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From: Jim Ray (USNO 202-762-1444)
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Subject: [GPST] PTTI accuracy paper available
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An electronic preprint is available for the following paper at:
http://maia.usno.navy.mil/gpst/refs/seniorray-ptti01.ps

Senior, K., and J. Ray, Accuracy and precision of GPS carrier phase clock estimates, Proc. 33st Precise Time and Time Interval Meeting, in press 2001. [397 kB ps format]

The accuracy of GPS-based clock estimates is determined by the pseudorange data. For 24-hour arcs of global data sampled at 5-minute intervals, the formal errors for the clock estimates are typically about 115 ps. An internal test of the actual time transfer measurement accuracy has been made by comparing clock estimates at the boundaries between successive analysis arcs for receivers equipped with very stable oscillators, using the combined daily clock estimates provided by the International GPS Service (IGS). During the period 29 October 2000 to 28 July 2001, the observed day-boundary discontinuities for individual IGS stations have distributions well described as zero-mean and Gaussian. However, the variances among the 23 stations span a wide range, from RMS values of about 170 ps to 1200 ps, implying time transfer accuracies ranging from about equal to the formal errors to nearly an order of magnitude greater. For a few stations, the performance changes dramatically with time. Since the same receiver and antenna models are common for many stations, it is likely that the dominant site-dependent effects are related more to local factors affecting data quality than to specific hardware choices. The ALGO and NRC1 stations display notable temporal variations that might be seasonal. We find that a portion of the variability is caused by sensitivities to long-term temperature changes, with coefficients of -101 ps/C and 156 ps/C. Smaller, less significant temperature-dependent effects are seen at some of the other stations. After allowing for temperature-dependent effects, much larger day-boundary jumps remain for ALGO and NRC1 during winter 2000/2001, possibly due to signal reflection off snow-covered surfaces near the antennas. Temporal changes in time transfer accuracy at HOB2 are probably related to damage to the antenna cable. The causes for similar changes at MATE and briefly at NYAL/NYA1 have not been identified. Using our thermal sensitivity results for USNO, where the cable and receiver systems are well isolated from environmental changes, we have extended our previous study of diurnal temperature effects on Dorne Margolin choke ring antennas to put an upper limit of 10.1 ps/C on any possible pseudorange-induced long-term variations due to this type of antenna.

The precision of clock estimates within a given analysis arc is usually assumed to be better than indicated by the formal errors or the accuracy measures because the relative clock estimates are determined mostly by the carrier phase observations. We confirm this for intervals shorter than about 1 day, the analysis arc length. Average Allan deviations are well correlated with the day-boundary accuracy measures and imply a stability floor for carrier phase time transfer of 2 x 10^-13 tau^-0.44,

consistent within measurement errors with a random walk process.