CCTF 2001: Report of the Royal Observatory of Belgium

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Clocks and Time scales:

The Time Lab of the Royal Observatory of Belgium contains presently 3 Cesium clocks HP5071A with standard tubes, one active H-maser CH1-75 (not tuned at present) and one passive H-maser CH1-76. The UTC(ORB) time scale is generated from the frequency of a Cesium clock with a micro-phase stepper. The control of UTC(ORB) is performed two times per week using the comparison UTC(ORB)-GPS time. The behavior of UTC(ORB) with respect to TAI is shown in Figure1.

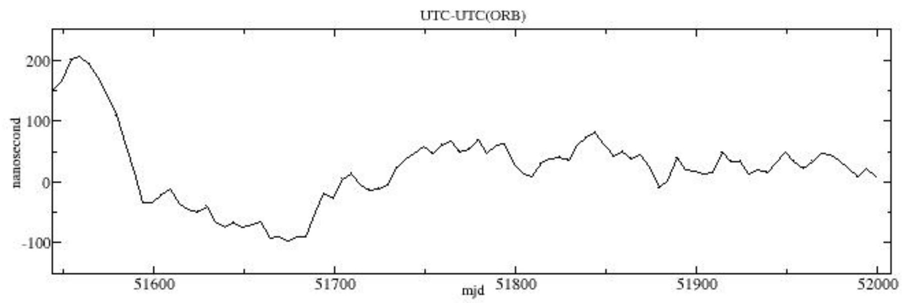

Figure 1. UTC-UTC(ORB) from 2000.0 to 2001.25

During the year 2000, we observed a change of the trend of one of the Cesium clocks HP5071A (see Figure 2). The clock was then returned to the Agilent Technologies manufactory where several tests were performed, but it was found no anomaly in the clock behavior. This change in the clock drift is thus not explained, and the new drift remains now constant as seen in Figure 2.

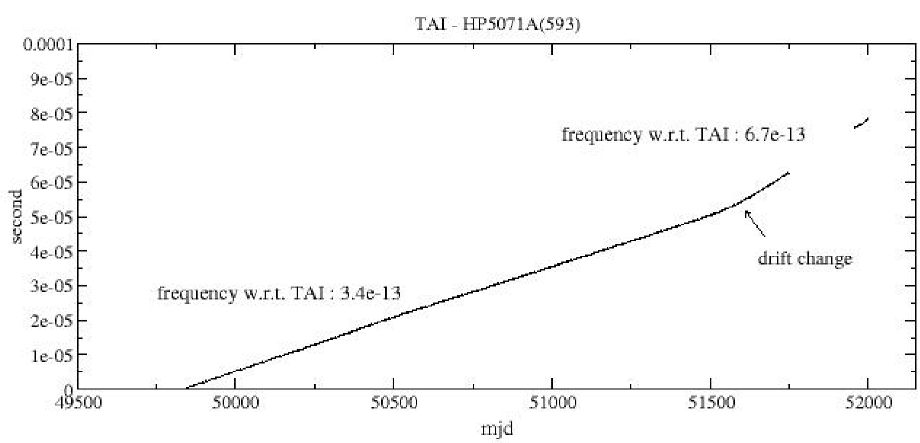

Figure 2. Drift change of the Cesium clock HP5071A(593)

Time and frequency transfer using GPS and GLONASS codes, and GPS carrier phases.

Frequency transfer using GPS carrier phases

GPS codes and carrier phases measured by multi-channel geodetic receivers can be used for accurate frequency transfer applications when using geodetic data analysis methods.

At the Royal Observatory of Belgium, previous on-site studies had shown (see CCTF 1999 report) the sensitivity of the frequency transfer to the temperature variations around the hardware (GPS receiver, cable, and antenna). Now, some parts of the old set-up have been improved: the GPS receiver was moved to an environmentally controlled chamber where temperature variations are kept smaller than 0.2°C and the old antenna cable has been replaced by a new cable with a low electrical length change versus temperature. We demonstrated (Bruyninx and Defraigne, 2000) that this upgrade improves the stability of the frequency transfer especially for sub-daily averaging times. Stabilities of 1.5 to 3.10^{-15} can be routinely obtained for averaging durations of only 4 hours. The daily estimation process, in addition to the presence of multipath in the code observations, introduces jumps in the estimated clock differences, which can grow up to a few ns. We used overlapping data files with careful modeling of all parameters at the day boundaries in order to suppress jumps between successive days. Using IGS tracking stations, separated by 280 km and driven by an H-maser, the results demonstrate frequency stabilities of 1.10^{-15} for averaging durations of 32 hours (see Figure 3).

