. The change in the ionospheric delay was estimated using the difference between the code and carrier phases. Since we are characterizing frequency transfer, the absolute ionospheric delay is not important.

Previous results were reported [1] with a similar setup, i.e. using high-gain directional antennas, between the National Research Council (NRC) in Ottawa, Canada, and USNO, reporting stability approaching 1×10^{-15} at less than 1 day. If such stabilities could be produced in a repeatable system, they would compete with

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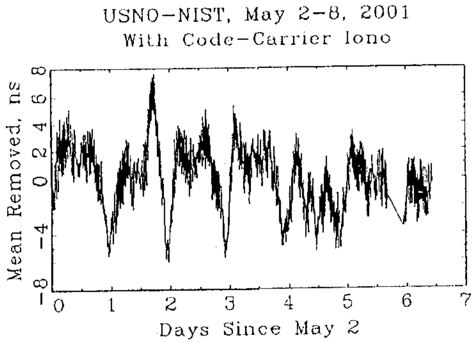

Figure 1: Common—view frequency transfer results

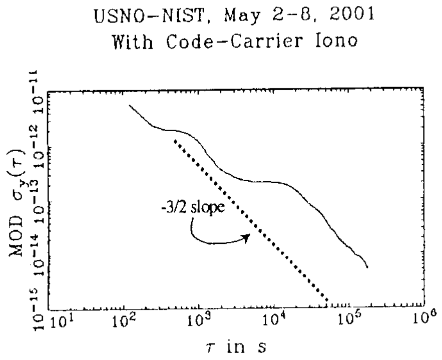

Figure 2: Modified All Deviation of the Figure 1 data.

the best frequency transfer techniques currently available: two-way time and frequency transfer, and GPS carrier phase frequency transfer [2,3].

2 Results

Unfortunately, problems were found in this experiment that were not seen previously. We chose May 2-8, 2001 as a period with minimum cycle slips to compute our USNO-NIST frequency transfer. Figure 1 shows the common-view data from code measurements after correcting for the range, the tropospheric delay and the ionospheric delay computed from the code – carrier changes. The mean has been removed. Figure 2 is the Modified Allan Deviation of these data.

The –3/2 slope in Figure 2 is the stability we would obtain with white phase noise. This is similar to what was reported previously in [1]. There now appear to be three periodic effects that perturb the data with periods of 1000 s, ½ d, and 1 d. These must be due to effects that appear differently at the two stations of USNO and NIST. Such effects could include multi-path interference, satellite ephemeris errors, or local receiver system effects. Side-lobes in the dish antennas could allow multi-path interference. Also, the strong signals from the dish antennas could over-drive the receivers intermittently. Temperature effects are possible.

There were 4 cycle slips detected in these data, all at the NIST receiver. At those times, the NIST system with an omni-directional antenna was also tracking the WAAS satellite and did not slip. Hence we were able to use those data to correct the slips.

We plan on checking carefully our set-ups at both stations. Attenuating the signals properly, pointing the antennas, and monitoring the 1pps out of the receiver could improve tracking. Also, we will determine if a precise ephemeris is available.

3 Bibliography

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