CCTF 2017: Report of the Royal Observatory of Belgium

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Clocks and Time scales:

The Precise Time Facility (PTF) of the Royal Observatory of Belgium (ROB) contains presently 3 Cesium clocks HP5071A, with High Perf. tubes, and one active H-maser CH1-75A (since 2006). UTC(ORB) is generated from the CH1-75A frequency, steered weekly upon the UTC values.
The behavior of UTC(ORB) with respect to UTC is shown in Figure1.

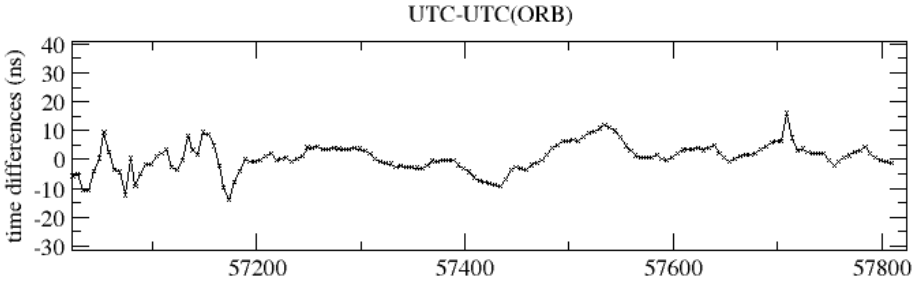

Figure 1. UTC-UTC(ORB) from 2015.0 to 2017.3

- The station BRUX, used for the ling of ORB with TAI, was calibrated in march 2017 using the traveling equipment from the Observatoire de Paris. The cal_id has not yet been given by the BIPM.

- A GNSS station ORBA located at the ORB has been absolutely calibrated by the CNES in September 2015.

Participation to the EGNSS Activities

- The ORB team was responsible for the validation and calibration of the UTC and GGTO information broadcasted in the navigation message of the Galileo satellites, in the frame of a technical support to the ESA.
- The ORB started an activity of monitoring the EGNOS time in collaboration with the OP, INRIM and CNES colleagues.

GNSS time and frequency transfer

- ORB assured the coordination of the project TIME5 (ESA EGEP ID-89): Improving Time transfer with Galileo E5 AltBOC. The main conclusions of the study are summarized here:

1. For synchronization: in single-frequency, E1 should be preferred to E5 AltBOC because of the uncertainties on the ionospheric corrections; their impact is larger than the noise difference between E1 and E5 AltBOC.
2. In dual-frequency, the combination (E1,E5 AltBOC) provides the smallest noise level, but cannot be used as no navigation message and no satellite group delay is provided for that combination.
3. For frequency steering: the advantage of using E5 AltBOC was demonstrated for the short term stability up to about 15 minutes. (see Figure2)

- ORB studied the stability and accuracy of the P1 and P2 hardware delays in GNSS equipment dedicated to time transfer, using ionospheric maps. The conclusion is that the differences between the computed dP1-dP2 and the calibrated values are well inside the combined uncertainty of the two quantities. Furthermore some variations of up to 500 ps can be observed, explaining variations of 750 ps variations in the clock solutions based on P3.

- ORB developed and distributed to the time laboratories a new R2CGGTTS software (version 7.1) allowing analysis of RINEX3, for GPS, GLONASS and Galileo

- ORB participated to the H2020 project DEMETRA coordinated by the INRIM. ORB was responsible for calibrating GNSS stations for timing applications, a real-time steering of the User oscillator from the remote reference which is a realization of UTC based on GNSS common-view, and a real-time monitoring and alert system based on PPP, for user atomic clock, by a comparison with the reference which is a realization of UTC.

Publications with peer review

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3 W. Aerts, C. Bruyninx, P. Defraigne, G. Vandenbosch and P. Zeimetz, On the Influence of RF Absorbing Material on the GNSS Position, *GPS Solut*, 20 (1), pp 1-7, doi: 10.1007/s10291-014-0428-y, 2016.

4 P. Defraigne and J.-M. Sleewaegen, Code-Phase Clock Bias and frequency offset in PPP clock solutions, *IEEE transactions on ultrasonics, ferroelectrics, and frequency control*, vol. 63 (7), pp. 986-992, 2016. DOI 10.1109/TUFFC.2015.2501350

5 W. Huang and P. Defraigne, CGGTTS Results with BeiDou Using the R2CGGTTS, *IEEE transactions on ultrasonics, ferroelectrics, and frequency control*, vol. 63 (7), pp. 1005-1012, 2016. DOI: 10.1109/TUFFC.2016.2517818

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