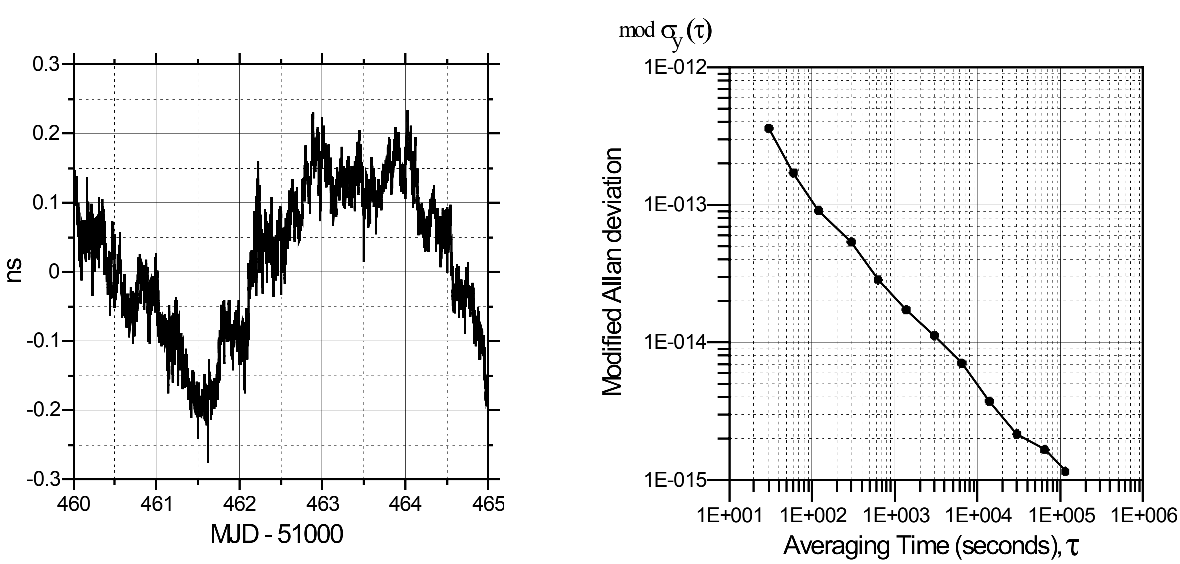

Figure 3. (left) Clock estimates for five consecutive days of the link Brussels-Westerbork (280 km), both receivers are driven by a H-maser. (right) Corresponding Modified Allan deviation.

Time transfer with GPS/GLONASS code data

We used GLONASS P-codes from RINEX files of geodetic GPS/GLONASS receivers (R100 from 3S-Navigation), involved in the IGEX campaign, to perform frequency/time transfer between remote clocks (Roosbeek et al., 2001). We pointed out that the GLONASS broadcast ephemerides give rise to a considerable number of outliers in the time transfer, compared to the precise IGEX ephemerides. Due to receiver clock resets at day boundaries, characteristic of the R100 receivers from 3S-Navigation, continuous data sets exceeding one day are not available. In this context, it is therefore impossible to perform RINEX-based precise frequency transfer with GLONASS P-codes on a time scale longer than one day. Because the frequency emitted by each GLONASS satellite is different, the time transfer results must be corrected for the different receiver hardware delays. After this correction, the final precision of our time transfer results corresponds to a root-mean-square (rms) of 1.8 nanoseconds (ns) (maximum difference of 11.8 ns) compared to a rms of about 4.4 ns (maximum difference of 31.9 ns) for time transfer based on GPS C/A code observations (see Figure 4).

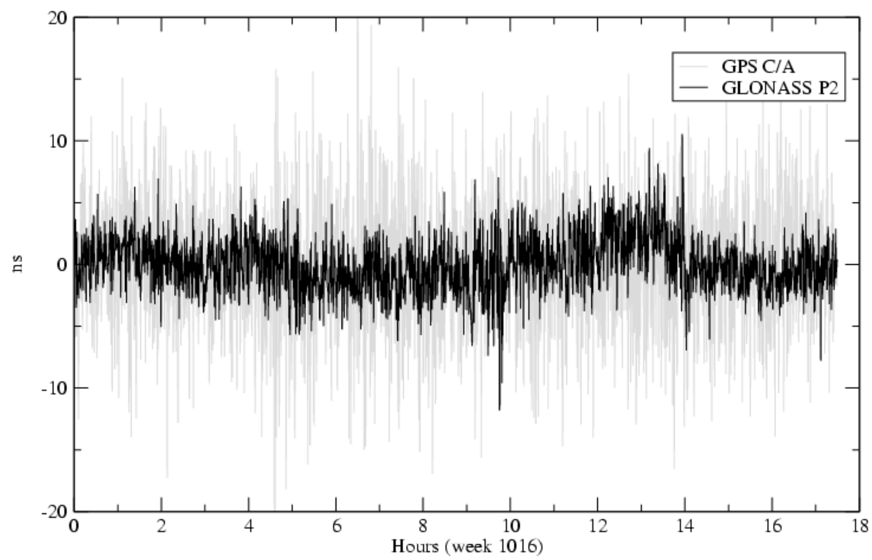

Figure 4. Time transfer between BRUG and NPLC for the first day of the GPS week 1016

Time transfer to TAI using geodetic receivers

We developed both the procedure and the software tool that allow to generate the CCTF files needed for time transfer to TAI using RINEX files produced by geodetic receivers driven by an external frequency. The CCTF files are then generated from the RINEX observation files. The clock resets of the geodetic receivers are accounted for by monitoring with a time interval counter the 1pps out signal of the receiver. Applied to

IGS (International GPS Service) receivers, this procedure will provide a direct link between TAI and the IGS clock products.

We applied this procedure successfully on different types of geodetic receivers. The correctness of the method was demonstrated from the comparison of the results with colocated time receivers (see Defraigne and Bruyninx, 2001; Defraigne et al., 2001).

References:

Bruyninx C. and Defraigne P., 2000. "Frequency transfer using GPS codes and phases: short and long term stability"y, Proc. 31th PPTI, pp. 471-478.

Defraigne P. and Bruyninx C. (2001) "Time transfer for TAI using a geodetic receiver, an example with the Ashtech ZXII-T", GPS Solution, in press.

Defraigne P., Bruyninx C., Clarke J., Ray J., Senior K. , 2001, *"Time transfer to TAI using geodetic receivers",* Proc. EFTF 2001, in press.

Roosbeek F., Defraigne P. and Bruyninx C. (2001), *"Time Transfer experiments using GLONASS P-codes measurements from RINEX files"*, GPS Solutions, in press.